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# A Cross-Sectional Study to Assess Cardiac Structure and Diastolic Function in Young Adults with Type 2 Diabetes Mellitus

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## Abstract

**Background:** Type 2 Diabetes Mellitus (T2DM) is increasingly recognized as a disease of young adults; however, early cardiovascular sequelae including diabetic cardiomyopathy and left ventricular diastolic dysfunction may be developing earlier still. Identifying these early signs of cardiac dysfunction are a key to preventing overt heart failure.

**Materials and Methods:** It was a cross-sectional study conducted in the Department of Cardiology at Chinese University of Hong Kong Faculty of Medicine, china during 12 months. Methods: All 150 young adults (<40 years) with T2DM were subjected to extensive clinical work-up, metabolic parameters and two-dimensional echocardiography in this cross-sectional study. Echocardiographic measures including left ventricular mass, E/A ratio and E/e′ ratio and ejection fraction were conducted. Statistical analyses were performed using SPSS and a P <0.05 was considered statistically significant.

**Results:** The mean age was 34.8 ± 4.2 years with male predominance (58.7%). Left ventricular diastolic dysfunction was observed in 45.3% of the patients, predominantly Grade I. Mean E/a ratio 1.02 ± 0.28 and mean E/e′ ratio, an index of LV diastolic function was11.2 ± 2.6 suggesting impaired diastolic relaxation Detraining analysis and myostatin level. Diastolic dysfunction was significantly associated with glycemic control ($p < 0.001$) and duration of diabetes ($p = 0.002$). In most patients, the left ventricular systolic function was preserved.

**Conclusion:** Subclinical left ventricular diastolic dysfunction is very common in young adults with T2DM. This puts patients in the window for therapy delivery when they undergo an early echocardiographic screening and have optimal glycemic control, ideally utilizing other adjuncts to reduce cardiovascular event risk.

**Keywords:** Type 2 Diabetes Mellitus; Diastolic Dysfunction; Echocardiography; Diabetic Cardiomyopathy; Young Adults; Left Ventricular Dysfunction.

## Introduction

Type 2 Diabetes Mellitus (T2DM) is a common metabolic disorder and has become one of the biggest public health problems in all societies [1]. The lifetime incidence of Type 2 Diabetes Mellitus (T2DM) among young adults has more than doubled in recent decades due, at least in part, to rising rates of overweight and obesity compounded by a declining level of physical activity, poor eating habits and urbanisation. Due to long-term exposure to hyperglycemia and metabolic derangements, youth with T2DM are at increased risk for early development of cardiovascular complications. [1,2]

Despite this development, cardiovascular disease continues to be the leading cause of morbidity and

mortality among individuals with diabetes mellitus. In addition to accelerated atherosclerosis and coronary artery disease, diabetes can also have direct effects on myocardial structure and function, causing diabetic cardiomyopathy. [3] In the absence of hypertension, valvular heart disease, or ischemic heart disease we identified and defined diabetic cardiomyopathy as cortical ventricular dysfunction. Background: Left ventricular (LV) diastolic dysfunction has long been recognized as one of the earliest findings of diabetic cardiomyopathy and may antedate the development of overt heart failure. [4] Type 2 Diabetes Mellitus (DM2 P) has been recognized as a higher risk for Heart failure with preserved ejection fraction (HFpEF), in which left ventricular diastolic dysfunction appears to play a central role in its pathogenesis. [5] Diastolic dysfunction in early stages are usually asymptomatic and remains undiagnosed unless actively searched for. In diabetic patients with asymptomatic cardiac involvement, recognition of subclinical abnormalities is desirable because early intervention and strict glycemic control as well as adequate management of cardiovascular risk factors may help to prevent progression to manifest cardiac disease. [6]

Echocardiography is a practical, non-invasive and reproducible imaging modality that can be applied to assess cardiac geometry and ventricular function. This is important because: 1) it detects left ventricular geometry and diastolic function abnormalities earlier in the setting of diabetic patients. Studies have shown that patients with Type 2 Diabetes Mellitus start to gain mass of the left ventricle, subsequently develop left ventricular geometry dysfunction at a much earlier and greater level than previously appreciated, which can also be connected to diastolic function impairment [7]. Additionally, recent data indicate that younger patients with T2DM experience stage-specific myocardial dysfunctions in the absence of overt clinical and/or imaging-evident complications. [8,9] [10]

This cohort is at significant risk, including young adults with T2DM, as the early manifestation of cardiovascular alterations frequently occurs during early stages of disease. However, there is a paucity of data regarding echocardiographic evaluation of cardiac structure and diastolic dysfunction specifically in Indian young adults with Type 2 Diabetes mellitus. Thus, the current study was carried out to evaluate cardiac structure and diastolic function by echocardiography in non-asymptomatic adolescents/young adults with Type 2 Diabetes Mellitus and their relation to clinical and metabolic variables.

## Materials & Methods

### Study Design and Setting

This hospital-based cross-sectional observational study was conducted in the Department of Cardiology at Chinese University of Hong Kong Faculty of Medicine, China over a period of 12 months. The study was undertaken to evaluate cardiac structural changes and left ventricular diastolic function among young adults with Type 2 Diabetes Mellitus (T2DM). Participants were recruited consecutively from the outpatient and inpatient services of the Departments of Cardiology and General Medicine. A total of 150 eligible patients with T2DM were enrolled after obtaining written informed consent.

### Study Population

The study population comprised young adults diagnosed with Type 2 Diabetes Mellitus attending the Departments of Cardiology and General Medicine during the study period. All eligible participants underwent clinical evaluation, laboratory investigations, and echocardiographic assessment according to the study protocol.

### Inclusion Criteria

Patients with a confirmed diagnosis of Type 2 Diabetes Mellitus who were younger than 40 years of age were considered eligible for inclusion in the study. Both male and female patients were included. Only those who were willing to participate and provided written informed consent after receiving a detailed explanation of the study were enrolled.

**Exclusion Criteria**

Patients diagnosed with Type 1 Diabetes Mellitus were excluded from the study. Individuals with a previous history of ischemic heart disease, valvular heart disease, congenital heart disease, or cardiomyopathy due to causes other than diabetes were also excluded to avoid confounding cardiac abnormalities. Patients with chronic kidney disease, chronic liver disease, or pregnancy were not included because these conditions could independently influence cardiac structure and function. In addition, patients who declined participation or were unwilling to provide written informed consent were excluded from the study.

**Data Collection**

Following enrolment, each participant underwent a comprehensive clinical evaluation. Detailed demographic characteristics and medical history were obtained using a structured case record form. Information regarding the duration of diabetes, treatment history, smoking status, alcohol consumption, associated comorbidities, and relevant family history was documented. A complete general physical examination and systemic examination were performed for all participants.

Anthropometric measurements were obtained using standardized techniques. Height and weight were measured with participants wearing light clothing and no footwear, and body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters ($kg/m^2$). Blood pressure was measured using a calibrated sphygmomanometer after the participant had rested in the seated position for at least five minutes. Two measurements were recorded, and the average value was used for analysis.

**Laboratory Investigations**

Venous blood samples were collected from all participants after an overnight fast. Fasting blood glucose, postprandial blood glucose, and glycated hemoglobin (HbA1c) levels were estimated using standard laboratory methods to assess glycemic status and long-term glycemic control. A complete lipid profile, including total cholesterol, triglycerides, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol, was performed using automated biochemical analyzers. Renal function was evaluated by measuring serum urea and creatinine levels to identify underlying renal impairment.

**Echocardiographic Assessment**

All participants underwent comprehensive two-dimensional transthoracic echocardiography using a standard echocardiographic machine in the Department of Cardiology. Echocardiographic examinations were performed by experienced cardiologists according to the recommendations of the American Society of Echocardiography. Cardiac structural assessment included measurement of left ventricular mass, left ventricular wall thickness, and left atrial dimensions.

Left ventricular diastolic function was evaluated using conventional pulsed-wave Doppler and tissue Doppler imaging techniques. Mitral inflow early (E) and late (A) diastolic velocities were recorded, and the E/A ratio was calculated. Tissue Doppler imaging was used to measure the early diastolic mitral annular velocity (e′), from which the E/e′ ratio was derived to estimate left ventricular filling pressure. Based on these echocardiographic findings, left ventricular diastolic dysfunction was graded according to internationally accepted echocardiographic guidelines.

**Statistical Analysis**

The collected data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Comparisons between study variables were performed using the Student's *t*-test for continuous variables and the Chi-square test for categorical variables, as appropriate. A two-tailed p-value of less than 0.05 was considered statistically significant.

**Ethical Considerations**

The study protocol was approved by the Institutional Ethics Committee before the conducting of the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment after explaining the purpose and

procedures of the study. Participant confidentiality and anonymity were maintained throughout the study, and all collected information was used exclusively for research purposes.

## Results

**Table 1. Demographic Characteristics of Study Participants (n = 150)**

| Variable | Mean ± SD / n (%) |
|---|---|
| Age (years) | 34.8 ± 4.2 |
| Male | 88 (58.7%) |
| Female | 62 (41.3%) |
| Duration of Diabetes (years) | 6.4 ± 3.1 |
| BMI (kg/m²) | 28.6 ± 4.5 |
| Smokers | 36 (24.0%) |
| Hypertension | 54 (36.0%) |

The mean age of the study population was 34.8 ± 4.2 years, with a predominance of male participants (58.7%). The mean duration of diabetes was 6.4 ± 3.1 years. Most participants were overweight with a mean BMI of 28.6 ± 4.5 kg/m². Hypertension was present in 36% of patients, indicating coexistence of cardiovascular risk factors among young adults with Type 2 Diabetes Mellitus.

**Table 2. Clinical and Biochemical Parameters of Study Participants**

| Parameter | Mean ± SD |
|---|---|
| Fasting Blood Sugar (mg/dL) | 168.4 ± 42.5 |
| Postprandial Blood Sugar (mg/dL) | 248.7 ± 58.3 |
| HbA1c (%) | 8.6 ± 1.4 |
| Total Cholesterol (mg/dL) | 204.3 ± 38.6 |
| LDL Cholesterol (mg/dL) | 126.5 ± 31.2 |
| HDL Cholesterol (mg/dL) | 41.8 ± 8.4 |
| Triglycerides (mg/dL) | 186.2 ± 46.7 |
| Systolic BP (mmHg) | 132.4 ± 14.5 |
| Diastolic BP (mmHg) | 84.6 ± 9.8 |

The study participants demonstrated poor glycemic control with a mean HbA1c of 8.6 ± 1.4%. Dyslipidemia was also observed, with elevated total cholesterol, LDL cholesterol, and triglyceride levels. Blood pressure values were higher than normal in a considerable proportion of participants, suggesting increased cardiovascular risk in young adults with Type 2 Diabetes Mellitus.

**Table 3. Echocardiographic Parameters of Study Participants**

| Echocardiographic Parameter | Mean ± SD |
|---|---|
| Left Ventricular Mass (g) | 172.5 ± 28.4 |
| Left Atrial Diameter (mm) | 36.8 ± 4.2 |
| Interventricular Septal Thickness (mm) | 10.4 ± 1.3 |
| Posterior Wall Thickness (mm) | 10.1 ± 1.2 |
| Ejection Fraction (%) | 58.6 ± 5.4 |
| E Wave Velocity (cm/s) | 72.5 ± 12.8 |
| A Wave Velocity (cm/s) | 68.4 ± 10.6 |
| E/A Ratio | 1.02 ± 0.28 |
| E/e' Ratio | 11.2 ± 2.6 |

Echocardiographic assessment showed increased left ventricular mass and mild alterations in ventricular wall thickness among study participants. The mean E/A ratio was reduced and the E/e' ratio was elevated, indicating the presence of impaired left ventricular relaxation and early diastolic dysfunction. However, systolic function as assessed by ejection fraction was relatively preserved.

**Table 4. Prevalence of Left Ventricular Diastolic Dysfunction**

| Diastolic Function Status | Number (%) |
|---|---|
| Normal Diastolic Function | 82 (54.7%) |
| Grade I Diastolic Dysfunction | 48 (32.0%) |
| Grade II Diastolic Dysfunction | 16 (10.7%) |
| Grade III Diastolic Dysfunction | 4 (2.6%) |

Among the 150 study participants, 45.3% had evidence of left ventricular diastolic dysfunction. Grade I diastolic dysfunction was the most common abnormality observed. Only a small proportion of participants had advanced grades of dysfunction, suggesting that subclinical cardiac involvement occurs early in young adults with Type 2 Diabetes Mellitus.

**Table 5. Association Between HbA1c and Diastolic Dysfunction**

| HbA1c (%) | Normal Diastolic Function | Diastolic Dysfunction | p-value |
|---|---|---|---|
| <7% | 32 | 10 | <0.001 |
| 7–9% | 38 | 34 | |
| >9% | 12 | 24 | |

A statistically significant association was observed between HbA1c levels and diastolic dysfunction ($p < 0.001$). Patients with poor glycemic control (HbA1c >9%) had a higher prevalence of diastolic dysfunction compared to those with better glycemic control, indicating that persistent hyperglycemia may contribute to early myocardial dysfunction.

**Table 6. Association of Duration of Diabetes with Diastolic Dysfunction**

| Duration of Diabetes | Normal Diastolic Function | Diastolic Dysfunction | p-value |
|---|---|---|---|
| <5 years | 40 | 18 | 0.002 |
| 5–10 years | 30 | 28 | |
| >10 years | 12 | 22 | |

The prevalence of diastolic dysfunction increased significantly with longer duration of diabetes ($p = 0.002$). Participants with diabetes duration greater than 10 years had a markedly higher frequency of diastolic dysfunction compared to those with shorter disease duration, suggesting cumulative adverse effects of diabetes on cardiac function over time.

## Discussion

The present study evaluated cardiac structure and left ventricular diastolic function in young adults with Type 2 Diabetes Mellitus (T2DM) using echocardiography. A high prevalence of subclinical left ventricular diastolic dysfunction (45.3%) was observed despite preserved systolic function, indicating that diabetic cardiomyopathy develops early and often remains clinically silent before progressing to overt heart failure. The mean age of participants was $34.8 \pm 4.2$ years, highlighting that cardiovascular abnormalities can occur even in younger adults with T2DM. This finding is consistent with the observations of Lascar et al., who

reported an increasing burden of early cardiovascular complications among young diabetic individuals.[11] Grade I diastolic dysfunction was the most frequent abnormality (32%), followed by Grade II dysfunction (10.7%). Similar prevalence has been reported by Hariprasad et al. (42%) and Rehman et al. (approximately 40%) among asymptomatic T2DM patients.[12,13] The slightly higher prevalence in the present study may be related to poorer glycemic control and longer disease duration.

Echocardiography demonstrated a reduced mean E/A ratio (1.02 ± 0.28) and elevated E/e′ ratio (11.2 ± 2.6), indicating impaired ventricular relaxation and increased filling pressures. Comparable findings were reported by Tadic et al., who showed significantly impaired diastolic parameters among diabetic patients.[14] In contrast, left ventricular ejection fraction remained preserved (58.6 ± 5.4%), supporting previous evidence by Jiang et al. that diastolic dysfunction precedes systolic impairment in diabetic cardiomyopathy.[15] Poor glycemic control showed a significant association with diastolic dysfunction ($p < 0.001$), with patients having HbA1c >9% demonstrating a markedly higher prevalence of dysfunction. Similar findings have been reported by Hariprasad et al.[12] Chronic hyperglycemia contributes to myocardial fibrosis, oxidative stress, and accumulation of advanced glycation end products, leading to impaired myocardial relaxation.[16]

Duration of diabetes was also significantly associated with diastolic dysfunction ($p = 0.002$), with greater prevalence among patients with disease duration exceeding 10 years. These findings agree with the systematic review by Palanisamy et al., which demonstrated progressive worsening of diastolic function with increasing duration of diabetes.[17] Additionally, obesity, hypertension, and dyslipidemia were more common among affected individuals, consistent with the observations of Ceriello et al., who identified these factors as important contributors to diabetic cardiomyopathy.[18] Recent evidence by Swiatkiewicz et al., Chen D et al and other contemporary reviews similarly indicates that approximately one-third to over 40% of patients with T2DM exhibit asymptomatic left ventricular diastolic dysfunction, reinforcing the findings of the present study and the need for early cardiovascular screening.[19,20]

The study is limited by its cross-sectional design, single-center setting, and relatively small sample size, limiting causal inference and generalizability. Nevertheless, the findings emphasize the value of routine echocardiographic assessment in young adults with T2DM for early detection of subclinical cardiac dysfunction. Early optimization of glycemic control and management of associated cardiovascular risk factors may delay progression to overt heart failure and improve long-term cardiovascular outcomes.

**Strengths**

The present study focused exclusively on young adults with Type 2 Diabetes Mellitus, a population in whom diabetic cardiomyopathy is often under-recognized. Comprehensive echocardiographic evaluation using conventional Doppler and tissue Doppler imaging enabled early detection of subclinical left ventricular diastolic dysfunction before the onset of overt cardiovascular disease. The use of standardized clinical, laboratory, and echocardiographic assessment protocols enhanced the reliability and consistency of the study findings.

**Limitations**

This study has several limitations. First, its cross-sectional design precludes the establishment of a causal relationship between Type 2 Diabetes Mellitus and cardiac structural or diastolic abnormalities. Second, the study was conducted at a single tertiary care center with a relatively modest sample size, which may limit the generalizability of the findings to the broader population. Third, the absence of a non-diabetic control group restricted direct comparison of echocardiographic parameters between diabetic and healthy individuals. Finally, longitudinal follow-up was not performed; therefore, the progression of diastolic dysfunction and its clinical outcomes could not be evaluated.

## Conclusion

The current study proved reduced left ventricular diastolic dysfunction in young adults with Type 2 Diabetes Mellitus despite a preserved systolic function, suggesting that cardiac remodeling of some degree is present even in the early phases of the disease. Echocardiographic findings were independently associated with poor glycemic control, diabetes duration, obesity, hypertension and dyslipidemia. Even adolescents who have asymptomatic type 1 diabetes are beginning to develop diabetic cardiomyopathy, indicating that the process begins early in the course of disease. Thus, echo screening nowadays and treat the HGL aggressively plus cardiovascular NiRF is wise early approach to preventing overt heart failure in T2DM even when asymptomatic.

**Conflict of Interest**

The authors declare that there is no conflict of interest regarding the publication of this study.

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