Journal of Teachers Association
https://tajrmc.com/taj
Vol. 38, No. 1, 2025

pISSN 1019-8555
eISSN 2408-8854

RESEARCH ARTICLE | OPEN ACCESS **DOI:** https://doi.org/10.70818/taj.v38i01.0439

Association between Type 2 Diabetes Mellitus and Heart Failure in Bangladesh: Clinical and Epidemiologic Perspectives

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Citation:
Hossain MI, Alam MN, Sadiq N; Association between Type 2 Diabetes Mellitus and Heart Failure in Bangladesh: Clinical and Epidemiologic Perspectives. Journal of Teachers Association. 2025;38(1):236-240

Article History:
Received: 25.01.2025
Accepted: 22.02.2025
Published: 31.03.2025

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ABSTRACT: ***Background:*** Type 2 Diabetes Mellitus (T2DM) and heart failure represent a growing public health burden in Bangladesh, with their co-existence leading to increased morbidity and mortality. This study was conducted to determine the prevalence of heart failure and its associated factors among T2DM patients in a tertiary care setting in Dhaka. ***Methods:*** This descriptive cross-sectional study was conducted from January to June 2024. A total of 220 adult patients with T2DM were enrolled using consecutive convenient sampling. Data on socio-demographic, clinical, and laboratory parameters were collected. All participants underwent echocardiographic evaluation to assess cardiac function. Statistical analysis, including t-tests and Chi-square tests, was performed to identify significant associations. ***Results:*** The mean age of participants was 58.5±9.2 years, with a male predominance (55.5%). The prevalence of heart failure was found to be 21.4% (n=47). Patients with heart failure were significantly older ($p<0.01$), had a longer duration of diabetes ($p<0.05$), and had higher mean HbA1c levels ($p<0.01$) compared to those without heart failure. Hypertension was highly prevalent in the heart failure group (91.5%). A notable finding was the high prevalence of diastolic dysfunction (DD), observed in 51.8% of the total cohort, highlighting a significant rate of subclinical cardiac impairment. ***Conclusion:*** The prevalence of heart failure among T2DM patients in Bangladesh is substantial and is significantly associated with advanced age, longer diabetes duration, poor glycemic control, and hypertension. The high rate of subclinical cardiac dysfunction underscores the need for proactive screening and early intervention strategies to mitigate this growing health burden.

Keywords: Type 2 Diabetes Mellitus, Heart Failure, Diastolic Dysfunction, Bangladesh.

INTRODUCTION

In the contemporary landscape of global health, the escalating prevalence of Type 2 Diabetes Mellitus (T2DM) and cardiovascular diseases (CVDs) presents an unprecedented public health challenge.[1] The World Health Organization (WHO) and the International Diabetes Federation (IDF) have identified these non-communicable diseases (NCDs) as leading causes of morbidity and mortality worldwide, especially in low- and middle-income countries.[2] This dual epidemic is particularly potent because T2DM is a significant independent risk factor for the development of heart failure, and their co-existence substantially worsens patient prognosis, increases healthcare costs, and reduces quality of life.[3] The mechanisms linking T2DM to heart failure are multifaceted, involving hyperglycemia-induced oxidative stress, insulin resistance, and activation of inflammatory pathways that contribute to structural and functional changes in the myocardium, culminating in a condition known as diabetic cardiomyopathy.[4] Globally, the number of individuals living with diabetes is projected to exceed 600 million by 2045, with a disproportionate increase occurring in Asia and Africa. South Asia, in particular, is considered the epicenter of this diabetes pandemic. This region's populations are genetically and phenotypically more susceptible to developing T2DM and its associated complications, often at a younger age and lower body mass index (BMI) compared to their Western counterparts.[5] A systematic review and meta-analysis of studies from 1995 to 2010 found a clear upward trend in the prevalence of both T2DM and hypertension in Bangladesh. This rapid epidemiological transition, driven by urbanization, lifestyle changes, and dietary shifts, has created a

fertile ground for the co-occurrence of T2DM and heart failure.[6]

Within this global context, Bangladesh faces a particularly high burden of T2DM and its related cardiovascular complications. The IDF estimates that over 13.1 million adults in Bangladesh are currently living with diabetes, a figure expected to rise to 22.3 million by 2045.[7] This dramatic increase is not merely a statistical anomaly but a reflection of the profound changes in the nation's health profile. A study conducted in an urbanizing rural community found that the prevalence of T2DM and impaired glucose regulation was 7.9% and 8.6% respectively.[8] This is further compounded by a high prevalence of other cardiovascular risk factors, such as hypertension, with one study finding that 64.4% of T2DM patients in a multi-hospital study had coexisting hypertension.[9] From a clinical perspective, the association between T2DM and heart failure is a pressing issue. A cross-sectional study of hospitalized T2DM patients with heart failure found the mean age to be approximately 60.9 years, with a notable male predominance (male-to-female ratio of roughly 2:1).[10] These patients often present with classic symptoms like dyspnea and cough, and clinical assessments frequently reveal key heart failure biomarkers. More critically, the subclinical connection is profound. A study on normotensive T2DM patients revealed that nearly half (46.3%) exhibited early signs of cardiac impairment, specifically diastolic dysfunction (DD). The study further highlighted that poor glycemic control, with a staggering 91.9% of subjects having an HbA1c ≥7%, was significantly associated with the presence of DD.[11] The significant proportion of subclinical cardiac dysfunction in T2DM patients underscores a critical diagnostic gap. Many patients may be progressing towards overt heart failure without being clinically symptomatic. The link is further strengthened by the finding that heart failure is the most prevalent CVD among diabetic patients, affecting 14.9% of middle-aged individuals with T2DM.[11] This cross-sectional **study** was therefore designed to provide a comprehensive and nuanced analysis of the direct association between T2DM and heart failure in the specific clinical and epidemiological context of Bangladesh. By assessing a diverse cohort of patients at a single point in time, we aimed to capture the current state of this critical comorbidity. The findings will provide essential quantitative data and clinical perspectives to help bridge the existing gaps in knowledge and inform the development of targeted, evidence-based interventions. The ultimate goal was to enhance early diagnosis, improve management strategies, and ultimately reduce the substantial burden of T2DM-related heart failure in Bangladesh.

Objective

To determine the prevalence of heart failure and its associated factors among patients with Type 2 Diabetes Mellitus (T2DM) in Bangladesh.

METHODOLOGY

Study Design

This descriptive cross-sectional study was conducted in the cardiology and endocrinology outpatient departments of Mugda Medical College & Hospital in Dhaka, Bangladesh. The study was carried out over a six-month period, from January to June 2024. Ethical approval was obtained from the Institutional Review Board of the hospital, and all participants provided written informed consent prior to their enrollment.

Study Population

The study population consisted of adult patients (aged 18 years and older) who had a confirmed diagnosis of Type 2 Diabetes Mellitus (T2DM) for at least one year. Participants were recruited through consecutive convenient sampling. Patients were included if they were willing to participate and met the inclusion criteria. Patients with a known history of heart failure from other causes, such as severe valvular heart disease, congenital heart disease, or a history of a previous myocardial infarction, were excluded. Other exclusion criteria included a history of severe chronic kidney disease (stage 4 or 5) or end-stage liver disease that could confound the diagnosis of heart failure.

Sample Size Calculation

The required sample size was calculated using the formula for a single-population proportion:

$n=(Z1-\alpha/2)^2\times p(1-p)/d^2$

Where,

n = the required sample size

$Z1-\alpha/2$ = the Z-score corresponding to the desired confidence level (1.96 for a 95% confidence interval)

p = the anticipated prevalence of heart failure among T2DM patients. Based on a previous study [11],

the prevalence of heart failure in a similar population was 14.9%. We used a conservative estimate of p=0.15 to ensure an adequate sample size.
d = the desired margin of error or precision (0.05).

Substituting these values into the formula, the minimum required sample size was calculated as:
$n= (1.96)^2 \times 0.15(1-0.15)/ (0.05)^2$
$n=3.8416 \times 0.1275/0.0025$
$n=0.4898/0.0025$
$n \approx 196$

To account for potential non-response and incomplete data, a 10% attrition rate was added, resulting in a target sample size of approximately 216 patients. A total of 220 patients were enrolled to ensure sufficient statistical power.

Data Collection

Data were collected by trained investigators using a pre-designed, structured questionnaire. The questionnaire was developed based on established guidelines and previous studies to gather comprehensive information on each participant.

Data points included:

Socio-demographic Information: Age, sex, occupation, and educational status.
Clinical History: Duration of diabetes, duration of hypertension, presence of other comorbidities, and current medication use.

Physical Examination:

Anthropometric measurements (height, weight, and waist circumference), blood pressure, and heart rate. Body Mass Index (BMI) was calculated for each participant. Laboratory Investigations: Fasting plasma glucose (FPG), HbA1c, lipid profile (total cholesterol, triglycerides, HDL, LDL), serum creatinine, and estimated glomerular filtration rate (eGFR). Echocardiographic Evaluation: All participants underwent a comprehensive echocardiogram performed by a qualified cardiologist. Left ventricular ejection fraction (LVEF), left atrial size, and diastolic function parameters were measured. Diastolic dysfunction (DD) was defined according to established guidelines based on mitral inflow velocity and tissue Doppler imaging. The diagnosis of heart failure was made based on the presence of typical signs and symptoms, supported by objective evidence of cardiac structural or functional abnormality. For the purpose of this study, heart failure with preserved ejection fraction (HFpEF) and heart failure with reduced ejection fraction (HFrEF) were considered.

Statistical Analysis

Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) software, version 26.0. Descriptive statistics, including mean and standard deviation for continuous variables and frequencies and percentages for categorical variables, were used to summarize the data. The Chi-square test was employed to assess the association between categorical variables. The independent samples t-test was used to compare continuous variables between groups. Bivariate and multivariate logistic regression analyses were performed to identify significant risk factors associated with heart failure. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 220 patients with Type 2 Diabetes Mellitus were included in the final analysis. The mean age of the participants was 58.5±9.2 years, with a slight male predominance (55.5% male). The mean duration of diabetes was 8.1±4.5 years. The majority of participants had poor glycemic control, with a mean HbA1c of 8.9±1.5%. The prevalence of heart failure in our cohort was found to be 21.4% (n=47). Of those with heart failure, 68% (n=32) had heart failure with preserved ejection fraction (HFpEF), and 32% (n=15) had heart failure with reduced ejection fraction (HFrEF). Table 1 provides a detailed summary of the demographic and clinical characteristics of the study participants, comparing those with and without a heart failure diagnosis.

Table 1: Comparison of Demographic and Clinical Characteristics

Characteristic	All Participants (N=220)	Patients without Heart Failure (N=173)	Patients with Heart Failure (N=47)	p-value
Age (years, mean ± SD)	58.5 ± 9.2	57.1 ± 8.5	63.8 ± 9.8	< 0.01
Male gender, n (%)	122 (55.5)	91 (52.6)	31 (66.0)	0.08

Duration of Diabetes (years, mean ± SD)	8.1 ± 4.5	7.5 ± 4.2	10.2 ± 5.1	< 0.05
BMI (kg/m^2, mean ± SD)	27.5 ± 3.8	27.2 ± 3.7	28.6 ± 4.1	0.06
Hypertension, n (%)	158 (71.8)	115 (66.5)	43 (91.5)	< 0.01
Diastolic Dysfunction, n (%)	114 (51.8)	71 (41.0)	43 (91.5)	< 0.01

The study found that patients with heart failure were significantly older (p<0.01), had a longer duration of diabetes (p<0.05), and a higher mean HbA1c level (p<0.01) compared to those without heart failure. Hypertension and dyslipidemia were also significantly more prevalent in the heart failure group. The significant findings from laboratory and echocardiographic evaluations are presented in Table 2.

Table 2: Comparison of Laboratory and Echocardiographic Findings

Characteristic	All Participants (N=220)	Patients without Heart Failure (N=173)	Patients with Heart Failure (N=47)	p-value
HbA1c (%, mean ± SD)	8.9 ± 1.5	8.6 ± 1.4	9.8 ± 1.6	< 0.01
Total Cholesterol (mg/dL, mean ± SD)	201.5 ± 32.1	199.2 ± 31.5	210.8 ± 34.2	0.03
LVEF (%, mean ± SD)	61.2 ± 5.5	62.5 ± 4.8	56.4 ± 6.1	< 0.01

Note: The p-values represent the significance of the difference between the groups with and without heart failure. Statistical significance was set at p<0.05.

DISCUSSION

The present study aimed to determine the prevalence of heart failure and its associated factors in a cohort of patients with Type 2 Diabetes Mellitus (T2DM) in Bangladesh. Our key finding was a substantial prevalence of heart failure at 21.4%, which is consistent with the increasing burden of non-communicable diseases in the country. This finding is higher than the 14.9% reported in a previous study among middle-aged diabetic subjects in Bangladesh, suggesting a potentially escalating trend or differences in patient populations.[11] However, it is comparable to a study from another developing country where the prevalence was found to be 24% among hospitalized T2DM patients with cardiovascular disease.[12] Our data revealed that older age, longer duration of diabetes, and poor glycemic control (indicated by higher HbA1c) were significantly associated with heart failure. These findings are in strong agreement with the existing literature. A large systematic review and meta-analysis confirmed that the risk of heart failure increases by 15% to 20% for every 1% rise in HbA1c.[13] Similarly, an older study from Bangladesh also found that increasing age and duration of diabetes were significant risk factors for chronic heart failure in T2DM patients.[9] The strong association between hypertension and heart failure in our cohort, with 91.5% of heart failure patients also being hypertensive, further underscores the synergy between these two conditions in driving cardiac morbidity.[14] A particularly significant finding of our study was the high prevalence of diastolic dysfunction (DD), observed in 51.8% of the overall study population and in 91.5% of those with heart failure. This is higher than a previous study on normotensive T2DM patients in Bangladesh which reported a DD prevalence of 46.3%, possibly due to our cohort including both normotensive and hypertensive patients.[10] This subclinical cardiac impairment highlights a critical diagnostic gap, as many patients with T2DM may be progressing towards overt heart failure without clinical symptoms. This underscores the need for routine echocardiographic screening, particularly for older patients with long-standing diabetes and poor glycemic control, to enable early detection and intervention.

Limitations

The study has several limitations. The cross-sectional design restricts our ability to establish causality between the identified risk factors and heart failure. The consecutive convenient sampling from a single tertiary care center in an urban area may limit the generalizability of our findings to the broader rural population of Bangladesh.

CONCLUSION

In conclusion, our study confirms a high prevalence of heart failure among T2DM patients in Bangladesh. We identified several key risk factors, including age, duration of diabetes, and poor glycemic control. The high rate of subclinical diastolic dysfunction highlights an urgent need for targeted screening and early intervention programs. Future prospective studies with larger, multi-center cohorts are warranted to further explore the pathophysiological mechanisms and the long-term impact of these risk factors in this population.

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