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Original Research Article

A COMPARATIVE STUDY OF SYSTOLIC DYSFUNCTION IN ASYMPTOMATIC TYPE II DIABETIC PATIENTS WITH AND WITHOUT MICROVASCULAR COMPLICATIONS

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ABSTRACT

Background: Microvascular complications such as diabetic neuropathy (DN), retinopathy (DR), and nephropathy (DN) are common in type 2 diabetes mellitus (T2DM) and may impact cardiac function. This study aimed to assess the relationship between microvascular complications and cardiac dysfunction in asymptomatic T2DM patients.

Materials and Methods: A cross-sectional study was conducted with T2DM patients divided into two groups: those with and without microvascular complications. Various parameters, including anthropometric data, glycemic control (HbA1c), blood pressure, renal function (24-hour urine protein), and echocardiographic measures (e.g., left ventricular ejection fraction, stroke volume), were compared between the two groups.

Results: Patients with microvascular complications had higher BMI (24.05 vs. 19.54, $p<0.05$), poorer glycemic control (HbA1c 9.83% vs. 8.77%, $p<0.05$), and elevated blood sugar levels (FBS: 166.57 mg/dL vs. 124.94 mg/dL, $p<0.05$). Proteinuria was significantly higher in this group (153.42 mg vs. 61.01 mg, $p<0.05$). Systolic dysfunction was more prevalent in the microvascular complications group (85.19% vs. 38.89%, $p<0.05$). Echocardiographic findings showed smaller left atrial (LA) volume, left ventricular end-diastolic (LVED) volume, and left ventricular end-systolic (LVES) volume, along with a lower left ventricular ejection fraction (50.78% vs. 56.64%, $p<0.05$). Additionally, stroke volume, fractional shortening, and cardiac index were lower in the microvascular complications group.

Conclusion: Microvascular complications in T2DM are associated with significant cardiac dysfunction. Early detection and management of these complications including strict glycemic control are crucial to prevent cardiovascular issues in diabetic patients. Further studies should investigate the causal relationships and therapeutic interventions for this high-risk population.

Keywords: Diabetic Cardiomyopathy, Microvascular Complications, Type 2 Diabetes Mellitus, Systolic Dysfunction, Echocardiography.

INTRODUCTION

Diabetes mellitus (DM) has become a leading global health challenge, with a sharp rise in prevalence over recent decades. The World Health Organization (WHO) reported an increase in the global diabetic population from 108 million in 1980 to 422 million by 2014, with the prevalence among adults rising from 4.7% to 8.5% during the same period. India, as the second-largest contributor to the global diabetes

epidemic, had an estimated diabetes prevalence of 8.9% in 2019, with projections indicating a significant rise in the population at risk by 2045, highlighting the growing public health burden.[1,2]

Type 2 Diabetes Mellitus (T2DM) is a multifactorial metabolic disorder primarily driven by impaired insulin secretion and resistance in insulin-sensitive tissues. The resulting metabolic dysregulation manifests as chronic hyperglycemia, which plays a critical role in the development of microvascular complications, including diabetic nephropathy, retinopathy, and neuropathy.[3] These complications arise from capillary-level pathological changes and are a major contributor to morbidity and mortality in patients with chronic diabetes.[4]

One of the most serious complications of T2DM is its association with cardiovascular diseases (CVDs), including ischemic heart disease, stroke, coronary artery disease, and heart failure (HF). HF is particularly prevalent among diabetics, affecting up to 40% of patients with acute T2DM, which is significantly higher than in the general population. The pathophysiology involves metabolic abnormalities such as impaired glucose and free fatty acid utilization and systemic inflammation, which are linked to oxidative stress and chronic hyperglycemia.[5]

Systolic dysfunction, particularly involving the left ventricle, has been observed even in asymptomatic diabetic patients with preserved ejection fraction and no overt signs of coronary artery disease or heart failure. Microvascular complications have been implicated in the progression of cardiac dysfunction, underscoring the need for early detection to mitigate the risk of severe outcomes. Evidence suggests that asymptomatic left ventricular dysfunction with reduced ejection fraction (ALVD-REF) is prevalent among both general and high-risk populations. Early identification and pharmacological interventions have been shown to improve clinical outcomes in such cases.[4,5]

Given the asymptomatic nature of many cardiac dysfunctions in diabetes, the early detection of microvascular complications could serve as a crucial screening tool for identifying patients at risk of systolic dysfunction. This study aims to compare the prevalence of systolic dysfunction in asymptomatic T2DM patients with and without microvascular complications to better understand its clinical implications and to guide early interventions.

MATERIALS AND METHODS

This comparative, cross-sectional study aimed to evaluate systolic dysfunction in asymptomatic Type 2 Diabetes Mellitus (T2DM) patients with and without microvascular complications. The specific objectives were to estimate the prevalence of systolic dysfunction in these patients, identify microvascular complications (neuropathy, nephropathy, retinopathy), and assess their association with left ventricular (LV) systolic dysfunction.

The study was conducted in the outpatient (OPD) and inpatient (IPD) departments of Dr. D.Y. Patil Hospital following approval from the Institutional Ethical Committee. A total of 216 T2DM patients, aged >18 years, with normal ECG findings and no clinical evidence of heart disease, were enrolled based on inclusion criteria. Patients with comorbidities such as hypertension, thyroid disorders, congenital heart disease, anemia (Hb <9 g/dL), dyslipidemia, and smoking or alcohol use were excluded. The sample size calculation, based on the prevalence of systolic dysfunction (16.9%), yielded a minimum of 108 patients per group.

Each participant underwent detailed history taking, clinical examination, and evaluation of diabetes duration and treatment modalities. Microvascular complications were assessed using specific diagnostic methods: nephropathy by 24-hour urinary protein analysis, neuropathy by nerve conduction studies, and retinopathy by ophthalmoscopic examination. Patients were divided into two groups based on the presence or absence of microvascular complications. Both groups underwent conventional two-dimensional (2D) echocardiography to assess LV systolic function.

LV systolic function was evaluated using fractional shortening (FS), ejection fraction (EF), stroke volume, cardiac index, and regional wall motion analysis. FS, reflecting global ventricular function, was calculated using the formula:

$$F(\%) = \frac{\text{LVED} - \text{LVES}}{\text{LVED}} \times 100$$

where LVED and LVES represent LV end-diastolic and end-systolic dimensions, respectively. EF was measured using volumetric measurements from M-mode and 2D echocardiograms.

$$\text{LVEF}(\%) = \frac{\text{LVEDV} - \text{LVESV}}{\text{LVEDV}} \times 100$$

$$\text{CO} = \text{SV} \times \text{HR}; \quad \text{CI} = \frac{\text{CO}}{\text{BSA}}$$

The correlation between the presence of microvascular complications and LV systolic dysfunction was analyzed using multivariate statistical techniques. Data were processed using SPSS v23.0 software. Continuous variables were presented as mean ± standard deviation (SD) and compared using the t-test, while categorical variables were expressed as frequency (n) and percentage (%) and analyzed with Chi-square tests.

A p-value of <0.05 was considered statistically significant.

This study seeks to enhance early detection and management of systolic dysfunction in T2DM, emphasizing the role of microvascular complications as potential markers for cardiovascular risk.

RESULTS

The study compared demographic and anthropometric characteristics of T2DM patients with and without microvascular complications. The mean age was similar between the groups (53.59 ± 12.75 vs. 53.27 ± 15.53 years, p = 0.8671). The age distribution revealed that patients aged 51–60 years constituted the largest subgroup among those with microvascular complications (33.33%), whereas the 61–70 years subgroup was more prevalent in those without complications (25.93%). Gender distribution was comparable, with females slightly predominant in both groups (52.78% vs. 49.07%). Anthropometric analysis showed that patients with microvascular complications had significantly lower mean height (1.53 ± 0.09 m vs. 1.57 ± 0.08 m, p = 0.0046), higher mean weight (56.57 ± 9.74 kg vs. 48.27 ± 7.55 kg, p < 0.05), and higher BMI (24.05 ± 3.48 kg/m² vs. 19.54 ± 2.11 kg/m², p < 0.05). [Table 1]

Patients with microvascular complications demonstrated higher prevalence rates of diabetic retinopathy (67.59%), diabetic neuropathy (42.59%), and diabetic nephropathy (40.74%). Glycemic control was significantly poorer in this group, with higher mean HbA1c levels (9.83 ± 0.32 vs. 8.77 ± 0.26; p < 0.05), fasting blood sugar (166.57 ± 30.25 vs. 124.94 ± 24.79; p < 0.05), and post-prandial blood sugar (236.52 ± 47.65 vs. 156.02 ± 34.68; p < 0.05). Systolic blood pressure was significantly lower in the microvascular group (114.17 ± 6.28 vs. 124.85 ± 8.58; p < 0.05), while diastolic blood pressure was comparable (p = 0.9037). Additionally, 24-hour urine protein levels were markedly elevated in patients with microvascular complications (153.42 ± 90.53 vs. 61.01 ± 16.61; p < 0.05), reflecting greater renal involvement. [Table 2]

Patients with microvascular complications exhibited significantly higher rates of systolic dysfunction (85.19% vs. 38.89%) and hypokinesia (81.48% vs. 37.03%) compared to those without microvascular complications. Echocardiographic parameters revealed worse left ventricular function in the microvascular group, with lower ejection fraction (50.78 ± 4.77% vs. 56.64 ± 4.86%; p < 0.05) and fractional shortening (27.22 ± 3.76% vs. 31.84 ± 2.80%; p < 0.05). Additionally, this group had reduced stroke volume (62.04 ± 12.44 mL vs. 78.26 ± 7.38 mL; p < 0.05) and cardiac index (2.33 ± 0.60 vs. 3.08 ± 0.36; p < 0.05). Regional wall motion abnormalities, including hypokinesia and akinesia, were more prevalent among those with microvascular complications. [Table 3, 4]

Table 1: Comparison of Demographic and Anthropometric Characteristics in T2DM Patients with and Without Microvascular Complications

Characteristic	With Microvascular (n = 108)	Without Microvascular (n = 108)	P-Value
Age (years)			
Mean ± SD	53.59 ± 12.75	53.27 ± 15.53	0.8671
< 30	3 (2.78%)	9 (8.33%)	
31–40	15 (13.89%)	22 (20.37%)	
41–50	30 (27.78%)	16 (14.81%)	
51–60	36 (33.33%)	18 (16.67%)	
61–70	11 (10.19%)	28 (25.93%)	
> 70	13 (12.04%)	15 (13.89%)	
Gender			
Female	57 (52.78%)	53 (49.07%)	
Male	51 (47.22%)	55 (50.93%)	
Anthropometric Measurements			
Height (m)	1.53 ± 0.09	1.57 ± 0.08	0.0046
Weight (kg)	56.57 ± 9.74	48.27 ± 7.55	< 0.05
BMI (kg/m²)	24.05 ± 3.48	19.54 ± 2.11	< 0.05

Table 2: Comparison of Microvascular Complications, Glycemic Parameters, Blood Pressure, and 24-Hour Urine Protein Between T2DM Patients with and Without Microvascular Complications

Parameter	Group	Mean ± SD	P-Value	Frequency (n)	Percentage (%)
Microvascular Complications					
Diabetic Neuropathy				46	42.59%
Diabetic Retinopathy (DR)				73	67.59%
Diabetic Nephropathy (DN)				44	40.74%
HbA1c (%)	With Microvascular	9.83 ± 0.32	< 0.05		
	Without Microvascular	8.77 ± 0.26			
Systolic Blood Pressure (SBP)	With Microvascular	114.17 ± 6.28	< 0.05		
	Without Microvascular	124.85 ± 8.58			
Diastolic Blood Pressure (DBP)	With Microvascular	73.98 ± 5.79	0.9037		
	Without Microvascular	73.89 ± 5.44			
Fasting Blood Sugar (FBS)	With Microvascular	166.57 ±	< 0.05		

		30.25			
	Without Microvascular	124.94 ± 24.79			
Post-Prandial Blood Sugar (mg/dL)	With Microvascular	236.52 ± 47.65	< 0.05		
	Without Microvascular	156.02 ± 34.68			
24-Hour Urine Protein (mg/day)	With Microvascular	153.42 ± 90.53	< 0.05		
	Without Microvascular	61.01 ± 16.61			

Table 3: Distribution of Systolic Dysfunction and Regional Wall Motion Abnormalities

Parameter	With Microvascular (n = 108)	Without Microvascular (n = 108)	P-Value
Systolic Dysfunction			
No	16 (14.81%)	66 (61.11%)	
Yes	92 (85.19%)	42 (38.89%)	
Regional Wall Motion			
Normal	16 (14.81%)	66 (61.11%)	
Hypokinesia	88 (81.48%)	40 (37.03%)	
Akinesia	4 (3.70%)	2 (1.85%)	

Table 4: Comparison of Echocardiographic Parameters

Parameter	With Microvascular (Mean ± SD)	Without Microvascular (Mean ± SD)	P-Value
LA Volume (mL)	30.63 ± 3.48	34.08 ± 3.93	<0.05
LVED Volume (mL)	44.45 ± 11.23	51.27 ± 12.69	<0.05
LVES Volume (mL)	19.98 ± 2.30	22.79 ± 3.09	<0.05
LVEF (%)	50.78 ± 4.77	56.64 ± 4.86	<0.05
FS of LV (%)	27.22 ± 3.76	31.84 ± 2.80	<0.05
Stroke Volume (mL)	62.04 ± 12.44	78.26 ± 7.38	<0.05
Cardiac Index (L/min/m²)	2.33 ± 0.60	3.08 ± 0.36	<0.05

DISCUSSION

This study aimed to investigate the relationship between microvascular complications and cardiac function in asymptomatic type 2 diabetes mellitus (T2DM) patients. It highlighted significant differences between patients with and without microvascular complications, contributing valuable insights into the complex cardiovascular implications of diabetes. The study population showed no significant age differences between the two groups, with a mean age of 53.59 years for those with microvascular complications and 53.27 years for those without (p=0.8671). This suggests that age alone is not a determining factor for the presence of microvascular complications in this cohort. Additionally, gender distribution was comparable, with a slight predominance of females in both groups, indicating that gender did not play a major role in the development of microvascular complications in this study.

One of the most notable findings was the significant difference in anthropometric measurements between the two groups. Patients with microvascular complications had a lower mean height (1.53 meters vs. 1.57 meters, p=0.0046) and a higher mean weight (56.57 kg vs. 48.27 kg, p<0.05), leading to a significantly higher mean BMI in the group with microvascular complications (24.05 vs. 19.54, p<0.05). These results suggest that increased BMI, indicative of overweight or obesity, is linked to the presence of microvascular complications, which could exacerbate the risk of cardiovascular issues. This finding is consistent with a study by Shillah WB et al,[6] which emphasized the association between obesity and microvascular complications in diabetic patients.

Glycemic control, as measured by HbA1c levels, was poorer in patients with microvascular complications (mean HbA1c 9.83% vs. 8.77%, p<0.05). This supports the understanding that poor glycemic control contributes to the development and progression of microvascular complications. Furthermore, while systolic blood pressure (SBP) was within normal range for both groups, patients with microvascular complications had lower SBP (114.17 mmHg vs. 124.85 mmHg, p<0.05), whereas diastolic blood pressure (DBP) was similar in both groups. Both fasting blood sugar (FBS) and postprandial blood sugar levels were significantly higher in the group with microvascular complications (FBS: 166.57 mg/dL vs. 124.94 mg/dL, p<0.05; postprandial: 236.52 mg/dL vs. 156.02 mg/dL, p<0.05), reinforcing the notion that elevated blood sugar contributes to endothelial damage and the development of microvascular complications, emphasizing the importance of strict glycemic control in diabetes management.

Proteinuria, as measured by 24-hour urine protein, was markedly higher in patients with microvascular complications (153.42 mg vs. 61.01 mg, p<0.05), suggesting significant renal involvement and progression of diabetic nephropathy (DN) in this group. This finding aligns with the study by Gong M et al,[7] which found a similar association between microvascular complications and renal dysfunction.

The prevalence of systolic dysfunction was significantly higher in patients with microvascular

complications (85.19% vs. 38.89%), highlighting a strong link between microvascular complications and impaired cardiac function. This observation is consistent with Chee KH et al,[8] and Suresh G et al.[9], who found high rates of diastolic dysfunction in T2DM patients, suggesting that microvascular damage may precede or coexist with detectable cardiac impairment. Additionally, Roy S et al,[9] reported that diabetic neuropathy and diabetic retinopathy were associated with subclinical left ventricular (LV) dysfunction.

Echocardiographic parameters, including left atrial (LA) volume, left ventricular end-diastolic (LVED) volume, and left ventricular end-systolic (LVES) volume, were significantly different between the two groups. Patients with microvascular complications had smaller LA, LVED, and LVES volumes, indicating altered cardiac remodeling and possible diastolic dysfunction. The lower left ventricular ejection fraction (LVEF) in this group (50.78% vs. 56.64%, $p<0.05$) further supports the presence of systolic dysfunction.

Additionally, the study found that fractional shortening (FS), stroke volume, and cardiac index were significantly lower in patients with microvascular complications. These findings suggest compromised cardiac contractility in this group, which could result from the cumulative effects of chronic hyperglycemia, hypertension, and other metabolic abnormalities associated with diabetes. Furthermore, a significantly higher proportion of patients with microvascular complications exhibited hypokinesia and akinesia of regional wall motion, suggesting the presence of subclinical ischemia or fibrosis, common in diabetic cardiomyopathy.

CONCLUSION

This study underscores the critical relationship between microvascular complications and cardiac dysfunction in asymptomatic T2DM patients. The findings emphasize the need for early detection and comprehensive management of these complications, including stringent glycemic control, optimal blood pressure management, and regular monitoring of renal function to mitigate cardiovascular risks. Future research should focus on longitudinal studies to better understand the causal relationships and therapeutic interventions to improve outcomes in this high-risk population.

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