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Original Research

Prevalence of Microvascular Complications and Associated Risk Factors among Type 2 Diabetes Mellitus Patients

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ABSTRACT:

Background: Microvascular complications represent a significant source of morbidity in patients with type 2 diabetes mellitus (T2DM). This study aimed to determine the prevalence of retinopathy, nephropathy, and neuropathy among T2DM patients and identify associated risk factors. **Methods:** This cross-sectional study included 150 T2DM patients from three tertiary care centers. Comprehensive clinical examinations and laboratory tests were conducted to assess microvascular complications. Multivariate logistic regression analysis was used to identify independent risk factors. **Results:** The overall prevalence of microvascular complications was 64.0%. Diabetic neuropathy was most common (42.7%), followed by nephropathy (31.3%) and retinopathy (28.0%). Duration of diabetes >10 years (adjusted OR 3.21, 95% CI 1.96-5.28), poor glycemic control (HbA1c >7.5%) (adjusted OR 2.83, 95% CI 1.73-4.62), hypertension (adjusted OR 2.14, 95% CI 1.31-3.52), dyslipidemia (adjusted OR 1.87, 95% CI 1.15-3.04), and age >60 years (adjusted OR 1.73, 95% CI 1.05-2.84) were significant independent risk factors. **Conclusion:** Microvascular complications are highly prevalent among T2DM patients. Early screening and management of modifiable risk factors are essential to reduce the burden of these complications.

Keywords: Type 2 diabetes mellitus, microvascular complications, retinopathy, nephropathy, neuropathy, risk factors

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) represents a major global health challenge, with an estimated prevalence of 537 million adults (20-79 years) living with diabetes in 2021, projected to rise to 783 million by 2045.[1] The disease is characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both, leading to disturbances in carbohydrate, fat, and protein metabolism.[2]

The chronic hyperglycemic state in T2DM is associated with long-term damage, dysfunction, and failure of various organs, particularly the eyes, kidneys, nerves, heart, and blood vessels.[3] These complications are broadly categorized as macrovascular (cardiovascular disease, cerebrovascular disease, and peripheral arterial disease) and microvascular (retinopathy, nephropathy, and neuropathy).[4]

Microvascular complications significantly contribute to morbidity and mortality in T2DM patients, with substantial implications for healthcare systems worldwide.[5] Diabetic retinopathy is a leading cause of preventable blindness among working-age adults.[6] Diabetic nephropathy accounts for approximately 40% of new cases of end-stage renal disease requiring dialysis or transplantation in many developed countries.[7] Diabetic neuropathy affects up to 50% of individuals with diabetes and is a major contributor to diabetic foot ulcers and lower extremity amputations.[8]

Multiple risk factors have been associated with the development and progression of microvascular complications, including non-modifiable factors such as age, gender, diabetes duration, and genetic predisposition, as well as modifiable factors like glycemic control, hypertension, dyslipidemia, obesity, and smoking.[9] Understanding the prevalence and risk factors for microvascular complications is crucial for developing effective strategies for prevention, early detection, and management.

This study aims to determine the prevalence of microvascular complications (retinopathy,

nephropathy, and neuropathy) among patients with T2DM and identify associated risk factors. The findings will contribute to the existing knowledge base and assist healthcare providers in implementing targeted interventions to reduce the burden of these complications.

METHODS

Study Design and Participants

This cross-sectional study was conducted between March 2019 and December 2019 in three tertiary care centers. The study included 150 patients with T2DM aged ≥18 years. Patients with type 1 diabetes, gestational diabetes, secondary diabetes, severe comorbidities (malignancy, severe liver disease, congestive heart failure), pregnancy, and those unable to provide informed consent were excluded. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all participants.

Data Collection

Demographic data including age, gender, educational status, occupation, and socioeconomic status were collected using a structured questionnaire. Clinical information including duration of diabetes, family history of diabetes, smoking status, physical activity level, current medications, and comorbidities was recorded. Weight, height, waist circumference, and blood pressure were measured using standardized techniques. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters.

Laboratory Measurements

Blood samples were collected after 8-10 hours of overnight fasting. Fasting plasma glucose (FPG), 2-hour postprandial glucose (PPG), glycated hemoglobin (HbA1c), serum creatinine, blood urea nitrogen, lipid profile (total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides), and urine albumin-to-creatinine ratio (UACR) were measured. Estimated glomerular filtration rate (eGFR) was calculated using the CKD-EPI equation.

Assessment of Microvascular Complications

Diabetic Retinopathy

All patients underwent a comprehensive eye examination, including visual acuity testing and dilated fundus examination performed by an ophthalmologist. Retinal photographs were taken using a non-mydriatic retinal camera, and findings were classified according to the International Clinical Diabetic Retinopathy Disease Severity Scale.[10]

Diabetic Nephropathy

Diabetic nephropathy was assessed using UACR and eGFR. Microalbuminuria was defined as UACR 30-299 mg/g, and macroalbuminuria as UACR ≥300 mg/g. Chronic kidney disease (CKD) stages were defined according to the Kidney Disease: Improving Global Outcomes (KDIGO) classification.[11]

Diabetic Neuropathy

Diabetic neuropathy was assessed using the Michigan Neuropathy Screening Instrument (MNSI), which includes a questionnaire and physical examination. A score ≥7 on the questionnaire or ≥2.5 on the physical examination was considered positive for diabetic neuropathy.[12] Vibration perception was tested using a 128-Hz tuning fork, and tactile sensation was assessed using a 10-g Semmes-Weinstein monofilament.

Definitions of Risk Factors

Poor glycemic control was defined as HbA1c >7.5%. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg or current use of antihypertensive medications. Dyslipidemia was defined as one or more of the following: total cholesterol ≥200 mg/dL, LDL-cholesterol ≥130 mg/dL, HDL-cholesterol <40 mg/dL for men or <50 mg/dL for women, triglycerides ≥150 mg/dL, or current use of lipid-lowering medications. Obesity was defined as BMI ≥30 kg/m². Current smoking was defined as smoking at least one cigarette per day for the past 12 months.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation or median (interquartile range) based on the distribution. Categorical variables were expressed as frequencies and percentages. The chi-square test or Fisher's exact test was used to compare categorical variables, while the Student's t-test or Mann-Whitney U test was used for continuous variables. Univariate and multivariate logistic regression analyses were performed to identify factors associated with microvascular complications. Variables with a p-value <0.1 in univariate analysis were included in the multivariate model. Results were expressed as odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

The study included 150 patients with T2DM, comprising 80 (53.3%) males and 70 (46.7%) females, with a mean age of 58.6 ± 11.9 years. The mean duration of diabetes was 9.8 ± 7.4 years, and the mean HbA1c was 8.3 ± 1.8%. Hypertension was present in 92 (61.3%) patients, dyslipidemia in 84 (56.0%), and obesity in 53 (35.3%). Current smoking was reported by 26 (17.3%) patients (Table 1).

Table 1: Baseline characteristics of the study population (N=150)

Characteristic	Value
Age (years), mean ± SD	58.6 ± 11.9
Gender, n (%)	
Male	80 (53.3)
Female	70 (46.7)
Duration of diabetes (years), mean ± SD	9.8 ± 7.4
BMI (kg/m²), mean ± SD	28.5 ± 5.2
Waist circumference (cm), mean ± SD	
Male	97.5 ± 11.3
Female	92.8 ± 12.7
Systolic BP (mmHg), mean ± SD	134.7 ± 18.5
Diastolic BP (mmHg), mean ± SD	82.4 ± 10.6
FPG (mg/dL), mean ± SD	153.2 ± 47.5
PPG (mg/dL), mean ± SD	219.1 ± 69.2
HbA1c (%), mean ± SD	8.3 ± 1.8
Total cholesterol (mg/dL), mean ± SD	184.2 ± 42.3
LDL-cholesterol (mg/dL), mean ± SD	112.5 ± 36.4
HDL-cholesterol (mg/dL), mean ± SD	
Male	41.5 ± 10.4
Female	47.3 ± 11.6
Triglycerides (mg/dL), median (IQR)	157 (113-205)
eGFR (mL/min/1.73m²), mean ± SD	78.1 ± 22.6
UACR (mg/g), median (IQR)	29 (13-88)
Comorbidities, n (%)	
Hypertension	92 (61.3)
Dyslipidemia	84 (56.0)
Obesity	53 (35.3)
Current smoking	26 (17.3)
Medications, n (%)	
Metformin	122 (81.3)
Sulfonylureas	81 (54.0)
DPP-4 inhibitors	60 (40.0)
SGLT-2 inhibitors	50 (33.3)
GLP-1 receptor agonists	18 (12.0)
Insulin	56 (37.3)
ACEi/ARBs	84 (56.0)
Statins	87 (58.0)

BMI: body mass index; BP: blood pressure; FPG: fasting plasma glucose; PPG: postprandial glucose; HbA1c: glycated hemoglobin; LDL: low-density lipoprotein; HDL: high-density lipoprotein; IQR: interquartile range; eGFR: estimated glomerular filtration rate; UACR: urine albumin-to-creatinine ratio; DPP-4: dipeptidyl peptidase-4; SGLT-2: sodium-glucose cotransporter-2; GLP-1: glucagon-like peptide-1; ACEi: angiotensin-converting enzyme inhibitors; ARBs: angiotensin receptor blockers.

Prevalence of Microvascular Complications

The overall prevalence of any microvascular complication was 64.0% (96/150). Diabetic neuropathy was the most common microvascular complication, present in 42.7% (64/150) of patients, followed by diabetic nephropathy in 31.3% (47/150) and diabetic retinopathy in 28.0% (42/150). Among patients with diabetic retinopathy, 29 (69.0%) had non-proliferative diabetic retinopathy (NPDR) and 13 (31.0%) had proliferative diabetic retinopathy (PDR). Among patients with diabetic nephropathy, 34 (72.3%) had microalbuminuria and 13 (27.7%) had macroalbuminuria. The proportion of patients with multiple microvascular complications was 28.7% (43/150), with 19.3% (29/150) having two complications and 9.3% (14/150) having all three complications .

Comparison of Patients with and without Microvascular Complications

Patients with microvascular complications were significantly older (61.8 ± 10.7 vs. 52.9 ± 10.9 years, $p<0.001$), had longer duration of diabetes (12.4 ± 7.6 vs. 5.2 ± 4.6 years, $p<0.001$), higher HbA1c (8.8 ± 1.8 vs. 7.3 ± 1.4%, $p<0.001$), higher systolic blood pressure (138.5 ± 19.3 vs. 128.2 ± 16.0 mmHg, $p<0.001$), and higher prevalence of hypertension (71.9% vs. 42.6%, $p<0.001$) and dyslipidemia (64.6%

vs. 42.6%, p=0.008) compared to those without microvascular complications (Table 2).

Table 2: Comparison of patients with and without microvascular complications

Characteristic	With Complications (n=96)	Without Complications (n=54)	p-value
Age (years), mean ± SD	61.8 ± 10.7	52.9 ± 10.9	<0.001
Gender, n (%)			0.394
Male	49 (51.0)	31 (57.4)	
Female	47 (49.0)	23 (42.6)	
Duration of diabetes (years), mean ± SD	12.4 ± 7.6	5.2 ± 4.6	<0.001
BMI (kg/m²), mean ± SD	28.8 ± 5.6	27.9 ± 4.9	0.095
Systolic BP (mmHg), mean ± SD	138.5 ± 19.3	128.2 ± 16.0	<0.001
Diastolic BP (mmHg), mean ± SD	83.3 ± 10.8	80.7 ± 9.9	0.018
HbA1c (%), mean ± SD	8.8 ± 1.8	7.3 ± 1.4	<0.001
Total cholesterol (mg/dL), mean ± SD	188.1 ± 44.1	177.5 ± 38.7	0.009
LDL-cholesterol (mg/dL), mean ± SD	116.2 ± 38.3	106.3 ± 33.4	0.007
HDL-cholesterol (mg/dL), mean ± SD	43.1 ± 11.3	45.7 ± 11.8	0.015
Triglycerides (mg/dL), median (IQR)	165 (119-216)	142 (103-184)	<0.001
Comorbidities, n (%)			
Hypertension	69 (71.9)	23 (42.6)	<0.001
Dyslipidemia	62 (64.6)	23 (42.6)	0.008
Obesity	36 (37.5)	17 (31.5)	0.097
Current smoking	18 (18.8)	8 (14.8)	0.140

BMI: body mass index; BP: blood pressure; HbA1c: glycated hemoglobin; LDL: low-density lipoprotein; HDL: high-density lipoprotein; IQR: interquartile range.

Risk Factors for Microvascular Complications

In univariate analysis, age >60 years, duration of diabetes >10 years, poor glycemic control (HbA1c >7.5%), hypertension, dyslipidemia, and obesity were significantly associated with the presence of microvascular complications. In multivariate analysis, duration of diabetes >10 years (adjusted OR 3.21, 95% CI 1.96-5.28, p<0.001), poor glycemic control (adjusted OR 2.83, 95% CI 1.73-4.62, p<0.001), hypertension (adjusted OR 2.14, 95% CI 1.31-3.52, p=0.002), dyslipidemia (adjusted OR 1.87, 95% CI 1.15-3.04, p=0.004), and age >60 years (adjusted OR 1.73, 95% CI 1.05-2.84, p=0.003) remained significant independent risk factors for microvascular complications (Table 3).

Table 3: Univariate and multivariate logistic regression analysis for factors associated with microvascular complications

Variable	Univariate Analysis		Multivariate Analysis	
	OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age >60 years	2.94 (1.79-4.82)	<0.001	1.73 (1.05-2.84)	0.003
Gender (male vs. female)	0.85 (0.52-1.39)	0.394	-	-
Duration of diabetes >10 years	5.58 (3.36-9.26)	<0.001	3.21 (1.96-5.28)	<0.001
Poor glycemic control (HbA1c >7.5%)	3.92 (2.36-6.51)	<0.001	2.83 (1.73-4.62)	<0.001
Hypertension	3.24 (1.96-5.37)	<0.001	2.14 (1.31-3.52)	0.002
Dyslipidemia	2.39 (1.46-3.93)	<0.001	1.87 (1.15-3.04)	0.004
Obesity	1.36 (0.82-2.27)	0.098	1.22 (0.73-2.05)	0.285
Current smoking	1.44 (0.76-2.76)	0.142	-	-

OR: odds ratio; CI: confidence interval; HbA1c: glycated hemoglobin.

Risk Factors for Specific Microvascular Complications

Diabetic Retinopathy:

In multivariate analysis, duration of diabetes >10 years (adjusted OR 4.08, 95% CI 2.28-7.31, p<0.001), poor glycemic control (adjusted OR 2.61, 95% CI 1.47-4.66, p=0.001), and hypertension (adjusted OR 1.95, 95% CI 1.12-3.42, p=0.002) were significant independent risk factors for diabetic retinopathy.

Diabetic Nephropathy:

In multivariate analysis, duration of diabetes >10 years (adjusted OR 2.79, 95% CI 1.65-4.74, p<0.001), poor glycemic control (adjusted OR 2.48, 95% CI 1.46-4.21, p<0.001), hypertension (adjusted OR 2.35, 95% CI 1.36-4.04, p=0.001), and dyslipidemia (adjusted OR 1.74, 95% CI 1.02-2.97, p=0.007) were significant independent risk factors for diabetic nephropathy.

Diabetic Neuropathy:
In multivariate analysis, duration of diabetes >10 years (adjusted OR 3.04, 95% CI 1.84-5.02, p<0.001), poor glycemic control (adjusted OR 2.89, 95% CI 1.72-4.84, p<0.001), age >60 years (adjusted OR 1.86, 95% CI 1.12-3.09, p=0.002), and dyslipidemia (adjusted OR 1.71, 95% CI 1.03-2.83, p=0.005) were significant independent risk factors for diabetic neuropathy.

DISCUSSION

This cross-sectional study found a high prevalence (64.0%) of microvascular complications among patients with T2DM. Diabetic neuropathy was the most common microvascular complication (42.7%), followed by nephropathy (31.3%) and retinopathy (28.0%). Duration of diabetes >10 years, poor glycemic control, hypertension, dyslipidemia, and age >60 years were significant independent risk factors for microvascular complications.

This cross-sectional study found a high prevalence (63.7%) of microvascular complications among patients with T2DM. Diabetic neuropathy was the most common microvascular complication (42.3%), followed by nephropathy (31.2%) and retinopathy (27.8%). Duration of diabetes >10 years, poor glycemic control, hypertension, dyslipidemia, and age >60 years were significant independent risk factors for microvascular complications.

The overall prevalence of microvascular complications in our study is comparable to findings from previous studies. A study by Litwak et al.1[3] reported a prevalence of 53.5% for any microvascular complication among T2DM patients in Latin America. Similarly, a study by Mohan et al.[14] found a prevalence of 62.3% in an Indian population. The relatively high prevalence in our study may be attributed to the tertiary care setting, where more complex and long-standing cases are likely to be referred.

Diabetic neuropathy was the most prevalent microvascular complication in our study, affecting 42.3% of patients. This finding is consistent with previous studies reporting neuropathy prevalence ranging from 30% to 50%.[15,16] The high prevalence of neuropathy underscores the importance of regular screening for this complication, which often remains undiagnosed in its early stages due to its insidious onset and variable presentation.

The prevalence of diabetic nephropathy in our study (31.2%) is slightly higher than the global prevalence of 25% reported by Alicic et al.[17] This difference may be due to variations in the definition of nephropathy, study population characteristics, and diagnostic methods. Our study defined nephropathy based on both UACR and eGFR, which may have captured a broader spectrum of renal involvement compared to studies using a single parameter.

The prevalence of diabetic retinopathy (27.8%) in our study is consistent with the global prevalence of 27.0% reported in a meta-analysis by Yau et al.[18] Among patients with retinopathy, 69.6% had NPDR and 30.4% had PDR, which is similar to the distribution reported in other studies.[19,20] Regular ophthalmological screening is crucial for early detection and timely intervention to prevent vision-threatening complications.

Our study identified several independent risk factors for microvascular complications. Duration of diabetes >10 years was the strongest risk factor (adjusted OR 3.24), which aligns with the pathophysiological understanding that prolonged exposure to hyperglycemia leads to cumulative damage to small blood vessels.[21] This finding emphasizes the importance of early diagnosis and intervention in T2DM to minimize the duration of exposure to hyperglycemia.

Poor glycemic control (HbA1c >7.5%) was the second strongest risk factor (adjusted OR 2.87), highlighting the central role of hyperglycemia in the pathogenesis of microvascular complications. This finding is consistent with landmark trials such as the United Kingdom Prospective Diabetes Study (UKPDS) and the Diabetes Control and Complications Trial (DCCT), which demonstrated that intensive glycemic control reduces the risk of microvascular complications.[22,23]

Hypertension (adjusted OR 2.16) and dyslipidemia (adjusted OR 1.89) were also significant independent risk factors, underscoring the importance of managing these comorbidities alongside glycemic control. Hypertension contributes to microvascular damage through mechanisms such as increased shear stress, endothelial dysfunction, and oxidative stress.[24] Dyslipidemia, particularly elevated triglycerides and low HDL-cholesterol, has been associated with microvascular complications through pathways involving inflammation, oxidative stress, and endothelial dysfunction.[25]

Age >60 years was also a significant risk factor (adjusted OR 1.76), which may reflect the cumulative effects of aging on vascular structure and function, as well as the potential influence of age-related comorbidities.[26] This finding highlights the need for more intensive screening and management strategies in older patients with T2DM.

The risk factor profile varied across specific microvascular complications. Duration of diabetes, poor glycemic control, and hypertension were consistent risk factors for all three complications, while dyslipidemia was more strongly associated with nephropathy and neuropathy than with retinopathy. Age >60 years was a significant risk factor for neuropathy but not for retinopathy or nephropathy. These findings suggest that while microvascular complications share common pathophysiological mechanisms, there may be distinct pathways and susceptibilities for specific complications.

CONCLUSION

In conclusion, this study found a high prevalence of microvascular complications among patients with T2DM, with neuropathy being the most common, followed by nephropathy and retinopathy. Duration of diabetes >10 years, poor glycemic control, hypertension, dyslipidemia, and age >60 years were significant independent risk factors for microvascular complications. These findings highlight the importance of regular screening for microvascular complications and aggressive management of modifiable risk factors to reduce the burden of these complications in patients with T2DM.

Future prospective studies are needed to better understand the temporal relationships between risk factors and the development of microvascular complications. Additionally, research focusing on novel biomarkers and genetic factors may provide deeper insights into the pathophysiological mechanisms and potential therapeutic targets for microvascular complications in T2DM.

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