International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/
Original Researcher Article DOI: 10.61336/im/26-07-221

Association of hematological indices with diabetes, impaired glucose regulation and microvascular complications of diabetes.

Dr. Megha Agarwal[1], Dr. Pradeep Kumar Bansal[2*], Dr. C L Nawal[3].
[1]*Consultant Pathologist, Mansarovar, Jaipur.*
[2]*Consultant Cardiologist, Mansarovar, Jaipur.*
[3]*Professor, Department of General Medicine, SMS Medical College, Jaipur.*

Correspondence:
Dr. Dr Pradeep Kumar Bansal.

Consultant
Cardiologist, Jaipur.

Received: 25-06-2026
Revised: 07-07-2026
Accepted: 18-07-2026
Published: 31-07-2026

Abstract

Background: Type 2 diabetes mellitus (T2DM) is associated with chronic inflammation and microvascular complications. Hematological indices from routine blood tests have emerged as simple markers of inflammation and metabolic status. This study evaluated their association with glycemic control and microvascular complications. ***Methods:*** This prospective observational study included 200 participants: 100 T2DM patients and 100 healthy controls. Diabetic patients were categorized based on HbA1c into good (<7%) and poor (≥7%) glycemic control. Clinical, biochemical, and hematological parameters—including MPV, PDW, PCT, WBC, NLR, and PLR—were analyzed. Microvascular complications were assessed using standard criteria. ***Results:*** Diabetic patients showed significantly higher MPV, PDW, PCT, platelet count, WBC, NLR, and PLR compared to controls ($p < 0.05$). Patients with poor glycemic control had significantly elevated platelet indices (MPV, PDW, PCT) and markedly higher albuminuria ($p < 0.05$), indicating a strong association with microvascular complications. NLR and PLR did not differ significantly between glycemic control groups. ***Conclusion:*** Hematological indices, particularly platelet parameters, are associated with glycemic status and microvascular complications in T2DM. These inexpensive and easily available markers may help identify high-risk patients and monitor disease progression. Further large-scale studies are needed to confirm their clinical utility.

Keywords: Type 2 diabetes mellitus (T2DM), Hematological indices, Microvascular complications, Glycemic control.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major global health concern, with its impact largely driven by the development of microvascular complications such as retinopathy, nephropathy, and neuropathy. Impaired glucose regulation (prediabetes) further increases the risk of progression to overt diabetes and associated vascular damage. Early identification of individuals at higher risk for poor glycemic control and complications remains an important clinical challenge. (1-3)

Chronic hyperglycemia is associated with low-grade inflammation, oxidative stress, endothelial dysfunction, and increased platelet activation. These processes contribute to alterations in hematological parameters, reflecting an underlying pro-inflammatory and pro-thrombotic state. In recent years, hematological indices derived from routine complete blood counts have emerged as potential, cost-effective markers for assessing glycemic status and disease severity. (4-5)

Parameters such as total leukocyte count, red cell distribution width (RDW), mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), neutrophil-to-lymphocyte ratio (NLR), and platelet-to-lymphocyte ratio (PLR) have been reported to be significantly altered in patients with diabetes, particularly in those with poor glycemic control. Several studies have demonstrated a positive correlation between these indices and glycated hemoglobin (HbA1c), suggesting their role as indicators of metabolic dysregulation. Additionally, these hematological markers have been found to be associated with diabetic microvascular complications, reflecting the contribution of inflammation and vascular dysfunction in their pathogenesis. (6-7)

Despite these findings, there is limited evidence evaluating hematological indices across the full spectrum of glycemic status, including impaired glucose regulation, and their relationship with microvascular complications within a single study population.

Therefore, the present study aimed to assess the association of hematological indices with glycemic status and to evaluate their relationship with microvascular complications of diabetes, as well as their correlation with HbA1c as a marker of glycemic control.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at sms hospital. The study followed a cross-sectional design and included both diabetic patients and healthy controls.

Study Population

A total of 200 participants were enrolled, comprising 100 patients with diabetes mellitus (DM) and 100 age- and sex-matched healthy controls. The diabetic group was further subdivided based on glycemic control as assessed by glycated hemoglobin (HbA1c) levels into:

- Group 1: HbA1c < 7% (n = 18)
- Group 2: HbA1c ≥ 7% (n = 82)

Inclusion and Exclusion Criteria

Patients with diagnosed diabetes mellitus were included in the study. Individuals with the following conditions were excluded: hematological disorders, hepatic failure, renal failure, heart failure, acute illnesses, chronic infections, alcohol abuse, and those receiving medications affecting platelet function. Patients with known atherosclerotic diseases, except for arterial hypertension, were also excluded.

Clinical and Demographic Assessment

Detailed demographic and clinical data were recorded for all participants, including age, gender, smoking status, medical history, medication use, and comorbid conditions. Physical examination included measurement of blood pressure, height, and weight. Body mass index (BMI) was calculated using the Quetelet index (weight in kilograms divided by height in meters squared, kg/m^2).

Patients with diabetes were further evaluated for metabolic control and the presence of microvascular complications, including nephropathy, retinopathy, and neuropathy.

- Retinopathy was diagnosed based on documented ophthalmologic findings, including the presence of at least two microaneurysms, retinal hemorrhages, or other retinal abnormalities.
- Nephropathy was assessed using the urine albumin-to-creatinine ratio (ACR) measured in a morning spot urine sample.

Biochemical and Hematological Analysis

Fasting blood samples were collected from all participants.

- Serum glucose levels were measured using the glucose oxidase method.
- Serum creatinine was determined by the Jaffe method.
- Lipid profile, including total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C), was measured using enzymatic colorimetric methods.
- Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula.
- HbA1c levels were measured using high-performance liquid chromatography (HPLC).

Complete blood count parameters, including white blood cell (WBC) count, mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), neutrophil count, lymphocyte count, and platelet count, were obtained using an automated hematology analyzer.

Inflammatory indices were calculated as follows:

- Neutrophil-to-lymphocyte ratio (NLR): neutrophil count divided by lymphocyte count
- Platelet-to-lymphocyte ratio (PLR): platelet count divided by lymphocyte count

Statistical Analysis

Statistical analysis was performed using appropriate software . Descriptive statistics were calculated for all variables. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data and as median for non-normally distributed data. Categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the chi-square test for categorical variables and the independent sample t-test for continuous variables, as appropriate. A p-value of < 0.05 was considered statistically significant.

RESULTS

Table 1. Baseline demographic and laboratory characteristics of study participants

Parameters	Diabetes Group (n=100) Mean ± SD	Control Group (n=100) Mean ± SD	P value
Age (years)	59.55 ± 6.57	58.53 ± 4.51	>0.05
Gender (F/M)	35/65	37/63	>0.05
BMI (kg/m²)	28.55 ± 1.35	28.72 ± 1.09	>0.05
Waist circumference (cm)	96.80 ± 8.14	94.94 ± 3.18	>0.05
SBP (mmHg)	136.25 ± 6.11	136.03 ± 6.30	>0.05
DBP (mmHg)	88.30 ± 4.89	88.20 ± 5.04	>0.05
TC (mg/dL)	181.55 ± 12.18	181.27 ± 11.81	>0.05
HDL-C (mg/dL)	41.25 ± 1.34	40.99 ± 3.94	>0.05
LDL-C (mg/dL)	135.00 ± 8.74	134.74 ± 8.50	>0.05
TG (mg/dL)	98.05 ± 4.47	97.22 ± 4.17	>0.05
Creatinine (mg/dL)	1.57 ± 0.44	1.45 ± 0.30	<0.05
MPV (fL)	9.63 ± 0.51	8.64 ± 0.62	<0.001
PCT (%)	0.25 ± 0.02	0.22 ± 0.02	<0.001
PDW (fL)	9.97 ± 0.76	9.23 ± 0.88	<0.001
Platelet count (×10³/µL)	250.90 ± 18.99	234.45 ± 11.85	<0.001
FPG (mg/dL)	149.10 ± 28.03	84.37 ± 6.20	<0.001
HbA1c (%)	8.98 ± 1.79	5.30 ± 0.17	<0.001
WBC (×10³/µL)	6.97 ± 1.49	6.32 ± 0.90	<0.001
NLR	2.65 ± 0.81	2.38 ± 0.72	<0.05
PLR	137.07 ± 32.80	125.42 ± 24.02	<0.05

The study included 100 patients with diabetes and 100 age- and sex-matched controls. There were no significant differences between the two groups in terms of age, gender distribution, BMI, waist circumference, blood pressure, or lipid profile ($p > 0.05$ for all).

However, diabetic patients showed significantly higher levels of creatinine, MPV, PCT, PDW, platelet count, fasting plasma glucose (FPG), HbA1c, total leukocyte count (WBC), NLR, and PLR compared to controls ($p < 0.05$).

Table 2. Clinical and laboratory characteristics according to glycemic control (HbA1c levels)

Parameters	HbA1c <7% (n=18) Mean ± SD	HbA1c ≥7% (n=82) Mean ± SD	P value
Age (years)	54.94 ± 4.17	60.56 ± 6.58	<0.001
Gender (F/M)	16/2	49/33	<0.05
BMI (kg/m²)	28.44 ± 1.29	28.57 ± 1.37	>0.05
Waist circumference (cm)	99.11 ± 3.23	96.29 ± 8.79	>0.05
SBP (mmHg)	131.50 ± 5.10	137.29 ± 5.83	<0.001
DBP (mmHg)	88.88 ± 1.56	88.17 ± 5.35	>0.05
TC (mg/dL)	174.94 ± 15.78	183.00 ± 10.83	<0.05
HDL-C (mg/dL)	41.88 ± 1.07	41.10 ± 1.36	<0.05
LDL-C (mg/dL)	125.06 ± 14.59	137.18 ± 4.68	<0.001
TG (mg/dL)	94.55 ± 3.69	98.81 ± 4.28	<0.001
Creatinine (mg/dL)	1.33 ± 0.52	1.62 ± 0.40	<0.05
MPV (fL)	9.12 ± 0.68	9.74 ± 0.38	<0.001
PCT (%)	0.24 ± 0.01	0.26 ± 0.02	<0.05
PDW (fL)	9.32 ± 0.61	10.11 ± 0.72	<0.001
Platelet count (×10³/µL)	246.50 ± 7.52	251.87 ± 20.58	>0.05
WBC (×10³/µL)	6.60 ± 0.45	7.05 ± 1.62	>0.05
NLR	2.76 ± 1.07	2.63 ± 0.75	>0.05
PLR	132.78 ± 32.79	138.01 ± 32.93	>0.05
Albuminuria (mg/gCr)	265.03 ± 220.93	1042.9 ± 592.85	<0.001

When diabetic patients were stratified based on glycemic control, those with HbA1c ≥7% had significantly higher age, systolic blood pressure, total cholesterol, LDL-C, triglycerides, creatinine, MPV, PCT, PDW, and albuminuria compared to those with HbA1c <7% ($p < 0.05$). No significant differences were observed in BMI, diastolic blood pressure, platelet count, WBC, NLR, or PLR between the two groups.

Notably, albuminuria levels were markedly higher in patients with poor glycemic control, indicating a strong association between hyperglycemia and microvascular complications.

DISCUSSION

In the present study, we evaluated the association of hematological indices with glycemic status and microvascular complications in patients with type 2 diabetes mellitus. We observed that key hematological parameters, including mean platelet volume (9.63 ± 0.51 vs 8.64 ± 0.62 fL), platelet distribution width (9.97 ± 0.76 vs 9.23 ± 0.88 fL), plateletcrit (0.25 ± 0.02 vs 0.22 ± 0.02%), platelet count (250.90 ± 18.99 vs 234.45 ± 11.85 $\times 10^3/\mu L$), total leukocyte count (6.97 ± 1.49 vs 6.32 ± 0.90 $\times 10^3/\mu L$), neutrophil-to-lymphocyte ratio (2.65 ± 0.81 vs 2.38 ± 0.72), and platelet-to-lymphocyte ratio (137.07 ± 32.80 vs 125.42 ± 24.02) were significantly higher in diabetic patients compared to controls ($p < 0.05$). Furthermore, patients with poor glycemic control (HbA1c ≥7%) demonstrated significantly elevated MPV (9.74 ± 0.38 vs 9.12 ± 0.68 fL), PDW (10.11 ± 0.72 vs 9.32 ± 0.61 fL), and PCT (0.26 ± 0.02 vs 0.24 ± 0.01%), along with markedly higher albuminuria levels (1042.9 ± 592.85 vs 265.03 ± 220.93 mg/gCr) ($p < 0.05$). These findings highlight a strong association between altered hematological indices, poor glycemic control, and the presence of microvascular complications in diabetes.

A large cohort study (8) analyzing participants across HbA1c tertiles demonstrated that mean platelet volume (MPV) and red cell distribution width (RDW) increased significantly with rising HbA1c levels ($p < 0.001$), indicating a strong association between worsening glycemic status and hematological alterations. In line with these findings, our study also observed significantly higher MPV and other platelet indices in patients with poor glycemic control (HbA1c ≥7%), supporting the role of these indices as markers of hyperglycemia and disease severity.

Previous studies have consistently demonstrated significant alterations in hematological indices in patients with diabetes. Demirtas et al. (1) reported significantly higher platelet indices, including MPV, PCT, PDW, platelet count, WBC, NLR, and PLR in diabetic patients compared to controls ($p < 0.05$), indicating an underlying inflammatory and pro-thrombotic state. Similarly, Zuberi et al. (9) observed increased MPV (9.34 fL) and platelet count in diabetic individuals compared to those with impaired fasting glucose and non-diabetic subjects, with a progressive rise across worsening glycemic status. In another large cohort study analyzing HbA1c tertiles, MPV and RDW were found to increase significantly with higher HbA1c levels ($p < 0.001$), further supporting the association between hyperglycemia and hematological alterations. In agreement with these findings, our study also demonstrated significantly elevated platelet indices (MPV, PDW, PCT), platelet count, WBC, NLR, and PLR in diabetic patients compared to controls, as well as higher values in patients with poor glycemic control, reinforcing the role of these indices as markers of inflammation, platelet activation, and disease severity in diabetes.

Patients with type 2 diabetes mellitus (T2DM) are at increased risk of coagulation abnormalities and thromboembolic events, largely due to enhanced platelet activity. Platelet dysfunction in diabetes is characterized by increased adhesion, activation, and aggregation, which are driven by metabolic disturbances such as hyperglycemia, insulin resistance, and dyslipidemia. These changes are further exacerbated by chronic inflammation, oxidative stress, impaired calcium homeostasis, reduced nitric oxide availability, and post-translational modifications of proteins, all of which contribute to a prothrombotic and proinflammatory state. Larger platelets, reflected by increased mean platelet volume (MPV), are metabolically and enzymatically more active, containing higher levels of prothrombotic substances such as thromboxane A2, platelet factor 4, serotonin, and platelet-derived growth factor, thereby enhancing thrombotic risk in diabetic patients (10–12).

Previous studies have consistently reported an association between elevated mean platelet volume (MPV) and prediabetes, diabetes, as well as diabetic vascular complications. In addition, a relationship between MPV and impaired glucose regulation has also been described. Similar to MPV, increased platelet distribution width (PDW) has been linked to diabetes and its vascular complications. (1-3) However, current evidence does not support a consistent association between plateletcrit (PCT) and diabetes or its related complications. The relationship between platelet count and diabetes remains inconclusive, with some studies demonstrating no significant association, while others have reported a positive correlation. In summary, the findings of the present study highlight that simple hematological indices, particularly platelet parameters and inflammatory markers, are closely associated with glycemic status and microvascular complications in patients with type 2 diabetes mellitus. These parameters are routinely available, cost-effective, and easy to interpret, making them practical tools in everyday clinical settings. Their significant association with poor glycemic control and complications such as nephropathy suggests that they may aid in early identification of high-risk patients and timely intervention. However, larger prospective studies are needed to further clarify their predictive value and to establish their role in routine risk stratification and monitoring of patients with diabetes.

Limitations

This study has certain limitations that should be considered while interpreting the findings. The cross-sectional design limits the ability to establish a causal relationship between hematological indices and the development of diabetic complications. The sample size, particularly in the subgroup with good glycemic control, was relatively small, which may affect the generalizability of the results. In addition, other potential confounding factors such as lifestyle habits, duration of diabetes, and use of medications were not extensively evaluated. Furthermore, more specific inflammatory markers were not included, which could have provided additional insights into the underlying mechanisms.

CONCLUSION

In conclusion, the present study demonstrates that hematological indices, especially platelet parameters and inflammatory markers, are significantly associated with glycemic status and microvascular complications in type 2 diabetes mellitus. Given that these parameters are simple, inexpensive, and routinely available, they may serve as useful adjunctive tools for identifying patients at higher risk and for monitoring disease progression. Further large-scale and longitudinal studies are warranted to validate these findings and to better define their role in clinical practice.

REFERENCES

1. Demirtas L, Degirmenci H, Akbas EM, Ozcicek A, Timuroglu A, Gurel A, Ozcicek F. Association of hematological indicies with diabetes, impaired glucose regulation and microvascular complications of diabetes. Int J Clin Exp Med. 2015 Jul 15;8(7):11420-7. PMID: 26379958; PMCID: PMC4565341.
2. Nawal CL, Singh A, Saini HL, Rankawat G. Impact of blood glucose level on hematological indices in patients with type 2 diabetes mellitus. J Assoc Physicians India. 2025 Feb 1;73(2):16-20.
3. Kumar J, Bind MK, Kumar V, Shukla A, Singh DK. Inflammatory and Hematological Markers in Type 2 Diabetes Mellitus and Their Correlation with Microvascular Complications. International Journal of Medical and Pharmaceutical Research. 2026 Mar 26;7:1403-12.
4. Demirkol S, Balta S, Kucuk U, Kucuk HO. The neutrophil lymphocyte ratio may be useful inflammatory indicator before applying other expensive and invasive procedures. Indian J Nephrol. 2014 Jan;24(1):65-6. doi: 10.4103/0971-4065.125135. PMID: 24574639; PMCID: PMC3927199.
5. Pickup JC. Inflammation and activated innate immunity in the pathogenesis of type 2 diabetes. Diabetes Care. 2004 Mar;27(3):813-23. doi: 10.2337/diacare.27.3.813. PMID: 14988310.
6. Abali G, Akpinar O, Soylemez N. Correlation of the coronary severity scores and mean platelet volume in diabetes mellitus. Adv Ther. 2014;31:140–148. doi: 10.1007/s12325-013-0081-9.
7. Ozder A, Eker HH. Investigation of mean platelet volume in patients with type 2 diabetes mellitus and in subjects with impaired fasting glucose: a cost-effective tool in primary health care? Int J Clin Exp Med. 2014;7:2292–2297.
8. Findikli HA, Sirikci V, Kirac CO, Erdogan M. Evaluation of the Relationship between Blood Glucose Regulation and Hematological Indices in Patients with diabetes Mellitus. Eurasian Journal of Medical Investigation. 2022 Apr 1;6(2).
9. Zuberi BF, Akhtar N, Afsar S. Comparison of mean platelet volume in patients with diabetes mellitus, impaired fasting glucose and non-diabetic subjects. Singapore Med J. 2008 Feb;49(2):114-6. PMID: 18301837.
10. Kim JH, Bae HY, Kim SY. Clinical marker of platelet hyperreactivity in diabetes mellitus. Diabetes Metab J. 2013 Dec;37(6):423-8. doi: 10.4093/dmj.2013.37.6.423. PMID: 24404513; PMCID: PMC3881326.
11. Suslova TE, Sitozhevskii AV, Ogurkova ON, Kravchenko ES, Kologrivova IV, Anfinogenova Y, Karpov RS. Platelet hemostasis in patients with metabolic syndrome and type 2 diabetes mellitus: cGMP- and NO-dependent mechanisms in the insulin-mediated platelet aggregation. Front Physiol. 2015 Jan 5;5:501. doi: 10.3389/fphys.2014.00501. PMID: 25601838; PMCID: PMC4283519.
12. Gasparyan AY, Ayvazyan L, Mikhailidis DP, Kitas GD. Mean platelet volume: a link between thrombosis and inflammation? Curr Pharm Des. 2011;17(1):47-58. doi: 10.2174/138161211795049804. PMID: 21247392.