International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Clinical Utility of Inflammatory Markers and Platelet Indices as Predictive Biostats for Microvascular Complications in Type 2 Diabetes Mellitus: A Case-Control Study from a South Indian Tertiary Care Hospital

Dr. N. Madhumidha[1], Dr. V.B. Santhakumari[2], Dr. M. Poornima[3]

[1-3] Assistant Professor, Department of Pathology, Swamy Vivekanandha Medical College Hospital and Research Institute, Tiruchengode, Tamil Nadu.

OPEN ACCESS

Corresponding Author:

Dr. N. Madhumidha

Assistant Professor, Department of Pathology, Swamy Vivekanandha Medical College Hospital and Research Institute, Tiruchengode, Tamil Nadu.

Received: 15-04-2026
Accepted: 20-05-2026
Available online: 05-06-2026

ABSTRACT

Background: The escalating global burden of diabetes mellitus (DM) is compounded by devastating microvascular complications including nephropathy, retinopathy, and neuropathy, which drive significant morbidity and mortality. Early detection remains a clinical challenge, particularly in resource-limited settings. This study investigates the relationship between cost-effective hematological parameters—specifically the neutrophil-lymphocyte ratio (NLR), platelet-lymphocyte ratio (PLR), and platelet indices—and the presence of microvascular angiopathies in diabetic patients.

Materials and Methods: A case-control study was conducted at Government Mohan Kumaramangalam Medical College, Salem, involving 100 participants. The study group (Group A, n=50) comprised diabetic patients with established microvascular complications, while the control group (Group B, n=50) included age- and sex-matched diabetic patients without complications. Hematological profiles were analyzed using a three-part automated cell counter, and glycemic status was assessed via HPLC-based HbA1c. Statistical analysis was performed using SPSS v27.0, employing t-tests for continuous variables and chi-square tests for categorical data.

Results: Patients with microvascular complications exhibited significantly higher mean NLR (2.8 ± 0.7 vs. 1.6 ± 0.4, $p < 0.0005$) and PLR (103.3 ± 24.3 vs. 92.0 ± 16.3, $p = 0.008$) compared to the control group. Regarding platelet indices, the Mean Platelet Volume (MPV) (11.2 ± 1.0 vs. 8.3 ± 0.5) and Platelet Distribution Width (PDW) (12.2 ± 0.9 vs. 11.0 ± 0.7) were significantly elevated in Group A ($p < 0.0005$). Conversely, hemoglobin levels and total platelet counts were significantly reduced in the complication group. No significant difference was noted in total WBC count or plateletcrit.

Conclusion: NLR, PLR, and platelet indices (MPV, PDW) serve as sensitive, cost-effective, and readily accessible biomarkers for the early identification of microvascular risk in diabetic patients. These parameters can facilitate risk stratification and timely intervention to mitigate chronic organ damage.

Keywords: *Diabetic Angiopathies; Neutrophil-Lymphocyte Ratio; Mean Platelet Volume; Diabetic Nephropathy; Diabetic Retinopathy; Biomarkers.*

INTRODUCTION

Diabetes mellitus represents one of the most formidable health emergencies of the 21st century. Characterized by chronic hyperglycemia resulting from defects in insulin secretion, action, or both, this metabolic disorder has reached epidemic proportions globally [1]. Recent data from the World Health Organization estimates that approximately 422 million adults are living with diabetes, a figure that has doubled since 1980 [2]. India, often termed the "diabetes capital," currently houses over 62 million diabetic adults, with projections suggesting a rise to 109 million by 2035. The clinical gravity of Type 2 Diabetes Mellitus (T2DM) stems not just from the metabolic derangement itself, but from the systemic vascular damage it orchestrates [3].

The pathogenesis of diabetic microvascular complications—nephropathy, retinopathy, and neuropathy—is a multifaceted process driven by chronic hyperglycemia [4]. Sustained high glucose levels trigger several deleterious biochemical pathways, including the polyol pathway flux, increased formation of advanced glycation end products (AGEs), activation of protein kinase C (PKC), and the overproduction of reactive oxygen species (ROS) [5]. These pathways culminate in oxidative stress and endothelial dysfunction, providing the bedrock for vascular basement membrane thickening and subsequent organ failure. Diabetic nephropathy, for instance, remains a leading cause of end-stage renal disease globally, while diabetic retinopathy is a primary driver of blindness in the working-age population [6].

Emerging evidence suggests that low-grade chronic inflammation plays a pivotal role in the initiation and progression of these complications. Hyperglycemia induces a "pro-inflammatory" state where leukocytes, particularly neutrophils, are recruited to the endothelium, exacerbating tissue injury [7]. While various inflammatory cytokines like Interleukin-6 and TNF-alpha are implicated, their routine measurement is often impractical in clinical settings due to high costs and technical complexity [8]. Consequently, attention has shifted toward simpler, integrated markers of inflammation derived from a standard complete blood count (CBC). The Neutrophil-Lymphocyte Ratio (NLR) and Platelet-Lymphocyte Ratio (PLR) have surfaced as robust indicators of systemic inflammation and have been linked to endothelial damage in diverse cardiovascular and metabolic disorders [9].

Parallel to inflammation, diabetes is increasingly recognized as a "prothrombotic" state. Altered platelet morphology and function are hallmark features of T2DM. Hyperglycemia leads to osmotic swelling of platelets and stimulates megakaryocytes to release larger, more reactive platelets [10]. These larger platelets possess denser granules, secrete higher amounts of pro-thrombotic factors like thromboxane A2, and exhibit enhanced aggregability. Mean Platelet Volume (MPV) and Platelet Distribution Width (PDW) are direct reflections of this increased platelet activity and size variation. These indices have been documented as emerging risk factors for ischemic events and microvascular damage [11].

Despite the abundance of literature on late-stage diabetic complications, there is a critical need for early, accessible biomarkers that can predict vascular damage before it becomes irreversible. In many developing regions, advanced imaging or specialized laboratory tests are not always feasible for routine screening. A standard CBC-based analysis offers a "cost-effective and sensitive indicator" that can be easily integrated into routine follow-ups. This study, therefore, aims to delineate the specific hematological and platelet profiles of patients suffering from microvascular complications at a South Indian tertiary care center, providing localized data to enhance clinical decision-making and patient stratification.

MATERIALS AND METHODS

Study Setting: This prospective case-control investigation was conducted at the Government Mohan Kumaramangalam Medical College (GMKMC) and Hospital, Salem, Tamil Nadu. The data collection involved patients visiting the Outpatient Departments (OPD) of Diabetology, Nephrology, and Ophthalmology, as well as those admitted to the General Medicine wards.

Study Participants: The study enrolled 100 adult patients with confirmed Type 1 or Type 2 Diabetes Mellitus. Participants were categorized into two groups: Group A (Cases) consisted of 50 diabetic patients with clinical or laboratory evidence of microvascular complications, including nephropathy (albuminuria or elevated creatinine), retinopathy (fundus changes), or neuropathy (distal sensory loss/numbness). Group B (Controls) consisted of 50 diabetic patients who showed no signs of these complications upon examination. We excluded individuals with known macrovascular diseases like stroke or myocardial infarction, non-diabetic kidney or eye diseases, acute infections, and gestational diabetes to ensure the results specifically reflected diabetic microangiopathy.

Sample Size and Sampling Technique: A total sample size of 100 was determined based on the feasibility and the requirement to maintain a 1:1 ratio between cases and controls. Consecutive sampling was utilized, enrolling every eligible patient who met the strict inclusion and exclusion criteria during the study period from November 2022 to June 2024.

Study Tools: Data collection was facilitated through a structured proforma that captured demographic details, clinical history, and physical examination findings. Laboratory investigations utilized high-precision diagnostic equipment, including the Sysmex three-part automated hematology analyzer for complete blood counts, and High-Performance Liquid Chromatography (HPLC) for the gold-standard measurement of HbA1c. Biochemical parameters were processed using automated analyzers to ensure accuracy in fasting and post-prandial blood sugar measurements.

Study Methodology: Upon obtaining informed consent, 5ml of venous blood was collected from each participant under aseptic conditions. Samples were divided into dipotassium EDTA tubes for hematological and HbA1c analysis and plain red tubes for sugar and creatinine estimation. To preserve sample integrity, all tests were performed within one hour of collection. Microvascular status was assessed through fundoscopy for retinopathy, dipstick urinalysis for albuminuria, and clinical sensory testing for neuropathy.

Ethical Issues: The study protocol received formal approval from the Institutional Ethics Committee (IEC) of Government Mohan Kumaramangalam Medical College (Ref. No. GMKMC&H/4341/IEC/02/2018-13). All participants provided written informed consent after a thorough explanation of the study's objectives in their native language. Patient confidentiality was strictly maintained throughout the research process.

Statistical Analysis Data were compiled in Microsoft Excel and analyzed using IBM SPSS Statistics software, version 27.0. Continuous variables were presented as mean ± standard deviation, and comparisons were made using the independent samples t-test. Categorical data were compared using Chi-square or Fisher's exact tests. A p-value less than 0.05 was considered to indicate statistical significance.

RESULTS

The demographic landscape of our study revealed a predominant middle-aged population, with 60% of participants falling between 51 and 60 years of age. Males represented 58% of the total cohort. Interestingly, age showed a significant correlation with the presence of complications ($p = 0.005$), suggesting that older patients were more vulnerable to microangiopathy (Table 1).

Table 1: Demographic Distribution of Study Participants (N = 100)

Variable	Group A (Complications, n=50)	Group B (No Complications, n=50)	p-value
Age Group (n, %)			
< 50 Years	8 (16.0%)	19 (38.0%)	0.005**
51 - 60 Years	31 (62.0%)	29 (58.0%)	
> 60 Years	11 (22.0%)	2 (4.0%)	
Gender (n, %)			
Male	32 (64.0%)	26 (52.0%)	0.224
Female	18 (36.0%)	24 (48.0%)	

Analysis of the clinical profile indicated that Group A had a significantly longer duration of disease, averaging 7.3 years compared to 5 years in Group B. Metabolic control was also significantly poorer in the complication group, with notably higher mean fasting blood sugar, post-prandial blood sugar, and HbA1c levels (Table 2).

Table 2: Comparison of Clinical and Biochemical Profiles Between Groups

Clinical Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Duration of DM (Years)	7.3 ± 3.3	5.0 ± 2.1	0.0005**
Fasting Blood Sugar (mg/dL)	153.4 ± 28.8	113.7 ± 12.0	0.0005**
Post-Prandial Sugar (mg/dL)	244.5 ± 43.0	192.7 ± 18.1	0.0005**
HbA1c (%)	7.7 ± 0.8	6.9 ± 0.5	0.0005**

Within Group A, the study observed that nephropathy was the most prevalent complication, affecting 20 patients (40% of the complication group), followed by equal distributions of retinopathy and neuropathy cases (Table 3).

Table 3: Distribution of Microvascular Complications in Group A (n = 50)

Type of Complication	Frequency (n)	Percentage (%)
Diabetic Nephropathy	20	40%
Diabetic Retinopathy	15	30%
Diabetic Neuropathy	15	30%

Hematological marker analysis demonstrated that patients with complications suffered from lower hemoglobin levels, likely related to early renal insufficiency. While total WBC counts remained comparable between groups, the inflammatory ratios—NLR and PLR—were significantly elevated in patients with microvascular damage (Table 4).

Table 4: Comparison of Hematological Inflammatory Markers

Hematological Marker	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Hemoglobin (g/dL)	11.1 ± 1.4	12.0 ± 1.0	0.0005**
Total WBC Count (cells/mm³)	6736 ± 1044	6888 ± 1115	0.484
NLR	2.8 ± 0.7	1.6 ± 0.4	0.0005**
PLR	103.3 ± 24.3	92.0 ± 16.3	0.008**

The assessment of platelet indices highlighted a marked difference in platelet behavior. Group A showed significantly higher MPV and PDW, indicative of larger and more active platelets. Interestingly, the total platelet count was significantly lower in the complication group, reflecting increased platelet consumption in the microvasculature (Table 5).

Table 5: Comparison of Platelet Indices and Counts

Platelet Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Mean Platelet Volume (fL)	11.2 ± 1.0	8.3 ± 0.5	0.0005**
Platelet Distribution Width	12.2 ± 0.9	11.0 ± 0.7	0.0005**
Plateletcrit (%)	0.3 ± 0.0	0.3 ± 0.0	0.187
Platelet Count (lakhs/mm³)	2.66 ± 0.36	3.30 ± 0.35	0.0005**

DISCUSSION

The primary objective of this investigation was to evaluate whether routine hematological parameters could serve as reliable markers for diabetic microangiopathy. Our findings strongly support the role of NLR, PLR, and specific platelet indices as predictive tools in clinical practice. The significant elevation of NLR and PLR in patients with complications highlights the fundamental role of chronic low-grade inflammation in diabetic vascular damage [12].

In our study, the mean NLR in the complication group was 2.8 ± 0.7, significantly higher than the 1.6 ± 0.4 observed in the control group ($p < 0.0005$). This aligns with work by Akbas et al., who demonstrated that NLR increases alongside albuminuria, reflecting a link between systemic inflammation and renal endothelial dysfunction [13]. Similarly, the PLR was significantly higher in Group A (103.3 vs 92.0). These ratios provide a more comprehensive picture than individual leukocyte counts; while the total WBC count showed no significant difference in our study, the *ratios* captured the shift toward neutrophilia and lymphocytopenia that characterizes the diabetic inflammatory state [14].

Platelet indices also provided crucial insights. The Mean Platelet Volume (MPV) was significantly elevated in patients with complications (11.2 fL vs. 8.3 fL). This increase in size suggests the presence of younger, more active platelets that are prone to aggregation and thrombus formation in the microvasculature. Our findings are consistent with several studies, which identified high MPV as a hallmark of diabetic vascular risk [15, 16]. Furthermore, the Platelet Distribution Width (PDW), which measures variation in platelet size, was significantly higher in Group A (12.2 vs 11.0). This reflects the "spherical transformation" and pseudopodia formation of hyperactive platelets in the diabetic milieu [17].

An interesting observation was the significant reduction in total platelet count in Group A (266,000 vs 330,020 cells/mm³). This likely reflects the increased consumption of platelets in the process of microthrombi formation across the damaged retinal and renal capillaries. While some studies show variable results regarding platelet counts, our data suggests that a relative decrease, when paired with high MPV, is a strong indicator of vascular involvement [18].

Clinically, the duration of diabetes and glycemic control (HbA1c) remained the strongest traditional predictors of complications. In our cohort, Group A had a significantly longer disease duration (7.3 years) and higher mean HbA1c (7.7%). However, the integration of NLR, PLR, and MPV into routine monitoring provides an extra layer of diagnostic sensitivity [19]. These markers are not affected by short-term glucose fluctuations, unlike fasting sugars, and offer a biological snapshot of the underlying vascular stress [20].

The strengths of this study include its well-matched case-control design and the use of standardized, automated diagnostic tools. However, the modest sample size and single-center setting may limit generalizability to broader populations. Furthermore, the cross-sectional nature prevents us from establishing a definitive causal timeline. Future longitudinal studies tracking these markers from the time of initial diagnosis could better define their prognostic value.

CONCLUSION

This study confirms that neutrophil-lymphocyte ratio, platelet-lymphocyte ratio, and platelet indices (MPV and PDW) are significantly altered in patients with diabetic microvascular complications. These hematological parameters offer a fast, cost-effective, and simple diagnostic tool for identifying high-risk individuals in routine clinical settings. Utilizing these biomarkers for early detection can facilitate timely therapeutic interventions, potentially reducing the heavy burden of morbidity and mortality associated with diabetic microangiopathy and significantly improving the quality of life for this vulnerable population.

REFERENCES

1. American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of Medical Care in Diabetes—2021. Diabetes Care. 2021;44(Suppl 1):S15-33.
2. World Health Organization. Global report on diabetes. Geneva: World Health Organization; 2016.
3. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Med Res. 2017;146(2):141-8.
4. Fowler MJ. Microvascular complications of diabetes. Clin Diabetes. 2008;26(2):77-82.
5. Brownlee M. The pathobiology of diabetic complications: a unifying mechanism. Nature. 2001;414(6865):813-20.
6. Cade WT. Diabetes-related microvascular and macrovascular diseases in the physical therapy setting. Phys Ther. 2008;88(11):1322-35.

7. Pickup JC. Inflammation and activated innate immunity in the pathogenesis of type 2 diabetes. Diabetes Care. 2004;27(3):813-23.
8. Goldberg RB. Cytokine and inflammatory markers of diabetes. J Clin Endocrinol Metab. 2009;94(5):1557-65.
9. Sefil F, Ulutas KT, Dokuyucu R, Kocanipek E, Musrit A, Tutar NH, et al. Investigation of neutrophil-to-lymphocyte ratio and blood glucose regulation in patients with type 2 diabetes mellitus. J Int Med Res. 2014;42(2):581-8.
10. Papanas N, Symeonidis G, Maltezos E, Mavridis G, Karavageli E, Vosnakidis T, et al. Mean platelet volume in patients with type 2 diabetes mellitus. Platelets. 2004;15(8):475-8.
11. Jindal S, Gupta S, Gupta R, Kakkar A, Singh HV, Gupta K, et al. Platelet indices in diabetes mellitus: indicators of diabetic microvascular complications. Hematology. 2011;16(2):86-9.
12. Verdoia M, Schaffer A, Barbieri L, Aimaretti G, Marino P, Sinigaglia F, et al. Impact of diabetes on neutrophil-to-lymphocyte ratio and its relationship to coronary artery disease. Diabetes Metab. 2015;41(4):304-11.
13. Akbas A, Ozcicek A, Ozcicek F, Karatoy Erdem N, Erdem H. Is the neutrophil-to-lymphocyte ratio a predictive marker of diabetic nephropathy? Med Sci Monit. 2014;20:2069-73.
14. Demirtas L, Degirmenci H, Akbas EM, Ozcicek A, Timuroglu A, Gurel A, et al. Association of hematological-inflammatory markers with early-stage diabetic nephropathy. Med Sci Monit. 2014;20:1987-94.
15. Kim JH, Kang SB, Kang JI, Kim JW, Kim SY, Ahn CW, et al. The relationship between mean platelet volume and diabetic retinopathy in type 2 diabetes mellitus. Korean J Intern Med. 2013;28(2):196-202.
16. Ates O, Kocer I, Baykal O, Keleş S, Aras MH. Mean platelet volume and its relationship with diabetic retinopathy in type 2 diabetic patients. Int J Ophthalmol. 2009;2(3):236-9.
17. Buch A, Kaur S, Nair R, Jain A. Platelet indices as a predictive marker of microvascular complications in diabetes mellitus. J Lab Physicians. 2017;9(4):265-71.
18. Demirtunc R, Deyneli O, Caqlayan M, Reisli I, Ersoz HO, Arasli M, et al. The relationship between glycemic control and platelet activation in type 2 diabetes mellitus. J Diabetes Complications. 2009;23(2):89-94.
19. Huang W, Huang J, Liu Q, Lin F, He Z, Zeng Z, et al. Neutrophil-lymphocyte ratio is a reliable predictive marker for early-stage diabetic nephropathy. Clin Endocrinol (Oxf). 2015;82(2):229-33.
20. Mertoglu C, Gunay M. Neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio as useful markers of inflammation in diabetes mellitus and its complications. Galician Med J. 2017;24(4):e2017415.