



HEMATOLOGICAL RATIOS AND HEMATOLOGICAL PARAMETERS IN DIABETES MELLITUS AND THEIR ASSOCIATION WITH GLYCEMIC CONTROL: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Diabetes mellitus is associated with hyperglycemia, inflammation, and hematological alterations. Complete blood count parameters may provide accessible supportive markers of glycemic status. **Objective:** To assess hematological parameters and blood count-derived inflammatory ratios in adults with diabetes mellitus and examine their association with HbA1c. **Materials and Methods:** This hospital-based cross-sectional study included 220 adults attending a Diabetes Health Camp in Bilaspur, in collaboration with the Department of Pathology, CIMS. HbA1c and complete blood count parameters were recorded. Neutrophil-to-lymphocyte, platelet-to-lymphocyte, and monocyte-to-lymphocyte ratios were calculated. Glycemic control was categorized as good (HbA1c <7%) or poor (HbA1c ≥7%). **Results:** Among 220 participants, 155 (70.5%) had HbA1c in the diabetic range and 138 (62.7%) had poor glycemic control. Mean platelet volume was higher with poor control (10.74 ± 1.36 vs. 9.78 ± 0.90 fL; $p < 0.001$) and correlated with HbA1c ($r = 0.544$; $p < 0.001$). Mean corpuscular hemoglobin concentration also correlated with HbA1c ($r = 0.263$; $p < 0.001$). Platelet distribution width was higher in poor control ($p = 0.034$), while inflammatory ratios were not significantly associated with HbA1c. **Conclusion:** Mean platelet volume showed the strongest association with glycemic control. These hematological parameters may support, but should not replace, HbA1c assessment.

KEYWORDS : Diabetes Mellitus; HbA1c; Mean Platelet Volume; Hematological Parameters

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic condition in which persistently elevated blood glucose levels result from impaired insulin secretion, reduced insulin action, or a combination of both (American Diabetes Association Professional Practice Committee, 2025; World Health Organization, 2019). It is an important cause of morbidity and mortality worldwide, largely because of its long-term effects on the cardiovascular, renal, neurological, and hematological systems (American Diabetes Association Professional Practice Committee, 2025; International Diabetes Federation, 2021; World Health Organization, 2019).

The prevalence of diabetes has increased considerably over the past few decades, with India contributing substantially to the global burden (International Diabetes Federation, 2021). Persistent hyperglycemia is associated with oxidative stress, endothelial dysfunction, low-grade inflammation, and changes in immune responses, all of which may contribute to disease progression and vascular complications (American Diabetes Association Professional Practice Committee, 2025; Anandani et al., 2025; Khungala et al., 2025).

Routine complete blood count (CBC) parameters are increasingly being studied as simple, inexpensive, and readily available indicators of hematological and inflammatory changes. These include total leukocyte count, platelet count, red cell indices, mean platelet volume (MPV), platelet distribution width (PDW), and derived inflammatory ratios such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and monocyte-to-lymphocyte ratio (MLR) (Anandani et al., 2025; Hamdan et al., 2025).

MPV and PDW provide information related to platelet size, turnover, and activation, whereas NLR, PLR, and MLR reflect changes in the relative proportions of circulating leukocyte populations. Alterations in these parameters have been reported in patients with diabetes and may be associated with chronic inflammation, oxidative stress, and vascular

dysfunction (Anandani et al., 2025; Hamdan et al., 2025).

However, findings regarding their relationship with glycemic control have not been consistent. While some studies have reported increases in NLR, MPV, and other platelet indices with worsening glycemic control (Adane et al., 2023; Duman et al., 2019; Khungala et al., 2025), others have found weak or no significant associations, particularly for NLR, PLR, and MLR (Anandani et al., 2025; Duman et al., 2019). Differences in study populations, disease duration, treatment status, and study design may partly explain these variations.

Against this background, the present study was undertaken to evaluate routine hematological parameters and CBC-derived inflammatory ratios in adults with diabetes mellitus and to assess their relationship with glycemic control as measured by HbA1c.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional observational study was conducted in the Department of Pathology, Chhattisgarh Institute of Medical Sciences (CIMS), Bilaspur, in collaboration with the Department of Laboratory Medicine during the Diabetes Health Camp organized at Kumar Saheb Late Shri Dilip Singh Judev Ji Government Super Speciality Hospital, Koni, Bilaspur, Chhattisgarh, India. The study was conducted over a period of 12 months.

Study Population and Sample Size

The study contained 220 participants. The sample-size calculation yielded a minimum required sample of 196 participants using $Z = 1.96$, $p = 15\%$, $q = 85\%$, and $d = 5\%$ allowable error; all eligible participants available during the study period were included. The dataset contained no participant younger than 18 years (age range 21–81 years).

Inclusion and Exclusion Criteria

Individuals aged 18 years or above, including previously diagnosed diabetes mellitus and newly diagnosed diabetic

participants based on HbA1c criteria, were included. Participants with acute infection, chronic inflammatory disorders, autoimmune disease, hematological malignancy, chronic liver disease, chronic kidney disease, pregnancy, recent surgery or trauma, or current corticosteroid/immunosuppressive therapy were excluded. Written informed consent was obtained.

Laboratory Methods

Approximately 3 mL of venous blood was collected under aseptic precautions in EDTA vacutainers. HbA1c was estimated using the HB Vertex Fully Automated High-Performance Liquid Chromatography (HPLC) Analyzer. Glycemic control was categorized as good (HbA1c <7%) or poor (HbA1c ≥7%). Complete blood count was performed using the HORIBA H500 automated hematology analyzer. Hemoglobin, total leukocyte count, differential leukocyte count, RBC count, hematocrit, MCV, MCH, MCHC, RDW-CV, platelet count, MPV, and PDW were recorded.

Calculation of Hematological Ratios

NLR was calculated as absolute neutrophil count divided by absolute lymphocyte count; PLR as platelet count divided by absolute lymphocyte count; and MLR as absolute monocyte count divided by absolute lymphocyte count.

Statistical Analysis

Data were entered into Microsoft Excel 2021 and analyzed using descriptive and inferential statistical methods. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. An independent-samples Student's t-test was used to compare the good and poor glycemic-control groups. One-way analysis of variance (ANOVA) was used to compare mean platelet volume across the four HbA1c strata. Pearson's correlation coefficient was used to assess the relationship between HbA1c and hematological parameters or ratios. A two-sided p-value < 0.05 was considered statistically significant, with 95% confidence intervals reported where applicable.

RESULTS

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Characteristic	Value
Total participants	220
Age (years), mean ± SD	51.45 ± 13.95
Age range (years)	21–81
18–30 years, n (%)	20 (9.1%)
31–40 years, n (%)	31 (14.1%)
41–50 years, n (%)	55 (25.0%)
51–60 years, n (%)	51 (23.2%)
>60 years, n (%)	63 (28.6%)
Male, n (%)	154 (70.0%)
Female, n (%)	66 (30.0%)
Height (cm), mean ± SD	161.53 ± 8.31
Weight (kg), mean ± SD	68.08 ± 12.63
BMI (kg/m ²), mean ± SD	26.32 ± 5.06
Waist circumference (cm), mean ± SD	90.46 ± 11.80
Random blood sugar (mg/dL), mean ± SD	149.49 ± 93.68
HbA1c (%), mean ± SD	7.94 ± 2.23

Table 2. Distribution of Participants According to HbA1c Category

HbA1c category	HbA1c range (%)	n	%
Normal	<5.7	24	10.9
Prediabetes	5.7–<6.5	41	18.6
Diabetes	≥6.5	155	70.5
Total	—	220	100.0
Glycemic control	HbA1c range (%)	n	%
Good glycemic control	<7.0	82	37.3

Poor glycemic control	≥7.0	138	62.7
Total	—	220	100.0

Table 3. Comparison of Hematological Parameters According to Glycemic Control

Parameter	Good control (HbA1c <7%), mean ± SD	Poor control (HbA1c ≥7%), mean ± SD	t	95% CI of mean difference	p
Hemoglobin (g/dL)	13.30 ± 1.85	13.12 ± 1.81	0.71	-0.32 to 0.68	0.479
Total leukocyte count (×10 ⁹ /μL)	7.72 ± 6.07	8.08 ± 4.72	-0.50	-1.81 to 1.08	0.621
RBC count (×10 ⁶ /μL)	5.00 ± 0.63	4.93 ± 0.66	0.74	-0.11 to 0.25	0.462
Hematocrit (%)	42.11 ± 5.44	40.51 ± 5.80	2.03	0.05 to 3.16	0.044
MCV (fL)	84.21 ± 9.29	82.23 ± 8.22	1.65	-0.39 to 4.35	0.101
MCH (pg)	26.48 ± 3.59	27.38 ± 6.53	-1.14	-2.45 to 0.65	0.255
MCHC (g/dL)	31.61 ± 0.83	32.39 ± 0.90	-6.45	-1.02 to 0.55	<0.001
RDW-CV (%)	14.46 ± 2.31	14.27 ± 1.38	0.74	-0.31 to 0.67	0.461
Platelet count (×10 ³ /μL)	261.94 ± 73.28	244.66 ± 72.91	1.70	-2.79 to 37.35	0.091
MPV (fL)	9.78 ± 0.90	10.74 ± 1.36	-5.67	-1.29 to 0.62	<0.001
PDW (fL)	13.33 ± 3.61	14.45 ± 3.81	-2.14	-2.14 to 0.09	0.034

Table 4. Comparison of CBC-derived Inflammatory Ratios According to Glycemic Control

Ratio	Good control, mean ± SD	Poor control, mean ± SD	t	95% CI of mean difference	p
Neutrophil-to-lymphocyte ratio (NLR)	1.89 ± 1.04	1.97 ± 0.78	-0.66	-0.326 to 0.162	0.508
Platelet-to-lymphocyte ratio (PLR)	118.18 ± 41.46	108.56 ± 36.86	1.79	-1.001 to 20.235	0.076
Monocyte-to-lymphocyte ratio (MLR)	0.24 ± 0.09	0.26 ± 0.11	-1.63	-0.053 to 0.005	0.105

Table 5. Pearson Correlation Between HbA1c and Hematological Parameters

Parameter	Pearson r	95% CI for r	p
Hemoglobin (g/dL)	-0.072	-0.202 to 0.061	0.291
Total leukocyte count (×10 ⁹ /μL)	-0.007	-0.139 to 0.126	0.923
RBC count (×10 ⁶ /μL)	-0.040	-0.171 to 0.093	0.557
Hematocrit (%)	-0.128	-0.256 to 0.004	0.058
MCV (fL)	-0.114	-0.243 to 0.019	0.092
MCH (pg)	0.117	-0.016 to 0.246	0.085
MCHC (g/dL)	0.263	0.135 to 0.382	<0.001
RDW-CV (%)	-0.028	-0.160 to 0.104	0.675
Platelet count (×10 ³ /μL)	-0.009	-0.141 to 0.123	0.895
MPV (fL)	0.544	0.444 to 0.631	<0.001
PDW (fL)	0.126	-0.007 to 0.254	0.063

Table 6. Pearson Correlation Between HbA1c and CBC-derived Inflammatory Ratios

Ratio	Pearson r	95% CI for r	p
Neutrophil-to-lymphocyte ratio (NLR)	0.029	-0.104 to 0.161	0.669
Platelet-to-lymphocyte ratio (PLR)	-0.014	-0.146 to 0.119	0.837
Monocyte-to-lymphocyte ratio (MLR)	0.013	-0.119 to 0.145	0.847

Table 7. MPV Across HbA1c Strata

HbA1c stratum	n	MPV, mean ± SD (fL)	Median MPV (fL)
Normal (<5.7)	24	9.92 ± 1.08	10.00
Prediabetes (5.7–<6.5)	41	9.81 ± 0.81	9.90
Diabetes with HbA1c 6.5–<7.0	17	9.51 ± 0.83	9.40
Poor glycemic control (≥7.0)	138	10.74 ± 1.36	10.60

MPV differed significantly across the four HbA1c strata (one-way ANOVA $F = 11.09$, $p < 0.001$), with the highest mean MPV observed in participants with HbA1c $\geq 7\%$.

Principal Findings

Of the 220 participants, 155 (70.5%) had HbA1c $\geq 6.5\%$, and 138 (62.7%) had poor glycemic control. MPV was markedly higher in the poor-control group (10.74 ± 1.36 fL) than in the good-control group (9.78 ± 0.90 fL; $p < 0.001$). MPV showed a moderate positive correlation with HbA1c ($r = 0.544$, 95% CI 0.444–0.631; $p < 0.001$).

MCHC was also higher in poor glycemic control (32.39 ± 0.90 vs 31.61 ± 0.83 g/dL; $p < 0.001$) and showed a weak positive correlation with HbA1c ($r = 0.263$, 95% CI 0.135–0.382; $p < 0.001$). Hematocrit was significantly lower in the poor-control group ($p = 0.044$). PDW was higher in poor glycemic control ($p = 0.034$), but its correlation with HbA1c did not reach statistical significance ($r = 0.126$, $p = 0.063$).

NLR, PLR, and MLR did not differ significantly between the good- and poor-control groups and did not show significant correlations with HbA1c.

DISCUSSION

The most prominent finding in the study is the relationship between MPV and glycemic control. MPV was significantly higher in participants with HbA1c $\geq 7\%$ and showed a moderate positive correlation with HbA1c. This association was stronger than that observed for the other CBC parameters evaluated and remained evident across HbA1c strata, with the highest MPV among participants with poor glycemic control.

The association between MPV and HbA1c may reflect changes in platelet size and turnover accompanying chronic hyperglycemia. Hyperglycemia-related oxidative stress, endothelial dysfunction, and platelet activation may contribute to changes in platelet indices. However, because the present study is cross-sectional, the observed relationship should be interpreted as an association rather than evidence of causation.

MCHC also demonstrated a consistent association with glycemic status. It was significantly higher in the poor-control group and showed a weak positive correlation with HbA1c. Although statistically significant, the correlation was substantially weaker than that observed for MPV, suggesting that MCHC may have a supportive rather than primary role in assessing glycemic status.

Hematocrit was modestly lower in the poor-control group, reaching statistical significance in the updated dataset. In contrast, MCV did not show a statistically significant group difference or correlation with HbA1c in the updated analysis.

PDW was significantly higher among participants with poor glycemic control, but the correlation between PDW and HbA1c was not statistically significant. This distinction is important: a significant difference between two predefined groups does not necessarily imply a significant linear relationship with HbA1c as a continuous variable.

The inflammatory ratios showed no significant association with HbA1c. NLR was only slightly higher in the poor-control group, while PLR was numerically lower and MLR numerically higher, but none of these differences reached statistical

significance. Similarly, their Pearson correlations with HbA1c were negligible. These findings contrast with studies reporting positive associations between NLR and poor glycemic control and support the view that CBC-derived inflammatory ratios may vary across populations and clinical settings.

The present findings are broadly relevant to the literature cited in the original manuscript. Duman et al. (2019) and the meta-analysis by Adane et al. (2023) reported higher NLR with poor glycemic control, whereas the present dataset did not demonstrate a significant NLR–HbA1c association. Khungala et al. (2025) reported positive associations involving MPV, and the updated dataset similarly demonstrates a clear MPV–HbA1c relationship. The magnitude of the association in the present study is notable and makes MPV the principal hematological finding of this analysis.

Taken together, the updated data suggest that platelet-related indices, particularly MPV, may be more informative for glycemic status in this study population than NLR, PLR, or MLR. Nevertheless, MPV and other CBC parameters should be regarded as supportive markers and not substitutes for HbA1c.

CONCLUSION

The updated analysis demonstrates that poor glycemic control is associated with significant changes in selected hematological parameters, most notably MPV and MCHC. MPV showed a moderate positive correlation with HbA1c and was significantly higher in participants with HbA1c $\geq 7\%$, making it the strongest hematological parameter associated with glycemic control in the present study. MCHC also showed a significant, although weaker, positive relationship with HbA1c, while hematocrit and PDW showed significant group differences. In contrast, NLR, PLR, MLR, and MCV did not show significant associations with HbA1c. These findings suggest that selected routine CBC parameters, particularly MPV, may provide useful supportive information regarding glycemic status, but they should be interpreted alongside established measures such as HbA1c. Larger prospective and multicentric studies are needed to determine whether these associations have independent clinical or prognostic significance.

REFERENCES

- Adane, T., Getaneh, Z., Muluye, D., et al. (2023). The association between neutrophil-to-lymphocyte ratio and glycemic control in type 2 diabetes mellitus: A systematic review and meta-analysis. *Journal of Diabetes Research*, 2023.
- American Diabetes Association Professional Practice Committee. (2025). Classification and diagnosis of diabetes: Standards of Care in Diabetes—2025. *Diabetes Care*, 48(Suppl. 1), S20–S42.
- Anandani, G., Patel, M., Shah, H., et al. (2025). Novel inflammatory hematological ratios and hematological parameters in diabetes mellitus: A cross-sectional study. *Maedica*, 20(1).
- Duman, T. T., Aktas, G., Atak, B. M., Kocak, M. Z., Erkus, E., & Savli, H. (2019). Neutrophil-to-lymphocyte ratio as an indicator of diabetic control level in type 2 diabetes mellitus. *African Health Sciences*, 19(1), 1602–1606.
- Hamdan, T. A., Al-Saadi, A. H., & Mohammed, A. A. (2025). Evaluation of hematological parameters in patients with type 2 diabetes mellitus. *Acta Informatica Medica*, 33(1).
- International Diabetes Federation. (2021). *IDF Diabetes Atlas* (10th ed.). International Diabetes Federation.
- Khungala, A., Sharma, P., Verma, R., et al. (2025). Evaluation of hematological changes in type 2 diabetes mellitus and their correlation with glycemic control. *Journal of Pharmacy & Biomedical Sciences*, 17(1).
- World Health Organization. (2019). *Classification of diabetes mellitus*. World Health Organization.