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Correlation of complete blood count parameters with glycemic control in type 2 diabetes mellitus

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ABSTRACT

Background. *Several hematological alterations involving cellular components of the blood have been reported in patients with type 2 diabetes mellitus (T2DM) and may contribute to the development of diabetes-related complications. Chronic hyperglycemia increases oxidative stress, which can affect red blood cells, white blood cells, and platelets. Glycated hemoglobin (HbA1c) reflects glycemic control over the preceding three months and is widely used to assess disease management.*

Objective. *To evaluate the association between selected hematological parameters from the complete blood count (CBC), and glycemic control in patients with T2DM.*

Methods. *This cross-sectional, exploratory study included 50 patients with T2DM, who were divided into two groups based on their HbA1c level into a good glycemic control group (n = 25, HbA1c < 7%) and poor glycemic control (n = 25, HbA1c ≥ 7%). CBC parameters and HbA1c levels were measured. Group comparisons between groups were performed using the independent sample t-tests and Pearson's correlation analysis was used to assess the relationship between hematological parameters and HbA1c.*

Results. *Patients with poor glycemic control had significantly higher mean WBC count (7.90 ± 1.72 vs. 6.53 ± 0.89 × 10^9/L, p < 0.001), neutrophil count (4.98 ± 1.57 vs. 3.91 ± 0.82 × 10^9/L, p < 0.004), platelet count (286.88 ± 54.18 vs. 216.48 ± 39.33 × 10^9/L, p < 0.001)), and mean platelet volume (10.44 ± 2.11 vs. 8.21 ± 0.86 fL, p < 0.001) compared with the good control group. No significant differences were observed in RBC parameters. Platelet count showed a significant positive correlation with HbA1c (r = 0.516, p < 0.001). In addition, WBC count (r = 0.485, p = 0.001), neutrophil count (r = 0.431, p = 0.002), and mean platelet volume (MPV) (r = 0.598, p < 0.001) were also significantly positively correlated with HbA1c levels.*

Conclusion. *Poor glycemic control in this cohort of patients with T2DM was associated with higher WBC, neutrophil, and platelet counts, as well as increased MPV. These results suggest a potential correlation between subclinical inflammation, platelet activation, and hyperglycemia. However, given the small sample size and the exploratory cross-sectional design of the study, the findings should be interpreted with caution and confirmed in larger prospective studies before any clinical utility can be established.*

Keywords: diabetes mellitus, glycemic control, white blood cells, neutrophils, platelets, mean platelets volume

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease that is defined by the persistent hyperglycemia, caused by the deficiency of insulin secretion, decreased insulin response, or both [1]. It is a major worldwide public public-health issue, because its occurrence continues to increasing and is closely linked with serious micro vascular and macro vascular complications [2]. The International Diabetes Federation (IDF) estimates

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that there were approximately 589 million adults with diabetes in 2024; a figure expected to rise to 853 million by 2050 [3]. In Iraq, in 2021, the prevalence rate was estimated 13.2 % age-adjusted with the forecasts of 14.5 % by 2030 [4].

Glycated hemoglobin (HbA1c) is the gold-standard biomarker of long-term glycemic control, reflecting average blood glucose levels over the preceding last two to three months [5, 6]. The main determinant of diabetic complications development is suboptimal glycemic control. The pathophysiology is characterized by a chronic hyperglycemia that triggers a low grade an inflammatory condition of and increases the levels of oxidative stress, thus regulating the various cell systems, including hematological components [7,8].

Previous studies have reported inconsistent relationships between hematological parameters based on the complete blood count (CBC) and glycemic status in type 2 diabetes mellitus (T2DM). Some studies hypothesize that the number of white blood cells (WBCs), which a recognized indicator of inflammation, is higher in patients with poorly managed diabetes [9, 10] while other study reported claim no statistically significant relationship [11]. Similarly, the change in red blood cell (RBC) indices, such as red cell distribution width (RDW), has been associated with poor glycemic control and vascular complications, although the results are mixed [12,13]. Platelet indices, especially the mean platelet volume (MPV), have also been proposed as potential platelet hyper activation and inflammatory activity biomarkers in T2DM [14,15].

The complete blood count (CBC) is frequently used in clinical studies because it is both an inexpensive and readily available test. In this regard, useful hematologic to predict less-than-optimal glycemic control would be valuable in clinical practice. However, the existing literature shows is conflicting results, and many studies are limited by methodological flaws such as confounding variables. As a result, a considerable knowledge gap remains regarding the concerning the consistent relationship between a comprehensive set of CBC parameters and glycemic control as measured by glycated hemoglobin (HbA1c) levels.

Therefore, the aim of this study was to compare of hematological parameters (RBC, WBC, platelet counts) between T2DM patients with good versus poor glycemic control and to evaluate the correlation between these parameters and HbA1c levels.

MATERIALS AND METHODS

Study design and population

This cross-sectional exploratory study was conducted at the Diabetes Clinic of the Al-Sader Medical City between October 2024 and March 2025. A total of 50 adult patients with type 2 diabetes mellitus (T2DM) were enrolled consecutively during routine outpatient visits at the Diabetes Clinic of Al-Sader Medical City.

Inclusion criteria comprised adults aged ≥18 years with a clinically confirmed diagnosis of T2DM according to the American Diabetes Association (ADA) diagnostic criteria. Eligible participants were receiving ongoing diabetes treatment (oral hypoglycemic agents and/or insulin therapy), were registered for routine follow-up at the diabetes clinic, and were able to provide informed consent at the time of recruitment.

Exclusion criteria included patients with known hematological disorders (e.g. anemia of other etiologies, thalassemia), acute or chronic infections, malignancy, chronic kidney disease, liver disease, autoimmune or other chronic inflammatory diseases, recent surgery or trauma, and the use of medications known to affect hematological parameters (e.g. corticosteroids, anticoagulants), other than standard antidiabetic therapies.

Participants were stratified into two cohorts of 25 subjects each: a well-controlled group (HbA1c < 7.0 %) and a poorly-controlled group (HbA1c 7.0% and higher). The nature of the study was exploratory and therefore the study, we did not perform a formal sample size calculation due to the logistical constraints. Thus, the small sample significantly limits the generalizability of the results. Demographic characteristics and medical histories of the patients, including gender, age, and duration of the disease, were collected.

Blood specimen collection and laboratory analysis

A venous blood sample of three mL was collected from each patient of diabetic patients into vacutainer tubes containing ethylenediaminetetraacetic acid (EDTA) for CBC analysis and HbA1c measurement. CBC was performed using Hematological analyzer DH36 (Shenzhen DYMIND biotechnologies CO. China) to assess of hematological parameter.

Random Blood Sugar (RBS) assessment was conducted using an automated clinical chemistry analyzer DRI-CHEM NX600 (FUJIFILM Corporation. Japan), and HbA1c was measurement performed using D-10 hemoglobin A1c program (Bio-Rad Laboratories. Inc., Hercules, CA, USA).

Statistical analysis

Data were managed and analyzed using the statistical package for Social Sciences (SPSS) version 28. Descriptive statistics for categorical variables were presented as frequencies and percentages. while scale variables were presented as mean and standard deviation (SD). Categorical variables were compared between the two studied groups with Chi-square test. Continuous variables were compared with independent two samples t-test. Bivariate correlation analysis

was performed using Pearson's correlation coefficient, and a p-value ≤ 0.05 was considered statistically significant.

We performed various comparisons on various hematological parameters without correction of the family-wise error rate (e.g. the Bonferonni correction) . This methodological approach increases the risk of type I error (false-positive results). Given the exploratory nature of the study, no correction for multiple comparisons (e.g., Bonferroni adjustment) was applied. However, the findings must be interpreted cautiously, and statistically significant results must be replicated in larger, independent cohorts.

RESULTS

A total of 50 T2DM patients were recruited and divided into good (n=25) and poor (n=25) the glycemic controls group. were enrolled in this study, namely, the good and poor control groups, each group included 25 patients. The age and sex distribution of the studied groups were not statistically significantly different between two group (P > 0.05). The demographic characteristics of the groups are shown in Table 1.

As expected, the mean HbA1c was significantly lower in good glycemic control group compared with poor glycemic control group (6.15 ± 0.45% vs. 11.23 ± 1.60%, respectively; p < 0.001) confirming the validity of the group division in (Table 2).

The comparison of hematological parameters of the studied groups is summarized in Table 3, Patients in the poor glycemic control group had significantly higher mean white blood cell count (7.90 ± 1.72 vs. 6.53 ± 0.89 × 10^9/L, p = 0.001), neutrophil count (4.98 ± 1.57 vs. 3.91 ± 0.82 × 10^9/L, p = 0.004), platelet count (286.88 ± 54.18 vs. 216.48 ± 39.33 × 10^9/L, p < 0.001), and mean platelet volume (MPV; 10.44 ± 2.11 vs. 8.21 ± 0.86 fL, p < 0.001) when compared to the patients in the good glycemic control group. On the other hand, there were no statistically significant intergroup differences in red blood cell indices such as RBC count, hemoglobin concentration (HGB), mean corpuscular volume (MCV),

TABLE 2. *Comparison of Glycated Hemoglobin (HbA1c) between study groups*

Parameter	Group	Mean	SD	P-value
HbA1c (%)	Good control (n = 25)	6.15	0.45	<0.001[b]
	Poor control (n = 25)	11.23	1.60	

[b] P-value from independent samples t-test
SD: Standard Deviation

TABLE 3. *Comparison of hematological parameters between good and poor glycemic control groups*

Parameter (Unit)	Good control (n = 25)		Poor control (n = 25)		P-value[b]
	Mean	SD	Mean	SD	
RBC (×10^{12}/L)	4.58	0.51	4.81	0.47	0.113
HGB (g/dL)	12.77	1.23	13.34	1.78	0.196
MCV (fL)	83.15	7.24	83.90	4.76	0.670
MCH (pg)	28.30	2.73	28.92	2.16	0.377
RDW (%)	13.83	1.18	13.23	1.22	0.081
WBC (×10^9/L)	6.53	0.89	7.90	1.72	**0.001**
Neutrophils (×10^9/L)	3.91	0.82	4.98	1.57	**0.004**
Lymphocytes (×10^9/L)	2.04	0.47	2.08	1.06	0.876
Monocytes (×10^9/L)	0.42	0.20	0.42	0.16	0.957
Eosinophils (×10^9/L)	0.11	0.07	0.16	0.09	0.052
Basophils (×10^9/L)	0.03	0.02	0.03	0.02	0.716
PLT (×10^9/L)	216.48	39.33	286.88	54.18	**<0.001**
MPV (fL)	8.21	0.86	10.44	2.11	**<0.001**

[b] P-value from independent samples t-test
SD: Standard Deviation
RBC (red blood cell); HGB (hemoglobin); MCV, (mean corpuscular volume); MCH (mean corpuscular hemoglobin); RDW (red cell distribution width); WBC(white blood cell); NEUT (neutrophil); LYMPH (lymphocyte); MONO, (monocyte); EOS (eosinophil); BASO (basophil); PLT (platelet); MPV (mean platelet volume). Statistically significant at p < 0.05

TABLE 1. *Age and sex distribution of the studied groups*

Variable	Category	Good control (n = 25)		Poor control (n = 25)		Total (n = 50)		P-value
		No.	%	No.	%	No.	%	
Age (years)	40–49	12	48.0	10	40.0	22	(44.0)	0.625[a]
	50–59	8	32.0	7	28.0	15	(30.0)	
	≥60	5	20.0	8	32.0	13	(26.0)	
Mean (SD)		52.3 (9.2)		54.2 (11.1)		53.1	(10.1)	0.557[b]
Sex	Male	10	40.0	12	48.0	22	(44.0)	0.569[a]
	Female	15	60.0	13	52.0	28	(56.0)	

[a]P-value from THE Chi-square test. [b]P-value from independent samples t-test
SD: Standard Deviation

mean corpuscular hemoglobin (MCH), and red cell distribution width (RDW) or the differential leukocyte profile of lymphocytes, monocytes, eosinophils, and basophils did not show statistically significant differences between the two groups ($p > 0.05$).

Data offered as mean ± standard deviation. Statistical comparisons achieved using independent samples t-test. RBC (red blood cell); HGB (hemoglobin); MCV, (mean corpuscular volume); MCH (mean corpuscular hemoglobin); RDW (red cell distribution width); WBC (white blood cell); NEUT (neutrophil); LYMPH (lymphocyte); MONO, (monocyte); EOS (eosinophil); BASO (basophil); PLT (platelet); MPV (mean platelet volume). Statistically significant at $p < 0.05$.

To determine the relationship between hematological parameters and HbA1c concentrations of the group of 50 patients, Pearson analysis of correlation was conducted. The summary of the analysis in Table 4 shows that the thrombocyte (PLT) count was positively associated with HbA1c with a statistically significant moderate level ($r = 0.516$, $p = 0.001$). On the other hand, there was none of the tested red blood cell (RBC) indices that proved statistically significant with HbA1c ($p > 0.05$).

TABLE 4. *Pearson's correlation analysis between selected hematological parameters and HbA1c levels*

Parameter	Correlation coefficient r	P-value
RBC ($\times 10^{12}$/L)	0.227	0.113
HGB (g/dL)	0.100	0.490
MCV (fL)	0.030	0.836
MCH (pg)	0.117	0.419
RDW (%)	-0.151	0.297
WBC ($\times 10^{9}$/L)	0.485	0.001*
NEUT ($\times 10^{9}$/L)	0.431	0.002*
PLT ($\times 10^{9}$/L)	0.516	<0.001*
MPV (fL)	0.598	<0.001*

* Statistically significant correlation ($p < 0.05$)

DISCUSSION

The study was an exploratory cross-sectional study that investigated the association between complete blood count (CBC) parameters and glycemic control in patients with type 2 diabetes mellitus (T2DM). The main finding was that poor glycemic control as measured by hemoglobin A1c (HbA1c) ≥7.0% was significantly associated with the elevated white blood cell (WBC) count, neutrophil count, platelet count, and mean platelet volume (MPV). Besides, platelet count, WBC count, neutrophil count and MPV had statistically significant positive correlation with HbA1c levels. These findings support an association between poorer glycemic control, and a pro-inflammatory and pro-thrombotic state, that may be reflected in routine hematological measurements.

Leukocytes and Inflammation

The significantly high total white blood cell (WBC) and neutrophil counts of the poorly-controlled cohort group are consistent with the results of several previous studies [9, 10]. This relationship supports the contributory status of subclinical inflammation in the pathophysiology of type 2 diabetes mellitus (T2DM) and the associated complications. Prolonged hyperglycemia can trigger the development of advanced glycation end products (AGEs) and increase oxidative stress, which subsequently activates leukocytes [8]. Neutrophils become activated releasing pro-inflammatory cytokines and reactive oxygen species thus facilitating endothelial dysfunction and insulin resistance which further enhance a vicious cycle leading to progressive deterioration of glycemic control [18]. While this relationship is supported by our results, other recent studies have not identified any significant relationship between the two variables, which suggests that this relationship may be influenced by other factors that were not controlled in our study, including disease duration, specific comorbidities, or medication regimens [11].

Platelets and thrombotic risk

Higher platelet counts and a larger mean platelet volume (MPV) have been associated with poor glycemic control in our study. Platelet count in particular was significantly associated with higher HbA1c levels ($r = 0{\cdot}516$). These findings are comparable to the work of Bhattacharjee et al. [19] and Zaccardi et al. [20], who both reported that patients with poor glycemic control tended to have larger platelets and blood that was more likely to clot. MPV is a marker of platelet size and function; large platelets are both metabolically and enzymatically more active than normal-sized ones and so are more likely to form thrombi [15]. Consequently, high MPV should also be an indication of excess clotting tendency in our group of poorly controlled patients. The process is multifactorial, it entails hyperglycemia-induced reduction in the anti-aggregatory mediators like nitric oxide and prostacyclin; this leads to the increase of platelet turnover and the release of larger and more active platelets by the bone marrow [3,21]. Accordingly, such pro-thrombotic environment forms a key risk factor of macro vascular complications, such as myocardial infarction and stroke, among diabetic patients.

Red blood cell parameters

In contrast, in the case of the leukocytes and platelets, we found no statistically significant changes in the number of red blood cells (RBC) or in the different indi-

ces of hemoglobin (HGB), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and red cell distribution width (RDW) between the two cohorts with optimality in versus suboptimal glycaemic control; nor was any statistically significant difference identifiable in the parameters between the two groups in relation to the glycated hemoglobin Lack of such associations are consistent with some published reports [1,22], but contradict other studies that found an association between RDW or other measures of RBCs and glycaemic control [5,12,16]. An example is hyperglycaemia that has been reported to reduce deformability and lifespan of RBCs by non-enzymatic glycation of membrane proteins [7], which in theory can cause perturbation of the indices of the RBCs. The insignificant correlation in our cohort could be due to the relatively small sample size, which could not be adequately powered, and thus did not reveal more subtle changes. Further the effect of hyperglycemia on erythropoiesis may differ strongly in different individuals or it can be overshadowed by other supportive factors like nutritional status and this was not assessed in our investigation [23].

Limitations of the study

The current study has several limitations which should be considered with due attention. The first limitation is the small sample size (n = 50), which by itself interferes with the statistical power of our analyses and increases the risk of both type 1 errors (false positives due to chance findings), and type 2 error (false negatives due to insufficient power). There was no formal calculation of power and therefore, the results ought to be considered as exploratory. Second, the cross-sectional design does not allow us to establish a causality; we only report relationships but not predictive relationships. The research would need to be conducted in a longitudinal study to determine whether the hematological parameter changes happen before or after the change in the glycemic control. Third, despite the use of exclusion criteria, it is possible that undetermined offending factors, including nutritional status (e.g., iron, vitamin B12, and folate levels), smoking history, and physical activity levels, use of certain oral hypoglycemic agents or insulin regimens, and presence of undetermined subclinical conditions could have affected hematological parameters and glycemic control [24].

Finally, given the exploratory nature of this study, several statistical comparisons were performed without adjusting them formally adjustment multiple test (such as the Bonferonni correction), which increases the probability of type I error. Therefore, the results particularly those of borderline significance must be interpreted with caution, and require replication in independent cohorts [25].

CONCLUSION

In this exploratory study, patients with poor glycemic control exhibited significantly higher values of WBC, neutrophil, and platelet counts, as well as, an increased MPV, compared to the good glycemic control group. Notably, platelets count showed moderate positive correlations with the levels of HbA1c. On the other hand, RBC indices were statistically similar across the cohorts. These findings suggest that platelet activation and severity of glycemic dysregulation in T2DM are associated with inflammatory markers. The results suggest a relationship between inflammatory and thrombocytic parameters and glycemic control status, but the small sample size of the study, the use of cross-sectional design, and the likelihood of unmeasured confounding lead to the conclusion that the results are hypothesis-generating as opposed to conclusive. To confirm such associations, clarify the underlying processes, define the temporal relation, and also if these easily obtainable hematological measures have clinical value in the management of diabetes mellitus or whether they are useful in stratifying risk of diabetic complications, larger, prospective cohort studies are necessary.

Conflict of interest

All authors declare that there are no conflicts of interest in this article.

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