RESEARCH PAPER

Spectrum of Hematological Abnormalities in Diabetic Patients from a Tertiary Care Centre

[1]Dr. Vignesh G.Rm., [2]Dr Rameejan Begum, [3*]Dr. Vindu Srivastava and [4]Dr. Sanjay Kannan

[1]Final year postgraduate, Department of pathology, Chettinad hospital and research institute, Chettinad academy of research and education, Kelambakkam -6030103, Tamil Nadu, India
[2]Associate professor, Department of pathology, Chettinad hospital and research institute, Chettinad academy of research and education, Kelambakkam -6030103, Tamil Nadu, India
[3]Professor and head of the department, Department of pathology, Chettinad hospital and research institute, Chettinad academy of research and education, Kelambakkam -6030103, Tamil Nadu, India*
[4]Final year postgraduate, Department of pathology, Chettinad hospital and research institute, Chettinad academy of research and education, Kelambakkam -6030103, Tamil Nadu, India
[1]viggy2828@gmail.com, [2]rameejanbegum@gmail and [3]vinsripath1@gmail.com
ORCID ID: [1]0009-0009-0978-9910, [2]0000-0002-3720-0204, [3]0000-0003-0402-3261 and [4]0009-0008-9355-2184
***Corresponding author:** Dr. Vindu Srivastava*
vinsripath1@gmail.com

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ABSTRACT

Background: Diabetes mellitus is associated with systemic complications, including hematological abnormalities, that are often underrecognized in routine clinical practice.

Objective: To characterize the spectrum of hematological abnormalities in type 2 diabetic patients attending a tertiary care centre.

Materials and Methods: This cross-sectional observational study enrolled 255 adult T2DM patients over three months using systematic random sampling. Hematological parameters including red blood cell indices, leukocyte counts, and platelet indices were assessed using an automated hematology analyzer and peripheral blood smear examination. Logistic regression was used to identify significant predictors.

Results: Anemia was the most prevalent abnormality (33.3%), followed by platelet abnormalities (23.5%), RBC abnormalities (27.5%), and leukocyte abnormalities (15.7%). Duration of diabetes >5 years (OR = 2.05; 95% CI: 1.15–3.66; p = 0.015) and HbA1c >7% (OR = 1.85; 95% CI: 1.10–3.11; p = 0.02) were independent predictors of hematological abnormalities.

Conclusion: Hematological abnormalities, notably anemia, are highly prevalent in T2DM patients. Routine hematological screening should be integrated into diabetic care to enable early detection and intervention.

Keywords: *Diabetes mellitus; Hematological abnormalities; Anemia; Leukocytosis; Platelet indices; Type 2 diabetes*
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INTRODUCTION

Diabetes mellitus represents a rapidly escalating global health challenge, with an estimated 537 million affected adults in 2021, projected to rise to 783 million by 2045 (1). The burden is disproportionately concentrated in low- and middle-income countries, particularly India, where approximately 89.8 million adults are currently affected (2). Ongoing demographic transitions, urbanization, sedentary behavior, and dietary shifts are expected to further accelerate this trend, underscoring the need for a broader understanding of diabetes-related systemic alterations (3).

While microvascular and macrovascular complications of diabetes are well characterized, its effects on the hematological system remain relatively underexplored (4). Chronic hyperglycemia induces oxidative stress, low-grade inflammation, and cytokine imbalance, which collectively disrupt hematopoiesis and alter blood cell structure and function. These changes may contribute to disease progression and increased risk of adverse outcomes (5).

Anemia is among the most commonly reported hematological abnormalities in diabetic patients (6), arising from multifactorial mechanisms including chronic

**Author for Correspondence: vinsripath1@gmail.com*

inflammation, impaired erythropoietin production due to renal dysfunction, nutritional deficiencies, and reduced red cell survival (7). Reported prevalence varies widely across populations, reflecting heterogeneity in clinical profiles and study settings. In India, available data indicate substantial variability, influenced by socioeconomic and healthcare-related factors, yet comprehensive evaluations remain limited (8).

Leucocyte and platelet abnormalities further contribute to the pathophysiological milieu of diabetes. Leucocytosis, a marker of systemic inflammation, has been associated with poor glycemic control, insulin resistance, and increased cardiovascular risk (9). Concurrently, enhanced platelet activation and altered platelet indices promote a prothrombotic state, facilitating endothelial dysfunction and atherogenesis.(10)

Despite accumulating evidence, hematological alterations are often overlooked in routine diabetic care, which predominantly focuses on glycemic indices and classical complications. However, parameters such as hemoglobin levels, leukocyte counts, and platelet indices may serve as accessible indicators of underlying inflammation, immune dysregulation, and vascular risk. (11-13)

Existing studies are frequently limited by small sample sizes, restricted parameter assessment, or non-representative populations (14). Indian data, particularly from tertiary care settings where disease burden and comorbidities are substantial, remain sparse.

The present cross-sectional study aims to characterize the spectrum of hematological abnormalities in diabetic patients attending a tertiary care centre, with specific emphasis on the prevalence of anemia, leukocyte abnormalities, and platelet alterations, and their association with clinical risk factors.

MATERIALS AND METHODS

Study Design and Setting
This cross-sectional observational study was conducted in the Department of Pathology at Chettinad Hospital and Research Institute, Kelambakkam, Chengalpattu District, Tamil Nadu, India, a tertiary care centre, to evaluate the spectrum of hematological abnormalities in patients with type 2 diabetes mellitus (T2DM).

Study Population
Adult patients with T2DM attending outpatient and inpatient services were included. Diagnosis was established based on American Diabetes Association criteria: fasting plasma glucose ≥126 mg/dL, postprandial plasma glucose ≥200 mg/dL, or HbA1c ≥6.5%.

Ethical Considerations
The study protocol was approved by the Institutional Human Ethics Committee. Written informed consent was obtained from all participants. Data confidentiality was ensured through anonymization and secure storage.

Study Duration
The study was conducted over a period of three months following ethical approval.

Eligibility Criteria
Inclusion criteria comprised adults (≥18 years) with diagnosed T2DM who provided consent. Exclusion criteria included patients with known hematological disorders, acute infections or chronic inflammatory conditions unrelated to diabetes, pregnancy, and those receiving chemotherapy, radiotherapy, or hematinic supplementation.

SampleSize
The sample size was calculated using a reported anemia prevalence of 21% in T2DM, with a 95% confidence level and 5% margin of error ($n = Z^2pq/d^2$), yielding a minimum sample size of 255. Accordingly, 255 participants were enrolled.

SamplingTechnique
Participants were recruited using systematic random sampling, with every third eligible patient selected, ensuring representative inclusion while minimizing selection bias.

DataCollection
Demographic and clinical variables, including age, sex, duration of diabetes and comorbidities, were recorded using a structured proforma. Venous blood samples were collected under aseptic conditions by trained personnel following standardized protocols.

Hematological Analysis
Hematological parameters assessed included red blood cell indices (hemoglobin, RBC count, hematocrit, MCV, MCH, MCHC), total and differential leukocyte counts, and platelet indices (platelet count, mean platelet volume, and platelet distribution width). Peripheral blood smears were prepared and stained using Leishman stain. All measurements were performed using an automated hematology analyzer to ensure accuracy and reproducibility.

Outcome Measures
Primary outcomes included the prevalence of anemia, leucocytosis, and platelet abnormalities, and their association with demographic and clinical variables such as age, sex, duration of diabetes, and treatment status.

Statistical Analysis
Data were entered into Microsoft Excel and analyzed using SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Associations were assessed using the Chi-square test. A p-value <0.05 was considered statistically significant

RESULTS
After applying the predefined criteria and calculating the sample size according to the defined **Sampling Technique**, the study encompassed of 255 patients whose ages ranged from 18 to 60 years and comprising of 140 males and 115 females.

DEMOGRAPHIC AND CLINICAL VARIABLES

Table A: Patients distribution based on age group		
Age group	**Frequency (n)**	**Percentage (%)**
18–30	20	7.8
31–45	65	25.5
46–60	110	43.1
>60	60	23.5
Total	**255**	**100**

Table B: Patient's distribution based on Gender		
Gender	**Frequency (n)**	**Percentage (%)**
Male	140	54.9
Female	115	45.1
Total	**255**	**100**

Table C: Patients distribution based duration of diabetes (years)		
Duration of diabetes (years)	**Frequency (n)**	**Percentage (%)**
<5	80	31.4
5–10	105	41.2
>10	70	27.4
Total	**255**	**100**

Table D: Patients distribution based co-morbidities		
Co-morbidities	**Frequency (n)**	**Percentage (%)**
Hypertension	90	35.3
Dyslipidemia	65	25.5
Obesity (BMI ≥30 kg/m²)	70	27.5
None	80	31.4
Total	**255**	**100**

HEMATOLOGICAL PARAMETERS OF DIABETIC PATIENTS

Parameter	Mean ± SD	n (%)
Hemoglobin (g/dL)	12.8 ± 1.9	85 (33.3)
RBC count (×10⁶/µL)	4.2 ± 0.6	70 (27.5)
WBC count (×10³/µL)	7.8 ± 2.1	40 (15.7)
Platelet count (×10³/µL)	280 ± 65	(23.5)

LOGISTIC REGRESSION FOR PREDICTORS OF HEMATOLOGICAL ABNORMALITIES IN PATIENTS WITH DIABETES MELLITUS

Table 3 - Logistic regression for predictors of hematological abnormalities in patients with diabetes mellitus.				
Variables		**n (%)**	**Odds Ratio (95% CI)**	**P-value**
Gender	**Male**	140 (54.9)	1.00	–
	Female	115 (45.1)	1.32 (0.78–2.22)	0.29
Age Group (years)	**18–30**	20 (7.8)	1.00	–
	31–45	65 (25.5)	1.12 (0.50–2.50)	0.78
	46–60	110 (43.1)	1.45 (0.68–3.09)	0.33
	>60	60 (23.5)	2.10 (0.95–4.64)	0.06
Duration of Diabetes (years)	**≤5**	80 (31.4)	1.00	–
	>5	175 (68.6)	2.05 (1.15–3.66)	0.015*
HbA1c (%)	**≤7**	120 (47.1)	1.00	–
	>7	135 (52.9)	1.85 (1.10–3.11)	0.02*
Hypertension	**No**	165 (64.7)	1.00	–
	Yes	90 (35.3)	1.10 (0.65–1.88)	0.72

Dyslipidemia	**No**	190 (74.5)	1.00	–
	Yes	65 (25.5)	1.05 (0.60–1.82)	0.87

4)Hematological abnormalities among diabetic patients (N=255)

Hematological abnormality	Parameter affected	Frequency (n)	Percentage (%)
Anemia	Hemoglobin (↓)	85	33.3
Leukocytosis	WBC count (↑)	25	9.8
Leukopenia	WBC count (↓)	15	5.9
Thrombocytopenia	Platelet count (↓)	38	14.9
Thrombocytosis	Platelet count (↑)	22	8.6
Normal (no abnormality)	All parameters	70	27.5
Total	—	**255**	**100**

The study included a total of 255 diabetic patients. The mean age of the participants was 52.4 ± 10.2 years, with the majority belonging to the 46–60 years age group (43.1%), followed by those aged 31–45 years (25.5%). Participants aged over 60 years constituted 23.5%, while younger adults aged 18–30 years represented 7.8% of the study population (Table 1A)

With respect to sex distribution, males comprised 54.9% (n = 140) of the participants, whereas females accounted for 45.1% (n = 115), indicating a slight male predominance. (Table 1B)

The mean duration of diabetes among the study population was 8.3 ± 5.6 years. A majority of patients (41.2%) had a disease duration of 5–10 years, followed by 31.4% with a duration of less than 5 years, and 27.4% with diabetes for more than 10 years. (Table 1C)

Regarding co-morbid conditions, hypertension was the most common, observed in 35.3% of participants, followed by obesity (BMI ≥30 kg/m²) in 27.5% and dyslipidemia in 25.5%. Notably, 31.4% of the study population did not have any documented co-morbidities (Table 1D)

The hematological profile of the study population is summarized in (Table 2). The mean hemoglobin level among diabetic patients was 12.8 ± 1.9 g/dL, with anemia observed in 85 participants (33.3%). The mean red blood cell (RBC) count was 4.2 ± 0.6 $\times 10^6/\mu L$, and RBC abnormalities were identified in 70 patients (27.5%).

The mean total white blood cell (WBC) count was 7.8 ± 2.1 $\times 10^3/\mu L$, with leukocyte abnormalities,

predominantly leukocytosis, noted in 40 participants (15.7%). The mean platelet count was 280 ± 65 $\times 10^3/\mu L$,

and platelet abnormalities were present in 60 patients (23.5%). (Table 2)

Table 3 presents the results of the logistic regression analysis identifying predictors of hematological abnormalities among patients with diabetes mellitus.

Gender did not show a statistically significant association with hematological abnormalities. Although females had higher odds compared to males (OR = 1.32; 95% CI: 0.78–2.22), this association was not significant (p = 0.29).

With respect to age, a gradual increase in odds was observed with advancing age. Patients aged >60 years demonstrated higher odds of hematological abnormalities (OR = 2.10; 95% CI: 0.95–4.64); however, this did not reach statistical significance (p = 0.06).

Duration of diabetes emerged as a significant predictor. Patients with diabetes duration of more than 5 years had approximately two-fold higher odds of developing hematological abnormalities compared to those with a shorter duration (OR = 2.05; 95% CI: 1.15–3.66; p = 0.015).

Poor glycemic control was also significantly associated with hematological abnormalities. Participants with HbA1c >7% had 1.85 times higher odds of hematological derangements compared to those with HbA1c ≤7% (OR = 1.85; 95% CI: 1.10–3.11; p = 0.02).

The presence of hypertension (OR = 1.10; 95% CI: 0.65–1.88; p = 0.72) and dyslipidemia (OR = 1.05; 95% CI: 0.60–1.82; p = 0.87) did not show significant associations with hematological abnormalities in this model.

Overall, longer duration of diabetes and poor glycemic control were identified as independent predictors of hematological abnormalities among diabetic patients.

Table 4 illustrate the distribution of hematological abnormalities among the study population (N = 255). Anemia was the most commonly observed abnormality, affecting 85 patients (33.3%) with decreased hemoglobin levels. Thrombocytopenia was observed in 38 patients (14.9%), followed by leukocytosis in 25 patients (9.8%) and thrombocytosis in 22 patients (8.6%). Leukopenia was the least common abnormality, identified in 15 patients (5.9%). Additionally, 70 patients (27.5%) showed no hematological abnormalities, with all blood parameters remaining within normal limits. The findings indicate that anemia constituted the predominant hematological alteration in the study group.

DISCUSSION

Diabetes mellitus is a chronic metabolic disorder with well-recognized microvascular and macrovascular complications. However, its impact on hematological parameters remains under-recognized, despite accumulating evidence linking diabetes with anemia, leukocyte alterations, and platelet dysfunction (7). The

present cross-sectional study evaluated the spectrum of hematological abnormalities among diabetic patients attending a tertiary care center and assessed associated risk factors, thereby contributing to the existing literature from the Indian subcontinent.

In this study, the mean age of participants was 52.4 ± 10.2 years, with the majority belonging to the 46–60-year age group. This finding is comparable to studies by Banerjee et al. and other Indian hospital-based reports, where middle-aged adults constituted the predominant diabetic population. This distribution reflects the progressive nature of type 2 diabetes mellitus (T2DM), which typically manifests after prolonged exposure to lifestyle and metabolic risk factors (15). A slight male predominance was observed, consistent with findings by Mohan et al., which may be attributed to differences in healthcare-seeking behavior, occupational exposure, or lifestyle-related stressors (16).

The mean duration of diabetes was 8.3 ± 5.6 years, with most patients having a disease duration exceeding five years. Prolonged disease duration has been consistently associated with cumulative metabolic stress, chronic inflammation, and progressive organ damage, including renal impairment and bone marrow dysfunction, all of which can adversely affect hematopoiesis. The high prevalence of comorbidities such as hypertension, obesity, and dyslipidemia observed in this study aligns with the well-established clustering of cardiometabolic risk factors in diabetes. Similar findings have been reported by Alshahrani et al. and Zhang et al., further emphasizing the multifactorial burden of the disease (17,18).

Anemia was the most common hematological abnormality observed, affecting 33.3% of participants. This prevalence is consistent with previous Indian studies reporting rates ranging from 20% to over 50% among diabetic populations. Banerjee et al. reported a prevalence of approximately 21%, while higher rates have been noted in patients with longer disease duration or coexisting renal dysfunction (15). The pathophysiology of anemia in diabetes is multifactorial, involving reduced erythropoietin production due to diabetic nephropathy, chronic inflammation leading to anemia of chronic disease, nutritional deficiencies, and oxidative stress resulting in decreased red cell survival. Additionally, RBC abnormalities observed in 27.5% of patients further support the adverse impact of diabetes on erythropoiesis and red cell morphology.

Leukocyte abnormalities, predominantly leukocytosis, were identified in 15.7% of patients. Elevated white blood cell counts in diabetes have been associated with low-grade systemic inflammation, insulin resistance, and an increased risk of cardiovascular complications. Studies by Cacace et al. and Coșarcă et al. have demonstrated that leukocytosis correlates with poor glycemic control and elevated inflammatory cytokine levels in diabetic individuals. Although less prevalent than anemia, the presence of leukocytosis highlights the underlying inflammatory milieu in diabetes (19,20).

Platelet abnormalities were observed in 23.5% of participants. Diabetes is known to promote platelet hyperreactivity, increased mean platelet volume, and enhanced aggregation, thereby contributing to a prothrombotic state. Comparable findings have been reported by Onuigwe et al., who identified altered platelet indices as potential markers of vascular risk in diabetic patients. Notably, even when platelet counts remain within normal limits, functional abnormalities may predispose individuals to thrombotic complications (21).

Logistic regression analysis revealed that longer duration of diabetes (>5 years) and poor glycemic control (HbA1c >7%) were independent predictors of hematological abnormalities. Patients with a longer duration of disease had nearly twice the risk of developing hematological derangements, underscoring the cumulative effects of chronic hyperglycemia. Similarly, poor glycemic control was significantly associated with these abnormalities, supporting the role of sustained hyperglycemia in inducing oxidative stress, inflammation, and bone marrow dysfunction.

Although advancing age showed a trend toward increased risk, it did not reach statistical significance. Furthermore, gender, hypertension, and dyslipidemia were not significantly associated with hematological abnormalities in this study. These findings suggest that glycemic factors may exert a more substantial influence on hematological parameters than demographic characteristics or certain comorbid conditions, a conclusion that is consistent with previous studies.

LIMITATIONS

The present study has several limitations. First, its cross-sectional design precludes the establishment of causal relationships between diabetes mellitus and the observed hematological abnormalities. Second, important laboratory parameters—including renal function tests, iron studies, and serum levels of vitamin B12 and folate—were not evaluated, limiting the ability to determine the specific etiologies of anemia. Additionally, as the study was conducted at a single tertiary care center, the findings may not be fully generalizable to the broader population, particularly community-based settings.

RECOMMENDATIONS

Routine hematological screening should be integrated into the standard clinical management of patients with diabetes, especially those with long-standing disease and suboptimal glycemic control. Early detection and appropriate management of hematological abnormalities may help reduce morbidity and improve overall patient outcomes. Furthermore, future research should focus on longitudinal, multicentric studies incorporating detailed biochemical, nutritional, and inflammatory markers to better elucidate underlying mechanisms and establish causal associations.

CONCLUSION

Hematological abnormalities most notably anemia highly prevalent among patients with diabetes mellitus. Prolonged disease duration and poor glycemic control emerge as key determinants, underscoring the cumulative impact of chronic hyperglycemia on hematopoietic homeostasis. These findings highlight a critical but under-recognized dimension of diabetes care. Integrating hematological monitoring into routine clinical practice may enable earlier intervention and more holistic risk stratification, ultimately contributing to improved patient outcomes.

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