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RESEARCH ARTICLE
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TO STUDY RBC INDICES IN PATIENTS OF DIABETES MELLITUS AND IT'S PROGNOSTIC SIGNIFICANCE IN TERTIARY CARE CENTRE

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ABSTRACT

Background: Diabetes mellitus (DM) is a global health crisis with growing prevalence, notably in low- and middle-income countries like India. It leads to numerous microvascular and macrovascular complications and alters hematological parameters. Among these, red blood cell (RBC) indices such as MCV, MCH, MCHC, and RDW are gaining attention for their diagnostic and prognostic significance in chronic diseases including DM.

Objective: This study aimed to investigate the correlation between RBC indices and glycemic control and assess their prognostic relevance in diabetic patients at a tertiary care center.

Methods: A prospective observational study was conducted at Gajra Raja Medical College and associated hospitals in Gwalior from April 2023 to April 2025. Seventy-five diabetic patients, aged 15–80 years, were selected via purposive sampling. Hematological and biochemical investigations were performed, including Hb, MCV, MCH, MCHC, RDW, HbA1c, serum creatinine, and liver enzymes. ECG assessments were also conducted. Patients with confounding conditions affecting RBC indices were excluded. Statistical analysis included Pearson's correlation and chi-square tests using SPSS 22.0.

Results: The study found a significant association between poor glycemic control (HbA1c $\geq$ 7.5%) and alterations in RBC indices. Elevated RDW and MCHC were common in patients with diabetic complications like nephropathy and retinopathy, indicating their potential as prognostic markers. Anemia was frequently observed, especially normocytic normochromic anemia, linked to reduced the erythropoietin production and chronic inflammation.

Conclusion: RBC indices, especially RDW and MCHC, serve as accessible, cost-effective prognostic markers in diabetes mellitus. Regular evaluation of these indices can aid in early identification of complications and guide tailored treatment, thereby improving the clinical outcomes and quality of life in diabetic patients.

Keywords: Diabetes mellitus, RBC indices, RDW, MCHC, Prognostic marker

INTRODUCTION

Diabetes mellitus (DM) is a growing global health concern, particularly in low- and middle-income countries. This chronic condition, characterized by high blood sugar levels, arises either from insufficient insulin production or the body's inability to use insulin effectively. If left unmanaged, diabetes can lead to severe health complications, significantly affecting both individuals and

healthcare systems. The prevalence of diabetes has risen sharply in recent years, with approximately 828 million cases worldwide in 2022, nearly double the previous figures. This increase reflects various factors, including aging populations, urbanization, and lifestyle changes such as poor diet and lack of physical activity. Regions like the Pacific Islands, the Caribbean, the Middle East, North Africa, Pakistan, and Malaysia report the highest prevalence rates due to a mix of genetic factors, dietary habits, and limited healthcare access [1-3].

India, often called the "diabetes capital of the world," faces a critical diabetes crisis, with around 212 million people affected. Urban areas in India show significantly higher rates of diabetes, attributed to lifestyle differences and increased access to processed, calorie-dense foods. Alarmingly, over 50% of people with diabetes in India remain undiagnosed, leaving them vulnerable to complications from untreated high blood sugar. These trends highlight the urgent need for public health initiatives aimed at promoting awareness, early diagnosis, and prevention. Diabetes manifests in various forms, including type 1, type 2, and gestational diabetes. Type 1 diabetes, an autoimmune condition that destroys insulin-producing cells in the pancreas, typically requires lifelong insulin therapy. In contrast, type 2 diabetes, which accounts for the majority of cases, develops when the body becomes resistant to insulin or fails to produce enough insulin. The rising incidence of type 2 diabetes in younger individuals is closely linked to increasing obesity rates and sedentary lifestyles. Gestational diabetes, which occurs during pregnancy, usually resolves post-childbirth but increases the risk of type 2 diabetes later in life for both mother and child [4-6].

Diabetes symptoms vary but commonly include excessive thirst, frequent urination, hunger, unexplained weight loss, fatigue, and blurred vision. Slow-healing infections, particularly in the skin, gums, or urinary tract, are also common. Type 2 diabetes, however, often goes undiagnosed for years due to its mild or absent symptoms, which can delay treatment and increase the risk of complications. Uncontrolled diabetes can lead to severe health issues affecting multiple organs. Cardiovascular problems such as heart disease and stroke are frequent and life-threatening, while nerve damage (neuropathy) can cause pain, tingling, or numbness, often in the extremities. The kidneys are also at risk, as high blood sugar can impair their filtering capacity, potentially leading to kidney failure. Vision loss or blindness is another concern, as diabetes can damage the retina. Diabetic foot complications, resulting from poor circulation and nerve damage, can lead to ulcers and infections, sometimes requiring amputations [7-9].

Managing diabetes effectively involves a combination of lifestyle modifications and medical interventions. A balanced diet with high-fiber foods, whole grains, lean proteins, and healthy fats is crucial in controlling blood sugar levels. Regular physical activity improves insulin sensitivity and overall health. Monitoring blood glucose levels is essential for tracking progress and adjusting routines or medications. For many individuals, medications such as insulin therapy and oral drugs are necessary to maintain control over blood sugar levels. Advances in medications, including GLP-1 receptor agonists and SGLT2 inhibitors, offer additional benefits such as weight loss and cardiovascular protection. Preventing type 2 diabetes focuses on adopting healthy habits such as maintaining a healthy weight, regular exercise, and avoiding processed foods. Routine screenings for at-risk individuals, such as those with a family history of diabetes, are critical for early detection and intervention. Public health programs aimed at education and community engagement have proven effective in preventing and managing diabetes at a larger scale [10,11].

Diabetes mellitus requires a proactive approach to prevent complications and maintain a good quality of life. By making lifestyle changes, seeking timely medical care, and engaging with community support, individuals with diabetes can lead healthy lives. Addressing diabetes as a global health priority requires collective efforts from governments, healthcare providers, and communities. Through targeted prevention and management strategies, the health and economic burdens of diabetes can be reduced, leading to better outcomes for millions worldwide [12].

The importance of hematological parameters in chronic diseases like diabetes cannot be overstated. Hematological markers such as hemoglobin levels, white blood cell counts, platelet counts, and markers of inflammation provide valuable insights into the progression of chronic conditions. For instance, in diabetes, markers like the neutrophil-to-lymphocyte ratio (NLR) are associated with systemic inflammation and complications, making them important for managing the disease. In addition, RBC indices, including hemoglobin, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and red blood cell distribution width (RDW), have emerged as significant biomarkers for evaluating disease progression and prognosis in diabetes. These indices help assess the impact of the condition on various body systems and can guide clinical decision-making, improving the management of diabetes and its complications. Regular blood tests and hematological evaluations are crucial in detecting complications early and monitoring disease progression, ultimately enhancing patient outcomes and quality of life [13,14]. The aim of this study is to investigate the correlation between RBC indices in patients of diabetes mellitus and it's prognostic significance

MATERIAL AND METHODS

This prospective observational study was conducted at the Department of Medicine, Gajra Raja Medical College, associated with J.A. Group of Hospitals, Gwalior (Madhya Pradesh) from April 2023 to April 2025 for 2 years. Ethical approval has been obtained from the Ethical Approval Committee of Gajra Raja Medical College, associated with J.A. Group of Hospitals, Gwalior (Madhya Pradesh).

Study Population

The study population consisted of patients attending the Medicine OPD and IPD of J.A. Group of Hospitals, Gwalior, with a confirmed diagnosis of diabetes mellitus based on the American Diabetes Association (ADA) criteria. Inclusion criteria were known or newly diagnosed diabetes mellitus cases, aged 15–80 years, who provided informed consent, and had not received a blood transfusion within the last three months. Exclusion criteria included those younger than 15 or older than 80, those who declined consent, and those with chronic conditions affecting RBC indices, such as chronic renal failure or hematological malignancies.

Data Analysis

Data entry was performed in Microsoft Excel 2019, and statistical analysis was conducted using SPSS version 22.0 (IBM Corp.) and Excel for graphical representation. Descriptive statistics, including mean, standard deviation, minimum, maximum, and median, were used. Inferential statistics included the chi-square test for associations between categorical variables and Pearson's correlation coefficient to assess associations between HbA1c and hematological/biochemical parameters, with a p-value < 0.05 considered significant. Bar charts, box plots, and heatmaps were used for data presentation. Quality control measures included daily calibration of equipment, routine IQC samples, double-checking of ECGs, and repeated measurements for technical errors.

RESULTS

This study aimed to examine the correlation between red blood cell (RBC) indices and their prognostic significance in patients with diabetes mellitus. The study involved 75 diabetic patients aged between 18 and 79 years, with a mean age of 46.05 ± 13.97 years and a median of 43 years, showing a slightly right-skewed distribution. The highest prevalence was observed in the 40–49 age group (29.33%), followed by 30–39 (26.67%) and 50–59 (18.67%). A chi-square analysis revealed a statistically significant variation in age distribution ($\chi^2 = 19.38$, $P = 0.0036$), suggesting a higher burden of diabetes among middle-aged individuals, which may have implications for RBC index variations in this demographic. Gender distribution showed 60% male and 40% female participants, with no statistically significant difference ($\chi^2 = 1.14$, $P = 0.2861$), indicating a balanced representation across sexes.

Table 1: Descriptive statistics of biochemical parameters in diabetic patients

Statistic	Serum Creatinine	SGOT	SGPT	Alkaline Phosphatase
Count	75.0	75.0	75.0	75.0
Mean	0.84	24.45	31.42	108.88
Standard Deviation	0.15	10.24	12.36	23.33
Minimum	0.6	8.4	8.6	58.0
Maximum	1.1	39.8	50.0	153.9
Median	0.84	25.2	32.8	110.7

Biochemical analysis in diabetic patients showed normal mean serum creatinine (0.84 mg/dL) and liver enzymes (SGOT, SGPT, and alkaline phosphatase) within reference ranges. This indicates preserved renal and liver function in most participants, offering a stable baseline for assessing RBC index correlations.

Table 2: Hematological parameters among diabetic patients

Statistic	HbA1c	MCHC	RDW	HEMOGLOBIN	PCV	MCV	MCH	PLATELET COUNT	RBC COUNT
Count	75	75	75	75	75	75	75	75	75
Mean	10.90	32.68	15.81	13.39	34.57	81.72	28.87	250578.04	4.54
Standard Deviation	2.56	7.71	1.82	1.12	6.80	11.91	1.20	55997.35	0.52
Minimum	6.55	19.62	11.64	9.96	24.30	56.06	25.33	146193.10	3.50
Maximum	14.88	44.79	20.24	16.25	47.60	112.14	31.31	411830.57	5.88
Median	11.68	34.15	15.93	13.38	33.60	81.14	28.80	240016.93	4.52

Diabetic patients showed a high mean HbA1c of 10.90%, indicating poor glycemic control, while other hematological parameters like MCHC, RDW, hemoglobin, and RBC indices remained within typical ranges. These findings offer a foundation for assessing how red cell characteristics may correlate with diabetes severity and related complications.

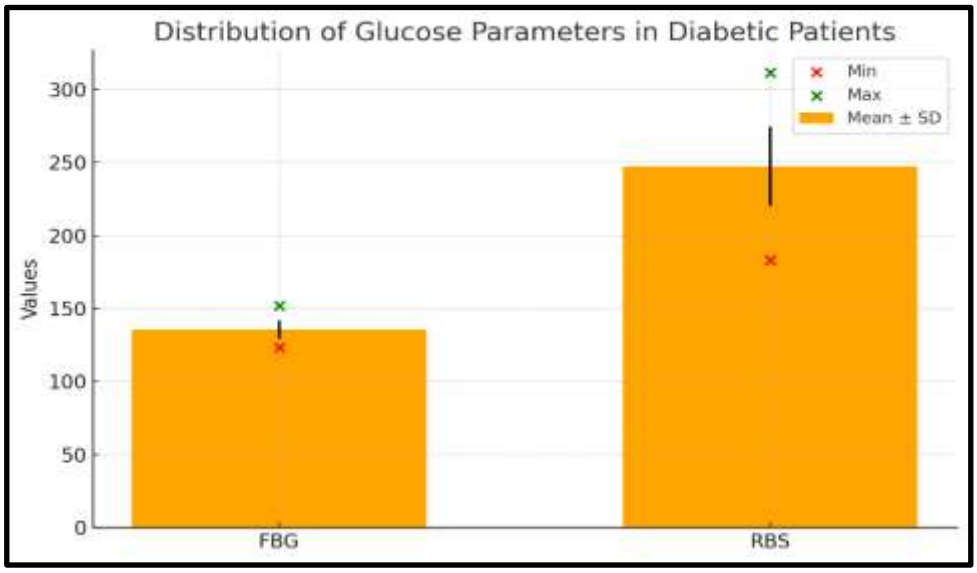

Figure 1: Bar chart showing glucose-related parameters (FBG and RBS) among the participants

The mean FBG and RBS levels were elevated at 135.61 mg/dL and 247.47 mg/dL respectively, confirming poor glycemic control among participants. This persistent hyperglycemia supports the rationale for exploring its impact on RBC indices and related hematological changes.

Table 3: Correlation of HbA1c with Hematological Parameters

Parameter	Correlation Coefficient (r)	P-value
MCHC	0.281	0.0146*
RDW	0.350	0.0021*
HEMOGLOBIN	0.127	0.2789
PCV	0.024	0.8413
MCV	0.013	0.9147
MCH	-0.103	0.3813
PLATELET COUNT	0.173	0.1386
RBC COUNT	0.212	0.0676
FBG	0.343	0.0026
RBS	0.312	0.0065

HbA1c showed significant positive correlations with RDW and MCHC, indicating that poor glycemic control is linked to increased red cell size variability and altered hemoglobin concentration. Other hematological parameters showed no significant associations, highlighting RDW and MCHC as more sensitive indicators of glycemic impact in diabetic patients.

Table 4: Correlation of HbA1c with Biochemical Parameters

Parameter	Correlation Coefficient (r)	P-value
Serum Creatinine	0.233	0.0445
SGOT	0.048	0.6819
SGPT	0.076	0.5155
ALKALINE PHOSPHATASE	0.136	0.2457

HbA1c showed a significant positive correlation with serum creatinine, indicating a potential early association between poor glycemic control and renal dysfunction in diabetic patients. Liver enzyme levels (SGOT, SGPT, and alkaline phosphatase) showed no significant correlation, suggesting minimal hepatic involvement.

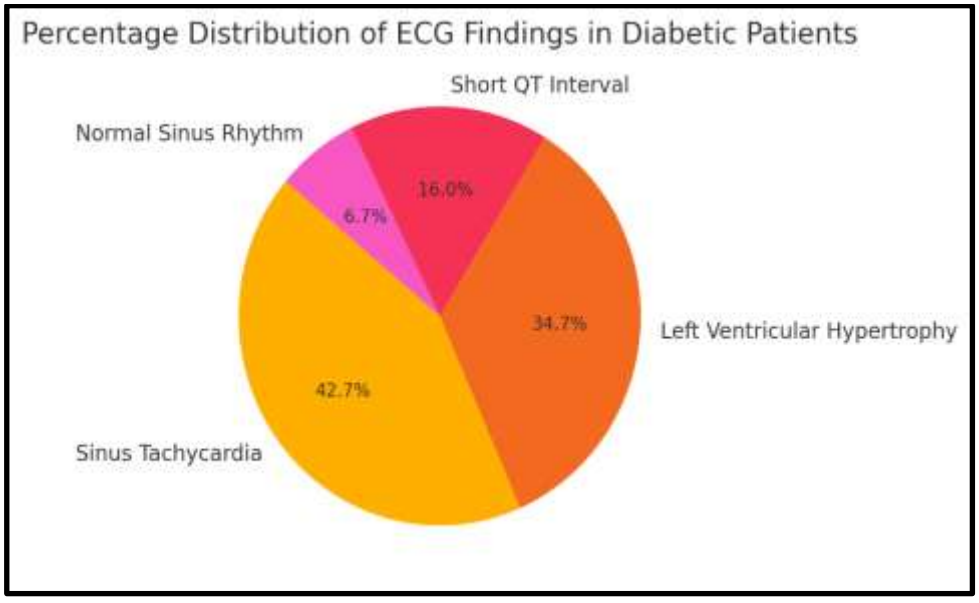

Figure 2: Pie chart illustrating the percentage distribution of ECG findings

In the ECG analysis of 75 diabetic patients, sinus tachycardia (42.67%) and left ventricular hypertrophy (34.67%) were the most frequent abnormalities, while only 6.67% had normal findings.

The significant chi-square value ($\chi^2 = 24.68$, $P < 0.0001$) indicates a strong association between diabetes and cardiovascular changes, highlighting the importance of routine ECG monitoring.

DISCUSSION

Diabetes mellitus (DM) is commonly associated with obesity and sedentary lifestyle choices, which contribute to its development. A balanced diet, regular exercise, and maintaining an appropriate weight according to BMI are crucial for managing diabetes. This study explores the potential of Complete Blood Count (CBC) as an innovative marker for assessing inflammatory responses, vascular complications, and chronic diseases in diabetic patients. CBC is a cost-effective and easily accessible test that can help identify chronic inflammation [15].

The study aimed to investigate the relationship between red blood cell (RBC) indices in diabetic patients and their prognostic significance. A total of 75 diabetic patients were included in this research, with ages ranging from 18 to 79 years, and a mean age of 46.05 ± 13.97 years. The most common age group was between 40 and 49 years, comprising 29.33% of the participants. These findings are consistent with other studies which reported a higher prevalence of Type 2 Diabetes Mellitus (T2DM) in individuals between the ages of 51 and 60, and even older age ranges like 60-69 years [16].

Regarding gender distribution, the study found that 60% of the participants were male, and 40% were female. This gender imbalance suggests that any potential gender-based differences in RBC indices would need further investigation. Other studies have also observed a similar gender distribution in diabetic populations.

The biochemical analysis revealed that most participants had normal renal function, with a mean serum creatinine level of 0.84 ± 0.15 mg/dL. Liver enzyme levels (SGOT, SGPT) were also within typical reference ranges, suggesting that liver and kidney dysfunction were not prominent in the study group. This provided a relatively healthy baseline for analyzing correlations with RBC indices [17].

Hematological parameters showed that the mean HbA1c level in the participants was 10.90 ± 2.56%, indicating poor glycemic control. Among the red cell indices, Mean Corpuscular Haemoglobin Concentration (MCHC) had a mean of 32.68 ± 7.71 g/dL, and Red Cell Distribution Width (RDW) averaged 15.81 ± 1.82%. Hemoglobin levels were 13.39 ± 1.12 g/dL, and the Packed Cell Volume (PCV) was 34.57 ± 6.80%. These values provide insight into how RBC morphology and variability may reflect or correlate with diabetic control and complications. Similar studies have also reported decreased values of hemoglobin, RBC, and other RBC indices in diabetic patients [18].

Regarding glucose parameters, the mean Fasting Blood Glucose (FBG) was 135.61 ± 6.47 mg/dL, while the mean Random Blood Sugar (RBS) was 247.47 ± 27.12 mg/dL, with a maximum value reaching 311.52 mg/dL. This is in line with other studies, which showed variations in RBS levels and identified a small percentage of subjects with diabetes based on their RBS levels.

The correlation analysis revealed that HbA1c had a significant positive correlation with RDW ($r = 0.350$, $P = 0.0021$) and MCHC ($r = 0.281$, $P = 0.0146$), suggesting that poor glycemic control is linked to greater variability in red blood cells and alterations in hemoglobin concentration. Although RBC count and platelet count showed a trend toward positive correlation with HbA1c, these associations were not statistically significant. Other parameters like hemoglobin and MCV showed no significant associations, highlighting that certain RBC indices, such as RDW and MCHC, are more sensitive markers in the context of glycemic control [19].

Additionally, HbA1c showed a significant positive correlation with serum creatinine ($r = 0.233$, $P = 0.0445$), indicating a possible link between poor glycemic control and early renal dysfunction in diabetics. However, no significant correlation was found with liver enzymes, suggesting that liver function remains relatively unaffected by glycemic dysregulation [20].

ECG findings showed that the most common abnormality in diabetic patients was Sinus Tachycardia, observed in 42.67% of participants, followed by Left Ventricular Hypertrophy (LVH)

in 34.67%. These findings underscore the importance of regular cardiovascular evaluation in diabetic patients to detect potential complications early [21].

This study suggests that older individuals are at a higher risk for diabetes-related complications and that glycemic control, measured by HbA1c, is a reliable predictor of such complications. RBC indices like RDW, serum creatinine, and platelet count correlate with HbA1c, making them potential markers for assessing glycemic control and predicting complications. Simple blood tests, including these parameters, could be cost-effective tools for early detection of complications in diabetic patients [22].

CONCLUSION

This study adds to the growing evidence supporting the role of RBC indices in monitoring and predicting diabetes mellitus prognosis. Specifically, RDW and MCHC appear to be strong indicators of poor glycemic control, as reflected by HbA1c levels. When used alongside serum creatinine and ECG analysis, these indices may provide a cost-effective, comprehensive tool for risk stratification in diabetic complications, especially in resource-limited settings. Utilizing readily available hematological parameters can help bridge diagnostic gaps, enhance early intervention, and ultimately improve outcomes and quality of life for diabetic patients.

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