PROCEEDING

5th International Conference of Health Polytechnic of Jambi 2025
icon@poltekkesjambi.ac.id
http://journal.poltekkesjambi.ac.id/index.php/ICoHPJ
doi.org/10.35910/icohpj.v5i0

CORRELATION OF HbA1C LEVELS AND ERYTHROCYTE INDICES IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

Laili Amelia[1], Witi Karwiti[1,2 *)], Muslina[1,2], Agraini[1,2]

[1]Department of Medical Laboratory Technology, Politeknik Kesehatan Kementerian Kesehatan Jambi, Indonesia
[2]PUI-PK, Politeknik Kesehatan Kementerian Kesehatan Jambi, Indonesia
Corresponding author : wieka261077@gmail.com

ABSTRACT

Background: *Hyperglycemia is a leading indicator of type 2 diabetes mellitus (T2DM). Long-lasting hyperglycemia has an effect on all body tissues. This effect is related to protein glycation namely HbA1C, and changes in structure and function of erythrocyte. The erythrocyte indices consist of MCV, MCH, and MCHC. This study aims to determine the correlation of HbA1C levels with erythrocyte indices in patients with T2DM.*
Methods: *This cross-sectional study was conducted on patients with T2DM visiting at the Multiwahana and Kampus Health Center Palembang from November to December 2024. After taking laboratory test of HbA1C, MCV, MCH, and MCHC, data were collected and computed by using Spearman correlation test.*
Results: *A total of 50 diabetic patients were eligible for this study with a mean HbA1C was 7.36±1.76%, MCV 83.69±6.70fL, MCH 27.96±2.70pg, MCHC 33.32±1.18%. Spearman's correlation analysis showed that HbA1C significantly correlated with MCHC, inversely correlated with MCV, but there was no significant correlation of HbA1C and MCH.*
Conclusion: *The study highlighted that MCHC significantly correlated with HbA1C, it's affordable and readily accessible test, it may be used as an indicator of glycemic status. It's important for diabetic patients to prevent long-lasting hyperglycemia by monitoring glycemic index and taking medication regularly.*

Keywords: *Diabetes mellitus, HbA1C, erythrocyte indices, hyperglycemia.*

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to insulin resistance and/or deficiency (PERKENI, 2021). Type 2 diabetes mellitus (T2DM) is a growing global concern. In Indonesia, the number of people with diabetes is increasing significantly. According to the International Diabetes Federation (IDF), Indonesia ranked fifth in the world for diabetes cases, with 19.5 million people affected in 2021 and a projected rise to 28.6 million by 2045.

Chronic hyperglycemia in DM can lead to serious complications and is often monitored using glycated hemoglobin (HbA1C), which reflects blood glucose control over the past 2–3 months. In addition to indicating glycemic control, high HbA1C levels may influence red blood cell characteristics, such as shape, flexibility, and lifespan, which are reflected in erythrocyte indices: mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC)(Chinmay, et.al. 2015).

Several studies have explored the relationship between HbA1C and these indices, with mixed results. Some found significant correlations, while others did not. These conflicting findings suggest the need for further investigation. Therefore, this study aims to examine the correlation between HbA1C levels and erythrocyte indices (MCV, MCH, and MCHC) in patients with type 2 diabetes mellitus.

METHODS

This study was an analytical observational method with a cross-sectional design. The study population included all patients with T2DM enrolled in the Chronic Disease Management Program (Prolanis) at Multiwahana and Kampus Primary Healthcare Centers in Palembang. A purposive sampling technique was used to select T2DM patients scheduled for HbA1C testing between November and December 2024. HbA1C was measured using the Standard F HbA1C analyzer, while erythrocyte indices (MCV, MCH, and MCHC) were obtained through direct examination using a Sysmex XP-100 hematology analyzer. All data were recorded and statistically analyzed. The total sample comprised all eligible patients who met the criteria and underwent testing during the specified period. Data were analyzed using Spearman correlation tests with significance level set at $p < 0.05$.

RESULTS AND DISCUSSION

This study was conducted in November to December 2024. A total of 50 patients diagnosed with T2DM were eligible for this study

Respondent Characteristics

The respondent characteristics in this study were analyzed based on age group and gender. Based on the data in Table 1, among the 50 respondents diagnosed with T2DM, the majority were female, accounting for 78% (n=39), while male respondents comprised only 22% (n=11). This indicates a predominance of female patients in the studied T2DM population. This aligns with a study by Komariah, et al (2020) at the Proklamasi Primary Clinic Depok of West Java Province, which also reported a higher number of female T2DM patients (60,4%).

The distribution of characteristics can be seen in the table below.

Table 1. Frequency Distribution of Respondent Characteristics

Characteristics	Frequency (f)	Percentage (%)
Age (years)		
26-32	1	2
33-39	0	0
40-46	2	4
47-53	9	18
54-60	14	28
61-67	16	32
68-74	8	16
Total	**50**	**100**
Gender		
Male	11	22
Female	39	78
Total	**50**	**100**

Women are at greater risk of developing diabetes due to physiological factors such as a higher body mass index (BMI), hormonal fluctuations associated with the menstrual cycle (premenstrual syndrome), and postmenopausal changes that lead to increased fat accumulation. These hormonal processes contribute to a higher susceptibility to type 2 diabetes mellitus.

In terms of age distribution, the highest proportion of respondents was in the 61–67-year age group, representing 32% (n=16) of the total sample. This was followed by the 54–60-year age group with 28% (n=14). The overall age range of respondents varied from a minimum of 26 years to a maximum of 74 years, suggesting that T2DM affects individuals across a broad age spectrum, with a tendency toward older age groups.

These align with a 2020 study by Latifah, which also reported a mean of T2DM was 61,79-year age, the majority was in the 65-79-year age group. This may be due to the fact that in elderly individuals (over 60 years of age), the risk of developing diabetes and glucose intolerance increases due to degenerative factors, particularly the decline in the body's ability to metabolize glucose, including reduced function of pancreatic β-cells in producing insulin. Yosmar et al., (2018) identifies that advanced age influences the progression of diabetes, as physiological functions decline, leading to decreased insulin secretion or increased insulin resistance. As a result, the body's ability to regulate elevated blood glucose levels becomes less effective.

Average HbA1C Levels and Erythrocyte Indices in Patients with T2DM

Table 2. Average HbA1C Levels and Erythrocyte Indices in Patients with T2DM

Variable	N	Mean	Min	Max	Std. Deviation
HbA1C Levels (%)	50	7.36	5.4	12.9	1.76
MCV (fL)	50	83.69	61.2	93.8	6.70
MCH (pg)	50	27.96	18.9	31.5	2.70
MCHC (%)	50	33.32	30.5	35.7	1.18

Table 3.2 presents the descriptive statistics of HbA1C levels and erythrocyte indices (MCV, MCH, and MCHC) in 50 patients diagnosed with T2DM. The findings of this study indicate that patients with T2DM exhibit elevated levels of HbA1C, with a mean value of 7.36% ± 1.76, exceeding the normal threshold of <5.7%. The HbA1C levels ranged from 5.4% to 12.9%, reflecting poor glycemic control among the majority of respondents. This elevation is consistent with the pathophysiology of type 2 diabetes, in which chronic hyperglycemia leads to increased glycation of hemoglobin. Over time, episodic spikes in blood glucose cause a non-enzymatic glycation of a portion of hemoglobin A, forming glycated hemoglobin (HbA1C) (Chinmay et al., 2015).

Interestingly, despite the elevated HbA1C values, the erythrocyte indices of the patients remained within normal ranges.The mean MCV was 83.69 ± 6.70 fL (normal range: 81–96 fL), mean MCH was 27.96 ± 2.70 pg (normal range: 27–31 pg), and mean MCHC was 33.32 ± 1.18% (normal range: 30–36%). These findings suggest that in this patient population, red blood cell morphology and hemoglobin concentration per cell were not significantly altered despite the presence of hyperglycemia.

This outcome differs from the findings of Bhutto et al. (2019), who reported a decreased MCV (76.65 ± 11.12 fL) and MCHC (28.21 ± 4.75%), although MCH values remained within the normal range (30.22 ± 23.87 pg). The discrepancy between studies may be attributed to several contributing factors, including differences in sample characteristics such as age, comorbidities, duration of diabetes, and the presence of chronic inflammation. Furthermore, conditions affecting red blood cell lifespan—such as blood transfusions, hemorrhage, or chronic kidney disease—can influence erythrocyte indices and HbA1C levels independently (Saraswati, 2019).

Correlation of HbA1C Levels and Erythrocyte Indices in Patients with T2DM

The correlation between HbA1C levels and erythrocyte indices (MCV, MCH, and MCHC) was analyzed using the Spearman correlation test, and the results are presented in Table 3.

Table 3. Spearman Correlation Test Between HbA1C Levels and Erythrocyte Indices

Variables	***Correlation Coefficient (r)***	***p-value***
HbA1C Levels MCV	-0.290	0.041
HbA1C Levels MCH	-0.170	0.239
HbA1C Levels Nilai MCHC	0.348	0.013

The analysis revealed a significant and moderately strong negative correlation between HbA1C levels and MCV ($r = -0.290$, $p = 0.041$). This indicates that as HbA1C levels increase, MCV values tend to decrease. No significant correlation was found between HbA1C levels and MCH ($r = -0.170$, $p = 0.239$), while a significant positive correlation was observed between HbA1C and MCHC ($r = 0.348$, $p = 0.013$), suggesting that higher HbA1C levels are associated with increased MCHC values.

The findings of this study highlight important relationships between long-term glycemic control, as measured by HbA1C, and erythrocyte indices in patients with type 2 T2DM.

A statistically significant and moderately strong negative correlation was found between HbA1C levels and MCV (r = -0.290, p = 0.041), suggesting that increased HbA1C levels are associated with a reduction in red blood cell volume. This finding aligns with the hypothesis that chronic hyperglycemia may alter erythrocyte morphology and structure. Alsalhi et al. (2018) described how glucose infiltration into erythrocyte membranes could change their shape from biconcave discs to flatter or convex forms. This morphological shift reduces the number of functional, normal erythrocytes and may increase the proportion of structurally impaired cells, contributing to diabetes-related complications (Wang et al., 2021).

Moreover, hyperglycemia is known to cause premature erythrocyte lysis through increased osmotic fragility of the cell membrane, resulting in a shortened red blood cell lifespan and ultimately lowering MCV (Handayati et al., 2020). Hyperglycemia also impacts erythropoiesis, cellular deformability, and the physiological function of red blood cells, particularly in the presence of chronic diabetic complications that alter viscosity, membrane stiffness, and erythrocyte survival (Aliviameita et al., 2021). Other contributing factors to MCV reduction may include advanced age (over 45 years), chronic inflammation, and diabetic complications (Rochman et al., 2022).

In contrast, this study found no significant correlation between HbA1C levels and MCH (r = -0.170, p = 0.239), indicating that hemoglobin content per red blood cell is not substantially influenced by glycemic control in this population. This result is consistent with findings from Bhutto et al. (2019), who observed no relationship between HbA1C and MCH in T2DM patients, as well as with Tayati (2021), who found similar outcomes in individuals with prediabetes.

A significant positive correlation was found between HbA1C levels and MCHC (r = 0.348, p = 0.013), indicating that higher HbA1C levels are associated with greater hemoglobin concentration within red blood cells. This may result from disruptions in the hematopoietic microenvironment, leading to increased internal viscosity and membrane rigidity, thereby altering erythrocyte composition and count. Jaman et al. (2018) also reported that MCHC could be used as a marker of systemic inflammation in diabetic patients.

Comparative analysis with prior studies reveals variability in findings. Bhutto et al. (2019) reported no significant correlations between HbA1C and any of the erythrocyte indices (MCV, MCH, or MCHC), while Tayati (2021) similarly observed no associations in prediabetic subjects. However, Jaman et al. (2018) found positive correlations between HbA1C and both MCH and MCHC, but not with MCV. These discrepancies may arise due to differences in sample characteristics, disease duration, and the presence of complications.

In summary, this study supports a significant inverse association between HbA1C and MCV, and a direct association with MCHC, suggesting that prolonged hyperglycemia in T2DM may lead to measurable hematological changes. Monitoring erythrocyte indices alongside HbA1C may provide additional insight into the systemic effects of chronic hyperglycemia and potential complications in diabetic patients.

CONCLUSION

The study highlighted that MCHC significantly positive correlated with HbA1C, indicating that higher HbA1C levels are associated with greater MCHC. MCHC is affordable and readily accessible test, it may be used as an marker of glycemic status. It's important for diabetic patients to prevent long-lasting hyperglycemia by monitoring glycemic index and taking medication regularly.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Multiwahana and Kampus Health Center Palembang for their support and permission to conduct this research. Special thanks are extended to all study participants for their cooperation and valuable contributions. The authors also acknowledge the guidance and input provided by academic supervisors and colleagues throughout the course of this study.

CONFLICT OF INTEREST

The authors declare there is no any conflict of interest during this study.

REFERENCES

Aliviameita, A., Puspitasari, P., Purwanti, Y., & Ariyanti, S. (2021). *Korelasi Kadar Glukosa Darah dengan Profil Hematologi Pada Pasien Diabetes Mellitus dengan Ulkus Diabetikum*. Prosiding University Research Colloquium, 791–799

Bhutto A, Abbasi A, Abro A. (2019) *Correlation of Hemoglobin A1c with Red Cell Width Distribution and Other Parameters of Red Blood Cells in Type II Diabetes Mellitus*. Cureus 11(8): e5533. DOI 10.7759/cureus.5533

Chinmay S, Manjula SD, Bekur R, Raghavendra RK. (2015). *Association of Increased Levels of GlycatedHemoglobin with Variations in Red Blood Cell Parameters in Diabetes Mellitus.International Journal of Advanced Research*. Vol 3(6): 31-37

Handayati, A., Anggraini, A. D., & Roaini, S. (2020). *Hubungan Kadar Glukosa Darah Dengan Jumlah Eritrosit Dan Jumlah Leukosit Pada Penderita Diabetes Melitus Baru Dan Lama*. Prosiding Seminar Nasional Kesehatan Politeknik Kesehatan Kementerian Kesehatan Surabaya, *7*, 1–7.

International Diabetes Federation. *IDF Diabetes Atlas* 10th ed. (2021). available from : https://diabetesatlas.org/data/en/country/94/id.html

Jaman MS, Rahman MS, Swarna RR, Mahato J, Miah MM, et al. (2018). *Diabetes and red blood cell parameters. Ann Clin Endocrinol Metabol*. Vol; 2: 001-009. https://doi.org/10.29328/journal.acem.1001004

Komariah, K (2020). *Hubungan Usia, Jenis Kelamin Dan Indeks Massa Tubuh Dengan Kadar Gula Darah Puasa Pada Pasien Diabetes Melitus Tipe 2 Di Klinik Pratama Rawat Jalan Proklamasi, Depok, Jawa Barat*. Vol 11 No 1. **https://doi.org/10.34035/jk.v11i1.412**

Latiifah, Itsnaani Rahmadita Nur and , Dr. Fahrun Nur Rosyid, S.Kep., Ns., M.Kes (2020). *Hubungan Antara Karakteristik Responden Dengan Kadar Glukosa Darah Puasa Pada Penderita Diabetes Melitus Tipe 2 Di Puskesmas Purwosari Surakarta*. Skripsi thesis, Universitas Muhammadiyah Surakarta.

Perkumpulan Endokrinologi Indonesia (PERKENI). (2021). *Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 di Indonesia*. Jakarta: Pengurus Besar Perkumpulan Endokrinologi Indonesia.

Rochman, A S., Suhariyadi, S., & Woelansari, ED. (2022). *Perbedaan Indeks Eritrosit Sebelum Dan Sesudah Pemberian Suplemen Spirulina Platensis Pada Penderita Diabetes Melitus Tipe 2 Di Puskesmas Waru*

Sidoarjo. Analis Kesehatan Sains, 10(1)

Sakamoto N, Hu H, Nanri A, Mizoue T, Eguchi M, Kochi T, et al. (2020). *Associations of anemia and hemoglobin with hemoglobin A1c among non-diabetic workers in Japan. J Diabetes Investig*. Vol : 11(3):719-725. doi: 10.1111/jdi.13159.

Saraswati, T. D., Rotty, L. W. A., & Pandelaki, K. (2019). *Gambaran Indeks Eritrosit Rerata pada Laki-laki Dewasa dengan Diabetes Melitus Tipe 2*. *E-CliniC*, *7*(2). available at : https://doi.org/10.35790/ecl.v7i2.26832

Tayati, Ameilia. (2021). *Hubungan Hasil Pemeriksaan HbA1C dengan Indeks Eritrosit Rerata Pada Pasien Prediabetes Melitus Tipe 2 Di Rumah Sakit Swasta Bekasi Barat*

Wang Y, Yang P, Yan Z, Liu Z, Ma Q, Zhang Z, et al.(2021) *The Relationship between Erythrocytes and Diabetes Mellitus. J Diabetes Res.* 25;2021:6656062. doi: 10.1155/2021/6656062. PMID: 33728350; PMCID: PMC7935596

Yosmar, R., Almasdy, D., & Rahma, F. (2018). *Survei Risiko Penyakit Diabetes Melitus Terhadap Masyarakat Kota Padang*. Jurnal Sains Farmasi & Klinis, 5(2), 134–141. https://doi.org/10.25077/jsfk.5.2.134-141.2018