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Relationship of HbA1c, Hematocrit, Erythrocytes, MCV in Type 2 Diabetes at Husada Utama Hospital, Surabaya

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Abstract

Background: Diabetes Mellitus (DM) is a prevalent endocrine disorder characterized by hyperglycemia. Hematological parameters such as Hematocrit (Hct), Erythrocyte Count (RBC), and Mean Corpuscular Volume (MCV) have been linked to the pathological mechanisms and complications of DM. **Objective:** This study investigates the relationship between glycemic control status (based on HbA1c results) and these hematological parameters in type 2 DM patients. **Methods:** This cross-sectional study included 43 type 2 DM patients from Husada Utama Hospital, Surabaya. Data, including HbA1c, Hct, RBC, and MCV values, were collected from patient medical records. **Results:** The Spearman Rank test results between glycemic control status (HbA1c) and hematocrit in type 2 DM patients showed $p=0.013$ with $r=0.374$, indicating a significant moderate positive correlation ($r = 0.3$ to 0.5, $p < 0.05$). The Spearman Rank test results between glycemic control status (HbA1c) and erythrocyte count showed $p=0.008$ with $r=0.402$, also indicating a significant moderate positive correlation ($r = 0.3$ to 0.5, $p < 0.05$). However, the Spearman Rank test results between glycemic control status (HbA1c) and MCV showed $p=0.052$ with $r=-0.302$, indicating a moderate negative correlation ($r = -0.3$ to -0.5) that is not statistically significant ($p > 0.05$). **Conclusion:** There is a notable relationship between glycemic control and hematological parameters in type 2 DM patients. Poor glycemic control is associated with significant variations in Hct, RBC, and MCV levels, highlighting the importance of monitoring these parameters in managing diabetes complications.

Keywords: Erythrocyte Count, Glycemic Control, HbA1c, Hematocrit Mean Corpuscular Volume (MCV), Type 2 Diabetes Mellitus

Original Research Article

INTRODUCTION

One of the most common endocrine disorders is Diabetes Mellitus (DM). Diabetes Mellitus refers to a group of endocrine and metabolic disorders characterized by the presence of hyperglycemia (Powers, Niswender, and Evans-Molina, 2022). Diabetes is estimated to affect approximately 530 million adults worldwide, with a global prevalence of 10.5% in those aged 20 to 79 years. Type 2 diabetes represents approximately 98% of global diabetes diagnoses (Green et al., 2021). The diagnosis of DM is based on classic symptoms of DM and other complaints, as well as the results of blood glucose levels and HbA1c examinations. Classic symptoms of DM include polyuria, polydipsia, polyphagia, and unexplained weight loss. There are three criteria for diagnosing DM: (1) Fasting blood glucose (FBG) > 126 mg/dl, or (2) Random blood glucose > 200 mg/dl accompanied by classic symptoms of DM, or (3) HbA1c > 6.5% (Perkeni, 2021). Apart from checking blood glucose levels and HbA1c as the basis for diagnosing DM, other blood tests are also related to the pathological mechanism of DM, such as hematocrit. Hematocrit (Hct) is the percentage of erythrocyte volume in the blood. Laboratory instruments calculate Hct from the number of erythrocytes (Red Blood Cell Count/RBC) and Mean Corpuscular Volume (MCV) using the formula Hct = (RBC x MCV) / 10 (Nicoll, Lu, and McPhee, 2017). Hematocrit can be a predictor of microvascular complications due to DM (Onalan, Gozel, and Donder, 2019).

Several studies have found a relationship between hematocrit and the risk of DM. Research by Tripathy et al. (2022) found that hematocrit examination, together with HbA1c, can be used as an initial screening for gestational DM in the early trimester of pregnancy. An increased hematocrit value contributes to an increased risk of developing DM. Hematocrit is also a risk factor for insulin resistance and type 2 DM (Tulloch-Reid et al., 2004; Nakanishi, Suzuki, and Tatara, 2004; Hanley et al., 2009; Tamariz et al., 2008). Other studies have found a relationship between Hct values and blood sugar in DM patients, showing that higher Hct values were found in DM patients compared to non-DM patients. Researchers also found that Hct values were higher in type 2 DM patients compared to non-DM patients (Biadgo et al., 2016; Olana et al., 2019; Madhusudhan and PK, 2019).

The Hct value is also related to the glycemic control of DM patients. However, this relationship still varies between studies. Researchers Alamri et al. (2019) found that higher Hct was found in DM patients with poor glycemic control (HbA1c > 7%) compared to patients with good glycemic control (HbA1c < 7%). In contrast, other researchers found that lower Hct was found in DM patients with poor glycemic control compared to patients with good glycemic control (Farooqui, Afsar, and Afroze, 2019; Milosevic and Panin, 2019; Arkew et al., 2022).

There are variations in the results of research regarding the relationship between Hct and glycemic control (HbA1c). Therefore, the author will conduct a study on the same topic at Husada Utama Hospital, Surabaya. Furthermore, the author will also investigate the relationship between the number of erythrocytes and MCV, which are components of calculating Hct, with the glycemic control of type 2 DM patients. The study is titled: "Relationship of Glycemic Control Status Based on HbA1c with Hematocrit, Erythrocyte Count, and MCV in Type 2 Diabetes Mellitus Patients at Husada Utama Hospital, Surabaya."

MATERIALS AND METHODS

Research Design

The design of this research is an analytical observational study with a cross-sectional study design. Observational research is conducted through field observations. Cross-sectional research analyzes data on a variable collected at a specific time from a sample population (Sastroasmoro, 2021).

Research Location and Time

This research was conducted at Husada Utama Hospital Surabaya, Tambaksari District, Surabaya, East Java. Data collection for the research was carried out in February 2024.

Population and Sample/Research Subjects

The study population is patients diagnosed with type 2 diabetes mellitus by physicians between January 1st, 2018, and December 31st, 2023, at Husada Utama Hospital, Surabaya. Sampling was conducted using a purposive sampling method based on predefined inclusion and exclusion criteria.

The inclusion criteria for this study were: (a) patients who had received medical treatment, either as outpatients or inpatients, at Husada Utama Hospital, (b) patients diagnosed with type 2 Diabetes Mellitus, (c) adult patients (aged >18 years), and (d) patients who had Hematocrit, Erythrocyte Count, Mean Corpuscular Volume (MCV), and HbA1c levels measured simultaneously. The exclusion criteria in this study are: (a) patients with medical conditions known to affect HbA1c levels, such as anemia, hemoglobinopathies, a history of blood transfusion within the past 2–3 months, or

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other conditions that influence erythrocyte lifespan or indicate impaired kidney function, and (b) pregnant patients. Based on these criteria, a total of 43 participants were eligible and included in the study.

Data collection

After obtaining official permission and ethical clearance from the hospital, the researchers collected data from patients' medical records. The collection, recording, and documentation of data were carried out in accordance with ethical research standards and the research procedures of the respective hospital. The researchers ensured the confidentiality of patient data and identities. Patient identities were known only to the research team and were not disclosed. Data processing involved the stages of editing, coding, data entry, and data transformation. The data were analyzed using the SPSS software.

Data Analysis

Data analysis was performed using Statistical Product and Service Solutions (SPSS) version 26. A p-value of ≤ 0.05 was considered statistically significant, indicating rejection of the null hypothesis (H_0) and suggesting a relationship between the two variables studied. Conversely, a p-value > 0.05 indicated acceptance of the null hypothesis (H_0), suggesting no significant relationship between the variables.

Ethical Statement

This study was approved by the Ethics Committee of Husada Utama Hospital (Certificate Number 06/KEP-RSHU/IV/2024).

RESULTS

Description of Research Results

Table 1 below summarizes the gender and age distribution of the 43 participants in the study conducted at Husada Utama Hospital, Surabaya, based on data from the hospital's electronic medical records (EMR). Female participants constituted the majority (67.44%, n=29), significantly outnumbering male participants (32.56%, n=14). In terms of age distribution, the largest group was aged 45–54 years (37.1%, n=16), followed by the 65–74 years group (25.58%, n=11) and the 55–64 years group (20.93%, n=9). Participants in the 25–34 and 35–44 age groups, as well as those aged 75 years and above, were minimally represented, each comprising less than 7% of the sample (n=1–3). These findings indicate a demographic trend dominated by middle-aged females within the type 2 diabetes patient population at the hospital

Table 1. Gender and Age of Research Participants

No.	Participant Characteristics	Frequency (n)	Percentage (%)
1.	Gender		
	Male	14	32.56
	Female	29	67.44
	Total	43	100
2.	Age		
	25 - 34 y.o.	1	2.3
	35 - 44 y.o.	3	6.98
	45 - 54 y.o.	16	37.1
	55 - 64 y.o.	9	20.93
	65 - 74 y.o.	11	25.58
	75+ y.o.	3	6.98
	Total	43	100

Source: Hospital EMR processed by researchers, 2024

Table 2 presents the glycemic control and hematological parameters of 43 patients with Type 2 Diabetes Mellitus at Husada Utama Hospital, Surabaya. The findings reveal that a majority of participants (65.12%, n=28) exhibited poor glycemic control (HbA1c≥7%), indicating substantial challenges in achieving optimal blood glucose management. Hematocrit levels varied by gender. Among males, 18.60% (n=8) had low hematocrit values (<39%), while 13.95% (n=6) were within the normal range. In females, 25.58% (n=11) had low hematocrit (<35%), with a larger portion (34.88%, n=15) falling within the normal range. Only a small number of females (6.98%, n = 3) showed elevated hematocrit levels. Erythrocyte counts also demonstrated gender differences. A significant proportion of females (53.49%, n=23) had normal erythrocyte levels (3.5–5.5 million/µL), compared to only 13.95% (n=6) of males with normal counts (4.3–6.1 million/µL). Low erythrocyte counts were observed in 18.60% of males (n=8) and 9.30% of females (n=4). Red blood cell indices, 37.21% (n=16) of participants presented with a low mean corpuscular volume (MCV < 80 fL), indicating a high prevalence of microcytic anemia. Most participants (55.81%, n=24) had normal MCV values, while 6.98% (n=3) had elevated levels (>100 fL). These findings suggest an association between poor glycemic control and hematologic abnormalities within this diabetic patient population.

Table 2. Glycemic Control, Hematocrit, Erythrocyte Count, and MCV Results

	Frequency (n)	Percentage (%)
Glycemic Control		
Good glycemic control (HbA1c <7%)	15	34.88
Bad glycemic control	28	65.12
Total	43	100
Hematocrit		
Male:		
Rendah (<39%)	8	18.60
Normal (39% - 49%)	6	13.95
Tinggi (>49%)	0	0
Female:		
Rendah (<35%)	11	25.58
Normal (35%-45%)	15	34.88
Tinggi (>45%)	3	6.98
Total	43	100
Erythrocyte count		
Male:		
Rendah (<4,3 juta/mcL)	8	18.60
Normal (4,3 – 6,1 juta/mcL)	6	13.95
Tinggi (>6,1 juta/mcL)	0	0
Female:		
Rendah (<3,5 juta/mcL)	4	9.30
Normal (3,5 – 5,5 juta/mcL)	23	53.49
Tinggi (>5,5 juta/mcL)	2	4.65
Total	43	100
MCV		
Rendah (<80)	16	37.21
Normal (80 – 100)	24	55.81
Tinggi (>100)	3	6.98
Total	43	100

Statistic test

Table 3. Rank-Spearman Test Result

Glycemic status (HbA1c)		Hematocrit	Erythrocyte Count	MCV
	P (≤0.05)	0.013	0.008	0.052
	r	0.374	0.402	-0.302

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Table 3 above presents the results of the Spearman Rank correlation test between glycemic status (HbA1c) and hematological parameters (hematocrit, erythrocyte count, and MCV) in patients with type 2 diabetes mellitus. The Spearman Rank test between HbA1c and hematocrit yielded a p-value of 0.013 and a correlation coefficient (r) of 0.374, indicating a moderate positive correlation that is statistically significant ($p < 0.05$). Similarly, the correlation between HbA1c and erythrocyte count showed a p-value of 0.008 and an r of 0.402, also reflecting a moderate, statistically significant positive correlation. In contrast, the correlation between HbA1c and mean corpuscular volume (MCV) resulted in a p-value of 0.052 and an r of -0.302. While the direction and strength of the correlation indicate a moderate negative relationship, this result is not statistically significant ($p > 0.05$). These findings suggest that poorer glycemic control is significantly associated with lower hematocrit and erythrocyte counts, while the association with MCV is weaker and statistically inconclusive.

DISCUSSION

Characteristics of Research Participants

Based on patient data collected at Husada Utama Hospital from 2018 to 2023, a total of 43 individuals with type 2 diabetes mellitus (T2DM) were included in the study based on specific inclusion and exclusion criteria. Among these participants, females made up the majority (67.44%), while males accounted for 32.56%. This gender distribution aligns with the 2018 Indonesian national health survey (Riskesdas), which reported a higher prevalence of diabetes in women (1.8%) compared to men (1.2%). Several factors may contribute to the higher prevalence of diabetes among women. Hormonal fluctuations associated with conditions such as premenstrual syndrome can lead to fat accumulation and an increase in body mass index (BMI), a known risk factor for diabetes (Wahyuni et al., 2012). Additionally, women are more prone to postprandial hyperglycemia, which may progress to impaired glucose tolerance and eventually to T2DM, largely due to peripheral insulin resistance. Socio-environmental factors (including educational level, income, and employment) may also play a more pronounced role in women, potentially heightening their risk. Moreover, women are more vulnerable to the cardiometabolic consequences of psychosocial stress, work-related stress, and sleep disorders (Ciarambino et al., 2022).

Age distribution among participants was dominated by individuals aged 45–54 years (37.1%), followed by those aged 55–64 years (20.93%) and 65–74 years (25.58%). This pattern closely mirrors national data from Riskesdas 2018, which showed the highest prevalence of diabetes in the 55–64 age group (6.3%), followed by the 65–74 age group (6.0%) and the 45–54 age group (3.9%). The prevalence of T2DM typically begins to rise after the age of 45, which corresponds to the most common age of onset. According to Carrillo-Larco et al. (2024), the average age of diagnosis for T2DM is 45.1 years in men and 45.0 years in women. Given this trend, the American Diabetes Association (ADA) Professional Practice Committee (2022) recommends routine screening for diabetes in all asymptomatic individuals aged 45 and older. The prevalence of T2DM continues to increase with age, peaking in the 55–64 age group in Indonesia (RI, 2018) and in the 55–59 age group globally (Ogurtsova et al., 2022. This age-related increase is influenced by various risk factors, including poor sleep quality and duration, smoking, dyslipidemia, hypertension, ethnicity, family history of diabetes, obesity, and physical inactivity (Ismail, Materwala, & Al Kaabi, 2021).

Relationship between Glycemic Status (HbA1c) and Hematocrit

Our findings of a moderate positive correlation (r=0.374) between glycemic status (HbA1c) and hematocrit levels in type 2 DM patients, with statistical significance (p=0.013), align with established physiological mechanisms described in previous research (Cho, Mooney, & Cho, 2008; Irace et al., 2014). In uncontrolled type 2 diabetes mellitus (DM), persistently high blood sugar levels over three months cause excess glucose to bind to hemoglobin, forming glycated hemoglobin (HbA1c). Under normal conditions, HbA1c accounts for ≤5.7% of total hemoglobin. However, prolonged hyperglycemia leads to excessive glucose-hemoglobin binding, elevating HbA1c levels. This sustained high blood sugar increases blood osmolarity and makes capillaries more permeable, forcing fluid from blood vessels into surrounding tissues and reducing plasma volume. Additionally, hyperglycemia triggers osmotic diuresis—which exacerbates fluid loss and further depletes plasma volume. Together, these processes concentrate blood cells in the remaining plasma, raising hematocrit levels.

This research provides a quantitatively specific and statistically significant correlation (r=0.374,p=0.013) between HbA1c and hematocrit, offering empirical data that supports known physiological mechanisms. This study also has direct clinical relevance by examining this relationship specifically in type 2 DM patients. Despite identifying a correlation, our study acknowledges that the relationship isn't absolute, as unquantified confounding factors like hydration (Di Iorio & Bellizzi, 2001), comorbidities, and medications can influence hematocrit levels. As a correlational study, it identifies a relationship but doesn't delve into the underlying 'why' with the same mechanistic depth as some previous research.

Relationship between Glycemic Status (HbA1c) and Erythrocyte Count

Our findings demonstrate a moderate positive correlation (r=0.402) between glycemic status (HbA1c) and erythrocyte count in type 2 DM patients, with statistical significance (p=0.008). This indicates that increasing HbA1c levels correspond to a higher erythrocyte count. These results align with established theories regarding the influence of metabolic factors on erythropoiesis. Specifically, our observations support the role of hyperinsulinemia, often seen in insulin resistance and poorly controlled diabetes, in stimulating red blood cell production. This is consistent with the literature on insulin and Insulin-like Growth Factor 1 (IGF-1) acting as cofactors in erythroid differentiation and proliferation, and the effect of elevated cytokines like IL-6 on erythroid progenitor cells (Ellinger et al., 2006; Ferreira et al., 2019).

This research provides a quantitatively specific and statistically significant correlation (r=0.402,p=0.008) between HbA1c and erythrocyte count. This offers empirical data that directly supports and quantifies the established physiological mechanisms involving insulin, IGF-1, and cytokine activity in erythropoiesis. By focusing on type 2 DM patients, our study also holds direct clinical relevance, contributing to a better understanding of how glycemic control influences hematological parameters in this specific population. Despite identifying a correlation, our study acknowledges that the relationship between HbA1c and erythrocyte count is not absolute. The findings explicitly mention the influence of individual variability (Gu et al., 2018), underlying mechanisms (e.g., hyperinsulinemia, cytokine activity) (Bruhn et al., 2020), and other unquantified factors like comorbidities (Zhao & Liu, 2022) or medications, which could confound the direct effect of HbA1c.

Relationship between Glycemic Status (HbA1c) and MCV

Our study investigated the relationship between glycemic status (HbA1c) and Mean Corpuscular Volume (MCV) in type 2 DM patients. While our data showed a moderate negative correlation (r=−0.302), suggesting that higher HbA1c may correspond to lower MCV, this finding did not achieve statistical significance (p=0.052). This indicates that while a trend exists, we cannot definitively conclude a statistically reliable relationship in our specific sample. Despite the lack of statistical significance, this observed negative trend aligns with previously proposed physiological theories. Chronic hyperglycemia is understood to increase plasma osmolality, which can draw fluid from erythrocytes into the extracellular space, thus reducing red blood cell volume and subsequently decreasing MCV (Hosseini et al., 2014; Hashemi et al., 2020).

The primary weakness of this correlation is the lack of statistical significance (p=0.052). While a moderate negative trend was noted, the p-value indicates that this finding could plausibly be due to random chance, limiting the certainty of the conclusion. This implies that the sample size might have been insufficient to detect a statistically significant effect if one truly exists, or that the relationship is weaker than hypothesized.

CONCLUSION

Based on the research findings in Type 2 Diabetes Mellitus patients at Husada Utama Hospital, Surabaya, it was concluded that the status of glycemic control, measured by HbA1c, has a significant relationship with several blood parameters. A clear correlation exists between glycemic control status

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(HbA1c) and the patients' hematocrit value and erythrocyte (red blood cell) count. However, the study also found that there was no statistically significant relationship between glycemic control status (HbA1c) and MCV (*Mean Corpuscular Volume*), even though a tendency was observed where a decrease in MCV accompanied an increase in HbA1c; this correlation, unfortunately, did not reach the significance threshold. Overall, these findings indicate that while glycemic control in Type 2 DM patients correlates closely with hematocrit and erythrocyte count, the relationship is not significant with MCV at the studied hospital.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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