Hba1c and Blood Pressure Correlation In Patients With Uncontrolled Type 2 Diabetes Mellitus

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Abstract.

The primary metabolic disorder in diabetes mellitus is hyperglycemia, which can be assessed through glycated hemoglobin (HbA1c) levels as an indicator of long-term blood glucose control. Abnormal glucose metabolism may affect vascular function and contribute to increased blood pressure, making hypertension a common complication among patients with uncontrolled diabetes mellitus. This study aimed to determine the correlation between HbA1c levels and blood pressure in patients with uncontrolled type 2 diabetes mellitus. An observational cross-sectional study was conducted at RSU PKU Muhammadiyah Gamping involving 90 subjects aged 31–65 years, consisting of 48 men and 42 women. HbA1c levels were measured using the boronate affinity method, and blood pressure was assessed with a sphygmomanometer. Statistical analysis used the independent t-test, Mann–Whitney U test, and Spearman correlation with a significance level of α = 0.05. The mean HbA1c level was 10 ± 2.08%, mean systolic pressure 132.75 ± 18.04 mmHg, and mean diastolic pressure 83.28 ± 10.38 mmHg. Hypertension occurred in 36.66% of subjects. The results showed no significant differences in blood pressure between sexes or glycemic control groups and no significant correlation between HbA1c levels and blood pressure. These findings suggest that factors other than glycemic control may influence blood pressure in diabetic patients.

Keywords: *Diabetes mellitus; HbA1c; blood pressure; hyperglycemia, glycemic control; hypertension and type 2 diabetes.*

I. INTRODUCTION

Hyperglycemia, a metabolic disorder caused by abnormalities in insulin action, secretion, or both, is the hallmark of diabetes mellitus. It represents a chronic condition in which the body either does not produce sufficient insulin or is unable to effectively use the insulin it produces, resulting in an abnormal elevation of blood glucose levels. This persistent hyperglycemia leads to various metabolic disturbances that affect carbohydrate, fat, and protein metabolism. The long-term consequences of uncontrolled blood glucose include microvascular and macrovascular complications such as neuropathy, nephropathy, retinopathy, coronary artery disease, and cerebrovascular disorders. It has been established that the pathophysiology of central damage in Type 2 diabetes is due to insulin resistance, which affects the liver, muscles, and pancreatic beta cells (PERKENI, 2021). Insulin resistance reduces glucose uptake by peripheral tissues and increases hepatic glucose output, contributing to a chronic elevation in plasma glucose levels. Over time, pancreatic β-cell dysfunction worsens, resulting in progressive hyperglycemia that becomes increasingly difficult to control through lifestyle modification and pharmacological treatment alone.Diabetes mellitus is a complex and multifactorial disease that requires continuous monitoring and management. If blood pressure, nutritional status, and HbA1c all achieve predetermined thresholds and blood glucose, lipid, and HbA1c levels reach the expected ranges, diabetes mellitus is considered well controlled (American Diabetes Association, 2020). Maintaining optimal glycemic control is essential in preventing long-term complications and improving patients' quality of life. HbA1c levels have significant prognostic value in DM patients (Sherwani et al., 2016).

The HbA1c level, also known as glycated hemoglobin, reflects the mean plasma glucose concentration over the previous two to three months and is therefore a reliable indicator of long-term glycemic control.Clinical HbA1c evaluations should be performed on a regular basis to guarantee effective glycaemic management and to inform therapeutic modifications (American Diabetes Association, 2020; Almutairi et al., 2022). Regular HbA1c monitoring allows physicians to evaluate whether therapeutic goals are being met and to adjust treatment regimens as needed. For instance, an increase in HbA1c over time may suggest treatment non-adherence, inadequate dosing, or lifestyle factors that interfere with glycemic regulation. Conversely, a decrease in HbA1c indicates improvement in glucose control, possibly due to

optimized therapy or better compliance with dietary and exercise recommendations. Therefore, HbA1c measurement not only serves as a diagnostic and prognostic tool but also functions as a clinical management guide for patients with type 2 diabetes mellitus.Haemoglobin with glucose linked is known as haemoglobin A1c. The HbA1c test measures the percentage of glycated haemoglobin to assess the average blood glucose level over the previous two to three months. The biochemical process occurs when glucose molecules in the bloodstream nonenzymatically bind to the N-terminal valine of the β-chain of hemoglobin, forming a stable ketoamine. This glycation process is directly proportional to ambient glucose concentration, meaning that higher blood glucose levels result in greater HbA1c formation. Haemoglobin A1c is therefore a sign of effective type 2 diabetes patient care (American Diabetes Association, 2020).

A lower HbA1c level typically signifies better metabolic control, while elevated levels indicate poor glycemic regulation and increased risk of diabetes-related complications.The importance of controlling HbA1c levels extends beyond preventing microvascular complications; numerous studies have demonstrated its relationship with cardiovascular outcomes as well. Elevated HbA1c is associated with a higher incidence of coronary heart disease, stroke, and peripheral arterial disease, regardless of fasting glucose levels. This emphasizes that HbA1c is not merely a marker of glycemia but also a risk predictor for systemic vascular damage. Hence, understanding factors associated with HbA1c levels—including blood pressure, lipid profile, and renal function—is crucial in comprehensive diabetes management.One of the leading causes of premature death worldwide is hypertension. It represents a major global health challenge, contributing significantly to the burden of cardiovascular morbidity and mortality. According to estimates from the World Health Organisation (WHO), 22% of people worldwide suffer from hypertension. Less than 20% of people with hypertension, however, try to lower their blood pressure. The prevalence in Southeast Asia, which accounts for roughly 25% of the world's population, indicates a growing public health concern. WHO estimates that 1 in 5 women globally have hypertension, and 1 in 4 males (WHO, 2023). These data illustrate the alarming magnitude of hypertension as a global epidemic and highlight the necessity of early detection, continuous monitoring, and effective management strategies.Hypertension and diabetes mellitus frequently coexist, and this comorbidity poses a serious health threat. Over two thirds of individuals with type 2 diabetes mellitus have hypertension. The coexistence of these two conditions leads to a multiplicative increase in the risk of cardiovascular complications. Hyperglycemia and the onset of hypertension are compatible and often interact pathophysiologically.

The mechanisms behind hypertension include insulin resistance, hyperinsulinemia, and the excitatory consequences of hyperglycemia itself (Song et al., 2020). Insulin resistance contributes to sodium retention, activation of the sympathetic nervous system, and stimulation of the renin–angiotensin–aldosterone system (RAAS), all of which play important roles in the development of hypertension. Furthermore, in those without type 2 diabetes, elevated and normal HbA1c levels are significantly linked to an increased risk of arterial stiffness (Lee et al., 2016). Arterial stiffness represents an early marker of vascular damage that predisposes individuals to hypertension. Chronic exposure to hyperglycemia induces endothelial dysfunction through oxidative stress, inflammation, and accumulation of advanced glycation end-products (AGEs), leading to impaired vasodilation and increased vascular resistance. The development of hypertension is significantly influenced by the activation of the sympathetic nervous system (SNS) and renin-angiotensin-aldosterone system (RAAS) in situations including obesity, insulin resistance, or hyperglycemia (Jia & Sowers, 2021). These interconnected pathways explain the strong association between metabolic disturbances and hemodynamic alterations in patients with type 2 diabetes mellitus.HbA1c has prognostic importance because it is used to predict cardiovascular complications associated with metabolic syndrome (Pan et al., 2019). The metabolic syndrome, characterized by central obesity, dyslipidemia, hypertension, and insulin resistance, represents a cluster of risk factors that together amplify cardiovascular risk.

Elevated HbA1c levels within this context serve as an integrative marker of metabolic dysregulation and vascular stress. Research findings consistently indicate that diabetic patients with poor glycemic control exhibit higher rates of hypertension and cardiovascular disease compared to those with optimal control. There is a significant difference in HbA1c levels in Type 2 Diabetes Mellitus patients with and without

hypertension (Haryati & Tyas, 2022). This finding suggests that hyperglycemia may contribute directly to the pathogenesis of elevated blood pressure. HbA1c, therefore, is not only a marker of long-term glycemic exposure but may also reflect the cumulative vascular effects of glucose toxicity. Omar et al. (2022) found that there was an increase in HbA1c with the incidence of hypertension. These results reinforce the hypothesis that poor metabolic control plays a pivotal role in the development and maintenance of high blood pressure in diabetic patients.Diabetes mellitus with hypertension is a dangerous disease because the presence of this condition will facilitate complications of other diseases, such as coronary heart disease, stroke, and blood vessel disease (Khorasani et al., 2019; Hardianto, 2021; Zeng et al., 2023). The coexistence of both disorders significantly worsens patient prognosis and increases healthcare costs. Hypertension exacerbates diabetic nephropathy, accelerates retinopathy progression, and increases the likelihood of myocardial infarction and cerebrovascular accidents.

This synergistic interaction between elevated blood glucose and high blood pressure underscores the importance of integrated management approaches addressing both metabolic and hemodynamic parameters.Despite the well-established link between diabetes and hypertension, numerous investigations have been carried out to examine the connection between HbA1c and the likelihood of hypertension; nevertheless, the results show mixed outcomes. Some studies demonstrate a positive correlation, indicating that higher HbA1c levels are associated with increased blood pressure, while others report no significant relationship. The variability in findings may be attributed to differences in study design, population characteristics, sample size, degree of glycemic control, and methods of blood pressure assessment. Additionally, confounding factors such as obesity, age, medication use, and renal function may influence both HbA1c and blood pressure, making it difficult to establish a clear causal relationship.In some studies, the relationship between HbA1c and hypertension is evident even in non-diabetic individuals. For instance, elevated HbA1c within the high-normal range has been linked to arterial stiffness and increased risk of developing hypertension later in life. This suggests that HbA1c may serve as a broader indicator of vascular health beyond its traditional role in diabetes monitoring. Conversely, other research has failed to identify such an association, implying that blood pressure regulation might be more strongly influenced by factors such as salt intake, genetic predisposition, kidney function, and sympathetic nervous system activity than by glycemic control alone.The biological mechanisms potentially linking HbA1c to hypertension involve several pathways. Chronic hyperglycemia promotes oxidative stress and endothelial dysfunction, leading to decreased nitric oxide bioavailability and impaired vasodilation.

Advanced glycation end-products (AGEs) formed through nonenzymatic glycation can cross-link with collagen in the vascular wall, increasing stiffness and reducing elasticity. These processes collectively elevate peripheral vascular resistance and systolic blood pressure. Moreover, hyperglycemia stimulates low-grade inflammation, contributing to vascular remodeling and arterial thickening. However, even with these plausible mechanisms, empirical findings remain inconsistent, highlighting the need for more rigorous and targeted research.The clinical significance of exploring the relationship between HbA1c and blood pressure lies in its potential to improve risk stratification and management in diabetic patients. If a strong correlation were consistently observed, HbA1c could serve as a dual marker for both glycemic control and hypertension risk, simplifying patient monitoring. It would also justify more aggressive blood pressure management in individuals with elevated HbA1c, even if their measured blood pressure remains within borderline ranges. Conversely, the absence of a correlation would imply that hypertension management should be addressed independently from glycemic control, emphasizing the need for comprehensive assessment beyond blood sugar monitoring.Uncontrolled type 2 diabetes mellitus remains a major challenge in both developed and developing countries. Many patients fail to achieve optimal HbA1c targets due to a combination of factors, including limited access to healthcare, inadequate medication adherence, suboptimal lifestyle modification, and lack of awareness regarding the importance of glycemic control. In Indonesia, for example, the prevalence of diabetes continues to rise, driven by sedentary lifestyles, urbanization, and changes in dietary habits. According to PERKENI (2021), maintaining HbA1c below 7% is the recommended goal for most diabetic patients, yet a significant proportion of individuals remain above this threshold, increasing their susceptibility to complications.

Given these challenges, understanding the complex relationship between blood glucose control (as reflected by HbA1c) and blood pressure regulation has crucial implications for clinical practice. If elevated HbA1c indeed predisposes individuals to hypertension, interventions aimed at improving glycemic control could have secondary benefits in reducing cardiovascular risk. On the other hand, if no such association exists, it reinforces the need for independent strategies targeting hypertension, such as dietary sodium restriction, physical activity, and pharmacological therapy.Therefore, research exploring this relationship remains essential. Studies focusing on uncontrolled type 2 diabetes mellitus populations can provide valuable insights, as this group represents individuals at the highest risk for complications. Investigating whether poor glycemic control, as indicated by elevated HbA1c, correlates with increased blood pressure may reveal underlying pathophysiological mechanisms and guide more effective therapeutic strategies.In conclusion, hyperglycemia represents a central feature of diabetes mellitus and is closely monitored using HbA1c as a key biomarker of glycemic control. Hypertension, a prevalent comorbidity in diabetic patients, significantly exacerbates the risk of cardiovascular and microvascular complications. Although several biological pathways suggest that elevated HbA1c could contribute to increased blood pressure through vascular dysfunction and insulin resistance, empirical findings remain inconsistent. Further research, particularly among patients with uncontrolled type 2 diabetes mellitus, is necessary to clarify this relationship. A clearer understanding could improve clinical management by integrating metabolic and hemodynamic control strategies, ultimately reducing morbidity and mortality among diabetic populations.

II. METHODS

This study is an analytical observational research employing a cross-sectional design, which allows researchers to observe the relationship between variables at a single point in time without manipulating the study environment. Such a design is particularly suitable for identifying correlations between biological parameters and clinical outcomes among patients with chronic diseases. The primary variables analyzed in this study were HbA1c levels and systolic and diastolic blood pressure, both of which serve as critical indicators of metabolic and cardiovascular health in individuals with type 2 diabetes mellitus (T2DM). HbA1c is a long-term marker of glycemic control, reflecting the average blood glucose concentration over the previous 8–12 weeks, while blood pressure represents a key measure of vascular function and cardiovascular risk.The study subjects consisted of patients with uncontrolled type 2 diabetes mellitus, operationally defined as individuals with HbA1c values exceeding 7%, who were undergoing outpatient treatment at the Polyclinic of PKU Muhammadiyah Gamping Hospital. This hospital serves as a referral center for chronic disease management in Yogyakarta and surrounding regions, making it a suitable setting for obtaining representative clinical samples. The minimum required sample size was determined using the Slovin formula, resulting in a total of 45 participants, which provided adequate statistical power to detect meaningful associations between variables.The inclusion criteria were rigorously defined to ensure the homogeneity of the sample: (1) individuals with a clinical diagnosis of type 2 diabetes mellitus confirmed by a physician, (2) HbA1c levels greater than 7% indicating poor glycemic control, and (3) participants aged 31–65 years, representing the adult population most affected by T2DM.

Conversely, exclusion criteria were applied to minimize confounding factors and ensure data validity, including (1) individuals experiencing acute diabetic complications such as diabetic ketoacidosis, (2) those with a history of chronic renal failure, and (3) patients with hyperthyroidism, as these conditions could independently influence glucose metabolism and blood pressure regulation.The sampling technique adopted was purposive sampling, a non-probability method that allows researchers to select subjects based on specific characteristics relevant to the research objectives. The study period extended from August 2022 to October 2022, during which all data collection and laboratory analyses were completed according to standardized protocols. The measurement of HbA1c was conducted using the Boronic Affinity method through High-Performance Liquid Chromatography (HPLC), a highly specific and reliable analytical approach widely regarded as the gold standard in glycated hemoglobin determination.Meanwhile, blood pressure measurements were obtained using a mercury sphygmomanometer, following standard clinical procedures. Participants were seated in a comfortable position for at least five minutes before measurement

to ensure accuracy and reduce situational variability. Both systolic and diastolic blood pressure values were recorded, and each measurement was repeated twice to obtain an average value. The classification of blood pressure levels was determined according to the Joint National Committee (JNC) guidelines on High Blood Pressure, ensuring that the data were comparable with international standards.

The data management and analysis process utilized SPSS version 25 for Windows, a widely recognized statistical software. Data were first checked for completeness and accuracy before being coded and entered into the database. The independent T-test and Mann–Whitney U test were employed to evaluate differences between groups depending on the normality of data distribution, while the Spearman correlation test was applied to assess the strength and direction of relationships between HbA1c levels and blood pressure parameters. The significance level was established at $\alpha = 0.05$, meaning that results with p-values below this threshold were considered statistically significant.To ensure that the study adhered to ethical standards, it obtained ethical clearance from the Health Research Ethics Committee, Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta (Ref No. 072/EC/KEPK FKIK UMY/III/2021). Moreover, permission to conduct the study was granted by the RSU PKU Muhammadiyah Gamping institution. Each participant was fully informed about the research objectives, procedures, and potential risks or benefits before participation. Written informed consent was obtained from all subjects to guarantee voluntary participation and protect their confidentiality.This meticulous approach ensured that the research was conducted in accordance with established ethical principles, including respect for autonomy, beneficence, nonmaleficence, and justice. By following rigorous inclusion and exclusion criteria, validated measurement techniques, and standardized statistical analyses, this study aimed to provide reliable and evidence-based insights into the relationship between HbA1c levels and blood pressure in patients with uncontrolled type 2 diabetes mellitus, contributing to a deeper understanding of the interplay between glycemic control and cardiovascular risk factors in clinical practice.

III. RESULT AND DISCUSSION

The research subjects were 90 patients suffering from uncontrolled type 2 DM who met the study inclusion and exclusion criteria. Subjects aged between 31-65 years consisted of 48 men (53.33%) and 42 women (46.67%). Demographic data can be seen in table 1.

Table 1. Respondents' characteristic

Respondents' characteristic	Respondent	
	Frequency	Percentage
Gender		
Male	48	53.33%
Female	42	46.67%
Total	90	100%
Age		
31-35 year	2	2.22%
36-40 year	6	6.67%
41-45 year	9	10.00%
46-50 year	18	20.00%
51-55 year	15	16.67%
56-60 year	24	26.67%
61-65 year	16	17.78%
Total	90	100%
Time Spent Affected by DM		
0-5 year	58	64.44%
6-10 year	16	17.78%
11-15 year	11	12.22%
16-20 year	4	4.44%
>20 year	1	1.11%
Total	90	100%

Source:

The HbA1c level of the research subjects ranged from 7.1% at the lowest to 15.0% at the highest, with a mean of 10 ± 2.08%. The mean systolic blood pressure was 132.75 ±18.04 mmHg, with a minimum of 90 mmHg and a maximum of 180 mmHg. With a mean of 83.28 ±10.38 mmHg, the diastolic blood pressure ranges from 60 mmHg at the minimum to 120 mmHg at the maximum. Table 2 displays the results of the blood pressure test in detai.

Table 2. Profile of HbA1c Levels and Blood Pressure

Information	Minimum	Maximum	Mean	SD
HbA1c (%)	7.1	15,0	10	2.08
Systolic Blood Pressure (mmHg)	90	180	132.75	18.04
Diastolic Blood Pressure (mmHg)	60	120	83.28	10.38

The systolic blood pressure of the study participants was classified into four groups: normal (14.44%), hypertension level II (13.33%), pre-hypertension (48.89%), and hypertension level I (23.33%). Meanwhile, the comparable diastolic blood pressure classifications are pre-hypertension (42.22%), hypertension level I (25.56%), normal (21.11%), and hypertension level II (11.11%). Hypertension (level I and II) was present in 36.66% of the participants (see table 3).

Table 3. Subject Blood Pressure Categories

Information	Frequency	Percentage
Systolic		
Normal	13	14.44%
Pre-Hypertension	44	48.89%
Hypertension level 1	21	23.33%
Hypertension level II	12	13.33%
Total	90	100%
Diastolic		
Normal	19	21.11%
Pre-Hypertension	38	42.22%
Hypertension level 1	23	25.56%
Hypertension level II	10	11.11%
Total	90	100%

The average systolic blood pressure for male subjects ranged from 100 to 170 mmHg, whereas the average for female subjects was 133.9 ± 19.4 mmHg (90-180). These results were based on gender. The difference test utilising the Mann-Whitney U test did not disclose a significant difference between the two (p=0.70) (see table 4).Male respondents had an average diastolic blood pressure of 82.72 ± 9.9 mmHg (60-100), whereas female subjects had an average of 83.9 ± 10.9 mmHg (90-180). There was no discernible difference between the two (p=0.58) according to the Mann-Whitney U test difference test (see table 5)

Table 4. Systolic Blood Pressure by Gender Group

Gender	Amount	Minimum (mmHg)	Maximum (mmHg)	Mean (mmHg)	SD	*p*
Male	48	100	170	131.7	16.9	
Female	42	90	180	133.9	19.4	0.7
Total	90					

Table 5. Diastolic Blood Pressure by Gender Group

Gender	Amount	Minimum (mmHg)	Maximum (mmHg)	Mean (mmHg)	SD	*p*
Male	48	60	100	82,7	9,9	
Female	42	60	120,00	83,9	10,9	0,58
Total	90					

Based on control criteria, DM patients can be divided into good, moderate and poor control groups. Uncontrolled DM patients have two criteria, namely moderate and poor. The moderate control group had HbA1c levels between 7-8%, while the poor control group had HbA1c levels of more than 8%.Of the 90 subjects, 18 patients (31.2%) had moderate control and 72 patients (68.8%) had poor control. The moderate DM control group had a mean systolic blood pressure of 130.2 ± 16.5 mmHg (100-160) while the poor control group had a mean of 133.3 ± 18.4 mmHg (90-180). Analysis of different tests using the independent T-test in the two groups did not reveal a significant difference (p= 0.50) (see table 6) The moderate DM control group had a mean diastolic blood pressure of 84.3 ± 12 mmHg (70-120) while the poor control group had a mean of 83.0 ± 10.0 mmHg (60-100). Analysis of different tests using the Mann-Whitney U Test in the two groups did not reveal a significant difference (p= 0.93) (see table 7).

Table 6. Systolic Blood Pressure Levels Based on Control Group

Control group	Minimum (mmHg)	Maksimum (mmHg)	Mean (mmHg)	SD	*p*
Medium(18)	100,0	160,0	130,2	16,5	0,51
Poor (72)	90,0	180,0	133,3	18,4	

Table 7. Diastolic Blood Pressure Levels Based on Control Group

Control group	Minimum (mmHg)	Maksimum (mmHg)	Mean (mmHg)	SD	*p*
Medium (18)	70,0	120,0	84,3	12,0	0,93
Poor (72)	60,0	100,0	83,0	10,0	

From the Spearman correlation test, no significant correlation was found between HbA1c levels and systolic blood pressure (r=0.07, p=0.47). There was no significant correlation between HbA1c levels and diastolic blood pressure (r=0.00, p=0.99). From the results of the Spearman correlation test, there was no correlation between the duration of DM and systolic blood pressure (r=.09 and p=0.38). There was no correlation between duration of DM and diastolic blood pressure (r= -0.03 and p=0.76) (see table 8).

Table 8. Correlation of HbA1c Levels and Duration of DM on Blood Pressure

	Systolic blood pressure	Diastolic blood pressure
HbA1c	*r*=0,07 dan *p*=0,47	*r*=0,00 dan *p*=0,99
Time spent	*r*=0,09 dan *p*=0,38	*r*= -0,03 dan *p*=0,76

Discussion

In this study, all participants with uncontrolled diabetes mellitus (DM) exhibited a remarkably high prevalence of elevated blood pressure, with 48.89% experiencing pre-hypertension and 36.66% meeting the criteria for hypertension. These figures suggest that the majority of patients with poorly controlled type 2 diabetes mellitus (T2DM) are prone to abnormal blood pressure regulation. Such findings reinforce the well-established understanding that the coexistence of diabetes and hypertension represents a frequent and clinically significant problem in metabolic disorders. According to Lumban et al. (2015), 38.7% of DM patients had hypertension, which is comparable to the prevalence observed in this current investigation. However, a higher prevalence was reported by Naseri et al. (2022), who found that 70.5% of individuals with DM were hypertensive, illustrating the variability of results across populations and study methodologies. A systematic review and meta-analysis by Nawi et al. (2021) reported that the overall incidence of hypertension among individuals with diabetes mellitus was 33.82%, while Haile et al. (2023) noted a higher prevalence of 55% among patients with type 2 DM. This wide range of reported values may be attributed to differences in study design, diagnostic thresholds, population demographics, and treatment adherence across studies.Hypertension in diabetic patients can result from multiple pathophysiological processes, including insulin resistance, endothelial dysfunction, and renal sodium retention. Persistent hyperglycemia causes oxidative stress and inflammation, leading to vascular remodeling and arterial stiffness, which together contribute to increased peripheral resistance and elevated blood pressure.

Furthermore, the renin–angiotensin–aldosterone system (RAAS) and the sympathetic nervous system (SNS) play a key role in blood pressure dysregulation in DM. Chronic activation of these systems

enhances vasoconstriction and sodium reabsorption, increasing intravascular volume and pressure. Therefore, the coexistence of hypertension and diabetes is not coincidental but represents a shared metabolic and vascular pathogenesis that exacerbates the risk of cardiovascular morbidity and mortality.In the current study, no significant differences were observed in systolic or diastolic blood pressure between male and female participants. This result suggests that sex did not play a determining role in the variation of blood pressure among uncontrolled diabetic patients in this sample. Nevertheless, several studies have identified a gender-related pattern in the development of hypertension. Mohanty et al. (2022) reported that men show a higher prevalence of hypertension up to the age of 50 years, whereas postmenopausal women experience an increase in hypertension incidence, possibly due to hormonal changes such as estrogen decline that alter vascular tone and endothelial function. Likewise, Salsabila et al. (2024) found that age is an influential risk factor for hypertension, with men being more prone to hypertension between 45–55 years of age, but as both sexes age, gender differences tend to diminish. This implies that age-related vascular changes and cumulative metabolic stress become more dominant than biological sex in determining hypertension risk in older adults.

The absence of a gender difference in this study might be attributed to several possible explanations. The relatively narrow age range (31–65 years), similar socioeconomic characteristics, and comparable treatment patterns between male and female patients may have contributed to the homogeneity of results. It is also plausible that the high proportion of uncontrolled diabetes in both groups overshadowed sex-related differences, as prolonged hyperglycemia and insulin resistance are powerful independent predictors of vascular dysfunction. Lifestyle factors such as diet, physical inactivity, and adherence to therapy—if similar between men and women—may further explain the lack of observable disparities in blood pressure outcomes.In this study, there was also no significant difference in systolic or diastolic blood pressure between the moderate and poor control HbA1c categories, and no observed correlation between the duration of diabetes and blood pressure. This outcome suggests that short-term glycemic control, as reflected by HbA1c levels, may not directly determine blood pressure variability among patients with uncontrolled DM. The findings differ from those of Ramanathan (2017), who reported a positive correlation between the duration of diabetes and the incidence of hypertension. Similarly, Akalu and Belsti (2020) also found that the longer the duration of diabetes, the higher the risk of developing hypertension, possibly due to cumulative microvascular and macrovascular damage over time.The divergence in findings between this study and previous research may be related to the biological and temporal characteristics of HbA1c. HbA1c primarily reflects glycemic control over the preceding 8–12 weeks, rather than representing long-term metabolic history. Thus, in a cross-sectional context, HbA1c may fluctuate based on recent lifestyle or treatment changes, limiting its capacity to capture the chronic impact of diabetes duration on vascular outcomes (American Diabetes Association, 2020; Hardianto, 2021).

The transient nature of HbA1c as a biomarker, combined with potential differences in antihypertensive therapy or renal function, could have influenced the non-significant relationship observed in this study.Moreover, this study found no correlation between HbA1c levels and blood pressure, which aligns with previous findings by Khorasani et al. (2019), who also concluded that HbA1c did not significantly affect either systolic or diastolic blood pressure among diabetic patients. Similarly, Arania et al. (2021) reported that there was no significant association between HbA1c and blood pressure, suggesting that factors beyond glycemic control may play a dominant role in determining hypertension in diabetics. Conversely, Song et al. (2020) identified increasing HbA1c as a potential risk factor for hypertension, implying that persistent hyperglycemia may promote vascular rigidity through glycation of arterial walls and endothelial dysfunction. Supporting this view, Huang et al. (2023) in a prospective cohort study demonstrated a positive association between HbA1c and blood pressure, reinforcing the concept that chronic poor glycemic control contributes to gradual vascular changes that predispose patients to hypertension.These contrasting findings across studies may be explained by differences in sample size, population characteristics, genetic factors, study design, and control for confounders. It is plausible that in certain populations, the effects of HbA1c on blood pressure are mediated by obesity, insulin resistance, or systemic inflammation—variables that were not measured in the current research. Additionally, variability in medication use (such as antihypertensives

or hypoglycemics) and dietary patterns could also account for the absence of a direct correlation between HbA1c and blood pressure.The lack of statistical significance in this study may be attributable to unmeasured confounding variables that were not comprehensively assessed, such as education level, socioeconomic status, dietary habits, physical activity, smoking history, and dyslipidemia (Nawi et al., 2021).

These factors have been widely recognized as critical determinants of both glycemic control and blood pressure regulation. For instance, lower educational attainment and limited health literacy can lead to suboptimal disease management and medication adherence. Socioeconomic disparities may influence access to healthcare, quality of diet, and opportunities for physical activity, which in turn affect metabolic outcomes. High sodium consumption, sedentary lifestyle, and smoking are well-documented risk factors for hypertension, while dyslipidemia commonly coexists with T2DM and accelerates atherosclerotic processes that increase vascular stiffness and elevate blood pressure.Although the study attempted to control for some confounding factors through its exclusion criteria—such as omitting patients with acute complications, chronic renal failure, or hyperthyroidism—the elimination of clinical comorbidities alone is insufficient to fully isolate the metabolic and behavioral influences on blood pressure. Consequently, the clinical exclusion of comorbidities does not guarantee control of lifestyle-related or subclinical risk factors, which could still distort the observed associations between HbA1c and hypertension.The cross-sectional design of this research inherently imposes limitations on establishing causal relationships between glycemic control and blood pressure outcomes. Because data were collected at a single point in time, it is impossible to determine the temporal sequence—whether elevated HbA1c contributes to hypertension, or whether hypertension exacerbates poor glycemic control through stress-induced hormonal and renal mechanisms. Longitudinal or prospective cohort designs would be more effective in clarifying the directionality of these associations and in capturing long-term metabolic trajectories.

Additionally, the sample size of 90 participants, although adequate for preliminary analysis, may not have provided sufficient statistical power to detect subtle associations between variables. The absence of stratification by treatment regimen, BMI, or comorbidities could have further diluted potential relationships. Moreover, the study did not evaluate medication use, such as antihypertensive or lipid-lowering drugs, which might have confounded the blood pressure readings and HbA1c values. Future research should incorporate a more comprehensive assessment of pharmacological therapy, anthropometric indicators, dietary intake, and physical activity levels to better capture the multifactorial nature of hypertension in diabetes.Despite these limitations, this study provides important insight into the profile of patients with uncontrolled type 2 diabetes in Indonesia, illustrating that a substantial proportion exhibit pre-hypertension or hypertension even in the absence of a clear correlation with HbA1c levels. This finding underscores the need for integrated patient management approaches, emphasizing both glycemic and blood pressure control, along with lifestyle interventions and regular monitoring. The results contribute to the ongoing debate regarding the independent and combined effects of hyperglycemia and hypertension in determining cardiovascular risk among diabetic populations.Ultimately, while HbA1c remains a key biomarker for evaluating glycemic control, its relationship with hypertension appears to be context-dependent and influenced by numerous interacting variables. Future studies should employ larger sample sizes, longitudinal designs, and multivariate models to explore these complex interactions. Understanding how these factors intersect will be vital in developing effective prevention and treatment strategies for patients living with both diabetes and hypertension.

IV. CONCLUSION

This study concludes that patients with uncontrolled type 2 diabetes mellitus exhibit a considerable prevalence of hypertension, recorded at 36.66%, while nearly half (48.89%) are in a pre-hypertensive state. These findings indicate that a large proportion of individuals with poor glycemic control are already at risk for developing hypertension, reinforcing the close clinical association between diabetes and cardiovascular complications. However, the analysis revealed no significant difference in hypertension prevalence between males and females, suggesting that gender alone may not be a determining factor once diabetes becomes uncontrolled.Furthermore, the study found no statistically significant relationship between blood pressure

and HbA1c levels, indicating that short-term glycemic instability may not directly influence blood pressure variation among diabetic patients. Similarly, no correlation was observed between the duration of diabetes and blood pressure, which may reflect individual differences in disease management, medication adherence, or lifestyle factors.Finally, no difference in blood pressure was identified between moderate and poor glycemic control groups, suggesting that hypertension in diabetic patients may be influenced more by multifactorial determinants—such as age, obesity, dyslipidemia, or lifestyle—than by HbA1c alone. Overall, these results underscore the importance of comprehensive management strategies addressing both metabolic and cardiovascular risk factors in patients with type 2 diabetes mellitus.

V. SUGGESTION

There is substantial confusion in the determination of HbA1c, as evidenced by the inconsistent connection between the two. What is more crucial, though, is that co-existence—the coexistence of diabetes mellitus and hypertension—has the potential to worsen coronary artery disease, which raises the risk of cardiovascular death and morbidity. Due to the strong correlation between the two phenomena and macro- and microvascular problems, patients who have both disorders may be at higher risk of vascular-related adverse outcomes than those who only have one. Consequently, it is crucial and critical for DM patients to have appropriate blood pressure regulation.

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