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CORRELATION OF PROTEINURIA AND GLUCOSURIA LEVELS IN TYPE 2 DIABETES MELLITUS IN KAMPUNG KLUMPANG, NORTH SUMATRA

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Abstract

Diabetes mellitus is the sixth cause of death worldwide, with 90% of cases being type II diabetes mellitus (T2DM), which is characterized by decreased insulin response and increased insulin resistance. T2DM patients have a higher risk of complications and worse health outcomes due to Glucosuria and proteinuria. This study investigated the relationship between proteinuria and diabetes mellitus, which is a relatively new topic in the medical literature. Although there have been previous studies regarding diabetes complications, the role of proteinuria as an early indicator in T2DM patients has not been widely explored. This study aims to improve the understanding and management of this condition by assessing the relationship between levels of proteinuria and Glucosuria in T2DM patients. This research was conducted in August 2024 at the Klumpang Village Office, Hamparan Perak. This cross-sectional study involved patients with blood glucose levels >126 mg/dL, HbA1c >6.5%, and who gave informed consent. Patients who meet the criteria are asked to provide a urine sample for measurement of proteinuria and Glucosuria using a dipstick test. Results showed that the average age of patients was ≤60 years, with a higher prevalence among women (ratio 55:44). Glucosuria and proteinuria were not detected in some patients (ratio 25:30). Among those with Glucosuria, 33.3% showed ++ levels. In contrast, the highest incidence of proteinuria was detected at trace levels (44.4%). The conclusion is that the Spearman's Rho correlation test revealed a moderate and statistically significant positive relationship between blood glucose levels, HbA1c, Glucosuria, and proteinuria ($p<0.05$). In conclusion, blood glucose and HbA1c levels are positively associated with proteinuria and Glucosuria in T2DM patients.

Keywords: HbA1c, Glucosuria, Proteinuria.

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1. INTRODUCTION

Diabetes mellitus is a chronic metabolic condition characterized by consistently elevated blood sugar levels (hyperglycemia) over an extended period (1,2). According to the World Health Organization (WHO), diabetes mellitus is the sixth leading cause of death in the world. The data reveals that approximately 1.3 million people die from diabetes, with around 4% of those fatalities occurring before the age of 70 (3). The American Diabetes Association has recommended using glycated hemoglobin (HbA1c) instead of fasting blood glucose for the diagnosis of diabetes (4). HbA1c is an important indicator of long-term glycemic control, and it can reflect the cumulative glycemic history of the previous two to three months (5). The diagnosis of diabetes indicates that HbA1c is a valuable tool for the diagnosis of diabetes if the HbA1c level is ≥6.5% (6).

Tests in patients with diabetes mellitus can also be performed using random urine samples, which include chemical tests such as glucose, protein, bilirubin, and urobilinogen (7). Urine tests can be used as a screening method, although they are less accurate than blood glucose tests (8). High glucose levels in the urine can be a sign of poorly managed diabetes, even in patients who are not experiencing ketoacidosis (9). Urine glucose tests can evaluate the kidneys' ability to filter sugar due to a lack of the hormone insulin, which causes glucose to be converted into glycogen (10).

For patients with type II diabetes (T2DM), a urine protein test is an effective method for assessing kidney function, as the presence of protein in the urine suggests damage to the kidney tubules or glomerulus (11). The level of albumin in urine is considered an indication of the onset and course of diabetic nephropathy (12). This fact suggests urine samples should be thoroughly investigated to identify proteins that could serve as diagnostic biomarkers for health issues (13). Proteinuria in individuals with diabetes mellitus, which impacts kidney function, is a common complication that typically results in a progressive decline in renal function (14). Approximately 10-50% of diabetic patients with proteinuria may eventually develop End-Stage Renal Disease (ESRD) (15). Proteinuria is a valuable indicator for predicting several diseases, including IgA nephropathy, which can lead to more severe outcomes for patients (16). So, in this study, we can investigate whether there is a relationship between proteinuria and diabetes mellitus patients, as no previous research has presented this connection. Modifications in lifestyle and sustained weight loss are strongly associated with reduced risk of developing T2DM, and these preventive benefits have been demonstrated to last for years following active intervention (17). The study aimed to analyze the correlation between proteinuria and glucosuria levels in patients with T2DM.

2. METHODS

This study was designed as an analytical study using a cross-sectional method to determine the relationship between proteinuria and glucosuria measurements in patients with T2DM in Klumpang Kampung Village, Hamparan Perak, Medan, Indonesia. The study used primary data, which was collected directly during the research at the Klumpang Village Office, Hamparan Perak, in August 2024.

This study's data collection was conducted randomly. After patients met the inclusion criteria, they were asked to sign an informed consent form. The research was approved by the Health Research Ethics Committee (KEPK) of University Prima Indonesia, number 030/KEPK/UNPRI/VIII/2024.

The tools and materials used in this study were a glucometer, blood glucose test strips, glycohemoglobin analyzer and strips, alcohol swabs, urine containers, a urinalysis reagent strip with 10 parameters, and random urine samples.

The population of this study was 68 people who came for examination at the Klumpang Village Office. All participants will initially be tested for their blood glucose levels. If a participant's level is above 126 mg/dl, they will move on to an HbA1c test. If the HbA1c value exceeds 6.5%, the patients will be requested to take a urine test. The inclusion criteria were patients with T2DM from Klumpang Village who met the following criteria: i) blood sugar level greater than 126 mg/dL, ii) HbA1c level > 6.5%, and iii) who consented to participate by signing the respondent's consent form. The exclusion criteria were patients with blood sugar levels (BGL) <126 mg/dL and HbA1c <6.5%.

Blood samples were collected from peripheral blood at one of the patient's fingertips. A sample of blood (approximately 0.3-1 µL) was then applied to the glucometer, and the result appeared on the glucometer screen after 5 seconds. If the result was high, the patient's blood was then applied to the HbA1c analyzer. After approximately 2 minutes, the result appeared on the screen.

After the patient's blood glucose level (BGL) results showed values > 126 mg/dL, the patients were requested to collect urine samples. Around 15 mL of urine samples were then gathered in sterile containers and analyzed within 15 minutes at the study locations. A reagent strip was immersed in the urine and then promptly removed, with results observed after waiting about 1-2 minutes. Urinalysis reagent strips are equipped to test for pH, protein, glucose, ketones, blood, leukocyte esterase, nitrite, bilirubin, urobilinogen, and specific gravity. In our study, we focused solely on two of these parameters: protein and glucose.

Examination of proteinuria test results: negative: it means that the increase in albuminuria is within normal limits. Trace: indicates an abnormality, with the consequence slightly rising to +1, meaning a moderate increase in albuminuria. +1 to +4 means a severe rise in albuminuria (18).

Examination of glucosuria test results: The color of the strip paper does not change: negative (-); color of the strip is turquoise, indicating 50-100 mg/dL is positive 1 (+); color of a dark green strip: indicate 101-200 mg/dL is positive 2 (++), Dark brown paper strip: indicating 201-350 mg/dL is positive 3 (+++), Dark brown paper strip: indicating >350 mg/dL is positive 4 (++++) (19).

Data were analyzed for normality using the Shapiro-Wilk test and, if normally distributed, continued with Spearman's rho test. The data were interpreted as follows: i) weak correlation (0.1-0.3), ii) moderate correlation (0.3-0.5), and iii) strong correlation (>0.5). Data were analyzed using IBM SPSS 27 for Windows, with a $p<0.05$ interpreted as statistically significant. Data analyzed were independent variables, including BGL levels and HbA1c levels, whereas the dependent variables consisted of proteinuria and glucosuria scores.

3. RESULT AND DISCUSSION

Result

From the population of 68 individuals, Data collected 36 samples diagnosed with T2DM showed a female-to-male ratio of 55:44. The highest number of individuals was in the age group of ≤60 years old (n =21, 58.3%) (Table 1).

Among the patients, 25 out of 36 with negative glycosuria and proteinuria were found, while those with glycosuria at levels of +3 and +4 had an equal number (n = 12; 33.3%). In terms of proteinuria, the highest occurrence was in trace proteinuria (n = 16; 44.4%), followed by proteinuria +2 (n = 4; 11.1%), as described in Table 2.

Based on the results of this statistical test, Spearman's rho correlation analysis showed a strong, positive, and statistically significant correlation between blood glucose levels and HbA1c, $rs(35) = 0.860$, $p < 0.05$. There was also a moderate, positive, and statistically significant correlation between blood glucose levels and proteinuria, $rs(35) = 0.461$, $p < 0.05$, as well as between HbA1c and proteinuria, $rs(35) = 0.461$, $p < 0.05$. Additionally, a moderate, positive, and statistically significant correlation was found between blood glucose levels and Glucosuria, $rs(35) = 0.399$, $p < 0.05$, and between HbA1c and Glucosuria, $rs(35) = 0.383$, $p < 0.05$. Therefore, there is a correlation between Glucosuria and proteinuria in patients with type II diabetes mellitus, as displayed in Table 3

Table 1. Characteristics of Patients with Type II Diabetes Mellitus (N= 36)

Variable	Category	N	%
Age	Age ≤60	21	58.3
	Age >60	15	41.7
Gender	Male	16	44.4
	Female	20	55.6

Source*: Primary data, 2024*

Table 2. Examination Results of Diabetes Mellitus Patients According to Characteristics (N=36)

Variable	Category	N	%
Glucosuria	Glucose negative	9	25
	Glucose ++	3	8.3
	Glucose +++	12	33.3
	Glucose ++++	12	33.3
Proteinuria	Protein negative	13	36.1
	Protein trace	16	44.4
	Protein +	3	8.3
	Protein ++	4	11.1

Source: *Primary data, 2024*

Table 3. Correlation of Blood Glucose Level, HbA1c, Proteinuria, and Glucosuria (N=36)

		BGL	HbA1c	Proteinuria	Glukosuria
BGL	r_s	1.000	.860 *	.461*	.399*
HbA1c	r_s		1.000	.461*	.383*
Proteinuria	r_s			1.000	.203
Glukosuria	r_s				1.000

Notes: BGL = Blood Glucose Level; Data showed normal distribution with Shapiro-Wilk, then it was continued with Spearman's rho test, and it was statistically significant if P <0.05 (*).
Source: *Primary data, 2024*

Discussion

In this study, it was found that women are more likely to experience diabetes mellitus, with an average age of under 60 years. Women are more susceptible to diabetes compared to men, especially if they have already gone through menopause (20).

Women with diabetes are at four times higher risk of stroke compared to those without the condition (21). Additionally, women are more prone than men to develop blindness related to diabetic retinopathy (22). Risk factors for diabetes mellitus generally emerge after the age of 45, primarily due to decreased physical activity and the age-related decline in β-cells (23). People aged 60-75 are twice as likely to develop diabetes mellitus compared to those older than 75, indicating that individuals under 60 might also face an elevated risk (24).

Hyperglycemia in diabetes mellitus is caused by increased extracellular glucose, resulting in increased glycation processes in proteins, especially haeme (25). Hemoglobin that undergoes glycation, carbamylation, or acetylation of the N-terminal chain valine amino acid (26). Hemoglobin undergoes this process called HbA1c. HbA1c is an indicator and correlates with red blood cell glucose levels during their 120-day life cycle. Intensive management of blood sugar levels can reduce HbA1c levels (27).

Increased blood sugar levels increase the risk of proteinuria due to microangiopathic complications of diabetes mellitus caused by damage to the glomerular epithelium characterized by excessive protein secretion (28). Urine dipstick tests can detect albumin-creatinine and protein-creatinine ratios with sensitivity and specificity (29). Proteinuria can be detected using

a urine dipstick if the protein level is above 30 mg/dL (30).

Chronic diabetes mellitus with proteinuria is caused by less intensive treatment and intervention to reduce blood sugar levels, increasing HbA1C, which is an indicator to predict complications of diabetic nephropathy in the form of proteinuria and poor long-term glycemic control (31).

Glucosuria is found if there is an increase in plasma glucose levels above 180 mg/dL, although sometimes it is normal. Pre- and intraglomerular pressure caused by hyperglycemia increases the glomerular filtration rate, which is characterized by diuresis and natriuresis. In the kidney's proximal tubule, hyperglycemia increases the reabsorption of glucose and salt; however, this is counteracted by a decrease in the distal tubule. Hyperglycemia-induced glycosuria is a sensitive indicator of compromised kidney function (32).

4. CONCLUSION

In conclusion, this study reveals a statistically significant positive correlation between blood glucose levels and HbA1c with both proteinuria and Glucosuria in type II diabetes mellitus patients. The analysis shows that among patients with Glucosuria, a notable proportion had elevated levels, and a significant percentage of those with proteinuria displayed trace levels. The results indicate that proteinuria may be an early indicator of diabetic complications, emphasizing its potential role in the timely assessment and management of T2DM. These findings underscore the importance of routine monitoring of urine protein and glucose levels to enhance patient care and prevent adverse health outcomes in this population.

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