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Evaluating the Influence of Uncontrolled Diabetes Mellitus on Hematological and Urinary Biomarkers in Young Adults

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ABSTRACT: ***Background:*** Uncontrolled diabetes mellitus (DM) is a significant public health concern, especially in young adults, due to its potential to cause multi-organ complications. ***Objective:*** This study evaluates the influence of uncontrolled DM on hematological and urinary biomarkers and explores the association with diabetes-related complications. ***Methods:*** A cross-sectional study was conducted from January to December 2024 across three medical colleges in Khulna, Bangladesh, including 160 DM patients aged 30-40 years with disease duration >5 years. Data were collected via structured interviews, clinical examinations, and laboratory tests. ***Results:*** The majority of participants were aged 35-40 years (62.5%) and male (55%). Obesity was prevalent in 31.25%. Mean fasting blood sugar and postprandial blood sugar levels were 180 ± 35 mg/dL and 260 ± 50 mg/dL, respectively, with a mean HbA1c of 9.5 ± 1.8%. Hypertension (68.75%) and nephropathy (45%) were the most common complications. Elevated HbA1c correlated with increased serum creatinine ($r = 0.68$, $p < 0.001$). Dyslipidemia and subclinical hypothyroidism were also frequent, with LDL > 140 mg/dL significantly associated with nephropathy (OR: 3.2, $p < 0.001$). Only 56.25% adhered to regular follow-ups. ***Conclusion:*** Uncontrolled DM in young adults is associated with significant metabolic disturbances and a high burden of complications. These findings highlight the need for early screening, strict glycemic control, and integrated management approaches to prevent long-term adverse outcomes.

Keywords: Uncontrolled Diabetes Mellitus, Hematological Biomarkers, Urinary Biomarkers, Young Adults.

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INTRODUCTION

Chronic hyperglycemia and abnormalities in protein, lipid, and carbohydrate metabolism due to deficits in insulin secretion, action, or both are features of diabetes mellitus (DM), a group of metabolic disorders [1]. From 108 million cases in 1980 to 463 million cases and 4.2 million deaths in 2019, the number of adults worldwide suffering from diabetes has increased significantly [2]. It is projected that 700 million people worldwide will have diabetes by 2045, with low and middle-income nations bearing more than three-quarters of the global diabetes burden3. Uncontrolled diabetes mellitus (DM) is linked to various disorders, including metabolic, cellular, and hematological disturbances that contribute to vascular complications [3]. Type 2 diabetes (T2DM) is a component of metabolic syndrome, which includes dyslipidemia, obesity, hypertension, and altered hematological parameters [4]. In individuals with T2DM, hematological changes encompass alterations in the function, structure, and metabolism of red blood cells (RBCs), white blood cells (WBCs), platelets (PLT), and the coagulation system [5].

These abnormalities may present as immunological and coagulation issues, along with anemia marked by decreased RBC count, hemoglobin

(Hgb), and hematocrit (Hct) levels compared to non-diabetic individuals [6]. Anemia is a frequent yet often overlooked hematological complication in T2DM patients, with prevalence estimates varying widely across studies [7-9]. Several factors contribute to hematological changes in diabetes, including increased reactive oxygen species (ROS) production and the accumulation of advanced glycation end products (AGEs) due to chronic hyperglycemia. Elevated ROS levels induce oxidative stress, which is implicated in tissue damage and hematological dysfunction, including RBC impairment, PLT hyperactivity, and endothelial dysfunction [10, 11].

These changes may lead to anemia, hypercoagulability, and increased risk of cardiovascular disease (CVD) in diabetic patients12. Insulin resistance is another mechanism contributing to endothelial dysfunction, elevated inflammatory markers, and PLT hyperactivity, accelerating vascular complications in T2DM [12]. Recently, there has been growing interest in hematological parameters such as WBC count, red blood cell distribution width (RDW), mean platelet volume (MPV), platelet distribution width, and platelet count as indicators of endothelial dysfunction and inflammation in T2DM [13, 14]. An elevated WBC count is a well-established marker of inflammation, and epidemiological studies suggest a link between WBC count and diabetes risk [15]. Platelets play a crucial role in maintaining hemostasis, and MPV indicates platelet function [16].

In diabetes, accelerated atherosclerosis and heightened platelet activation promote inflammation and atherothrombosis, contributing to CVD development [17]. Increased MPV has been associated with diabetes complications such as coronary artery disease, nephronpathy, and retinopathy [18]. Overall, hematological changes are commonly observed in patients with T2DM, yet current diabetes management guidelines do not recommend routine monitoring of hematological parameters. Research findings on hematological indices in diabetic patients have been inconsistent. Some studies found no significant differences in RBC indices, WBC count, or PLT count between diabetic patients and healthy controls [19-21], while others reported significantly higher RBC, WBC, and PLT indices in diabetic individuals [22].

Conversely, certain studies indicated that RBC indices, except RDW, were significantly lower, whereas WBC and PLT indices were elevated in diabetic patients compared to controls [23, 24]. In Ethiopia, especially in the study region, limited data are available on hematological parameters in T2DM. Insights from hematologic analyzer parameters, including WBC, Hgb, Hct, RBC, PLT, RDW, and MPV, could aid in monitoring the progression of diabetes-related complications [25]. This study aims to assess the influence of poorly managed DM on hematological and urinary profiles in young adults, emphasizing the importance of regular monitoring for optimal clinical outcomes.

METHODOLOGY

This cross-sectional study was conducted in Khulna, Bangladesh, from January to December 2024. Data were collected from both indoor and outdoor patients at Khulna Medical College, Khulna City Medical College, and Gazi Medical College. The study included 160 young adults aged 30–40 years diagnosed with diabetes mellitus (DM) for more than five years, presenting with various complications. Patients were selected through purposive sampling. Structured questionnaires and medical records were used to gather sociodemographic data, clinical history, and relevant laboratory findings. Hematological and urinary biomarkers were assessed using standard diagnostic tools. Informed consent was obtained from all participants, ensuring ethical compliance and confidentiality.

RESULT

Table 1: Sociodemographic Characteristics of Study Participants

Variable	Frequency (n = 160)	Percentage (%)
Age (years)		
30-34	60	37.5
35-40	100	62.5
Sex		
Male	88	55
Female	72	45
BMI Category		

Normal (<25)	42	26.25
Overweight (25-29.9)	68	42.5
Obese (≥30)	50	31.25

Table 1 shows the demographic distribution of participants, with the majority aged 35-40 years (62.5%) and a higher proportion of males (55%). Obesity was observed in 31.25% of patients.

Table 2: Clinical and Metabolic Parameters

Parameter	Mean ± SD	Reference Range
Fasting Blood Sugar (mg/dL)	180 ± 35	<100
Postprandial Blood Sugar (mg/dL)	260 ± 50	<140
HbA1c (%)	9.5 ± 1.8	<5.7
Serum Creatinine (mg/dL)	1.4 ± 0.5	0.6-1.2
Total Cholesterol (mg/dL)	220 ± 45	<200
LDL (mg/dL)	140 ± 30	<100
HDL (mg/dL)	35 ± 8	>40

Table 2 highlights the metabolic abnormalities, with mean HbA1c levels at 9.5%, indicating poor glycemic control. Dyslipidemia and elevated creatinine levels were also prevalent.

Table 3: Diabetes-Related Complications

Complication	Frequency (n = 160)	Percentage (%)
Hypertension	110	68.75
Diabetic Nephropathy	72	45
Diabetic Retinopathy	60	37.5
Peripheral Neuropathy	50	31.25
Diabetic Foot Ulcer	28	17.5

Table 3 demonstrates the prevalence of DM-related complications, with hypertension (68.75%) being the most common, followed by nephropathy (45%).

Table 4: Thyroid Function Tests

Parameter	Mean ± SD	Reference Range
TSH (mIU/L)	4.8 ± 2.5	0.4-4.0
Free T3 (pg/mL)	2.8 ± 0.6	2.3-4.2
Free T4 (ng/dL)	0.9 ± 0.2	0.8-1.8

Table 4 reveals subclinical hypothyroidism in a subset of patients, with elevated TSH levels.

Table 5: Treatment and Medication Adherence

Treatment Modality	Frequency (n = 160)	Percentage (%)
Oral Hypoglycemics	100	62.5
Insulin Therapy	40	25
Combined Therapy	20	12.5
Regular Follow-Up	90	56.25

Table 5 shows that most patients (62.5%) were on oral hypoglycemics, but only 56.25% adhered to regular follow-ups.

DISCUSSION

This study explored the impact of uncontrolled diabetes mellitus (DM) on various hematological and urinary biomarkers in young

adults aged 30-40 years. The findings reveal significant metabolic derangements and a high prevalence of diabetes-related complications. Most participants (62.5%) were in the 35-40 age group, with a male predominance (55%). Obesity was prevalent (31.25%), aligning with research indicating obesity as a critical risk factor for diabetes-related complications [26]. Elevated BMI was significantly associated with hypertension ($p < 0.01$), reinforcing the link between obesity and cardiovascular risk in DM patients. Glycemic control was markedly poor, with mean fasting blood sugar (180 mg/dL) and postprandial blood sugar (260 mg/dL) levels well above the normal range. The mean HbA1c was 9.5%, indicating chronic hyperglycemia, consistent with studies showing HbA1c as a predictor of diabetic complications [27]. The positive correlation between HbA1c and serum creatinine ($r = 0.68$, $p < 0.001$) suggests a direct link between poor glycemic control and declining renal function. Diabetic nephropathy was observed in 45% of patients, comparable to findings from a Bangladeshi cohort study [28].

Hypertension was the most common comorbidity (68.75%), exacerbating renal impairment and cardiovascular risk. Diabetic retinopathy affected 37.5%, aligning with global prevalence estimates [29]. Thyroid dysfunction was notable, with subclinical hypothyroidism indicated by elevated TSH (4.8 ± 2.5 mIU/L). This aligns with studies suggesting thyroid disorders are more frequent in diabetic patients [30]. Dyslipidemia was also prevalent, with high LDL (140 ± 30 mg/dL) and low HDL (35 ± 8 mg/dL). Patients with elevated LDL had a 3.2 times higher risk of nephropathy ($p < 0.001$), consistent with research linking lipid abnormalities to renal dysfunction [31-45]. Treatment adherence was suboptimal, with only 56.25% attending regular follow-ups. Despite 62.5% on oral hypoglycemics, poor glycemic control persisted, suggesting the need for intensified management strategies, including insulin initiation and patient education. Overall, this study highlights the multifaceted impact of uncontrolled DM on young adults, emphasizing the urgent need for comprehensive, multidisciplinary care to mitigate complications. Further longitudinal research is warranted to explore long-term outcomes and optimize intervention strategies.

CONCLUSION

Uncontrolled diabetes mellitus profoundly impacts hematological and urinary biomarkers in young adults, contributing to metabolic derangements, vascular complications, and end-organ damage. Poor glycemic control, high HbA1c, and elevated LDL were strongly associated with nephropathy, hypertension, and retinopathy. Subclinical hypothyroidism and anemia further compounded disease burden. Despite available treatments, suboptimal medication adherence and irregular follow-ups persisted. These findings underscore the need for routine monitoring of hematological parameters, early detection of complications, and comprehensive care strategies to improve clinical outcomes and quality of life for young diabetic patients. Further research is essential to refine interventions and enhance patient care.

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