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Anemia and Some Renal Biochemical Changes in Diabetic Patients Type2 in Baghdad Province

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Abstract

This study aimed to investigate the prevalence of anemia and its association with hematological, biochemical, and inflammatory parameters in patients with Type 2 Diabetes Mellitus (T2DM). A total of 100 participants were enrolled, including 50 diabetic patients and 50 healthy controls, with equal numbers of males and females Consisted of 50 (25 males; 25 females) for control and diabetic patients' group. Fasting blood glucose, glycated hemoglobin, complete blood count, renal function markers, C-reactive protein, and insulin resistance were evaluated using standard laboratory methods. The results showed significantly higher fasting blood glucose, glycated hemoglobin, creatinine, C-reactive protein, white blood cell count, and insulin resistance in diabetic patients compared with controls. In contrast, red blood cell count, hemoglobin concentration, and hematocrit values were significantly reduced in diabetic patients, indicating a higher prevalence of anemia. The findings suggest that Type 2 Diabetes Mellitus is associated with hematological alterations, inflammation, and impaired renal function, which may contribute to the development of anemia and increase the risk of diabetic complications.

Keywords

Type 2 Diabetes Mellitus, Anemia, Hematological Parameters, Fasting Blood Glucose, Glycated Hemoglobin.

List of abbreviations: MCV (Mean corpuscular volume), MCH (mean corpuscular hemoglobin), MCHC (mean corpuscular hemoglobincocentration), HBA1C (glycated hemoglobin), EPO (erythropoietin), RBC (red blood cell), WBC (white blood cells). CRP (c reactiveprotein), IR (Insulin resistance). ELISA = Enzyme linked immunosorbent assay ,DM diabetes mellitus

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1-INTRODUCTION

Diabetes mellitus is a long-term metabolic condition. characterized by high blood glucose levels brought on by either insufficient insulin production or inefficient insulin use by the body. Uncontrolled diabetes can eventually cause serious complications that impact the kidneys, heart, blood vessels, eyes, and nerves [Siam et al., 2024]. Insulin is attacked and destroyed by the immune system in type 1 diabetes, an autoimmune condition. Generating beta cells in the pancreas, which results in minimal or nonexistent insulin production. Although it can happen at any age, it is typically diagnosed in children and young people [Azim, 2026].

However, the pathophysiology of anemia in type 2 diabetes is complex, including multiple mechanisms Diabetic Nephropathy: Chronic kidney disease (CKD) is one of the most frequent causes of anemia in diabetic patients. The production of erythropoietin (EPO), which is necessary for the production of red blood cells (RBCs), is hampered by hyperglycemia, which causes kidney damage [Shaker, 2026].

Iron deficiency is caused by poor nutritional intake, chronic inflammation, and gastrointestinal bleeding, particularly in patients using aspirin or metformin [Hussain, 2025]. Iron deficiency is more common in those with DM1 (adults and children) and DM2.A lack of folate and vitamin B12 can result in high homocysteine levels, which are a risk factor for both macrovascular and microvascular DM problems.

Folate and vitamin B12 are essential for converting homocysteine to methionine. Diabetes-related anemia is a complicated and poorly understood etiology. The most frequent underlying cause is either decreased bone marrow responsiveness or decreased EPO secretion, either in absolute terms or in relation to the severity of anemia [Măgureanu and others,2026].

According to Rah et al. (2026), diabetes is linked to low-grade inflammation, which results in increased production of hepcidin, which inhibits iron absorption and impairs erythropoiesis. As a result, anemia in DM can be essentially viewed as a kind of chronic inflammation, Bone marrow function and red blood cell production can be directly impacted by erythropoiesis dysfunction, insulin resistance, and oxidative stress [Obeagu et al., 2024].

Effects of Medication: Certain antidiabetic drugs, such metformin, have been connected to vitamin B12 insufficiency, which can lead to anemia [Sayedali et al., 2023]. Among individuals with type 2 diabetes mellitus (T2DM), anemia is a significant problem [Barbieri et al., 2015]. Diabetes patients may develop anemia for a variety of reasons. Renal anemia appears to be primarily caused by the kidney's inability to enhance erythropoietin (Epo) secretion in response to a declining hemoglobin (Hb) level [Gwozdzinski et al., 2021], a number of theories have been put out, such as efferent denervation of the kidney brought on by symptomatic autonomic neuropathy that results in decreased erythropoietin production, chronic renal hypoxia, tubulo interstitial disease, altered iron metabolism, drugs, hyper glycaemia and systemic inflammation [Luo et al.,2025].

Anemia has been connected to the microvascular and macrovascular consequences of diabetes [Nithya et al., 2023]. The onset and development of these problems are significantly impacted by anemia [Kolarš et al., 2025]. Anemia is regarded as a significant cardiovascular risk factor and is linked to a faster fall in GFR [Xie et al., 2023]. Due to anemia, the HbA1c values are deceptively low, which results in poor hyperglycemia control and may worsen the severity of diabetes consequences [Sureshkumar, 2026].

Compared to people with diabetes but not anemia, with both conditions have a higher death rate.

Therefore, detecting and treating anemia in the early stages of diabetes may lower the morbidity and mortality associated with diabetes complications. [Mazumder and others, 2023]. Hemoglobin (Hb) values of less than 12.0 g/dl for women and less than 13.0 g/dl for men are considered anemia, according to the World Health Organization (WHO). However, normal Hb levels vary by sex, ethnicity, physiological status, and altitude [World Health Organization, 2024].

Increased production of reactive oxygen species (ROS) and advanced glycation end products (AGEs), which are directly linked to endothelial dysfunction and hematological alterations, might result from prolonged hyperglycemia. Tissue damage and hematological changes such RBC dysfunction, platelet hyperactivation, and endothelial dysfunction may result from the increased generation of oxidative stress brought on by the excessive release of ROS. Additionally, endothelial dysfunction, elevated plasma levels of inflammatory markers, elevated WBC counts, and platelet hyperactivation are linked to insulin resistance, which may cause and hasten vascular problems in T2DM patients [Das, 2023].

Hematological alterations in diabetes are closely linked to inflammation and endothelial dysfunction. Changes in the morphology, size, and physiological functions of red blood cells, white blood cells, and platelets can be linked to hyperglycemia and accompanying metabolic syndrome [Hamed, 2016]. Additionally, oxidative stress causes tissue damage, platelet loss, and RBC malfunction, all of which can impact blood cell function and hemostatic parameters and result in a number of consequences [Scridon 2022].

2-Materials and methods

Study Population

A Total Of 100 Participants were Enrolled In this Study, Divided into Two Groups:

- Diabetic Group (Patients): Consisted Of 50 (25 males; 25 females) Individuals Diagnosed with Type 2 Diabetes Mellitus, Based on American Diabetes Association (ADA) Criteria.
- Control Group: Consisted Of 50 (25 males; 25 females) Healthy Individuals Without a History of Diabetes, Matched for age and gender With the Diabetic Group.

2.2.1 Inclusion Criteria

- Diagnosed With Type 2 Diabetes Mellitus for At Least One Year.
- Age Between 40 And 60 Years.
- Both Males and Females Were Included.
- Willingness To Participate and Provide Informed Consent.

2.2.2 Exclusion Criteria

- Presence Of Type 1 Diabetes or Gestational Diabetes.
- Chronic Liver Disease, Malignancy, Or Autoimmune Disorders.
- Severe Infections or Recent Hospitalization Within the last three months.
- Use Of Iron, Erythropoietin, Or Vitamin B12 Supplements in the last three months.
- Pregnancy Or Lactation.

2.3 Ethical Considerations

The Study was Approved by the Institutional Ethics Committee. Written Informed Consent Was Obtained from All Participants Before Enrollment, and the study adhered to the ethical principles outlined in the declaration of Helsinki.

2.4 Data Collection

Demographic And Clinical Data, Including Age, Gender, Body Mass Index (BMI), And Medical history, were collected through structured interviews and medical record reviews.

2.5 Sample Collection and Laboratory Analysis

2.5.1 Blood Sample Collection

- Venous blood samples (5 ml) were collected after an overnight fast (at least 8–12 hours) from all participants.
- Samples were divided into two Aliquots: One for immediate biochemical analysis and another stored at -80°c for further investigations.

2.5.2 Biochemical Analysis: -All Biochemical Parameters Were Analyzed Using Standard Laboratory Techniques:

- Fasting Blood Glucose (FBG): Measured Using an Enzymatic Colorimetric Method.
- Glycated Hemoglobin (HbA1c): Determined by High-Performance Liquid Chromatography (HPLC).
- Renal Function Tests:
  - Serum Urea and Creatinine Were Measured Using an Automated Chemistry Analyzer.
- Inflammatory Marker:
  - High-Sensitivity C-Reactive Protein (CRP-Hs) was Quantified Using an Enzyme-Linked Immunosorbent Assay (ELISA) Technique.
- Complete Blood Count (CBC):
  - Hemoglobin (Hb), Hematocrit (PCV), Red Blood Cell (RBC) Count, White Blood Cell (WBC) Count, And Platelet Count Were Measured Using An Automated Hematology Analyzer.

2.6 Statistical Analysis

The Statistical Packages of Social Sciences-SPSS (2019) Program was used to detect the effect of difference groups (Control and Diabetic) In Study Parameters. T-Test Was Used to Significant Compare Between Means in This Study. Descriptive Statistics were used to summarize the data. Independent T-Test was applied to compare Mean Values Between Diabetic and Control Groups. P-Value ≤ 0.05 Was Considered Statistically Significant.

3-Results and discussion

Table 1: Comparison between control and Patient/Diabetic groups in Glucose and HbA1c

Gender	Group	Means ±SE	
		Glucose (mg/dl)	HbA1c (%)
Male	Control	81.74 ±3.43	4.91 ±0.18
	Patients	197.17 ±12.95	8.79 ±0.53
	T-test	30.905 **	1.305 **
	P-value	0.0001	0.0001
Female	Control	79.64 ±3.05	4.98 ±0.18
	Patients	186.58 ±13.54	7.76 ±0.51
	T-test	32.029 **	1.259 **
	P-value	0.0001	0.0009
** (P≤0.01).			

In Table 1, male patients' fasting blood glucose levels were (197.17 ±12.95 mg/dl) significantly (P≤0.01) rose when compared to the control group. (81.74 ±3.43).The HbA1c% (8.79 ±0.53) Shows Significant Increase (P≤0.01) In Comparison With Control(4.91 ±0.18).The Patients Females Fasting Blood Glucose Showed Significant (P≤0.01)Variation (186.58 ±13.54) In Comparison With Control (79.64 ±3.05).The HbA1c% (7.76 ±0.51) Was Increased Significant (P≤0.01) In contrast to the control (4.98 ±0.18). Glycated hemoglobin (HbA1c) and fasting blood glucose (FBG) levels are crucial for managing diabetes, which is still a serious health issue. Additionally, high HBA1c levels and persistent hyperglycemia affect inflammation and may change haematological parameters in diabetics. Therefore, the primary goal of this study is to evaluate and connect HbA1c and FBG levels with specific

haematological markers in patients with type-2 diabetes mellitus. Psychological stress and smoking habits are other risk factors of diabetes, which have extensively been studied in recent years (Falcow et al.,2015). In physiological conditions, stress responses are regulated by two different pathways including sympathetic nervous system for quick responses and neuroendocrine system for prolonged system.

Briefly, stress stimulus will activate hypothalamic nuclei through the correlus nucleus and stimulate the medula adrenal gland to release catecolamine hormones such as adrenaline, noradrenaline and dopamine. If the stress is persistent, the hypothalamus-pituitary adrenal axis (HPA) will be activated and the hypothalamus produces corticotropin-releasing hormone to stimulate the anterior pituitary and the cortex adrenal, releasing the cortisol hormone (Chang,2012). It was shown that light or moderate stress will induce the release of growth hormones and endorphins. Furthermore, prolonged and severe stress lead to a higher release of cortisol hormone, which can increase blood glucose level through gluconeogenesis and inhibition of insulin action. Some evidences indicated that smoking can increase inflammation and oxidative stress, resulting in interferences in pancreatic β cells function (Inomata et al.,1997). High nicotine levels in cigarettes may lead to insulin resistance by inhibition of insulin secretion. So according to the WHO [WHO], fasting blood glucose (FBG), random blood glucose, glycated hemoglobin (HBA1c) values, or an oral glucose tolerance test (OGTT) can all be used to diagnose diabetes mellitus.

Nonetheless, FBG and HBA1c are important indicators in the treatment of diabetic patients. This is due to the fact that HBA1c values reflect the integrated blood glucose concentration throughout the eight to twelve weeks prior [ADA, 2017].

Table 2: Comparison between control and Patient/Diabetic groups in CBC

Gender	Group	Means ±SE				
		RBC (10^6 /µL)	Hb (g/dl)	PCV (%)	PLT (10^3 /µL)	WBC (10^3 /µL)
Male	Control	5.03 ±0.11	14.71 ±0.44	47.59 ±1.01	236.82 ±19.22	6.62 ±0.30
	Patients	4.02 ±0.07	10.10 ±057	32.05 ±1.53	194.51 ±28.32	15.83 ±0.57
	T-test	0.303 **	1.658 **	4.215 **	58.934 NS	1.488 **
	P-value	0.0001	0.0002	0.0001	0.251	0.0001
Female	Control	5.48 ±0.18	16.09 ±0.74	41.33 ±0.81	263.14 ±34.99	7.85 ±0.90
	Patients	4.15 ±0.08	10.24 ±0.49	30.60 ±1.39	205.78 ±18.01	14.43 ±0.62
	T-test	0.464 **	2.062 **	3.720 **	70.67 NS	2.533 **
	P-value	0.0002	0.0002	0.0002	0.183	0.0003
** (P≤0.01), NS: Non-Significant.						

In Table 2 The Number Of Red Blood Cells (RBcs) In Males Diabetic Patient(4.02 ±0.07x10^6) / µl decreased Significantly(P≤0.01) in Comparison With Control (5.03 ±0.11).The hemoglobin Level(10.10 ±057 Mg/Dl) Decreased Significantly (P≤0.01) In Comparison with control (14.71 ±0.44) .The hematocrit (PCV%) 32.05 ±1.53 decreased Significantly (P≤0.01) in Comparison With Control (47.59 ±1.01).The Platelets x10^3 / µl Show non-Significant difference In Diabetic and Control Groups (194.51 ±28.32 ; 236.82 ±19.22) respectively .

Figure 5 And 6. The Wbcs15.83 ±0.57 x10^3 increased Significantly (P≤0.01) in Patients Males Group In Comparison with Control 6.62 ±0.30x10^3 / µl. The Number Of Red Blood Cells (RBCs) In Females Diabetic Patient(4.15 ±0.0) In µl decreased Significantly (P≤0.01) In Comparison With Control (5.48 ±0.18).The hemoglobin level(10.24 ±0.49mg/dl) Decreased Significantly (P≤0.01) in Comparison with Control (16.09 ±0.74) .The hematocrit (PCV%) 30.60 ±1.39 decreased Significantly (P≤0.01) In Comparison With Control (41.33 ±0.81).The Platelets X10^3 In µl Show non-Significant difference in diabetic and Control groups (205.78 ±18.01; 263.14 ±34.99) respectively .Figure 5 And 6.The WBC increased (14.43 ±0.62 x10^3) Significantly (P≤0.01) In Patients Males group In comparison With control (7.85 ±0.90x10^3) .

The RBcs, hemoglobin and pcv% were deceased significantly in both diabetic patients. Patients with diabetes frequently have their hematological markers tested. Certain parameters, like the hematocrit (HCT) level and white blood cell (WBC) count, have been linked to incident T2DM and insulin resistance. Hyperinsulinemia and other risk factors for insulin resistance, such as high blood pressure, elevated serum triglycerides, and low HDL cholesterol, are positively connected with hematocrit. Our findings concurred with those published by [Khaled et al., 2017]. Compared to the controls, the diabetes patients' hematological tests revealed noticeably decreased HCT values, hemoglobin content, RBC count, and MCV concentration.

The current investigation revealed that patients with type 2 diabetes had lower hemoglobin concentrations and higher total WBC counts. Low hemoglobin concentration may be a factor in many clinical aspects of diabetes mellitus or its progression, and anemia is rather common in DM patients. Compared to other renal disorders, low hemoglobin concentration is linked to a faster drop-in glomerular filtration rate [Rossing et al., 2004]. Diabetic characteristics and hemoglobin concentration are tightly related. Although the exact process is yet understood, anemia in diabetic people increases the kidney's vulnerability to nephropathy. It is often acknowledged that individuals with diabetes are more susceptible to the consequences of anemia (Thomas et al., 2003). Al-Khoury et al. showed that individuals with diabetes have hemoglobin levels that are 1 g/dl lower than those of the non-diabetic population for every stage of chronic renal disease [Al-Khoury et al., 2006); Khaled et al., 2017.

Anaemia is one of the important conditions among patients with type 2 diabetes mellitus (T2DM) [Thomas et al.,2003]. Diabetes patients may develop anemia for a variety of reasons. Renal anemia appears to be primarily caused by the kidney's inability to enhance erythropoietin (Epo) release in response to a declining hemoglobin (Hb) level [Inomata et al., 1997, Bosman et al., 2001]. However, a number of theories have been put forth, such as efferent denervation of the kidney due to symptomatic autonomic neuropathy, which results in decreased erythropoietin production; chronic renal hypoxia; tubulo interstitial disease; altered iron metabolism; medications; hyperglycemia; and systemic inflammation [Craig et al., 2005]. Anemia has been associated with both microvascular and macrovascular consequences of diabetes [Abate et al., 2013].

The emergence and development of these problems are significantly impacted by anemia [Thomas et al., 2003]. Anemia has significant impact on

development and progression of these complications [Thomas et al.,2003]. Anemia is regarded as a significant cardiovascular risk factor and is linked to a faster drop in GFR [Astor et al., 2002]. Anemia causes the HbA1c levels to be deceptively low, which results in poor hyperglycemia control and may exacerbate the severity of diabetic consequences [Camargo and Gross 2004]. Compared to people with diabetes but not anemia, those with both conditions have a higher death rate. Therefore, detecting and treating anemia in the early stages of diabetes may lower the morbidity and mortality associated with diabetes complication. [Astor et al.,2002]. al. 2010].

Approximately 40% of diabetic patients are affected by kidney diseases. The decreased renal function and proinflammatory cytokines are the most important factors in determining reduction of hemoglobin levels in those patients. According to the World Health Organization (WHO), anemia is defined as hemoglobin (Hb) levels of less than 12.0 g/dl for women and less than 13.0 g/dl for men but, normal Hb level varies not only with sex but also with ethnicity, physiological status and altitude [Domenica et al.,2015].Increased production of reactive oxygen species (ROS) and advanced glycation end products (AGEs), which are directly linked to endothelial dysfunction and hematological alterations, might result from prolonged hyperglycemia. Tissue damage and hematological changes such RBC dysfunction, platelet hyperactivation, and endothelial dysfunction may result from the increased generation of oxidative stress brought on by the excessive release of ROS.

Moreover, endothelial dysfunction, elevated plasma levels of inflammatory markers, elevated WBC counts, and platelet counts are all linked to insulin resistance. hyper activation that may trigger accelerate vascular complications in T2DM patients [Akirca and Elik 2019]. Hematological alterations in diabetes are closely linked to inflammation and endothelial dysfunction. Changes in the form, size, and physiological functions of red blood cells, white blood cells, and platelets can be linked to hyperglycemia and accompanying metabolic syndrome [Milosevic and Panin 2019].

Additionally, oxidative stress causes tissue damage, platelet destruction, and RBC malfunction, all of which can impact blood cell function and hemostatic parameters and result in a number of issues [Abdel-Moneim 2019]. WBC count is an independent risk factor for diabetes in young men at values well within the normal range; it was elevated in diabetic patients and is a readily accessible test. Interleukin-6 (IL-6) and C-reactive protein (CRP) are two measures of inflammation that have been linked to diabetes risk prediction in a number of epidemiological studies (Festa 2002), but not all of them (Han et al., 2012). In certain cohorts, the total peripheral white blood cell (WBC) count—a nonspecific indicator of inflammation—has also been linked to an increased risk of diabetes (Nakanishi et al., 2003).

Table 3: Effect of Gender in Urea, Creatinine and CRP-hs of Patient/Diabetic groups

Gender	Means ±SE		
	Urea (mg/dl)	Creatinine (md/dl)	CRP-hs (mg/dl)
Male	33.34 ±4.59	2.070 ±0.19	8.39 ±0.77
Female	24.74 ±2.57	1.974 ±0.17	7.43 ±0.38
T-test	12.776 NS	0.595 NS	1.991 NS
P-value	0.110	0.719	0.295
NS: Non-Significant.			

In Table (3) The Level of Urea (33.34 ±4.59 mg/dl) In males diabetic patients group shows non-significant difference (P≥0.05) in comparison with control (30.19 ±4.45). The creatinine mg/dl (2.070 ±0.19) in diabetic patient's males increased significantly (p≤0.01) in comparison with control (0.966 ±0.09). The level of urea in females' diabetic patients (43.28 ±3.08 mg/dl) shows significant difference (p≤0.01) In comparison with control (24.74 ±2.57). The Creatinine mg/dl (1.974 ±0.17) Increased Significantly (P≤0.01) in females' diabetic patients in comparison with Control (0.950 ±0.10). Figure 3;4. The C Reactive Protein (8.39 ±0.77 mg/dl) Increased Significantly (P≤0.01) In Diabetic Group Males

In Comparison with Control Group (1.84 ±0.29). The CRP-hs In Diabetic Females Was (7.43 ±0.38) When Compared with Control Group (0.802 ±0.17). Figure 5 The C reactive protein (8.39 ±0.77 mg/dl) increased significantly (P≤0.01) in diabetic group males in comparison with control group (1.84 ±0.29). The CRP-hs in diabetic females was (7.43 ±0.38) when compared with control group (0.802 ±0.17). Increased insulin resistance and decreased insulin production may result from elevated urea levels. However, it is unknown if elevated blood urea nitrogen (BUN) levels are linked to a higher risk of incident diabetes mellitus in people [Mehta et al., 2006].

Correlation between diabetic and non-diabetic patients in a tertiary hospital and examine how blood sugar levels in type 2 diabetic patients differ from those in non-diabetic control subjects in terms of serum urea and creatinine levels. The variations in serum urea and creatinine levels in type 2 diabetic patients in relation to duration of disease were studied. We studied the usefulness of estimation of the serum creatinine and urea levels in type 2 diabetics as a simple easily available tool for diagnosis and prognosis of diabetic nephropathy [Wild *et al.*,2004].

Affected kidney function resulting from type 2 DM was estimated by testing the plasma levels of creatinine and blood urea in diabetics and non-diabetic controls. Although the plasma creatinine is the more responsive index for kidney dysfunction, plasma creatinine and blood urea are well-known markers for GFR. An increment in urea value is observed whenever there was kidney damage or ineffective kidney function. Raising of urea concentration with the raising of sugar level determines that the augment blood sugar concentration results in renal damage. Research carried out by [Anjanaeyulu *et al.*,2004] had noticed that elevated urea and serum creatinine in diabetic rats indicates progressive kidney damage.The increase of CRP in both diabetic males and female's patients were observed Accumulating evidence corroborates the crucial role of inflammation in T2DM pathologies [32, Lee *et al.*,2009].

Low-grade inflammation characterized by elevated inflammatory protein levels, including C-reactive protein (CRP), is linked with T2DMpathogenesis [Kanmani, *et al.*,2019]. CRP, the typical inflammatory biomarker produced in the liver, is regulated by adipocytederived proinflammatory cytokines, including interleukin 6 (IL-6) and tumor necrosis factor a (TNF-a). The level of CRP is usually low in healthy individuals but can elevate 100- to 200-fold or higher in acute systemic inflammation and is chronically elevated in patients with T2DM. In individuals with T2DM, CRP levels range between 4.49 and 16.48mg/L and among individuals with acute systemic inflammatory response syndromes from 31.08 to 226.1mg/L. The production of CRP may be triggered by many metabolic and inflammatory factors associated with the development of T2DM, such as increased blood glucose, adipokines, and free fatty acid levels. In addition, an increased level of CRP represents a reliable predictor of vascular complications and progression of cardiovascular disease in diabetic patients [Wang et al.,2013].

WBCcount, were increased in diabetic patient which are a commonly used and widely available test, is an independent risk factor for diabetes in young men at values well within the normal

range.Several epidemiological studies (Festa 2002), but not all (Han et al.,2012), have shown links between various markers of inflammation and diabetes risk prediction, including interleukin-6 (IL-6) and C-reactive protein (CRP). Total peripheral white blood cells (WBC) count, a nonspecific marker of inf lammation, has also been suggested to be associated with diabetes risk in some cohorts (Nakanishi et al.,2003).

Table 4: Comparison between patients and control groups in parameters study of male only

Group	Means ±SE			
	MCV (Ft)	MCH (pg)	MCHC (%)	Insulin resistance (µm/ml)
Patients	80.16 ±3.01	28.64 ±1.43	36.02 ±0.50	2.668 ±0.04
Control	73.54 ±2.51	26.78 ±1.60	36.26 ±0.68	1.396 ±0.07
T-test	6.205 *	4.529 NS	1.782 NS	0.180 **
P-value	0.0498	0.3996	0.7805	0.0001
* (P≤0.05), ** (P≤0.01), NS: Non-Significant.				

The table 4 shows that MCV in patients (80.16 ±3.01) increased significantly(P≤0.05) in comparison with control (73.54 ±2.51).The MCH in diabetic and control was non-significant (28.64 ±1.43);(26.78 ±1.60).Also MCHC% was non-significant (36.02 ±0.50);(36.26 ±0.68).Insulin resistance(IR) was higher significant (P≤0.01), in diabetic patients(2.668 ±0.04) when compared with control(1.396 ±0.07).our results with increasing MCV were comparable with[Ali and. Hassan,2019],who found the results of the their study revealed that there were statistically significant differences in blood parameters such as red blood cell (RBC) and white blood cell (WBC) count, mean cell volume (MCV) level, RBC count, hemoglobin, and other red blood cell indices mean corpuscular volume (MCV), and mean corpuscular hemoglobin(MCH) were significantly lower among the Compared to the controlled diabetic group, the uncontrolled diabetic group ($p < 0.05$). While Mean Corpuscular Hemoglobin Concentration (MCHC) was significantly lower in T2DM patients when compared to healthy controls and this finding is consistent with a study achieved BY [Arkew et al.,2022]

Throughout their lives, erythrocytes were exposed to hyperglycemic circumstances, which led to a number of structural and functional alterations, including hypochromia, which is characterized by a decrease in MCHC and is frequently observed in iron deficiency anemia, thalassemia, and anemia of inflammation. [Nematu et al.,2015]. Both in hyperglycemic diabetic patients and when a sample is taken close to a glucose infusion line, which also dilutes the sample and lowers RBC and hemoglobin levels, an increase in the MCV has been noted.Blood osmolality can be altered by solutes other than glucose, such as urea and salt. Therefore, as is the case with high glucose levels, hyper or hyponatremia contributes to alterations in MCV in vitro. [Louwage et al.,2019]. The increasing with IR was agree with [Nawal et al.,2023] due to the word "diabetes mellitus" refers to a metabolic disease with multiple etiologies that is characterized by persistent hyperglycemia brought on by insufficient insulin secretion and/or action, which results in an imbalance in the metabolism of proteins, fats, and carbohydrates.

Conclusion

The findings suggest that Type 2 Diabetes Mellitus is associated with hematological alterations, inflammation, and impaired renal function, which may contribute to the development of anemia and increase the risk of diabetic complications.

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