

## Hematological and Biochemical Changes in Female Type 2 Diabetes Mellitus (T2DM) Patients Attending a Tertiary Care Hospital

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### ABSTRACT

**Background:** Type 2 Diabetes Mellitus (T2DM) is an intricately complex and heterogeneous disorder with the possibility of impacting multiple organ systems. While formulating a glycemic control strategy the hematological and biochemical alterations in diabetes patients are neglected, more so in women, where the presentation may be subtle and diffuse modifications of a more global nature. Evaluate the hematological and biochemical abnormalities in women with Type 2 Diabetes Mellitus attending a tertiary care hospital.

**Methods:** A cross-sectional study was conducted between August 2023 and September 2024, enrolling 81 female patients with type 2 diabetes mellitus (T2DM). The study assessed hematological parameters like hemoglobin, red cell indices, ESR, along with biochemistry markers such as glucose, HbA1c, lipid profile and renal function assessment both in fasting and postprandial states. Data were analyzed using SPSS version 25 and a p-value of less than 0.05 was considered significant.

**Results:** Participants showed common instances of anemia alongside an elevated ESR, with notable reductions in hemoglobin, MCH, MCHC, and an increase in RDW. Marked elevation of glycemic indices also pointed towards an inadequately controlled diabetes mellitus. There were striking features of dyslipidemia as well which included elevated triglycerides and LDL alongside decreased levels of HDL cholesterol. The participants' renal and hepatic parameters remained largely within normal limits.

**Conclusion:** Female T2DM patients exhibit a range of hematological and biochemical alterations, suggesting systemic involvement beyond hyperglycemia. Routine evaluation of these parameters may assist in early detection of complications and guide comprehensive diabetes management strategies..

**Keywords:** Type 2 Diabetes Mellitus, Hematological changes, Biochemical profile, Female patients, Dyslipidemia, Glycemic control, Anemia

### 1. INTRODUCTION

As with other chronic metabolic conditions, Type 2 Diabetes Mellitus (T2DM) is spreading around the world, especially among older and middle-aged populations. Its increasing incidence is particularly linked to genetic predisposition, obesity, dietary habits, and a sedentary lifestyle. In addition to the common challenges associated with diabetes management, women

with T2DM encounter additional pervasive complications involving multiple body systems which may progress gradually and unnoticed [1-3].

Historically, the primary focus on managing diabetes has been glucose control; however, it is now understood to have multisystem impacts. Changes in red blood cells and some inflammatory markers show changes in the blood that may reflect oxygen transport, immune system processes, and ongoing mild inflammation. Likewise, diabetes can show biochemical signs such as imbalanced lipids, altered liver enzymes, or renal markers which indicate subclinical organ damage, organ dysfunction, or low-grade inflammation decoupled from evident diabetes symptoms [4-6].

Such changes may particularly go unnoticed in women. Anemia in women is often attributed to inadequate nutrient intake, and fatigue along with other nonspecific symptoms may obscure more significant underlying metabolic disturbances. This highlights the necessity to evaluate the complete nutritional and metabolic profile of diabetic women, particularly for timely interventions to mitigate long-term complications [7-9].

This study aims to investigate these changes among female T2DM patients attending a tertiary care hospital. By identifying common trends and significant deviations, the findings may help enhance routine screening protocols and promote more comprehensive disease management.

## 2. METHODOLOGY

The purpose of this study was to assess the clinical and laboratory parameters of a sample population within a single geographical region suffering from T2DM, focusing specifically on females. It was performed from August 2023 and September 2024 at Independent Medical College Faisalabad. Prior to data collection, ethical review board clearance was attained and all sociocultural considerations were adhered to within the study framework. All aspects of the study were conducted ethically and attended to privacy, anonymity, and voluntary participation.

The study enrolled 81 female subjects diagnosed with T2DM. These individuals were selected through purposive sampling from both the outpatient and inpatient areas of the hospital. Eligibility included 35 to 70 year old women with a confirmed diagnosis of Type 2 diabetes for more than one year, without regard to treatment received. Women with active infections, malignancies, autoimmune diseases, advanced chronic kidney disease or receiving corticosteroid medications were excluded in order to mitigate confounding factors.

Informed consent having been obtained, demographic and clinical data such as age, body mass index (BMI), diabetes duration, family history, comorbid conditions, and other relevant lifestyle factors were captured through systematic interviews and medical file reviews.

Blood samples were collected after an 8-12 hour overnight fast. Some blood parameters such as hemoglobin, total leukocyte count, neutrophil and lymphocyte percentages, platelet count, and hematocrit were evaluated with an automated hematology analyzer along with the red cell indices MCV, MCH, MCHC, RDW and ESR.

The biochemical assessments comprised fasting blood glucose and postprandial blood sugar levels, glycated hemoglobin estimation (HbA1c), lipids profiling which included total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), serum creatinine, blood urea, and sodium and potassium serum electrolytes. These tests were performed with standardized enzymatic techniques and colorimetric methods in the hospital's primary lab.

All data were recorded and analyzed using SPSS (Statistical Package for the Social Sciences) version 25. Descriptive statistics were calculated for each variable. Continuous variables were expressed as mean  $\pm$  standard deviation, and categorical variables as frequencies and percentages. A p-value of less than 0.05 was considered statistically significant.

## 3. RESULT

The average age of participants was 54.2 years, with most being overweight. Over half had hypertension, and a significant portion had a family history of diabetes. Urban residency and sedentary lifestyle were predominant, reflecting common risk patterns for Type 2 diabetes in female patients.

**Table 1: Demographic and Clinical Characteristics**

Variable	Mean $\pm$ SD / n (%)
Age (years)	54.2 $\pm$ 8.9
BMI (kg/m <sup>2</sup> )	29.5 $\pm$ 4.1
Duration of Diabetes	7.8 $\pm$ 3.5 years

Hypertension	48 (59.3%)
Family history of DM	41 (50.6%)
Urban residence	57 (70.4%)
Sedentary lifestyle	52 (64.2%)
Smoking history	9 (11.1%)

Hemoglobin levels were significantly reduced in diabetic females, indicating mild anemia. MCH, MCHC, and RDW values also showed statistically significant deviations, suggesting altered erythrocyte morphology. Elevated ESR in these patients hints at low-grade chronic inflammation, commonly associated with poor glycemic control.

**Table 2: Hematological Parameters in Diabetic Females**

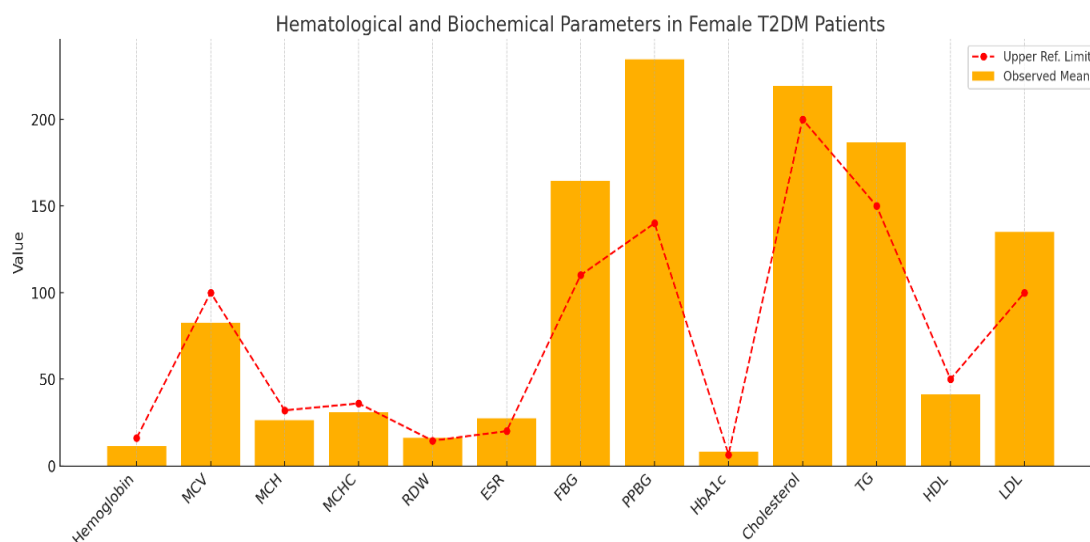
Parameter	Mean $\pm$ SD	Reference Range	p-value
Hemoglobin (g/dL)	11.4 $\pm$ 1.2	12–16	0.001*
TLC ( $\times 10^3/\mu\text{L}$ )	7.8 $\pm$ 2.1	4–11	0.092
Neutrophils (%)	64.5 $\pm$ 6.3	40–70	0.147
Lymphocytes (%)	26.8 $\pm$ 5.5	20–45	0.219
Platelet Count ( $\times 10^3/\mu\text{L}$ )	289 $\pm$ 74	150–400	0.736
HCT (%)	36.1 $\pm$ 3.4	36–46	0.042*
MCV (fL)	82.6 $\pm$ 5.1	80–100	0.368
MCH (pg)	26.3 $\pm$ 1.9	27–32	0.021*
MCHC (g/dL)	30.8 $\pm$ 1.5	32–36	0.003*
RDW (%)	16.1 $\pm$ 1.2	11.5–14.5	0.001*
ESR (mm/hr)	27.3 $\pm$ 11.2	<20	0.005*

Significant elevations were seen in fasting and postprandial glucose levels, as well as HbA1c, confirming poor glycemic control. Diabetic dyslipidemia was evident, with raised LDL, triglycerides, and reduced HDL levels all statistically significant. Electrolyte values remained within normal limits. No major alterations were seen in renal or liver markers in this cohort.

**Table 3: Biochemical Parameters in Diabetic Females**

Parameter	Mean $\pm$ SD	Reference Range	p-value
Fasting Blood Glucose (mg/dL)	164.5 $\pm$ 42.7	70–110	<0.001*
Postprandial Glucose (mg/dL)	234.6 $\pm$ 54.3	<140	<0.001*
HbA1c (%)	8.2 $\pm$ 1.3	<6.5	<0.001*
Serum Creatinine (mg/dL)	1.03 $\pm$ 0.28	0.6–1.1	0.108
Blood Urea (mg/dL)	34.9 $\pm$ 10.6	15–40	0.472
Sodium (Na <sup>+</sup> , mmol/L)	136.2 $\pm$ 3.1	135–145	0.385
Potassium (K <sup>+</sup> , mmol/L)	4.3 $\pm$ 0.4	3.5–5.0	0.241
Total Cholesterol (mg/dL)	219.4 $\pm$ 38.5	<200	0.001*
Triglycerides (mg/dL)	186.7 $\pm$ 57.9	<150	0.002*

HDL-C (mg/dL)	41.2 ± 8.4	>50	0.001*
LDL-C (mg/dL)	134.9 ± 29.6	<100	0.001*
ALT (U/L)	32.1 ± 11.7	<40	0.087
AST (U/L)	31.3 ± 10.9	<40	0.132



**Figure 1**

Bar graph comparing the observed mean values of selected hematological and biochemical parameters in female T2DM patients against their upper reference limits (dashed red line).

#### 4. DISCUSSION

This study explored the hematological and biochemical changes in female patients with Type 2 Diabetes Mellitus (T2DM), offering insights into the systemic effects of the disease beyond glycemic dysregulation.

One of the key findings was the significantly reduced hemoglobin levels in diabetic females, indicating a high prevalence of anemia. This was consistent with previous literature, reported an increased incidence of anemia in diabetics, potentially linked to renal microvascular complications and chronic inflammation. Additionally, alterations in red cell indices such as reduced MCH and MCHC, along with increased RDW, further suggest disordered erythropoiesis or iron metabolism, both of which are commonly disturbed in long-standing diabetes[10-12].

The elevated ESR observed in many patients supports the presence of subclinical inflammation, a known contributor to insulin resistance and vascular complications. Similar inflammatory trends have been noted in studies highlighting the importance of monitoring inflammatory markers as part of diabetic care [13-15].

In terms of biochemical parameters, the persistently raised fasting and postprandial glucose levels, as well as HbA1c values above 8%, reflect poor glycemic control in the majority of the patients. This finding was aligned with the studies noted that suboptimal glucose regulation is common among diabetic populations in tertiary care settings, particularly among females with sedentary lifestyles [16-18].

The lipid profile results demonstrated classical features of diabetic dyslipidemia: elevated triglycerides, increased LDL cholesterol, and reduced HDL cholesterol. These abnormalities are well-documented in the literature, attributed to insulin resistance, which alters lipid metabolism by increasing hepatic triglyceride synthesis and reducing HDL formation [19].

Interestingly, while liver enzymes and renal function tests remained within acceptable limits for most patients, continuous monitoring remains vital, as the risk of nephropathy and hepatopathy increases with disease progression. Study emphasizes the need for routine biochemical surveillance in diabetic individuals, especially women, to detect early organ dysfunction [20].

Overall, the findings underline the complex, multisystem nature of Type 2 diabetes in women. It highlights how even routine blood investigations can uncover underlying complications, which, if addressed early, can significantly reduce morbidity.

## 5. CONCLUSION

This study demonstrates that female patients with Type 2 Diabetes Mellitus exhibit significant hematological and biochemical alterations, particularly anemia, elevated inflammatory markers, and lipid abnormalities. These findings reinforce the importance of routine screening beyond glucose levels to include full blood counts and lipid profiles. Early identification and correction of these abnormalities can help in delaying complications and improving overall disease management. The integration of multidisciplinary care involving endocrinologists, nutritionists, and hematologists is essential in optimizing long-term outcomes for diabetic women..

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