Original Article

Assessment of the Alteration of Blood Indices in Patients with Type 2 Diabetic Mellitus: A Cross-Sectional Study

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Abstract

Background: The prevalence of diabetes mellitus has a major impact on national and global health. Diabetes, a noncommunicable disease, was considered one of the top ten causes of death. Diabetic patients with chronic hyperglycemia have increased risk of macrovascular and microvascular complications in the long term. Diabetes is associated with an increased risk for morbidity from anemia which leads to dysfunction and structural change in all formed elements. **Objective:** This study focused on the alteration of blood parameters in diabetic patients compared with healthy controls. **Materials and Methods:** This is a comparative study including 230 patients treated at a specialized center for endocrinology and diabetes from December 2017 to January 2018. Of the total 230 diabetic patients enrolled in this study, 46 were male and 184 were female, their age range was 20–70 years, and they were compared with 100 healthy individuals that served as control group. A questionnaire was administered as data collection form. Body mass index was estimated. Fasting blood glucose, HbA1c, and formed element indices were laboratory investigated and analyzed by using autohematology analyzer (Huroba ABX). Data were statistically analyzed using SPSS software version 17. **Results:** The results of the current 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, and red cell distribution width (RDW) level ($P \leq 0.05$), whereas no significant differences were recorded in RBC (hemoglobin, hematocrit, mean cell hemoglobin [MHC], and MCH concentration) and platelet (platelet count, MPV, and PDW) parameters ($P \geq 0.05$) when compared with the control group. **Conclusions:** The present study concluded that blood parameters such as RBCs, MCV, RDW, and WBCs are significantly higher among diabetic patients.

Keywords: Control group, diabetes mellitus, formed element indices

Introduction

According to the global estimates of the prevalence of diabetes in 2017, 451 million (age: 18–99 years) people are suffering from diabetes.[1] These statistics were expected to elevate to 693 million by 2045. It has been reported that almost half of all people (49.7%) living with diabetes (asymptomatic disease) are left undiagnosed. According to the global health estimates 2016, diabetes mellitus (DM) has been considered as one among the leading ten causes of death in low-, middle-, and upper-income countries.[2]

Nationally, Iraq is one of the 19 countries and territories of the International Diabetes Federation Middle East and North African region.[3] There were 1411.5 cases of diabetes in Iraq in 2017.[4]

DM is a symptomatic disease characterized by chronic hyperglycemia. It arises because of dysfunction of insulin secretion or dysfunction of insulin action, or both. Individuals with chronic or acute diabetes, particularly those with type 2 diabetes, are at an increased risk for myocardial infarction, stroke, and hematological disease.[5] The effects of metabolic products such as toxic chemical compounds and foreign bodies on the blood cell structure often result in change in blood parameter indices, especially, in red blood cell (RBC) indices which causes decrease in the number of erythrocytes or reduction of hemoglobin concentration, which in turn leads to different types of anemia.[6] White blood cells (WBCs) play an important role in immunity functions and phagocytic action to defend the body against foreign bodies and microorganisms.

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Platelets (thrombocytes) have a basic role in hemostasis to stop bleeding and coagulation.[7] The formed elements in medical term refer to all the blood cells, cell remnants, and cell fragments.[8]

Several studies in diabetic patients demonstrated that persistent hyperglycemia can contribute to the formation of glycation products that perform free radical damage and increase oxidative stress. Furthermore, free radicals damage the cell DNA and causes cell apoptosis, besides hyperglycemia produce pro-inflammatory cytokines as well as advanced glycation end products.[9] The metabolic products from diabetic and various diabetic complication is interaction with blood components and alter physiological function of blood parameters.[10] Therefore assessment of formed element indices can be making decision for the management and treatment of diabetic complication.[11]

Hematological abnormality such as low or elevated RBCs and hemoglobin can give indicator for anemia or polycythemia. There is a positive correlation between packed cell volume (PCV) and hemoglobin and RBCs indices and anemia in old patients.[12] Other parameters such as mean cell volume (MCV), mean cell hemoglobin (MCH) and mean cell hemoglobin concentration (MCHC) are calculated mathematically to reflect the concentration of hemoglobin and size of RBCs.[13] Diabetes often impaired the immune system of the body. Leukocytosis was correlated to the severity of infection and reduce WBCs (leukopenia) correlated to inflammatory lesion.[14,15,16] Platelets indices have a role in clotting factors and fibrinolysis activity specially in diabetic complication such as atherosclerosis and vascular disease.[17,18]

This study aimed to study the alteration of blood parameters in diabetic patients compared to healthy control.

Materials and Methods

A comparative, cross-sectional study was performed from December 2017 to January 2018. A total 230 patients were diagnosed with Type 2 diabetic mellitus compared with one hundred apparently healthy control subjects. Data were collected by using questionnaire and bio-information conduced in specialized center for endocrinology and diabetic in Baghdad city. All patients demographic features (age, sex, and residency) medical history, physical examination and anthropometric measurement such as body mass index were recorded for all subjects. Glycemic status investigated for fasting blood glucose (FPG) and HbA1c were estimated and analyzed by Bio-chemical (erauto) analyzer. Hematology auto analyzer (Huroba ABX) used to measure blood parameters such as Red cell indices, platelet indices and white blood cells (WBC) parameters (granulocytes and A granulocytes). Data were statistically analyzed using statistical package SPSS version 17 (New York, USA) in

Table 1: Distribution of the diabetic patients regarding gender and age (study and control)

Variable	Groups	Samples		Chi-square test, *P*
		Study (%)	Control (%)	
Age samples	20-29	24	18	0.09
		40	60	
		10.4	18	
	30-39	46	13	
		63.9	36.1	
		20	13	
	40-49	74	31	
		54.4	45.6	
		32.2	31	
	50-59	66	21	
		61.1	38.9	
		28.7	21	
	60-70	20	17	
		37	63	
		8.7	17	
	$\bar{x}$±SD	44.01±10.7	44.7±13.0	0.6
Gender	Male			0.2
	Frequency	46	25	
	Percentage gender	47.9	52.1	
	Percentage samples	20	25	
	Female			
	Frequency	184	75	
	Percentage gender	55.1	44.9	
	Percentage samples	80	75	
OR		Female/male (1: 1.33)		

OR: Odds ratio, SD: Standard deviation

Table 2: Distribution of the diabetic patients regarding body mass index (study and control)

Variable	Groups	Samples		Chi-square test, *P*
		Study (%)	Control (%)	
BMI	Under weight	2 (0.9)	1 (1)	0.14*
	Normal weight	36 (15)	27 (27)	
	Over weight	94 (40.9)	26 (26)	
	Obese-1	62 (27)	34 (34)	
	Obese-2	16 (7)	6 (6)	
	Obese-3	20 (8.7)	6 (6)	
$\bar{x}$±SD		29.5±6.8	28.8±6.04	0.8*

*Nonsignificant at *P*>0.05. SD: Standard deviation, BMI: Body mass index

order to analyze and assess the results of study. Descriptive statistics table (frequencies and percentage), Pearson's correlation coefficients. Statistical hypotheses which include Chi-square, Fisher's exact probability, Levene test and odds ratio for control and study.

Results

Table 1 shows the association between the two groups according to age, the result had been indicated that there was a nonsignificant differences at $P > 0.05$ for the distribution of age groups between the two samples. Table 1 shows again the association between the two groups according to gender, the result had been indicated that there was a nonsignificant differences at $P > 0.05$ for the distribution of gender between the two samples rather than odd ratio (female/male) reported (1:1.33) times at the (study/control) samples respectively.

Table 2 shows the association between the different groups according to BMI, the result had been indicated that there was a nonsignificant difference at $P > 0.05$ for the distribution of BMI groups between the two samples. In the study group, BMI ranged between (17.0 and 57.0), as well as at control BMI ranged between (18.0 and 46.0).

Table 3 shows the follows:

1. HbA1c parameter shows that with the study group, the mean value and 95% confidence interval (CI) of the population mean value fall outside of a normal range (4.5–7.0)% at the upstairs bound.
2. Glucose parameter shows that with the study group, the mean value and 95% CI of the population mean value fall outside of a normal range (3.6–6.3) mmol/L at the upstairs bound
3. All blood parameters show that with the study group, the mean value and 95% CI of the population mean value fall inside of a normal range Hb (12–16) g/dl, HCT (36–46) %, RBC (3.5–5.5) 106/mm^3, MCV (80–100) µm^3, MCH (27–32) pg, MCHC (32–36) g/dl, RDW (11–16) %, platelet (150–500) 10^2/mm^3, and some of original readings were recorded abnormal values at the upper bound in both samples.

Table 3: Descriptive statistics of the studied parameters for the mean±standard deviation (95% confidence interval) (study and control)

Parameters	Samples	SD	95% CI for mean	
			Lower bound	Upper bound
HbA1c (%)	Study	1.80	7.04	7.71
	Control	0.71	5.73	6.01
Glucose (mmol/L)	Study	2.92	6.07	7.15
	Control	0.92	5.60	5.97
Hb (g/dl)	Study	1.44	12.88	13.41
	Control	1.98	12.88	13.66
HCT (%)	Study	4.37	37.76	39.37
	Control	6.09	38.32	40.74
RBC (10^6/mm^3)	Study	0.55	4.54	4.74
	Control	0.63	4.65	4.90
MCV (fL)	Study	8.19	80.63	83.66
	Control	7.64	80.93	83.97
MCH (pg)	Study	3.17	27.92	29.09
	Control	2.95	27.06	28.24
MCHC (%)	Study	2.80	34.12	35.15
	Control	2.02	33.15	33.95
RDW (%)	Study	2.02	14.40	15.14
	Control	2.04	14.21	15.01
Platelets (10^3/mm^3)	Study	63.81	240.74	264.32
	Control	71.01	232.64	260.82
PDW (%)	Study	1.64	15.11	16.22
	Control	1.04	16.21	17.01
MPV (fL)	Study	1.053	7.12	9.15
	Control	1.15	8.24	9.97
WBCs (10^3/mm^3)	Study	2.45	6.31	8.77
	Control	1.52	5.7	8.22

CI: Confidence interval, SD: Standard deviation, RBC: Red blood cells, MCV: Mean cell volume, MCH: Mean cell hemoglobin, MCHC: Mean cell hemoglobin concentration, WBCs: White blood cells, MPV: Mean platelet volume, PDW: Platelet distribution width, RDW: Red cell distribution width, HCT: Hematocrit, Hb: Hemoglobin

The results in Table 4 represent the distribution of study patients compared with control groups according to the RBCs parameters; Hb level no significant ($P = 0.6$) and the ratio was reported (1:0.84). HCT% level was found no significant differences ($P = 0.8$) and the ratio was recorded (1:1.08). RBCs count a significant difference was found ($P = 0.04$) and the ratio was estimated (1:1.33). MCV value a significant difference was reported ($P = 0.08$) and the ratio was recorded (1:1.09). MCH level no significant differences was found ($P = 0.79$) and the ratio was recorded (1:0.92). MCHC level showed no significant differences ($P = 0.15$) when compared with the control group. RDW level statistically a significant difference was found ($P = 0.03$) and the ratio was recorded (1:2.024).

Result in Table 5 regarding platelet count no significant differences was demonstrated ($P = 0.17$) and the ratio was reported (1:0.336). PDW level showed no significant differences ($P = 0.19$) when compared with the control group. MPV level showed no significant differences ($P = 0.18$) when compared with the control group.

Table 4: Distribution of the diabetic patients regarding the red blood cells indices tests compared with control groups

Variables	Groups	Frequency and percents	Samples		FEP test, *P*
			Study	Control	
Hb (g/dl)	Normal	Frequency	188	79	0.6
		Percentage Hb	54.3	45.7	
		Percentage samples	81.7	79	
	Abnormal	Frequency	42	21	
		Percentage Hb	50	50	
		Percentage samples	18.3	21	
	OR		1: 0.84		
HCT (%)	Normal	Frequency	162	72	0.8
		Percentage HCT	52.9	47.1	
		Percentage samples	70.4	72	
	Abnormal	Frequency	68	28	
		Percentage HCT	54.8	45.2	
		Percentage samples	29.6	28	
	OR		1: 1.08		
RBC	Normal	Frequency	165	90	0.04
		Percentage RBC	55.2	44.8	
		Percentage samples	70.3	90	
	Abnormal	Frequency	65	10	
		Percentage RBC	28.6	71.4	
		Percentage samples	29.7	10	
	OR		1: 1.33		
MCV (fL)	Normal	Frequency	164	73	0.08
		Percentage MCV	52.9	47.1	
		Percentage samples	71.3	73	
	Abnormal	Frequency	66	27	
		Percentage MCV	55	45	
		Percentage samples	28.7	27	
	OR		1: 1.09		
MCH (pg)	Normal	Frequency	176	75	0.79
		Percentage MCH	54	46	
		Percentage samples	76.5	75	
	Abnormal	Frequency	54	25	
		Percentage MCH	51.9	48.1	
		Percentage samples	23.5	25	
	OR		1: 0.92		
MCHC (%)	Normal	Frequency	192	86	0.15
		Percentage MCHC	52.7	47.3	
		Percentage samples	83.5	86	
	Abnormal	Frequency	38	9	
	Lower bound	Percentage MCHC	40	60	
		Percentage samples	5.2	9	
	Abnormal	Frequency	13	5	
	Upper bound	Percentage MCHC	72.2	27.8	
		Percentage samples	11.3	5	
RDW (%)	Normal	Frequency	166	84	0.03
		Percentage RDW	49.7	50.3	
		Percentage samples	72.2	84	
	Abnormal	Frequency	64	16	
		Percentage RDW	66.7	33.3	
		Percentage samples	27.8	16	
	OR		1: 2.024		

OR: Odds ratio, RBC: Red blood cells, MCV: Mean cell volume, MCH: Mean cell hemoglobin, MCHC: Mean cell hemoglobin concentration, RDW: Red cell distribution width, HCT: Hematocrit, FEP: Fisher exact probability, Hb: Hemoglobin

Table 5: Distribution of the diabetic patients regarding the platelet indices tests compared with control groups

Variables	Groups	Frequency and percents	Samples		FEP test, *P*
			Study	Control	
Platelets	Normal	Frequency	226	95	0.17
		Percentage platelet	54.3	45.7	
		Percentage samples	98.3	95	
	Abnormal	Frequency	4	5	
		Percentage platelet	28.6	71.4	
		Percentage samples	1.7	5	
	OR		1: 0.336		
PDW (%)	Normal	Frequency	160	80	0.19
		Percentage PDW	49.7	50.3	
		Percentage samples	70.2	84	
	Abnormal	Frequency	70	20	
		Percentage PDW	60.7%	39.3	
		Percentage samples	29.8	20	
	OR		1: 1.025		
MPV (fL)	Normal	Frequency	169	75	0.18
		Percentage MPV	50.9	49.1	
		Percentage samples	72.3	74	
	Abnormal	Frequency	71	25	
		Percentage MPV	54	46	
		Percentage samples	27.7	26	
	OR		1: 1.1		

OR: Odds ratio, MPV: Mean platelet volume, FEP: Fisher's exact probability, PDW: Platelet distribution width

Table 6: Distribution of the diabetic patients regarding the white blood cell count tests compared with control groups

Variables	Groups	Frequency and percents	Samples		FEP test, *P*
			Study	Control	
WBCs	Normal	Frequency	122	85	0.04
		Percentage WBC	55.2	44.8	
		Percentage samples	53.1	85	
	Abnormal	Frequency	108	15	
		Percentage WBC	28.6	71.4	
		Percentage samples	46.9	15	
	OR		1: 0.93		

OR: Odds ratio, WBCs: White blood cells, FEP: Fisher's exact probability

Result in Table 6 regarding WBCs count a significant difference was found ($P = 0.04$) and the ratio was estimated (1:0.93).

Discussion

The result in this study had been indicated that there was a nonsignificant differences at $P > 0.05$ for the distribution of gender, age and BMI at the (study/control) samples. The result in the present study showed statistically significant differences in RBCs, WBCs count, MCV level and RDW level ($P < 0.05$) while no significant differences was recorded in others parameters ($P > 0.05$). This finding is in agreement with several studies.[19,20-22] Study made by Shukla *et al*. found higher level of total RBCs, PCV and platelets in patients with hypertensive diabetic.[23] Others studies agreement with this results.[24-26] Study performed by Kumar *et al*. showed lower significant results in diabetics RBCs, MCV, Hb and PCV than nondiabetic. Whereas WBC count was higher in diabetes compared with nondiabetic.[27] Similar results observed in others studies.[28,29] The presence of biochemical and metabolic products in diabetic patients lead to elevated level of red cell indices indicated to develop of micro and macro-vascular complication and causes different severity of anemia due to reduce erythrocytes life span, blood viscosity and RBCs deformability.[30,31]

Conclusion

The present study concluded that blood parameters RBCs, MCV, RDW, and WBCs are significantly higher among diabetic patients.

Recommendation

Screening and good diabetic management are help to prevent diabetic complications and develop anemia.

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Conflicts of interest

There are no conflicts of interest.

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