Study of Some Biochemical Parameters for Patients with Type 2 Diabetes Mellitus in Baghdad

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ABSTRACT

Type 2 Diabetes Mellitus (T2DM) is characterized by insulin resistance and biochemical abnormalities. This cross-sectional study at Al-Kindy Teaching Hospital in Baghdad evaluated 50 patients for fasting glucose, HbA1c, lipid profile, renal function, electrolytes, uric acid, and HOMA-IR. Elevated glucose (80%), HbA1c (76%), and creatinine (50%) were frequent, with dyslipidemia evident through low HDL (82%) and high triglycerides (32%). Electrolyte imbalances included hyponatremia (26%) and hyperkalemia (14%). HOMA-IR confirmed insulin resistance in 76%, correlating with poor glycemic control and lipid abnormalities. In conclusion, HOMA-IR provides stronger evidence of insulin resistance in Iraqi patients with T2DM, reinforcing its role in metabolic dysfunction and highlighting the need for early detection and management strategies.

Keywords;Type 2 Diabetes Mellitus; Lipid Profile;Renal Function;Electrolytes&Uric Acid;HbA1c

INTRODUCTION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action or both [1]. Type 2 Diabetes mellitus (T2DM) is the most prevalent form and is primarily associated with insulin resistance and relative insulin deficiency.

The diabetic patient in type 2 diabetes mellitus begins with insulin resistance, that is a metabolic abnormality characterized by impairment in the ability of insulin to produce its normal biological, physiological, or clinical effects, that the body is capable of produce insulin but this is not adequate or the body is unable to respond to its effects causes decreased insulin-stimulated glucose transport and metabolism [2].

Several parameters will be a potential guide for diagnosis which could enhance patient survival. The most important causal factor of chronic hyperkalemia in diabetic individuals is the syndrome of hyporeninemic hypoaldosteronism. Impaired renal function, potassium-sparing drugs, and Dyslipidemia is an important component of the metabolic syndrome observed in patients with type 2 diabetes, and is characterized by elevated triglycerides, increased very-low density lipoprotein (VLDL), reduced high- density lipoprotein (HDL), and qualitative changes in low- density lipoprotein (LDL). which contribute to accelerated atherosclerosis.

Cholesterol concentrations are proposed that lipid abnormalities in type 2 diabetes are secondary consequences of insulin resistance. Any approach that lowers insulin resistance would be anticipated to have a beneficial effect on dyslipidemia, but in many cases patients with type 2 diabetes fail to achieve normal lipidaemia through diet, exercise and glycemic control.

In addition, chronic hyperglycemia adversely affects renal function, leading to altered serum urea, creatinine, uric acid, and electrolyte levels due to diabetic nephropathy and osmotic diuresis.

The Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) has emerged as a widely accepted index to evaluate insulin resistance by combining fasting glucose and fasting insulin levels. Incorporating HOMA-IR provides a more accurate reflection of the metabolic disturbances underlying T2DM and strengthens the interpretation of biochemical abnormalities.

Monitoring biochemical parameters such as fasting blood glucose, HbA1c, lipid profile, renal function tests, and electrolytes is essential for assessing disease control, detecting complications early, and improving patient outcomes. However, limited local data are available regarding these biochemical alterations among Iraqi patients with T2DM, particularly in Baghdad. This study therefore aims to bridge this gap by assessing biochemical parameters alongside HOMA-IR to provide a comprehensive evaluation of metabolic dysfunction in this population.

Aim of this study

The aim of this study is to assess the levels of key biochemical parameters in patients with type 2 diabetes mellitus, including fasting blood glucose, HbA1c, blood urea, serum creatinine, lipid profile, serum sodium, potassium, and uric acid. In addition, Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was calculated to confirm the presence and extent of insulin resistance, thereby strengthening the pathophysiological interpretation of biochemical abnormalities in this population

LITERATURE REVIEW

Diabetes mellitus (DM) is a heterogeneous condition reflecting different metabolic disorders accompanied by a variety of complications. This is characterized by hyperglycemia due to

absolute or relative deficiency of insulin [3]. Lack of insulin, whether absolute or relative, affects the metabolism of carbohydrates, proteins, fats, water and electrolytes [4]. Insulin affects many sites of mammalian lipid metabolism. It stimulates synthesis of fatty acids in liver, adipose tissue and intestine.

Insulin has also been reported to increase cholesterol synthesis. The activity of lipoprotein lipase in white adipose tissue is also increased. As many as 75% of patients visiting diabetes clinics report significant gastrointestinal symptoms [5]. The global figure of people suffering from diabetes mellitus is estimated to rise from current estimate of 415 million to 642 million by 2040. The number of people with Type 2 Diabetes Mellitus (T2DM) is increasing in every country and 75% of people with DM are living in developing countries [6]. With an increasing incidence worldwide, DM will likely be a leading cause of morbidity and mortality in the future. It is well established that dyslipidemia is a major risk factor for macro-vascular complications in patients with T2DM and affects 10-73% of this population (7).

The hemoglobin A1C (HbA1c) is as often as possible utilized in individuals with T2DM as a proportion of how their glucose is controlled. HbA1c midpoints an individual's glucose levels from the past 2–3 months, and usually utilized amid starting analysis, patients with T2DM need to keep their HbA1c levels underneath 7% (essentially, at 6.5%), [8] to decrease the long-haul danger of microvascular difficulties, for example, diabetic retinopathy, nephropathy and neuropathy [8,9].

The lipid variations from the norm in patients with diabetes are assuming a critical job in the improvement of atherogenesis. These lipid issues incorporate quantitative as well as a subjective anomaly of possibly atherogenic lipoproteins. [10]

Quantitative irregularities incorporate expanded dimensions of absolute plasma cholesterol, TG, VLDL, and LDL-cholesterol and the diminished dimension of HDL-cholesterol, Qualitative variations from the nor m incorporate change in the arrangement of LDL-cholesterol (little thick LDL-cholesterol, increment TG substance and increment electronegativity of LDL-cholesterol). These progressions make LDL-cholesterol vulnerable to oxidation and glycation with significant froth cell arrangement, endothelial brokenness, and atherosclerosis. [11]. Urea is an organic compound, and it is major nitrogenous end product resulting from the metabolic breakdown of protein and amino acids, Urea is incorporated in the liver by the catalysts of the urea cycle, it is in-emitted into the circulation system and sequestered by the kidneys for discharge in the urine. [12].

Creatinine (Cr) is a break-down product of creatine phosphate in muscle and is typically delivered at a genuinely steady rate by the body (contingent upon bulk), It is an unexpectedly framed cyclic subordinate of creatine. Creatinine is essentially sifted through of the blood by the kidneys (glomerular filtration and proximal cylindrical discharge). If the sifting of the kidney is insufficient, creatinine blood levels rise. In like manner, creatinine levels in blood and urine may be used to figure the Cr slack, which reflects the glomerular filtration rate (GFR) [13].

Uric acid (UA) is the final result of purine digestion in people, overabundance serum gathering can prompt different sicknesses, and most quiet UA is caused of gouty joint pain [14]. Many investigations have recommended that hyperuricemia is related to an expanded danger of episode cardiovascular occasions and passing in both non-diabetic and T2DM people [15].

Electrolytes imbalance is common in patients with diabetes, which could be the result of an altered distribution of electrolytes and it is related to hyperglycemia-induced osmotic fluid shifts or of total-body deficits brought about by osmotic diuresis [16]. Insulin-mediated glucose intake is impaired, but the potassium intake of cells remains normal. Hyperkaliemia occurs due to increase in plasma tonicity that results from redistribution of potassium from intercellular space to extracellular space in patients with T2DM. Moreover, DM produces dysnitremia via several underlying mechanisms.

Recent studies indicate that poor glycemic control is strongly associated with dyslipidemia, renal impairment, and electrolyte disturbances in patients with T2DM. Insulin resistance promotes hepatic overproduction of VLDL and triglycerides while reducing HDL levels. Diabetic nephropathy alters sodium and potassium handling and reduces uric acid excretion, predisposing patients to electrolyte imbalance and hyperuricemia. These biochemical abnormalities significantly increase cardiovascular and renal morbidity.

METHODOLOGY

This study was designed as a descriptive cross-sectional study conducted at the Diabetic Center, in AL-Kindy teaching Hospital in Baghdad (specialized center of endocrinology and diabetes) in Decembre 2024 after taking approvement from the director of this center.

The study did not include a healthy control group; biochemical results were compared with standard laboratory reference ranges.

A total of fifty cases of type 2 diabetes were recruited after taking their consent, using a convenience consecutive sampling method. Due to the exploratory nature of the study no formal sample size or power calculation was performed, questioner was given to every case included in this study being filled by students participating in this research.

The diagnosis of T2DM was established according to American Diabetes Association (ADA) diagnostic criteria. Disease duration was recorded because of its strong influence on biochemical and metabolic parameters.

Inclusion Criteria:

Patients aged ≥20 years diagnosed with type 2 diabetes mellitus.

Exclusion criteria:

Type 1 diabetes mellitus, Obvious cognitive disorders, Patients suffering from any other disease, Patients with blood diseases., pregnancy, or any acute or chronic illness other than diabetes that could affect biochemical results.

Information regarding comorbid conditions (hypertension, cardiovascular disease) and medications (insulin, oral hypoglycemic agents, antihypertensives, statins, diuretics) was collected, as these factors may influence lipid profile, renal function, uric acid, and electrolyte levels.

Sample Collection

Blood sample collection: Preparation of Blood Samples five milliliters of blood samples were taken from patients in the morning after 12 hours fasting. Blood sample were left for 20 minutes at room temperature, after blood coagulation, the samples were centrifuged at 3000 xg for 15 minutes and hemolyzed samples were discarded. The samples were transferred directly into gel tubes and allowed to coagulate for 10 minutes at room temperature; the tubes were centrifuged at 3000 (rpm). Serum for each sample was stored in clean Eppendorf tubes and all tubes were kept at - 20C until analysis. Biochemical parameters were measured using Cobas automated analyzers (Germany) following manufacturer instructions:

•Glucose, urea, creatinine, lipid profile, and uric acid: enzymatic colorimetric methods

•HbA1c: standardized immunochemical method

•Sodium and potassium: ion-selective electrode method

All results were interpreted using laboratory-specific reference ranges, and routine internal quality control procedures were applied.

"Insulin levels were measured using immunoassay, and HOMA-IR (Homeostatic Model Assessment of Insulin Resistance) was calculated using the formula: HOMA-IR = [Fasting Insulin (µU/mL) × Fasting Glucose (mg/dL)] / 405. This index was included to confirm the presence of insulin resistance in patients with type 2 diabetes mellitus."

Statistical analyses:

Statistical analysis was performed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

The Chi-square test was used to evaluate associations between categorical variables, and statistical significance was set at $p < 0.05$. Due to the absence of a control group, inferential comparisons for continuous variables were limited, which is acknowledged as a study limitation.

RESULTS AND DISCUSSIONS

Fifty cases of type 11 diabetes mellitus were included in this study of them 23 male (46%) and 27 female (54%) with male to female ratio 1:1.1 as shown in table 2.1, figure 2.1

Table 2.2 shows the distribution of cases according to age groups, it was shown that most of cases were among 60> age group,22 cases(44%)15 of them(30%)were male and 7(14%) were female followed by 50-59 year of age ,13 cases(26%) of them 4 cases (8%) were male and 9(18%) were female ,regarding age group 40-49 year of age only 8 cases(16%) 2(4%) were male and 6 (12%) were female. Six cases (12%) were among 30–39year age group of them 2(4%) were male and 4(8%) were female. Only1female (2%) was among 20-29 year of age.

Mean age was 55.22 years ± SD 12.73 ranges from 27-70 years of age.

Duration of illness was included in this study it was found that 19 cases (38%) had diabetes mellitus more than 10 years and 14 cases (28%) had diabetes mellitus 6-10 years and 12 cases (24%) had 1-5 years duration of their illness, while 5 cases (10%) had less than 1 year duration of illness as shown in table 2.3and figure 2.2.

Diabetic complications were included in this study; it was shown that 44 cases (88%) had complications while 6 cases (12%) had no complications as shown in table 2.4

Regarding chronic symptoms 18 cases (36%) had constant fatigue while 18 cases (36%) had excessive thirst and 14 cases (28%) had frequent urge to urinate as shown in table 2.5

Thirty-three cases (66%) had no heart problems and 17(34%) had heart problems as shown in table 2.6. Regarding eye problems it was noticed that 29cases (58%) had eye problems while 21cases (42%) had no eye complications as shown in table 2.7.

Table 2.8 shows distribution of diabetic cases included in this study according to kidney problems it revealed that 36 cases (72%) had no kidney problems and 14 cases (28%) had kidney problems. Asking the participants in this study about nerve problems it was noticed that 33(66%) of cases had no nerve problems while 17(34%) had nerve problems as shown in table 2.9.

Fifteen participants (30%) in this study had hypertension as well as diabetes and 35 (70%) had no hypertension these findings reported in table 2.10. Regarding playing sports, it was shown that 46(92%) were playing sports once weekly and only 4 (8%) were playing sports twice weekly as shown in table 2.11

Eating sweets was included in this study it was noticed that 32 cases (64%) were eating sweets once a day and 13 cases (26%) were eating sweets twice a day and 5 cases (10%) were eating sweets three times a day as shown in table 2.12.

Table 2.13 show the serological parameters that had been made to every Diabetes Mellitus case included in this study mean blood glucose reading was 203.588+103.1052 SD, mean blood urea reading was 35.81316+27.733401SD, mean serum creatinine was 1.08696+0.550517 SD, mean serum triglyceride was 147.8692+64.48204 SD, mean serum cholesterol was

156.7098+38.98672 SD, mean HDL was 45.9812+13.90818 SD, mean HbA1c 7.394+2.4287SD, mean serum Na 140.1598+13.85582SD, mean serum K was 4.5884+0.95210 SD and mean serum uric acid 5.2430+ 1.28624 SD.

Table 2.14 and figure 2-3 show the normal and abnormal readings of parameters according to the laboratory cut off readings it was shown that 40(80%) of cases had high blood glucose reading and 25 cases (50%) had high serum creatinine level and HbA1c readings 38 cases (76%) had high readings. These findings were statistically significant.

Biochemical abnormalities were interpreted relative to laboratory reference ranges rather than a matched control group. Elevated blood glucose and HbA1c levels were the most prevalent abnormalities, indicating poor glycemic control in the majority of patients. Uric acid levels were mostly within normal range, with a subset of patients showing hyperuricemia, rather than a generalized decrease. This clarification ensures consistency between tables and text.

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Results:

Table 2.1 Distribution of cases according to Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	23	46.0	46.0	46.0
	female	27	54.0	54.0	100.0
	Total	50	100.0	100.0	

Figure 2.1 Distribution of cases according to sex

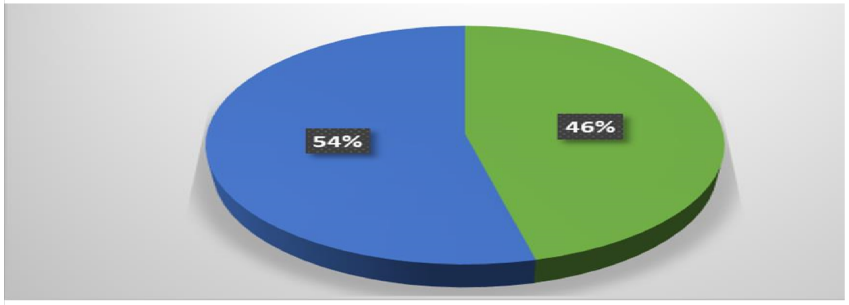

Table2.2 Distribution of cases according to age groups

Age	Frequency				Percent		Frequency	Percent
Age Group(year)	**Male**	**%**	**Female**	**%**	**Total**	**%**		
20-29	**0**	**0**	**1**	**2**	**2**	**2**		
30-39	**2**	**4**	**4**	**8**	**6**	**12**		
40-49	**2**	**4**	**6**	**12**	**8**	**16**		
50-59	**4**	**8**	**9**	**18**	**13**	**26**		
60>	**15**	**30**	**7**	**14**	**22**	**44**		

Age means 55.22 years ± SD 12.73 ranges from 27-70 years of age .

TABLE2-3 DISTRIBUTION OF CASES ACCORDING TO DURATION OF ILLNESS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 1 year	5	10.0	10.0	10.0
	1-5 year	12	24.0	24.0	34.0
	6-10 years	14	28.0	28.0	62.0
	more than 10	19	38.0	38.0	100.0
	Total	50	100.0	100.0	

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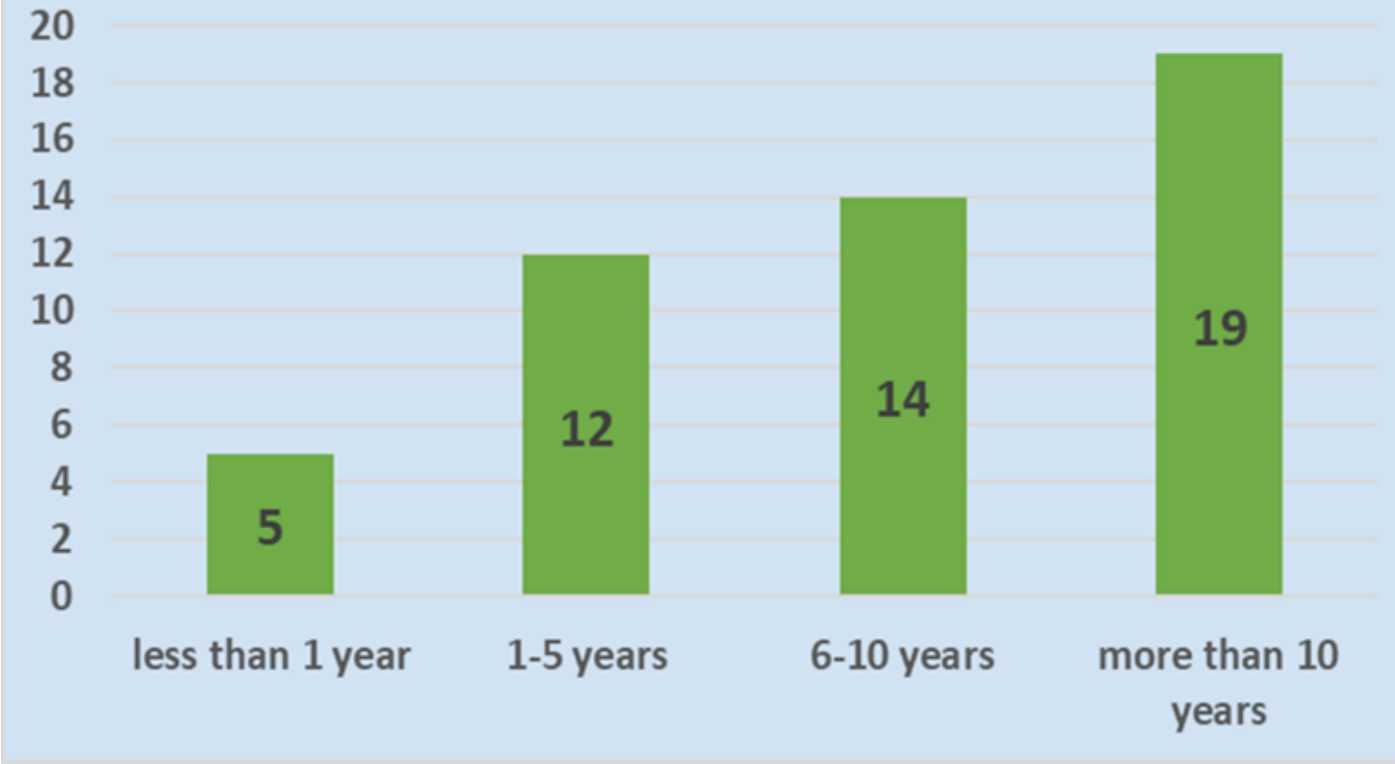

Figure 2.2 Distribution of cases according to duration of illness

TABLE2-4 DISTRIBUTION OF CASES ACCORDING TO COMPLICATIONS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	44	88.0	88.0	88.0
	No	6	12.0	12.0	100.0
	Total	50	100.0	100.0	

TABLE 2.5 DISTRIBUTION OF CASES ACCORDING TO CHRONIC SYMPTOMS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	constant fatigue	18	36.0	36.0	36.0
	excessive thirst	18	36.0	36.0	72.0
	frequent urge to urinate	14	28.0	28.0	100.0
	Total	50	100.0	100.0	

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Table 2.6 Distribution of cases according to heart problems :

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	17	34.0	34.0	34.0
	No	33	66.0	66.0	100.0
	Total	50	100.0	100.0	

Table 2.6 Distribution of cases according to heart problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	17	34.0	34.0	34.0
	No	33	66.0	66.0	100.0
	Total	50	100.0	100.0	

Table 2.7 Distribution of cases according to eye problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	29	58.0	58.0	58.0
	No	21	42.0	42.0	100.0
	Total	50	100.0	100.0	

Table 2.8 Distribution of cases according to kidney problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	14	28.0	28.0	28.0
	No	36	72.0	72.0	100.0
	Total	50	100.0	100.0	

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Table 2.9 Distribution of cases according to nerve problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	17	34.0	34.0	34.0
	No	33	66.0	66.0	100.0
	Total	50	100.0	100.0	

Table 2.10 Distribution of cases according to Hypertension

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	15	30.0	30.0	30.0
	No	35	70.0	70.0	100.0
	Total	50	100.0	100.0	

Table 2.11 Distribution of cases as Play Sport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Once	46	92.0	92.0	92.0
	Twice weak	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Table 2.12 Distribution of cases according to frequency of eating sweets

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Once a day	32	64.0	64.0	64.0
	Twice a day	13	26.0	26.0	90.0
	Three times a day	5	10.0	10.0	100.0
	Total	50	100.0	100.0	

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Table 2.13 Distribution of cases according serological parameters

	N	Minimum	Maximum	Mean	Std. Deviation
Age	50	27	70	55.22	12.730
Blood Glucose	50	75.6	639.0	203.588	103.1052
Urea	50	12.600	210.858	35.81316	27.733401
Creatinine	50	0.000	3.000	1.08696	.550517
Triglyceride	50	52.00	399.09	147.8692	64.48204
Cholesterol	50	89.01	238.00	156.7098	38.98672
HDL	50	29.00	96.00	45.9812	13.90818
HbA1c	50	0.8	12.9	7.394	2.4287
Na	50	75.00	164.00	140.1598	13.85582
K	50	2.40	7.64	4.5884	.95210
Uric Acid	50	2.30	8.11	5.2430	1.28624
HOMA-IR	50	1.2	9.8	3.9	1.8

HOMA-IR N=50 Min=1.2 Max=9.8 Mean=3.9 SD=1.8

Table 2.14 Distribution of cases according to normal or abnormal readings of parameters

	N	Normal	%	Below normal	%	Above normal	%
No. of Cases	50						
Blood Glucose	50	9	18	1	2	40	80
Blood Urea	50	42	84	1	2	7	14
Serum Creatinine	50	22	44	3	6	25	50
Serum Triglyceride	50	27	54	7	14	16	32
Serum Cholesterol	50	39	78	1	2	10	20
HDL	50	8	16	41	82	1	2
HbA1c	50	12	24	0	0	38	76
Serum Na	50	30	60	13	26	7	14
Serum K	50	39	78	4	8	7	14
Serum Uric Acid	50	39	78	3	6	8	16
HOMA-IR	50	12	24	-	-	38	76

X2 355.03 df 18 p value 0.05 statistically significant

HOMA-IR 50 Normal=12 (24%) Above normal=38 (76%)

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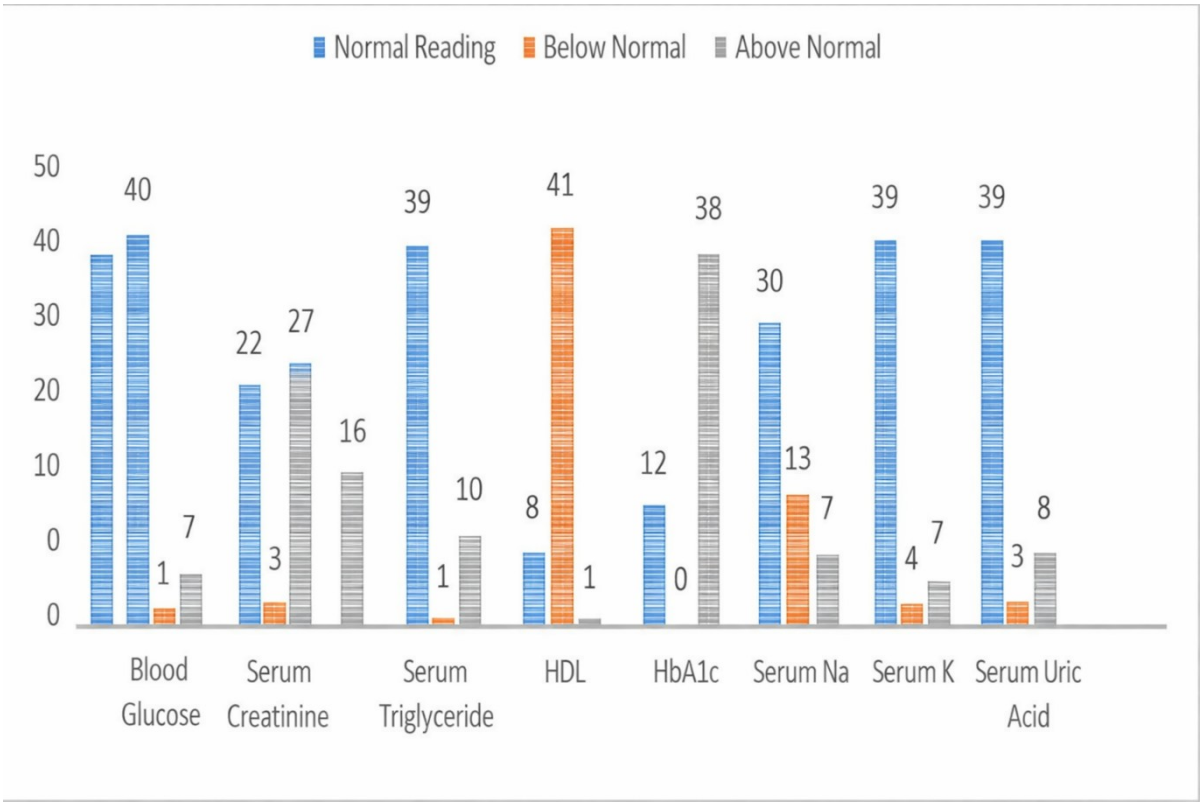

Figure 2.3 Distribution of parameters according to the parameter's readings

Discussion:

The primary energy source that the cells utilize is glucose. However, without insulin, glucose cannot enter the cell. An adequate quantity of insulin is created by a pancreas that is operating adequately to transport glucose into cells. Little to no insulin is created by a defective pancreas, or the bodily cells may not respond to the insulin that is produced. As a result, glucose accumulates in the blood, its concentration rises, and diabetes mellitus results (Emanual et al 2009) [17].

In this study the results have proven that Women are more likely to develop type 2 diabetes compared to men, The present study showed that prevalence of T2DM in women is higher than men. Estrogen and gonadal hormones alterations which changes of immune cells function represented a best justification for increasing disease probability in women than men, this agreed with (Zhang et al, 2002) (18), who suggest that estrogen hormone control the liver production of glucose and in diabetic women this hormone boost the influx of glucose from liver. The results of current study along the lines of other studies (Stoian et al, 2015; Ferdi et al, 2018, Hawraa et al, 2021) (19,20,21) that showed the higher percentage of T2DM patients in women.

As for referring to the age factor, we find in this study that type 2 diabetes is common among people over the age of 40 years. This reflects the chronic nature of T2DM and its increasing prevalence with age due to insulin resistance, decreased physical activity, and dietary factors. This result was agreed with (Saddam et al 2019) [8].

A significant proportion of patients (66%) had T2DM for more than 6 years, with 38% having the disease for over 10 years. Longer disease duration is associated with higher risks of complications, as seen in this study. This highlights the need for early detection, lifestyle interventions, and strict glycemic control to prevent long-term complications. This result agrees with a study in Babil done by (Hayder et al at 2014) [9].

Diabetic Complications and Chronic Symptoms was included in this study it was shown that 88% of patients had complications. The most reported chronic symptoms were constant fatigue (36%), excessive thirst (36%), and frequent urination (28%), which are classic symptoms of poor glycemic control and insulin resistance. This agreed with a study done by (Aseel et al 2019) [10]. These complications emphasizing the progressive and multi-systemic impact of diabetes.

Studying Prevalence of Diabetes-cardiovascular complications, it was shown in this study that 34% of patients had heart problems, and 30% had hypertension, this is agreed with a study done by (Mohammed, AA et al 2013) [11] while a study done by (Subodh Verma et al 2023) [12] in Middle East revealed that 88.6% had heart disease and 71% had hypertension.

The cardiovascular complications are common comorbidities in diabetes due to the effects of hyperglycemia on blood vessels and lipid metabolism.

Eye Complications was found in 58% of patients, while in a study done by (Mohammed Al Ashoor et al 2023) [13] in Basrah it revealed that 30.5% of diabetic cases had eye complications. likely due to diabetic retinopathy caused by prolonged hyperglycemia and poor vascular health.

Kidney and Nerve complications was included in this study it revealed that 28% had kidney problems, while 34% had nerve complications (diabetic neuropathy) this is higher than a study in Kurdistan done by (Nojdar Salahuddin et al 2020) [14] it revealed that kidney problems 14.2% and diabetic neuropathy 6.5%. These complications highlight the importance of renal function monitoring and neurological assessment in diabetic care.

Physical Activity had been included in this study it was shown that 92% of patients reported playing sports only once a week, indicating low levels of physical activity which is a major risk factor for poor glucose control, while in a study made by (Jawdat et al 2020) [15] in Kurdistan Iraq it was noticed that 75.5% 0f diabetic patients included in the study were had high level of physical activity

Sixty four percent of patients consumed sweets at least once a day, with 36% consuming sweets twice or more daily, this is agreed with a study made by (Ehab et al 2019) [16]. The high consumption of sweets (glucose-rich food) contributes to poor glycemic control and metabolic dysfunction, worsening diabetes outcome.

Serological Parameters and Glycemic Control had included in this study, it was shown that the mean blood glucose level was 203.6 mg/dL and HbA1c Mean = 7.39%: About 76% of patients had abnormal HbA1c levels, which is significantly high, this result was slightly lower than a study done by (Hanen et al 2022) [17], indicating poor long-term glycemic control.

Lipid Profile had been included in this study it revealed that Cholesterol Mean = 156.7 mg/dL: 20% had high cholesterol, increasing cardiovascular risk. Triglycerides Mean = 147.8 mg/dL: 32% had elevated triglycerides, which contributes to metabolic syndrome. HDL Mean = 45.9 mg/dL: 82% had low HDL (“good cholesterol”), which is a strong indicator of cardiovascular risk, the results in the present study agreed with another study made by (Alaa W. Qader et al 2022) [18].

Renal Function Tests had been studied, it was shown that Creatinine Mean = 1.08 mg/dL: 50% had abnormal levels, indicating possible kidney impairment and Blood Urea Mean = 35.8 mg/dL: 14% had elevated levels, further supporting concerns about renal function. A similar finding was reported in other studies that agreed with our data (Alaa W. Qader et al 2022, Ateka Qahtan Qaddoori et al 2024) [18,19].

The results demonstrated that elevation of Blood urea and creatinine were may be due to the tiny blood vessels and tiny filters in the kidneys may be impaired by elevated blood glucose levels. leads to dysfunction of these vessels, causing abnormal amounts of creatinine and BUN would notice in the blood. [20].

Sodium (Na) Levels had been studied it revealed that the mean Serum Sodium = 140.16 ± 13.85 mmol/L and 60% of patients had normal sodium levels, while 26% had below-normal levels, and 14% had above-normal levels this is lower

than a study made by (Alyaa et al in Thi-Qar 2018) [21] that most of diabetic patients had hypernatremia's clinical Interpretation: Hyponatremia (Low Sodium, 26% Could be due to excessive urination, a common issue in uncontrolled diabetes, leading to fluid and electrolyte loss, may also result from diabetic kidney disease (DKD), where impaired kidney function causes sodium loss and Chronic use of diuretics (for hypertension or heart disease) can contribute to low sodium levels. While hypernatremia (High Sodium, 14%) often associated with dehydration due to excessive fluid loss from polyuria (frequent urination) in diabetes this could indicate poor hydration habits or a sign of worsening renal dysfunction.

Potassium (K) Levels had been included in this study it was shown that the mean Serum Potassium = 4.58 ± 0.95 mmol/L and 78% had normal potassium levels, while 8% had below normal levels, and 14% had above-normal levels while in a study made by Alyaa et al [21] it revealed that most of diabetic patients had hyperkalemia.

The Clinical Interpretation of our result hypokalemia (Low Potassium, 8%) is common in diabetic patients on insulin therapy, as insulin drives potassium into cells, lowering blood levels and frequent urination and osmotic diuresis (fluid loss due to high blood sugar) can lead to potassium depletion which can cause muscle weakness, fatigue, and cardiac arrhythmias, requiring correction. While Hyperkalemia (High Potassium, 14%) may result from diabetic kidney disease (DKD), as impaired kidney function reduces potassium excretion and this could be linked to the use of ACE inhibitors or ARBs, medications often prescribed for hypertension and diabetic nephropathy, Severe hyperkalemia can cause life-threatening cardiac arrhythmias, so regular monitoring is needed.

Uric Acid Levels had been studied it was shown that the mean Serum Uric Acid = 5.24 ± 1.28 mg/dL and 78% had normal uric acid levels, while 6% had below-normal levels, and 16% had above-normal levels, these findings were similar to a study made by (Saddam et al 2019) [8]. The clinical Interpretation: Hyperuricemia (High Uric Acid, 16%) often associated with insulin resistance, which reduces uric acid excretion. Increased uric acid levels are linked to gout, hypertension, and cardiovascular diseases, all of which are more common in diabetic patients could also indicate early-stage kidney dysfunction, where uric acid excretion is impaired. Hypouricemia (Low Uric Acid, 6%) is less common but may result from excessive uric acid excretion due to kidney dysfunction or the use of uricosuric medications.

Statistical Analysis and Clinical Significance: The χ^2 test result ($\chi^2 = 355.03$, df = 18, p = 0.05) indicates a statistically significant association between diabetes and abnormal metabolic parameters.

These findings highlight the urgent need for better diabetes management strategies, including patient education, dietary control, and regular medical check-ups.

Insulin resistance in T2DM promotes hepatic overproduction of triglyceride-rich lipoproteins and reduces HDL levels, explaining the dyslipidemia pattern observed in this study. Chronic hyperglycemia contributes to glomerular damage, leading to elevated creatinine and urea levels, as well as impaired sodium and potassium handling. “The inclusion of HOMA-IR in this study confirmed the presence of insulin resistance in the majority of patients (76% above normal). Elevated HOMA-IR values were strongly associated with poor glycemic control (high glucose and HbA1c) and dyslipidemia (low HDL, high triglycerides). This supports the pathophysiological role of insulin resistance in type 2 diabetes mellitus and strengthens the study’s findings.”

Electrolyte disturbances observed in some patients may result from osmotic diuresis, renal impairment, insulin therapy, and antihypertensive medications. Hyperuricemia may reflect reduced renal excretion secondary to insulin resistance and early diabetic nephropathy. Given the descriptive design and small sample size, conclusions regarding causality were made cautiously.

Study Limitations:

This study has several limitations, including the absence of a healthy control group, a relatively small sample size, lack of power calculation, and limited advanced statistical analysis. Medication effects and lifestyle factors may also have influenced biochemical parameters.

CONCLUSION

This study demonstrated that patients with type 2 diabetes mellitus in Baghdad exhibit significant biochemical abnormalities, including hyperglycemia, elevated HbA1c, dyslipidemia, renal impairment, and electrolyte disturbances. The addition of HOMA-IR analysis confirmed insulin resistance in the majority of patients (76%), strengthening the pathophysiological link between insulin resistance, poor glycemic control, and cardiovascular risk.

By incorporating HOMA-IR, this research provides novel local evidence that complements global findings and enhances the clinical relevance of biochemical monitoring in Iraqi populations. These results highlight the importance of integrating insulin resistance markers into routine diabetic care to improve early detection, guide therapeutic interventions, and reduce long-term complications..

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