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Renal Diseases Risk Factors among Diabetic Patients with and without Hypertension in Messelata Region, Libya

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Abstract

***Background:** Diabetes and its complications are a major growing health problem in developing countries like Libya. High blood pressure is a complication of diabetes and both diseases are independent risk factors that lead to cardiovascular and kidney diseases.*

***Objectives:** This study aims to assess the risk factors for kidney disease in type 2 diabetes (T2DM) patients with and without hypertension in the Messelata region.*

***Materials and Methods:** This study included 240 diabetics with and without high blood pressure and 120 healthy subjects of both sexes (60 males and 60 females in all groups), attending the Messelata Central Hospital. The participants' blood pressure was measured in all groups, and age, gender were recorded for all study subjects. 5 ml of venous blood was drawn to measure the levels of glucose (FBS), hemoglobin (HbA1c), urea, creatinine, uric acid, Na+, K+, Cl-, Ca++, and Phosphorus. Glomerular filtration rate (eGFR) was calculated for all subjects.*

***Results:** The statistical analysis of the results showed that 71.7% females, 75% males with diabetes, and 78.3% females, 85% males with diabetes and hypertension were in age >50 years. HbA1c was> 9% in 43.3%, 33.3% of male diabetics only and diabetes and hypertension, in 36.7% of diabetic females, and diabetic with hypertension. Serum urea and creatinine levels were abnormal in 15%, 45%, 5%, and 5% & 21.7 %, 45%, 3.3%, and 5% of males diabetic, males diabetic + hypertension, females diabetic, and females diabetic + hypertension, respectively. Serum K^+ levels were abnormal in 3.3%, 15%, and 10% of males diabetic, males diabetic + hypertension, and females diabetic + hypertension, respectively. Serum Na^+ levels were abnormal in 21.7%, 10%, 11.7%, and 13% of males diabetic, males diabetic + hypertension, females diabetic, and females diabetic + hypertension . Also, the abnormal values of eGFR were (<60 ml/min/1.73m^2) in 3.3%, 90%, 93.3%, and 3.3% of males diabetic, males diabetic + hypertension, females diabetic, and females diabetic + hypertension, respectively. Conclusion: It can be concluded that the results showed a significant changes in most of the parameters in diabetic patients with and without hypertension compared to healthy subjects. Most of these changes were more pronounced in diabetics with hypertnsion patients than diabetics patients only.*

Keywords: *Renal disease risk factors, Kidney function, Electrolytes, Diabetes mellitus, Hypertension, Messelata region Libya.*

Introduction

Diabetes is an important metabolic disorder which is characterized by hyperglycemia with a variable degree of insulin resistance, impaired insulin secretion and increased glucose levels for Type-I and Type-II diabetes mellitus [1, 2]. Type 2 diabetes mellitus (T2DM) is now a common and serious global health problem associated with older age, obesity, family

history of diabetes, physical inactivity, other unhealthy lifestyle and behavioral patterns [3, 4].

Diabetes mellitus (DM) and its complications are the major and growing public health problem around the world, involvement in a developing country like Libya [5]. Satti *et al.,* [6] reported that the incidence of diabetes is increasing at an alarming rate, with a predicted worldwide incidence of more than 640 million people by 2040. The Middle East occupies the second region after North America with the highest diabetes prevalence rates (9.3%), and this number is expected to double in <20 years [4, 7]. However, the Libyan national non-communicable diseases survey in 2009 reported a prevalence of diabetes of 16.4% [7, 8]. In the Libyan population, Type II diabetes affected >70% in Libya which is the highest prevalence in North Africa and among Arabic nations. The most possible cause is eating habit [7, 9].

Lack of awareness and poor access to quality care increase diabetes-related complications such as visual impairment and blindness, kidney failure, heart attack, stroke and features of autonomic dysfunction [4, 10, 11]. Diabetes is the most common cause of kidney failure, accounting for more than 40 percent of new cases. Even when drugs and diet can control diabetes, the disease can lead to nephropathy and kidney failure [12].

Chronic kidney disease is a significant global public health problem, with an estimated prevalence between 1.5% and 43.3% [13, 14]. The main risk factors attributed to chronic kidney disease are increased life expectancy, diabetes mellitus, and hypertension [15].

Diabetes increases the risk of hypertension, due to its negative action on the arteries, which predisposes the narrowing of them and leads to hypertension. So, from 40 to 60 percent of diabetic patients tend to suffer hypertension, while people with hypertension have a 50% increase in the risk of type 2 diabetes. Hypertension is a complication of diabetes and both diseases are independent risk factors for cardiovascular, renal, cerebral disease and peripheral atherosclerotic vascular disease. It can be estimated that between 30 and 75% of the complications of diabetes can be attributed to high blood pressure [16].

Hypertension accelerates and worsens the harmful effects of diabetes on the arteries, so those who suffer from both diseases tend to suffer more frequently from kidney failure, myocardial infarction, thrombosis and other complications [16]. In developing countries, hypertension is on the rise due to the increase in urbanization and the adoption of western lifestyles [17, 18]. Kaur *et al.,* 2016). Hypertension has been termed 'silent killer' a chronic illness with adverse effects principally involving the central nervous system, the retina, the heart and the kidneys [18, 19]. It afflicts more than one billion population worldwide and is a leading cause of morbidity and mortality [19].

Data from several renal databases identifies systemic hypertension as the second most common cause of end-stage renal disease, with diabetes mellitus being the first. In the United States, hypertension is the leading cause of end-stage renal disease in African-American patients [19-21]. The association between hypertension and chronic kidney disease is well known, considering that chronic kidney disease is the greatest cause of secondary hypertension. Hypertension can also determine the emergence of chronic kidney disease and contribute to its progression to the terminal stage. Associations between blood pressure levels and kidney function deterioration have been shown by many research studies [22, 23].

Objectives

Considering that the great relevance of diabetes mellitus in Libya has been attributed to reduced mortality related to hypertension and other cardiovascular causes, greater attention must be given to the health care delivered to hypertensive patients, to minimize the risks and profile of morbimortality among them. In addition, to our knowledge, the evidence reporting the renal and cardiovascular risk factors in type II diabetic patients with and without hypertension in Libya is very few. Therefore, the present study aimed to evaluate the kidney function parameters in T2DM patients with and without hypertension in the Messelata region.

Subjects and Methods

Study Design and Population

A cross-sectional study was conducted among 240 participants, type 2 diabetes mellitus with hypertension and type 2 diabetes mellitus patients without hypertension (each included 120 patients) and 120 participants with normal BP (normotensives) and non-diabetic, attending central hospital of

Messelata for a routine health check-up in the period over six months from the 1st of January 2018 to 30th of June 2018. To eliminate the effects of age and gender on the comparison between cases and control groups, age and gender were selected in each pair of groups as similar as possible. All the participants were residents of surrounding areas in Messelata and aged between 30–70 years. Ethical approvals and patients consent statement were taken from every one; data were collected through face-to-face interviews, using a structured questionnaire. Demographic and anthropometric data were included age, gender. Blood pressure was measured for the participants. All patients and normal participants were free from chronic degenerative diseases such as cancer or peritonitis.

Samples and Biochemical Analysis

Five ml of blood were drawn by venous puncture. The blood samples were emptied in a plain vials for biochemical tests. After clotting of blood in the plain vial, serum was separated, within an hour; by centrifugation at 3000 - 5000 g for 5 min. Serum was used for measurements of the levels of serum glucose, urea, creatinine, uric acid, Na+, K+, Cl-, calcium,and phosphorus. Biochemical studies were performed using commercially available kits from Biomeriux (France), and serum parameters were quantified according to the manufacturer's instructions.

The formula of Cockcroft and Gault equation was used to calculate eGFR [24]. eGFR (in male)=(140-age [in years])×weight (in kg)/(72×serum creatinine [mg/dl]). A companion equation for women, based on their 15% lower muscle mass (on average). eGFR (in female)=(140-age [in years])×weight (in kg)×0.85/(72×serum creatinine [mg/dl]).

Ethical Considerations

Ethical approvals were obtained from ethical committee of Libyan Academy of Science, and from Messelata Central Hospital as a point for sample collection and analysis. Informed consent was taken from all the participants prior to their inclusion in this study.

Statistical Analysis

Results were expressed as mean ± SE. Data were analyzed by independent t-test, chi-square fisher exact test using the SPSS for Windows, version 25. The differences between means ± SD were tested at $P<0.05$. In all statistical tests, the probability level of $P<0.05$ was considered significant.

Results

This study included 240 participants, 120 of them with type 2 diabetes mellitus patients without hypertension, 120 with type 2 diabetes mellitus with hypertension and 120 participants with normal BP and non-diabetic, age and gender matched subjects were included as a control group. All the participants were aged between 30–70 years. The mean ages of all patients groups were showed non significant changes, where, control males, control females, diabetic males, diabetic females, and diabetic+ HTN males and females patients were (56.90 ± 1.10), (53.50 ± 1.03), (57.70 ± 2.30), (53.00 ± 1.59), (58.10 ± 2.40), and (56.60 ± 1.68) years, respectively.

Distribution of Patients According to Age Groups

The higher numbers of subjects were in males diabetic patients by age groups were 19 subjects (31.7%) in those aged (61-70) years, in males diabetic + HTN patients 21 subjects (35%) in those aged (71-80) years, in females diabetic patients 29 subjects (48.3%) in those aged (51-60) years, in females diabetic + HTN patients 27 subjects (45%) in those aged (51-60) years (Table. 1 & Figure. 1).

Table 1. *Distribution of patients according to age groups.*

Patients Groups Age Groups (Years)	Males Diabetic		Males (Diabetic+HTN)		Females Diabetic		Females (Diabetic+HTN)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
31-40	4	6.7	0	0	5	8.3	2	3.33
41-50	11	18.3	18	30	19	31.7	14	23.33
51-60	7	11.7	6	10	29	48.3	27	45
61-70	19	31.7	9	15	7	11.7	14	23.33
71-80	17	28.3	21	35	0	0	3	5
>80	0	0	6	10	0	0	0	0

Distribution of patients according to age more than 50 years

The subjects of age more than 50 year were 45 subjects (75%) in males diabetic patients, 51 subjects (85%) in males diabetic + HTN patients, 43 subjects (71.7%) in females diabetic patients, and 47 subjects (78.3%) in females diabetic + HTN patients (Table. 2 & Figure. 2).

Table 2. *Distribution of patients according to age more than 50 years.*

Parameters Groups	Age (>50 years)	
	Frequency	%
Males Diabetic	45	75
Males (Diabetic + HTN)	51	85
Females Diabetic	43	71.7
Females (Diabetic + HTN)	47	78.3

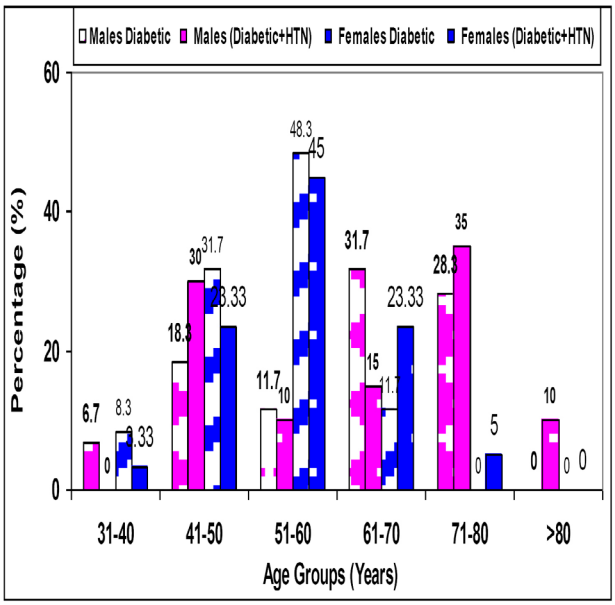

Figure 1. *Distribution of patients according to age groups.*

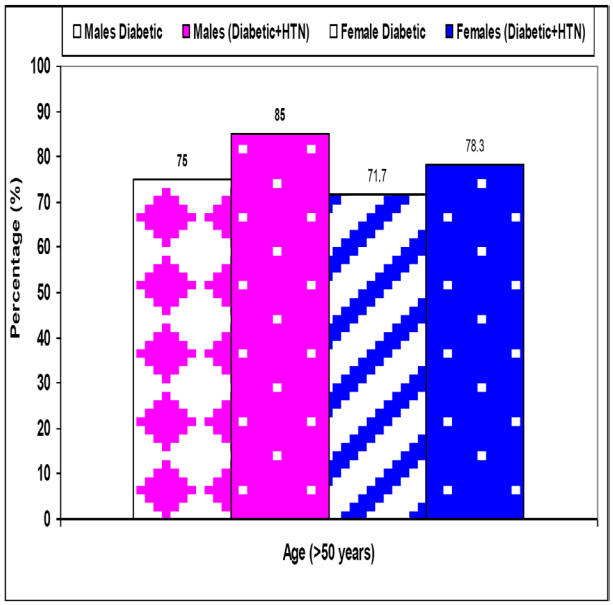

Figure 2. *Distribution of patients according to age more than 50 years.*

Distribution of patients according to abnormal levels of HbA1c.

The abnormal levels of HbA1c (7.5-9 %) were 22 subjects (36.7%) in males diabetic patients, 42 subjects (70%) in males diabetic + HTN patients, 16 subjects (26.7%) in females diabetic patients, and 22 subjects (36.7%) in females diabetic + HTN patients. But, the abnormal levels of HbA1c (>9 %) were 26 subjects (43.3%) in males diabetic, 20 subjects (33.3%) in males diabetic + HTN, 22 subjects (36.7%) in females diabetic and diabetic + HTN patients (Table. 3 & Figure. 3).

Table 3. *Distribution of patients according to abnormal levels of HbA1c.*

Parameters Groups	HbA1c (%)			
	(7.5-9)		(>9)	
	Frequency	%	Frequency	%
Males Diabetic	22	36.7	26	43.3
Males (Diabetic+HTN)	42	70	20	33.3
Females Diabetic	16	26.7	22	36.7
Females (Diabetic+HTN)	22	36.7	22	36.7

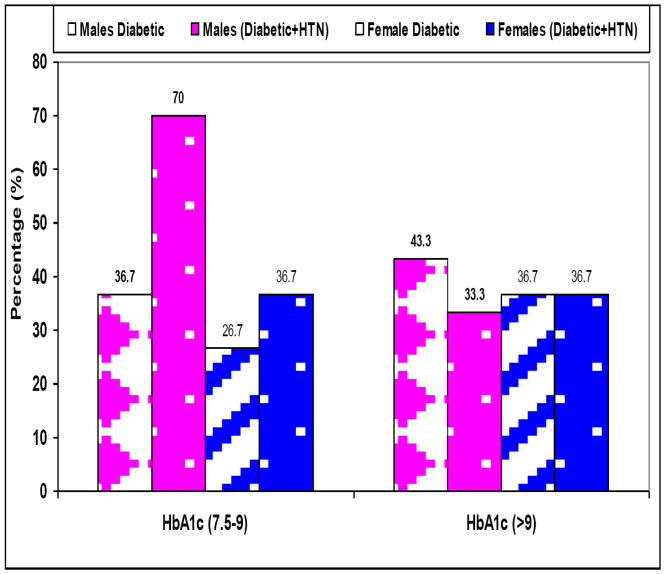

Figure 3. *Distribution of patients according to abnormal levels of HbA1c.*

Distribution of patients according to disturbance in serum urea, creatinine, uric acid, K+, and Na+ concentrations

Results in table (4) and figures (4) shows the distribution of patients according to disturbance in serum urea, creatinin, uric acid, K^+, and, Na^+ concentrations. Serum urea levels were abnormal in 15%, 45%, 5%, and 5% of males diabetic, males diabetic + HTN, females diabetic, and females diabetic + HTN, respectively. Serum creatinine levels were abnormal in 21.7 %, 45%, 3.3%, and 5% of males diabetic, males diabetic + HTN, females diabetic, and females diabetic + HTN, respectively. Serum K^+ levels were abnormal in 3.3%, 15%, and 10% of males diabetic, males diabetic + HTN, and females diabetic + HTN, respectively. Serum Na^+ levels were abnormal in 21.7%, 10%, 11.7%, and 13% of males diabetic, males diabetic + HTN, females diabetic, and females diabetic + HTN, respectively.

Table 4. *Distribution of patients according to disturbance in serum urea, creatinine, uric acid, K+, and Na+ concentrations*

Parameters	Urea (>40mg/dl)		Creatinine (>1.1mg/dl)		Uric Acid (>7mg/dl)		K+ (>3.5mmol/L)		Na+ (<135mmol/L)	
Groups	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Males Diabetic	9	15.0	13	21.7	7	11.7	2	3.3	13	21.7
Males (Diabetic+HTN)	27	45.0	27	45.0	15	25.0	9	15.0	6	10.0
Females Diabetic	3	5.0	2	3.3	2	3.3	0	0.0	7	11.7
Females (Diabetic+HTN)	3	5.0	3	5.0	5	8.3	6	10.0	8	13.3

Distribution of patients according to abnormal values of eGFR

Results in table (5) and figures (5) shows the distribution of patients according to abnormal values of eGFR. The abnormal values of eGFR were (<60 ml/min/1.73m^2) in 3.3%, 90%, 93.3%, and 3.3% of males diabetic, males diabetic + HTN, females diabetic, and females diabetic + HTN, respectively. The abnormal values of eGFR were (60-90 ml/min/ 1.73m^2) in 33.3%, 10%, and 23.3% of males diabetic, males diabetic + HTN, and females diabetic, respectively.

Table. 5. Distribution of patients according to abnormal values of eGFR

Parameters / Groups	eGFR (ml/min/1.73m²)			
	<60		(60-90)	
	Frequency	%	Frequency	%
Males Diabetic	2	3.3	20	33.3
Males (Diabetic+HTN)	54	90	6	10
Females Diabetic	42	70	14	23.3
Females (Diabetic+HTN)	56	93.3	0	0

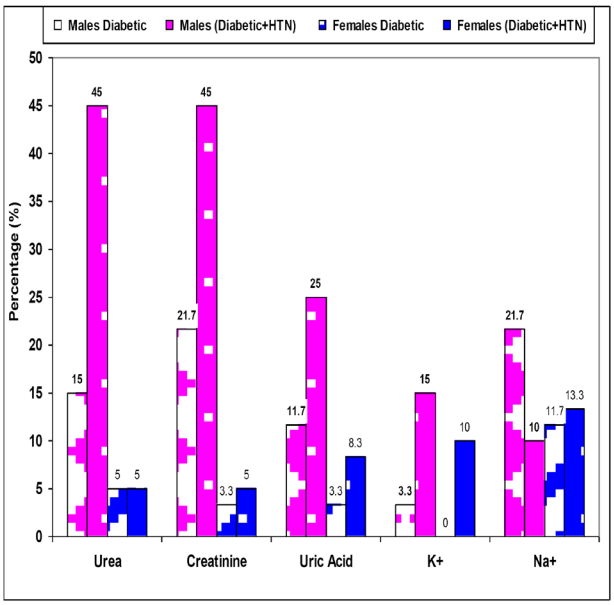

Figure 4. *Distribution of patients according to disturbance in serum urea, creatinine, uric acid, K+, and Na+ concentrations.*

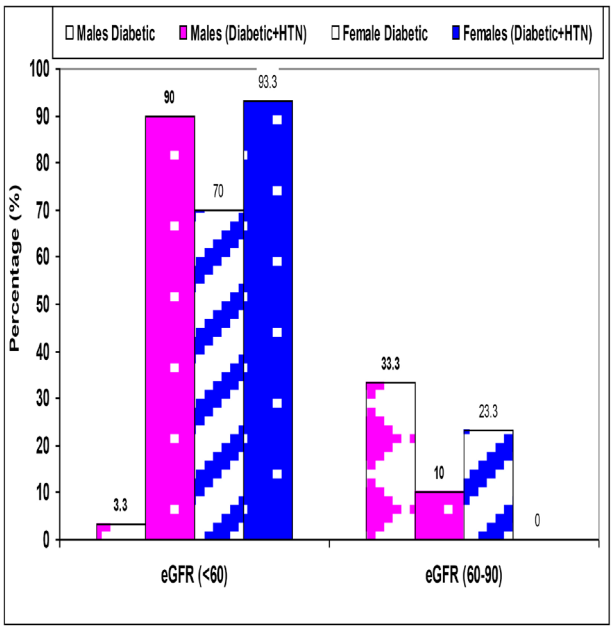

Figure 5. *Distribution of patients according to abnormal values of eGFR*

Systolic and diastolic blood pressure in control and diabetic patients

Diastolic blood pressure (mm Hg) was significantly (*P<0.01*) increased in males diabetic (81.50 ± 0.70) compared with control males (78.90 ± 0.60). Systolic blood pressure in males and females diabetic showed non-significant changes compared to controls (Table .6 & Figure .6).

Table 6. *Systolic and diastolic blood pressure in control and diabetic patients*

Groups / Parameters		Control	Diabetic Patients
		Mean ± SE	Mean ± SE
Systolic Blood Pressure (mm Hg)	Males	121.60 ± 0.40	121.70 ± 0.80
	Females	120.80 ± 0.24	120.50 ± 0.94
Diastolic Blood Pressure (mm Hg)	Males	78.90 ± 0.60	81.50 ± 0.70**
	Females	78.40 ± 0.48	78.80 ± 0.89

*: Significant differences as compared with control group (P < 0.05); **: Significant differences as compared with control group (P < 0.01)

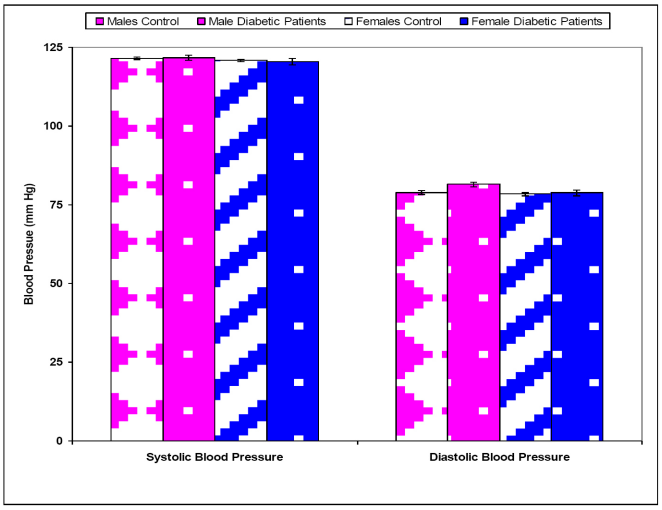

Figure 6. *Systolic and diastolic blood pressure in control and diabetic patients*

Comparison of fasting blood sugar (FBS) concentration and HbA1c between control and diabetic patients

Fasting blood sugar had a significant (*P<0.01*) increase in males diabetic (274.20 ± 17.20), females diabetic (218.00 ± 14.40) compared with controls (males & females) (86.40 ± 1.50), (83.20 ± 1.87), respectively, (Table .7 & Figure .7).

HbA1c had a significant (*P<0.01*) increase in males diabetic (9.00 ± 0.30), females diabetic (8.40 ± 0.36) compared with controls (males& females) (5.20 ± 0.10), (6.00 ± 0.14), respectively, (Table .7 & Figure .8).

Table 7. *Comparison of fasting blood sugar (FBS) concentration and Hemoglobin A1c between control and diabetic patients*

Parameters	Groups	Control	Diabetic Patients
		Mean ± SE	Mean ± SE
Fasting blood sugar (FBS) concentration (mg/dl)	Males	86.40 ± 1.50	274.20 ± 17.20**
	Females	83.20 ± 1.87	218.00 ± 14.40**
Hemoglobin A1c (HbA1c) (%)	Males	5.20 ± 0.10	9.00 ± 0.30**
	Females	6.00 ± 0.14	8.40 ± 0.36**

**: Significant differences as compared with control group (P < 0.01)

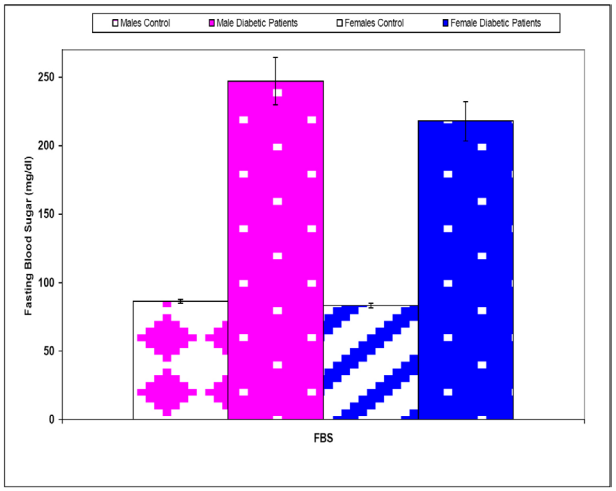

Figure 7. *Comparison of fasting blood sugar (FBS) concentration between control and diabetic patients*

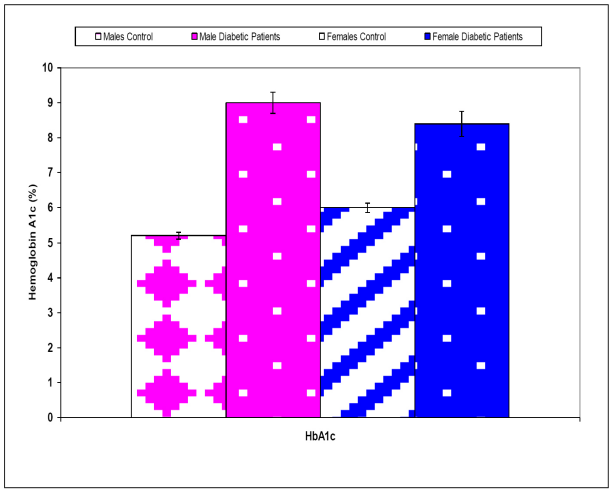

Figure 8. *Comparison of Hemoglobin A1c between control and diabetic patients*

Comparison of eGFR values, serum urea, creatinine, and uric acid concentrations between control and diabetic patients

The data obtained are presented in table (8) and demonstrated by figure (9-11). It is apparent from the results that eGFR (ml/min/1.73m^2) had a significant decrease (99.00 ± 4.10) in male diabetic patients as compared with the control males (119.6 ± 3.5) (Figure. 9).

Serum urea and creatinine concentrations (mg/dl) were significantly (*P<0.01*) increased (29.30 ± 1.60) and (0.90 ± 0.00) in males diabetic when compared with controls (22.7 ± 1.10) and (0.70 ± 0.00). In females diabetic, serum urea concentration (mg/dl) was significantly (*P<0.05*) increased (23.40 ± 1.43) as compared to control females (19.90 ± 0.78). Also, serum uric acid concentration (mg/dl) was a significant (*P<0.05*) increased (5.10 ± 0.30) in males diabetic when compared to control males (4.40 ± 0.10) (Figure .10 & 11).

Table 8. *Comparison of eGFR values, serum urea, creatinine, and uric acid concentrations between control and diabetic patients*

Groups / Parameters		Control	Diabetic Patients
		Mean ± SE	Mean ± SE
eGFR (ml/min/1.73m^2)	Males	119.6 ± 3.5	99.00 ± 4.10**
	Females	62.2 ± 1.75	55.90 ± 2.99
Urea concentration (mg/dl)	Males	22.7 ± 1.10	29.30 ± 1.60**
	Females	19.90 ± 0.78	23.40 ± 1.43*
Uric acid concentration (mg/dl)	Males	4.40 ± 0.10	5.10 ± 0.30*
	Females	4.80 ± 0.16	4.20 ± 0.27
Creatinine concentration (mg/dl)	Males	0.70 ± 0.00	0.90 ± 0.00**
	Females	0.70 ± 0.02	0.70 ± 0.03

***: Significant differences as compared with control group (P < 0.05), **: Significant differences as compared with control group (P < 0.01)**

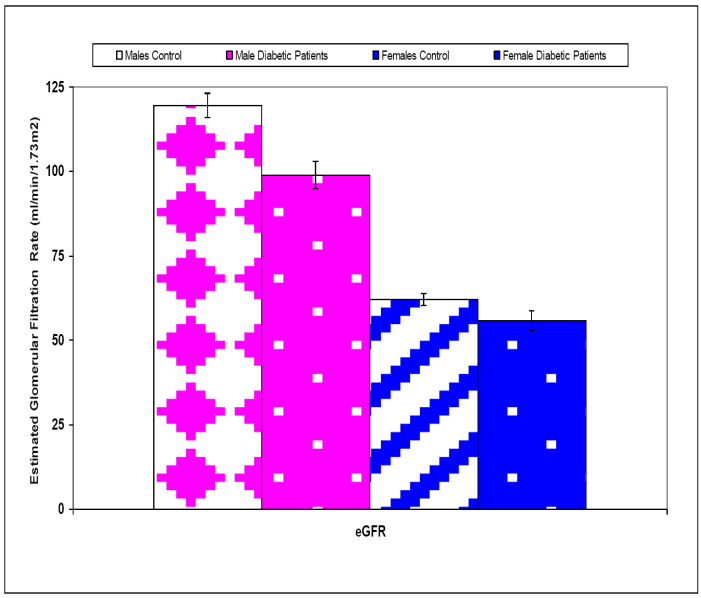

Figure 9. *Comparison of eGFR values between control and diabetic patients*

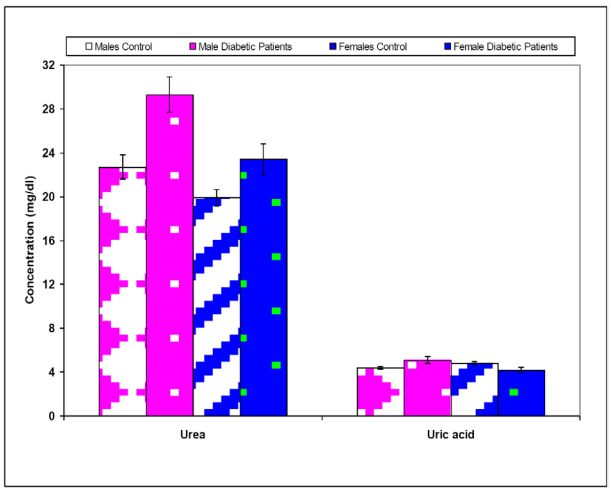

Figure 10. *Comparison of serum urea and uric acid concentrations between control and diabetic patients.*

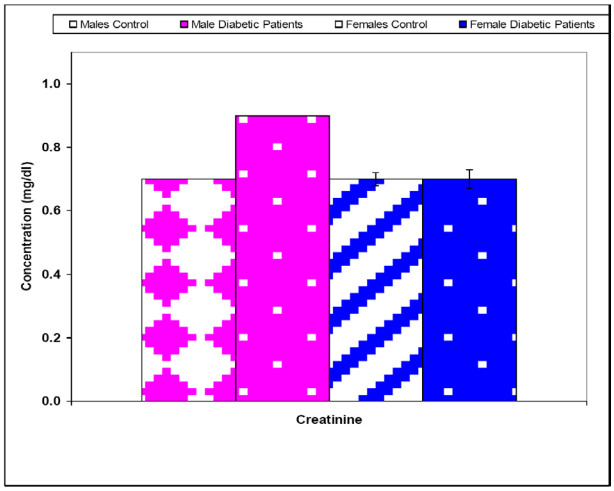

Figure 11. *Comparison of serum creatinine concentration between control and diabetic patients*

Comparison of serum Na+, K+, Cl-, Ca++, and phosphorus concentrations between control and diabetic patients

Sodium ions concentration (mmol/L) was exhibited a significant (*P<0.01*) decrease in males diabetic (137.0 ± 0.5), females diabetic (137.6 ± 0.51) as compared to controls (males& females) (139.1 ± 0.3) and (139.8 ± 0.39), respectively (Table. 9 & Figure. 12).

Chloride ions concentration (mmol/L) was exhibited a significant (*P<0.05*) decrease in males diabetic (100.9 ± 0.7), as compared to controls males (103.1 ± 0.5). Serum Ca^{++} and phosphorus were significantly (*P<0.01*) decreased (8.4 ± 0.15) in females diabetic and (3.6 ± 0.1) in males diabetic when compared with (9.1 ± 0.10) and (4.0 ± 0.1), respectively (Table. 9 & Figure. 12, 13).

Potassium ions concentration (mmol/L) was exhibited a significant increase (*P<0.05*) in males diabetic (4.1 ± 0.1), (*P<0.01*) females diabetic (3.9 ± 0.0) as compared to controls (males& females) (4.2 ± 0.07) and (3.9 ± 0.04), respectively. Also, serum Ca^{++} was significantly (*P<0.05*) increased in males diabetic (9.0 ± 0.1) compared to control males (8.6 ± 0.1) (Table. 9 & Figure. 13).

Table 9. *Comparison of serum Na+, K+, Cl-, Ca++, and phosphorus concentrations between control and diabetic patients*

Groups / Parameters		Control	Diabetic Patients
		Mean ± SE	Mean ± SE
Na^+ concentration (mmol/L)	**Males**	**139.1 ± 0.3**	**137.0 ± 0.5****
	Females	**139.8 ± 0.39**	**137.6 ± 0.51****
CL^- concentration (mmol/L)	**Males**	**103.1 ± 0.5**	**100.9 ± 0.7***
	Females	**103.2 ± 0.58**	**103.0 ± 0.59**
K^+ concentration (mmol/L)	**Males**	**3.9 ± 0.0**	**4.1 ± 0.1***
	Females	**3.9 ± 0.04**	**4.2 ± 0.07****
Ca^{++} concentration (mg/dl)	**Males**	**8.6 ± 0.1**	**9.0 ± 0.1***
	Females	**9.1 ± 0.10**	**8.4 ± 0.15****
Phos concentration (mg/dl)	**Males**	**4.0 ± 0.1**	**3.6 ± 0.1****
	Females	**3.8 ± 0.07**	**3.9 ± 0.06**

***: Significant differences as compared with control group (P < 0.05), **: Significant differences as compared with control group (P < 0.01)**

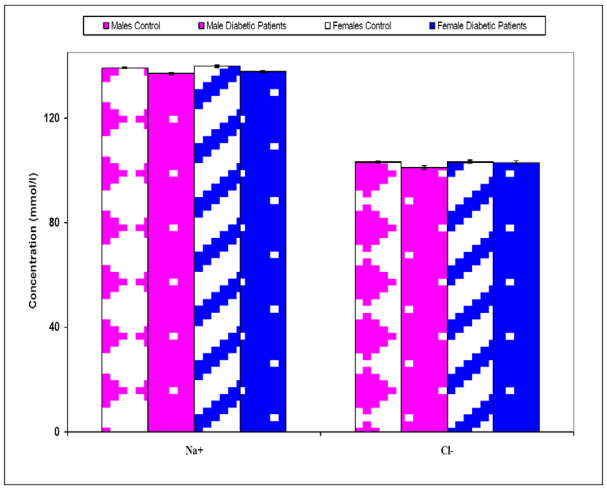

Figure 12. *Comparison of serum Na+, and Cl- concentrations between control and diabetic patients*

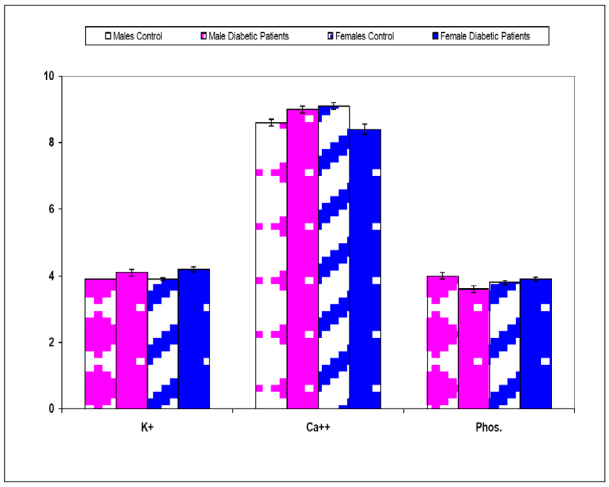

Figure 13. *Comparison of serum K+, Ca++, and phosphorus concentrations between control and diabetic patients.*

Systolic and diastolic blood pressure in control and diabetic + HTN patients

Systolic blood pressure (mm Hg) was significantly (*P<0.01*) increased in males and females diabetic + HTN patients (149.20 ± 3.00) and (136.50 ± 4.93) compared with control (males & females) (121.60 ± 0.40) and (120.80 ± 0.24), respectively (Table .10 & Figure .14).

Diastolic blood pressure (mm Hg) was significantly (*P<0.01*) increased in males and females diabetic + HTN patients (87.00 ± 1.00) and (86.70 ± 1.48) compared with control (males & females) (81.50 ± 0.70) and (78.40 ± 0.48), respectively (Table .10& Figure .14).

Table 10. *Systolic and diastolic blood pressure in control and diabetic + HTN patients*

Parameters	Groups	Control	(Diabetic + HTN) Patients
		Mean ± SE	Mean ± SE
Systolic Blood Pressure (mm Hg)	Males	121.60 ± 0.40	149.20 ± 3.00**
	Females	120.80 ± 0.24	136.50 ± 4.93**
Diastolic Blood Pressure (mm Hg)	Males	81.50 ± 0.70	87.00 ± 1.00**
	Females	78.40 ± 0.48	86.70 ± 1.48**

*: **Significant differences as compared with control group (P < 0.05); **: Significant differences as compared with control group (P < 0.01)**

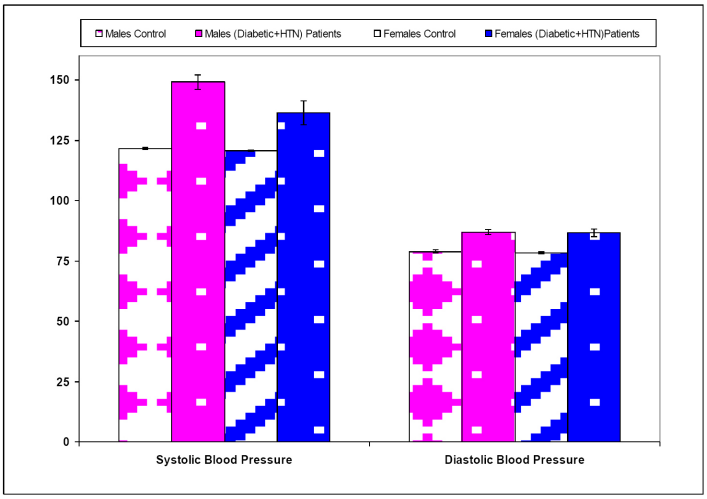

Figure 14. *Systolic, and diastolic blood pressure in control and diabetic + HTN patients.*

Comparison of fasting blood sugar (FBS) and Hemoglobin A1c between control and diabetic + HTN patients

Fasting blood sugar concentration had a significant (*P<0.01*) increase in males diabetic + HTN patients (214.40 ± 12.10), females diabetic + HTN patients (203.40 ± 19.24) compared with controls (males & females) (86.40 ± 1.50), (83.20 ± 1.87), respectively, (Table 11 & Figure 15).

Hemoglobin A1c had a significant (*P<0.01*) increase in males diabetic + HTN patients (9.00 ± 0.20), females diabetic + HTN patients (8.60 ± 0.27) compared with controls (males& females) (5.20 ± 0.10), (6.00 ± 0.14), respectively, (Table 11 & Figure .16).

Table 11. *Comparison of fasting blood sugar (FBS) concentration and Hemoglobin A1c between control and diabetic + HTN patients*

Groups Parameters		Control	Diabetic + HTN Patients
		Mean ± SE	Mean ± SE
Fasting blood sugar (FBS) concentration (mg/dl)	Males	86.40 ± 1.50	214.40 ± 12.10**
	Females	83.20 ± 1.87	203.40 ± 19.24**
Hemoglobin A1c (HbA1c) (%)	Males	5.20 ± 0.10	9.00 ± 0.20**
	Females	6.00 ± 0.14	8.60 ± 0.27**

**: Significant differences as compared with control group (P < 0.01)

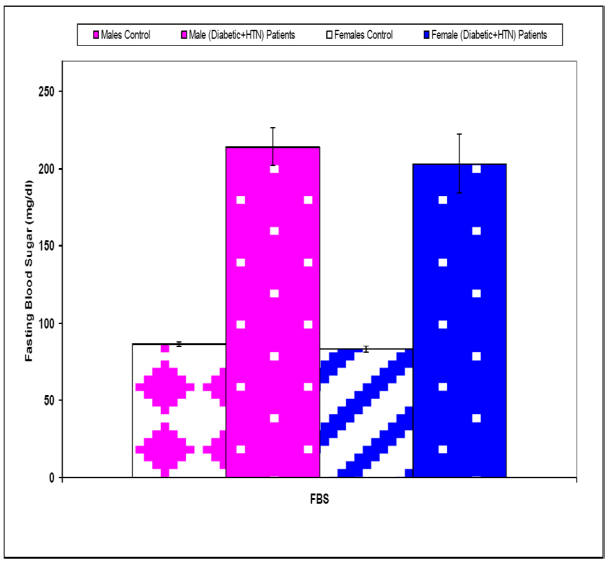

Figure 15. *Comparison of fasting blood sugar (FBS) concentration between control and diabetic + HTN patients*

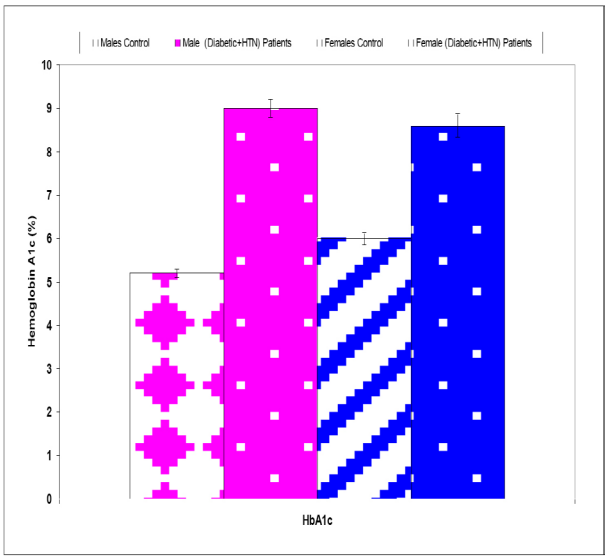

Figure 16. *Comparison of Hemoglobin A1c between control and diabetic + HTN patients*

Comparison of eGFR values, serum urea, creatinine, and uric acid concentrations between control and diabetic + HTN patients

It is apparent from the results that eGFR (ml/min/1.73m^2) had a significant (*P<0.01*) decrease (32.00 ± 3.60) and (17.20 ± 1.55) in male and females diabetic + HTN patients as compared with the control (males & females) (119.60 ± 3.50) and (62.20 ± 1.75), respectively (Table 12 & figure. 17).

Serum urea, uric acid and creatinine concentrations (mg/dl) were significantly (*P<0.01*) increased (41.60 ± 3.10), (6.00 ± 0.30), and (1.30 ± 0.10) in males diabetic + HTN patients when compared with control males (22.70 ± 1.10), (4.40 ± 0.10), and (0.70 ± 0.00), respectively. In females diabetic + HTN, serum urea concentrations (mg/dl) was significantly (*P<0.05*) increased (24.80 ± 2.06) as compared to control females (19.90 ± 0.78) (Table 12 & figure. 18, 19).

Table 12. *Comparison of eGFR values, serum urea, creatinine, and uric acid concentrations between control and diabetic + HTN patients*

Groups / Parameters		Control	Diabetic + HTN Patients
		Mean ± SE	Mean ± SE
eGFR (ml/min/1.73m^2)	Males	119.60 ± 3.50	32.00 ± 3.60**
	Females	62.20 ± 1.75	17.20 ± 1.55**
Urea concentration (mg/dl)	Males	22.70 ± 1.10	41.60 ± 3.10**
	Females	19.90 ± 0.78	24.80 ± 2.06*
Uric acid concentration (mg/dl)	Males	4.40 ± 0.10	6.00 ± 0.30**
	Females	4.80 ± 0.16	4.90 ± 0.22
Creatinine concentration (mg/dl)	Males	0.70 ± 0.00	1.30 ± 0.10**
	Females	0.70 ± 0.02	0.70 ± 0.03

***: Significant differences as compared with control group (P < 0.05), **: Significant differences as compared with control group (P < 0.01)**

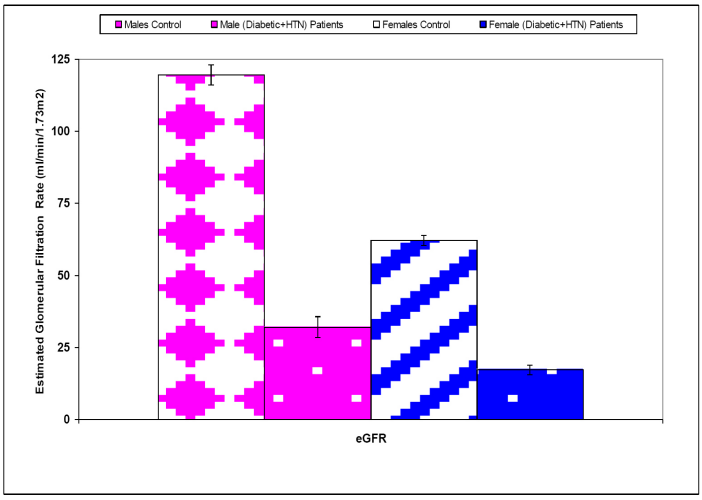

Figure 17. *Comparison of eGFR values between control and diabetic+HTN patients*

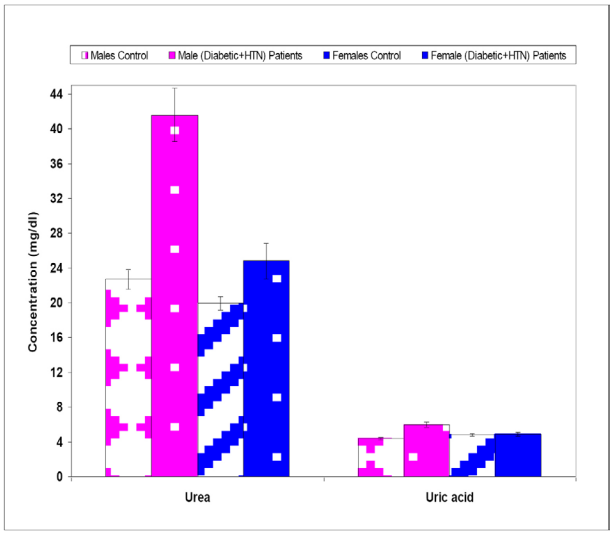

Figure 18. *Comparison of serum urea and uric acid concentrations between control and diabetic+HTN patients*

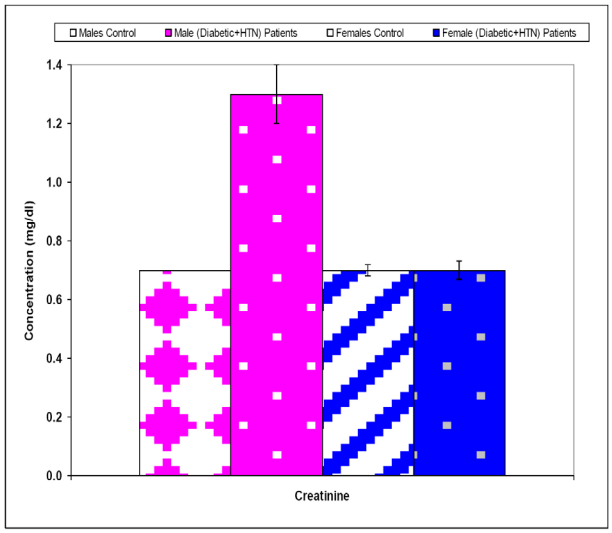

Figure 19. *Comparison of serum creatinine concentration between control and diabetic+HTN patients.*

Comparison of serum Na+, K+, Cl-, Ca++, and phosphorus concentrations between control and diabetic+HTN patients

Sodium ions concentration (mmol/L) was exhibited a significant (*P<0.01*) decrease in males diabetic + HTN patients (137.4 ± 0.4), females diabetic + HTN patients (137.8 ± 0.49) as compared to controls (males & females) (139.1 ± 0.3) and (139.8 ± 0.39), respectively (Table. 13 & Figure. 20).

Potassium ions concentration (mmol/L) was exhibited a significant increase (*P<0.05*) in males diabetic + HTN patients (4.1 ± 0.1) as compared to control males (4.2 ± 0.07) (Table. 13 & Figure. 21).

Phosphorus concentration (mg/dl) were significantly (*P<0.01*) decreased (3.6 ± 0.1) in males diabetic + HTN patients when compared with (3.6 ± 0.1) (Table. 13 & Figure. 21).

Table 13. *Comparison of serum Na+, K+, Cl-, Ca++, and phosphorus concentrations between control and diabetic + HTN patients*

Parameters	Groups	Control	Diabetic+HTN Patients
		Mean ± SE	Mean ± SE
Na^+ concentration (mmol/L)	**Males**	**139.1 ± 0.3**	**137.4 ± 0.4****
	Females	**139.8 ± 0.39**	**137.8 ± 0.49****
CL^- concentration (mmol/L)	**Males**	**103.1 ± 0.5**	**102.4 ± 0.5**
	Females	**103.2 ± 0.58**	**104.2 ± 0.47**
K^+ concentration (mmol/L)	**Males**	**3.9 ± 0.0**	**4.4 ± 0.2***
	Females	**3.9 ± 0.04**	**4.0 ± 0.10**
Ca^{++} concentration (mg/dl)	**Males**	**8.6 ± 0.1**	**8.3 ± 0.2**
	Females	**9.1 ± 0.10**	**11.0 ± 2.71**
Phos concentration (mg/dl)	**Males**	**4.0 ± 0.1**	**3.6 ± 0.1****
	Females	**3.8 ± 0.07**	**6.7 ± 3.05**

***: Significant differences as compared with control group (P < 0.05), **: Significant differences as compared with control group (P < 0.01)**

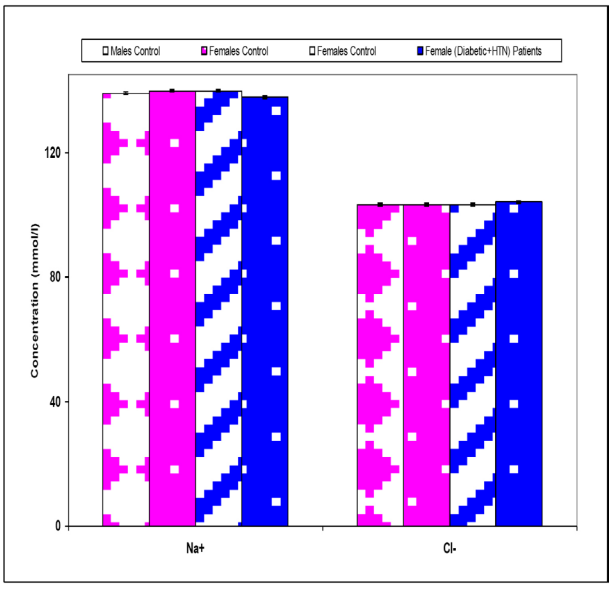

Figure 20. *Comparison of serum Na+, and Cl- concentrations between control and diabetic + HTN patients.*

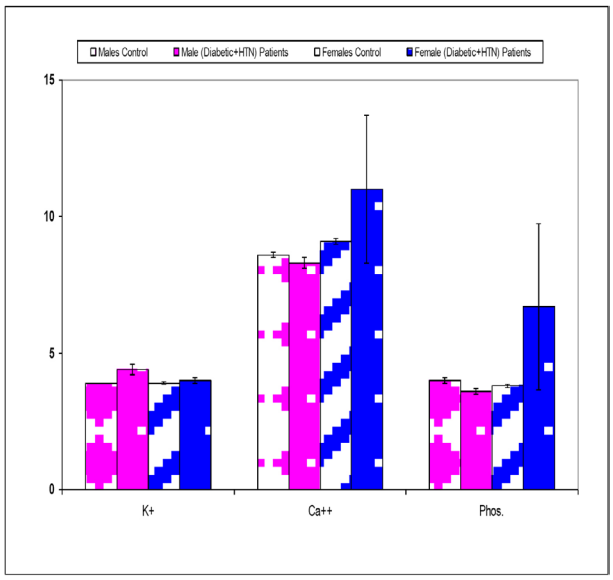

Figure 21. *Comparison of serum K+, Ca++, and phosphorus concentrations between control and diabetic + HTN patients.*

Systolic and diastolic blood pressure in diabetic patients and diabetic + HTN patients

Systolic blood pressure (mm Hg) was significantly (*P<0.01*) increased in males and females diabetic + HTN patients (149.2 ± 3.0) and (136.5 ± 4.93) compared with diabetic (males & females) (121.7 ± 0.8) and (120.5 ± 0.94), respectively (Table 14 & Figure 22).

Diastolic Systolic blood pressure (mm Hg) was significantly *(P<0.01*) increased in males and females diabetic + HTN patients (87.0 ± 1.0) and (86.7 ± 1.48) compared with diabetic (males & females) (78.9 ± 0.6) and (78.8 ± 0.89), respectively (Table .14 & Figure .22).

Table 14. *Systolic and diastolic blood pressure in diabetic patients and diabetic + HTN patients*

Parameters \ Groups		Diabetic Patients	)Diabetic+ HTN (Patients
		Mean ± SE	Mean ± SE
Systolic Blood Pressure (mm Hg)	Males	121.7 ± 0.8	149.2 ± 3.0**
	Females	120.5 ± 0.94	136.5 ± 4.93**
Diastolic Blood Pressure (mm Hg)	Males	78.9 ± 0.6	87.0 ± 1.0**
	Females	78.8 ± 0.89	86.7 ± 1.48**

**: Significant differences as compared with control group (P < 0.01)

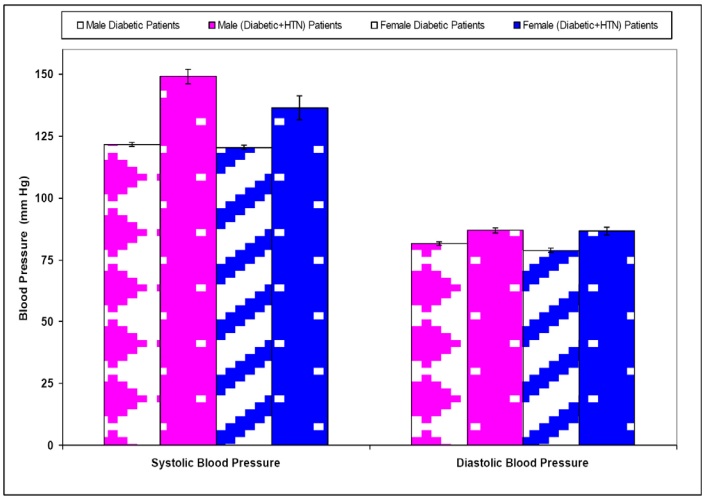

Figure 22. *Systolic and diastolic blood pressure in diabetic patients and diabetic + HTN patients*

Comparison of fasting blood sugar (FBS) concentration and Hemoglobin A1c between diabetic patients and diabetic + HTN patients

Fasting blood sugar concentration had a significant (*P<0.01*) increase in males diabetic + HTN patients (214.4 ± 12.1) compared with diabetic males (274.2 ± 17.2) (Table .15 & Figure 23).

Hemoglobin A1c had a non significant changes in males and females diabetic + HTN patients compared with diabetic (males & females) (Table .15 & Figure 24).

Table 15. *Comparison of fasting blood sugar (FBS) concentration and Hemoglobin A1c between diabetic patients and diabetic + HTN patients*

Groups / Parameters		Diabetic Patients	Diabetic + HTN Patients
		Mean ± SE	Mean ± SE
Fasting blood sugar (FBS) concentration (mg/dl)	Males	274.2 ± 17.2	214.4 ± 12.1**
	Females	218.0 ± 14.40	203.4 ± 19.24
Hemoglobin A1c (HbA1c) (%)	Males	9.0 ± 0.3	9.0 ± 0.2
	Females	8.4 ± 0.36	8.6 ± 0.27

**: Significant differences as compared with control group (P < 0.01)

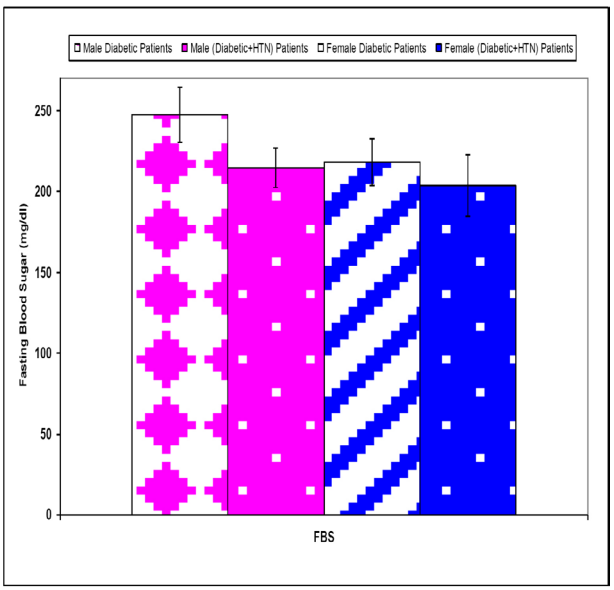

Figure 23. *Comparison of fasting blood sugar (FBS) concentration between diabetic patients and diabetic + HTN patients*

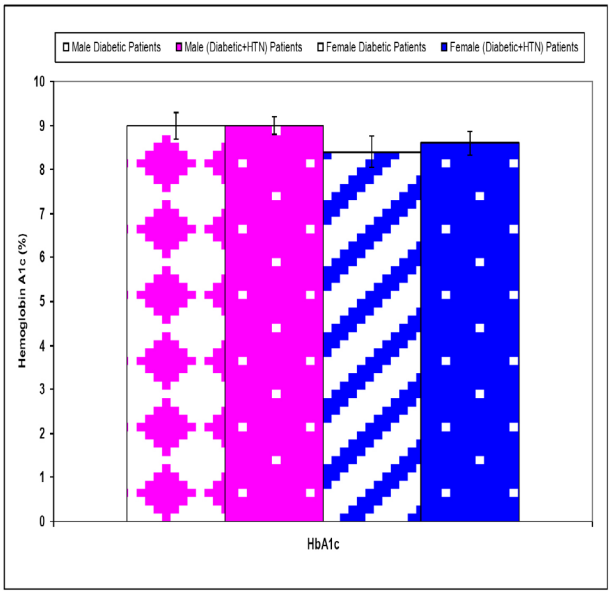

Figure 24. *Comparison of Hemoglobin A1c between diabetic patients and diabetic + HTN patients*

Comparison of eGFR values and serum urea, creatinine, and uric acid concentrations between diabetic patients and diabetic + HTN patients

eGFR (ml/min/1.73m^2) was a significantly (*P<0.01*) decreased (32.0 ± 3.6) and (17.2 ± 1.55) in male and females diabetic + HTN patients as compared with male and females diabetic (99.0 ± 4.1) and (55.9 ± 2.99), respectively (Table .16 & figure. 25).

Serum urea and creatinine concentrations (mg/dl) were significantly (*P<0.01*) increased (41.6 ± 3.1) and (1.3 ± 0.1) in males diabetic + HTN patients when compared with diabetic males (29.3 ± 1.6) and (0.9 ± 0.0), respectively (Table .16 & figure. 26, 27).

Serum uric acid was a significantly (*P<0.05*) increased (6.0 ± 0.3) and (4.9 ± 0.22) in male and females diabetic + HTN patients as compared with male and females diabetic (5.1 ± 0.3) and (4.2 ± 0.27), respectively (Table .16 & figure. 26).

Table 16. *Comparison of eGFR values and serum urea, creatinine, and uric acid concentrations between diabetic patients and diabetic + HTN patients*

Parameters	Groups	Diabetic Patients	Diabetic + HTN Patients
		Mean ± SE	Mean ± SE
eGFR (ml/min/1.73m^2)	Males	99.0 ± 4.1	32.0 ± 3.6**
	Females	55.9 ± 2.99	17.2 ± 1.55**
Urea concentration (mg/dl)	Males	29.3 ± 1.6	41.6 ± 3.1**
	Females	23.4 ± 1.43	24.8 ± 2.06
Uric acid concentration (mg/dl)	Males	0.9 ± 0.0	1.3 ± 0.1**
	Females	0.7 ± 0.03	0.7 ± 0.03
Creatinine concentration (mg/dl)	Males	5.1 ± 0.3	6.0 ± 0.3*
	Females	4.2 ± 0.27	4.9 ± 0.22*

***: Significant differences as compared with control group (P < 0.05), **: Significant differences as compared with control group (P < 0.01)**

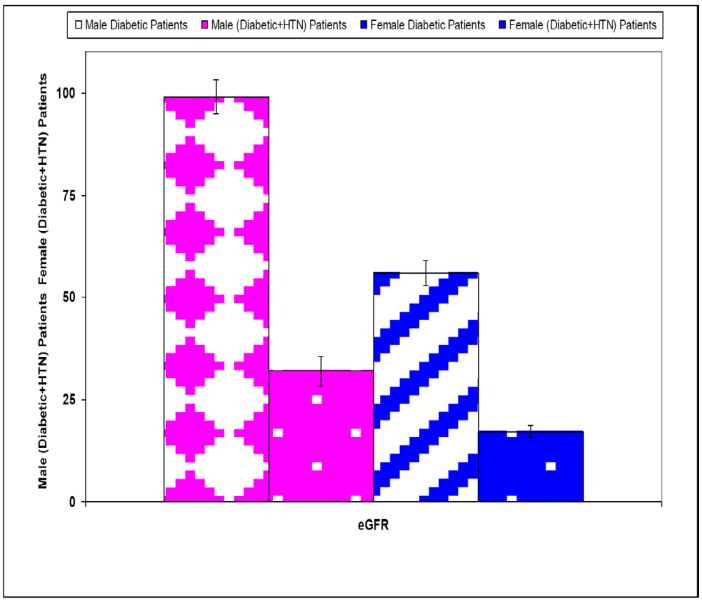

Figure 25. *Comparison of eGFR values between diabetic patients and diabetic + HTN patients*

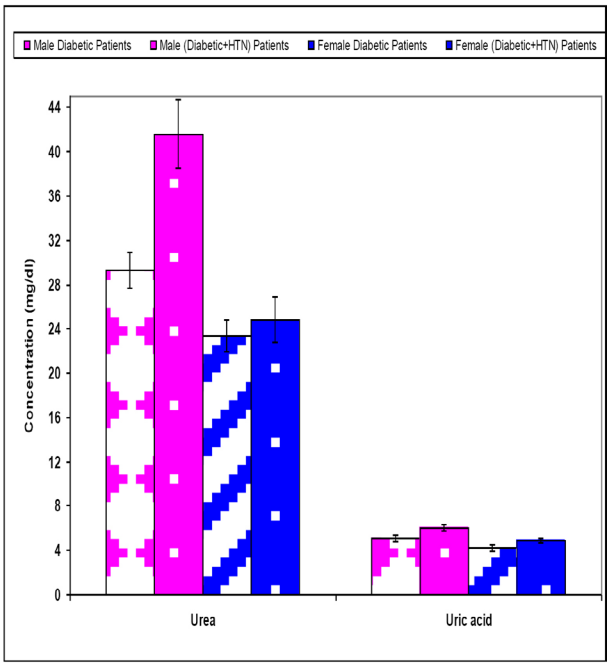

Figure 26. *Comparison of serum urea and uric acid concentrations between diabetic patients and diabetic + HTN patients.*

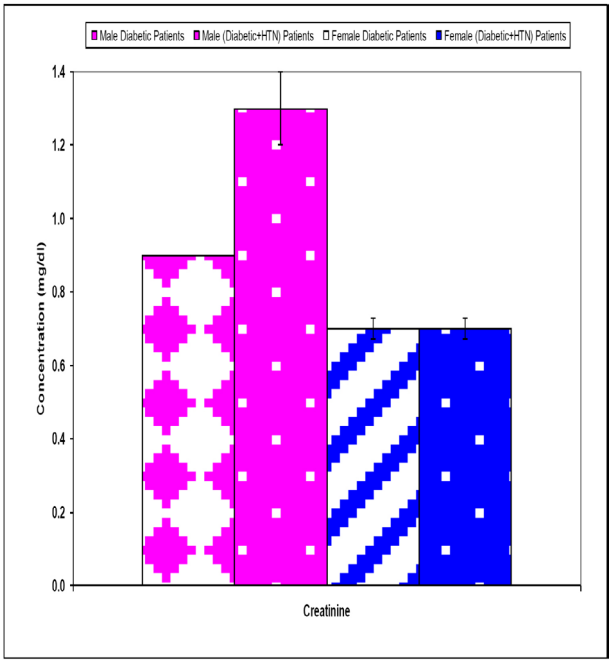

Figure 27. *Comparison of serum creatinine concentration between diabetic patients and diabetic + HTN patients*

Comparison of serum Na+, K+, Cl-, Ca++, and phosphorus concentrations between diabetic patients and diabetic + HTN patients

The data shown in table (17) and Figures (28 & 29) indicated a non significant changes in serum Na+, K+, Cl-, and phosphorus in males and females (diabetic + HTN) patients as compared to diabetic males and females (Table. 17 & Figure. 28, 29).

Serum Ca^{++} was significantly (*P<0.01*) decreased (8.3 ± 0.2) in males diabetic + HTN patients when compared with males diabetic patients (9.0 ± 0.1) (Table. 17 & Figure. 29).

Table 17. *Comparison of serum Na+, K+, Cl-, Ca++, and phosphorus concentrations between diabetic patients and diabetic + HTN patients*

Parameters	Groups	Diabetic patients	Diabetic + HTN Patients
		Mean ± SE	Mean ± SE
Na^+ concentration (mmol/L)	**Males**	**137.0 ± 0.5**	**137.4 ± 0.4**
	Females	**137.6 ± 0.51**	**137.8 ± 0.49**
CL^- concentration (mmol/L)	**Males**	**100.9 ± 0.7**	**102.4 ± 0.5**
	Females	**103.0 ± 0.59**	**104.2 ± 0.47**
K^+ concentration (mmol/L)	**Males**	**4.1 ± 0.1**	**4.4 ± 0.2**
	Females	**4.2 ± 0.07**	**4.0 ± 0.10**
Ca^{++} concentration (mg/dl)	**Males**	**9.0 ± 0.1**	**8.3 ± 0.2****
	Females	**8.4 ± 0.15**	**11.0 ± 2.71**
Phos concentration (mg/dl)	**Males**	**3.6 ± 0.1**	**3.6 ± 0.1**
	Females	**3.9 ± 0.06**	**6.7 ± 3.05**

****: Significant differences as compared with control group (P < 0.01)**

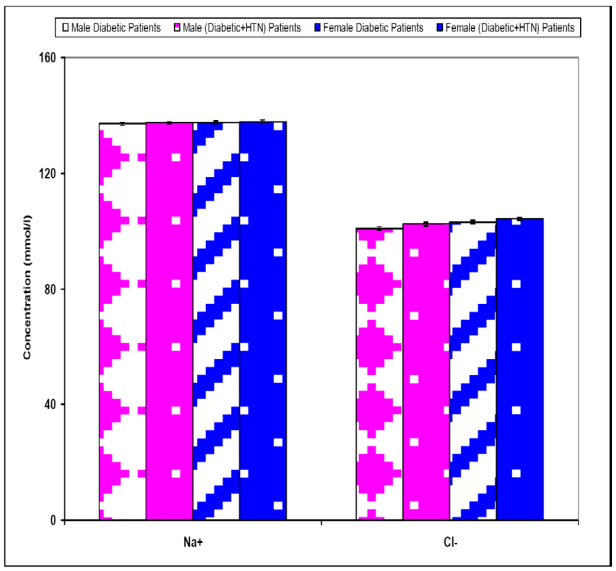

Figure 28. *Comparison of serum Na+, and Cl- concentrations between diabetic patients and diabetic + HTN patients.*

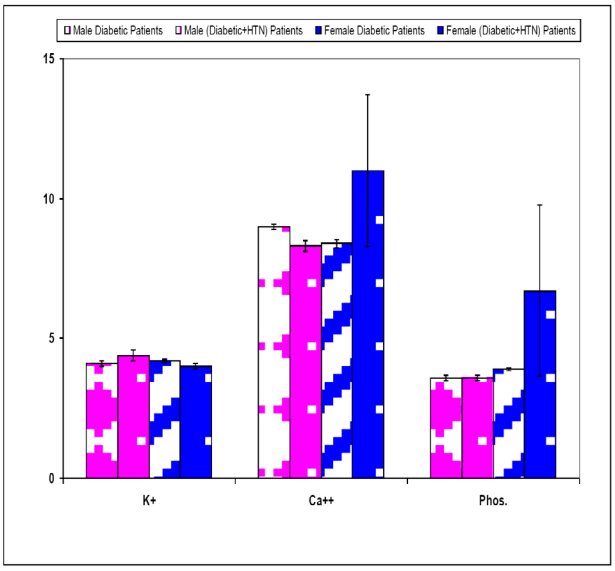

Figure 29. *Comparison of serum K+, Ca++, and phosphorus concentrations between diabetic patients and diabetic + HTN patients.*

Discussion

In diabetic patients, hyperglycemia leads to damage of the kidneys and heart diseases and when failing to control diabetes, it can give rise to many complications [7, 25].

In the present study, the mean ages of males diabetic, and females patients were (57.70 ± 2.30) and (53.00 ± 1.59) years, diabetic+ HTN males and females patients were (58.10 ± 2.40), and (56.60 ± 1.68), these results are similar with results of Al Salhen and Mahmoud, [7] who found that the mean ages of diabetic patients in El-Beida, Libya were (56.10 ± 7.82) years (Mean ± SD). In the present study, the subjects of age more than 50 year were 75% in males diabetic patients, and 71.7% in females diabetic patients, 85% in males diabetic + HTN patients and 78.3% in females diabetic + HTN patients. Al Salhen and Mahmoud, [7] and Umpierrez *et al.,* [26] were mentioned that T2DM usually develops after age 40 years. Choudhury *et al.,* 2014 reported that age was showed a significant increased in hypertensive patients as compared with normotensives.

The current study showed that a significantly increased in HbA1c and serum glucose in diabetic patients this result agrees with findings obtained by Sacks, [27] and Satti *et al.,* [6] who revealed that a positive correlation between serum blood glucose concentration and increased HbA1c.

The serum creatinine and urea levels are use for estimating renal dysfunction [7, 28]. So, renal dysfunction in T2DM was assessed by measurement of serum urea and creatinine concentrations in diabetic patients and healthy controls.

In the current study, serum urea, creatinine, and uric acid concentration were a significantly increased in diabetic patients. These results are in concordant with previous studies done by Shrestha *et al*., [29] and Alam *et al.,* [30] who found that a moderate increased in serum creatinine and urea levels in diabetic patients. Also, Al Salhen and Mahmoud, [7] concluded that elevation in renal function tests are associated with a worsening in insulin action and predicts the development of Type 2 diabetes in Libya diabetic patients. The present results support by several studies, it has been reported that there is a clear association of serum urea with fasting blood sugar [7, 28, 31-34].

Urea is one marker of the kidney function, it is an end product of protein breakdown and formed by the liver and is excreted with the urine by the kidney [7, 33]. An increase in serum urea may be due to disturbance in protein metabolism and/or impairment in its synthesis as a result of impaired hepatic function [7, 33, 35].

Creatinine is a waste product normally filtered from the blood and excreted with the urine by the kidney. Higher creatinine levels in diabetic patients may be related to impairment of kidney function [7, 33]. Serum creatinine and urea are established markers of GFR. Serum creatinine is a more sensitive index kidney function compared urea level. This is because creatinine fulfills most of the requirements for a perfect filtration marker [7, 33].

The study of Almutairi *et al.,* [36] which carried out on patients with end-stage renal disease on dialysis in Tabuk city, Saudi Arabia showed that diabetic nephropathy was the most common cause of ESRD, accounting for 30.4% of all cases, followed by unknown etiologies accounting for 25.2%. Nearly 22.6% of all ESRD cases had hypertension. Diabetic nephropathy (DN) was the most common cause of ESRD among studied patients. It is the leading cause of ESRD, accounting for approximately 50% of cases in the developed world [37]. It was estimated that patients having diabetic nephropathy in the USA were 6.9 million during 2005–2008 [38]. DN is also a common cause of ESRD in many Arabic countries such as Libya [39], Kuwait, Egypt, and Lebanon [40]. In Saudi Arabia, at the end of 2014, diabetic nephropathy affected 41.7% of all ESRD cases [41]. On the other hand, DM was one of the least encountered causes of ESRD in some countries such as Egypt [42] and Yemen [43]. Diabetic nephropathy is an important public health and clinical challenge. It is associated with an increased risk of death from cardiovascular disease [44, 45].

Hypertension was responsible for 22.6% of all cases in our ESRD patients, compared with 35.5% in the whole country [46]. Hypertension is highly prevalent in Saudi Arabia. It was reported that hypertension affected more than 25% of the adult population [47]. This high prevalence may be related to the change in diet and lifestyles of the Saudis [48]. In the USA, hypertension and diabetes are the two leading causes for the increasing number of individuals with ESRD [41]. Hypertension is also a major cause of ESRD in other regional countries such as Egypt [42], Iran [49], and Turkey [50]. Hypertension causes glomerular damage by affecting blood vessels and arteries which reduce blood flow to the kidneys [51].

Hyponatremia is associated with increased morbidity and mortality [6]. In the present, the results showed that a decrease in Na^+ in T2DM patients which similar to the results of Satti *et al*., [6] who reported that serum sodium ion levels were decreased in patients with T2DM in Sudan which may be due to many pathogenesis mechanisms in patients with poorly controlled DM. George *et al.,* [52] reported that both hyper- and hypo-natremia reflecting the coexistence of hyperglycemia-related mechanisms, which leads to change serum sodium in opposite directions. Serum osmolality increases by hyperglycemia leads to movement of water out of the cells and subsequently in a reduction of Na+ levels by dilution [6, 53]. Also, hyperglycemia can induce hypovolemic-hyponatremia due to osmotic diuresis. Also, in diabetic ketoacidosis ketone bodies obligate urinary electrolyte losses and aggravate renal sodium wasting [6, 53].

Conclusion

It can be concluded that diabetes mellitus and hypertension were induced a significant increases in the parameters of the kidney function. These abnormal alterations were more disturbances in diabetic with hypertension patients, which may be leads to increase the risks of renal disease among them. Thus, management and treatment of the disease should be executed very soon, even before the onset of symptoms of this disease. All diabetic and hypertensive patients must be make a routine monitoring for kidney function tests in periodic clinical practice because early diagnosis may play a role in slowing the progression of kidney disease and other harmful consequences of diabetes and hypertension. Further studies are essential in larger population and in other ethnic groups to confirm these results. Health educational should be implemented targeted to diabetic and hypertension patients and through all media and channels for spreading the needed information, which will help significantly in controlling of complications of diabetes and hypertension.

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