Potassium Level Among Diabetes Mellitus : Patients in Baghdad Teaching Hospital-2022

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Abstract

Backgrounds and Objectives: This study was an attempt to find importance of potassium among diabetes mellitus patients and the relationship between diabetes mellitus and level of serum potassium which affect the general health in different situations because the low serum potassium level could predisposing factor for development of diabetes mellitus type two due to decrease insulin level and sensitivity which could be reversed by using potassium supplement. In diabetes mellitus patients the serum potassium levels decreases in cases of ketoacidosis because of recurrent vomiting and polyuria and intracellular potassium depletion due to hyperglycemia ; while serum potassium level could be high in diabetic nephropathy due to the diabetic nephropathy which associated with hyperkalemia which lead to serious complications like arrhythmia , cardiac arrest and muscular dysfunction which lead to paralysis.Material and methods: Across sectional study was done among a sample of 200 diabetes mellitus patients were included , which conducted in the clinic of endocrinology of Baghdad teaching hospital between the 20th of June 2022 to the 20th of December 2022. Clinical diagnosis was based on history & clinical examination and appropriate investigation .Results: A total of 200 diabetes mellitus patients with ages ranged from 8 to 90 years with a mean age of (50.1+-17.1) years. DM1 / DM2 ratio was 1/9 with potassium levels range between (2.76-6.20 mmol/dl) . Tested examined the relationships among these cases by using statistical analysis (student t-test & ANOVA test) p. Value is positive in male gender , height , duration of hypertension , FBS , RBS , s. Creatinine, s. Cholesterol, HDL .Conclusions: Electrolyte abnormalities are common in diabetic patients and may be associated with increased morbidity and mortality ,in this study we have measured the level of potassium in diabetic patients and found strong direct correlations between level of potassium and poorly controlled DM patients especially with higher BMI , central obesity , height, Hb A1c ; higher RBS , FBS , cholesterol , HDL, S. creatinine , while S. Potassium level have inverse correlation with duration of hypertension in diabetes mellitus type one .

Keywords: diabetes mellitus , potassium , DM1 , DM2 .

1. Introduction

The prevalence of diabetes mellitus in Iraq is more than 13.9% of adults , and many do not know that they have the disease.(1) , the prevalence of diabetes in the middle east is varied from about 3% in Palestine to more than 21.9% in Kuwait (2).

Potassium is generally stored in the fluid inside of the cells, but when there's too much glucose outside of the cells (blood sugar is too high), potassium moves outside of the cell, raising potassium levels in the blood.

Insulin then comes to move glucose into the cell to restore potassium homeostasis, causing potassium levels to drop so the People with low potassium levels will release less insulin, which causes higher blood sugar levels, and increases the risk of developing type 2 diabetes. When administering insulin, it's crucial for healthcare providers to monitor potassium levels. (3)

Diabetes is a chronic, metabolic endocrine disease characterized by elevated levels of blood glucose in the blood , which leads over time to serious damage to the heart, blood vessels, eyes, kidneys and nerves (4)

The patient is diagnosing as diabetes mellitus if his fasting blood sugar level 126 mg/dl or higher or random blood sugar level is 200 mg/dl or higher or

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Hb A1c is 6.5% or higher or oral glucose tolerance test is 200 mg/dl or higher , in pregnancy glucose challenge test is 140 mg/dl or higher (5) .

Type one diabetes mellitus is mainly genetic, and caused by infectious disease affect mainly children and young adults also called insulin dependent while type 2 diabetes is a disorder that develops over time and is primarily due to diet, called insulin resistance diabetes mellitus. This form of diabetes could be preventable. Risk factors are sedentary lifestyle and being physically inactive , obesity, and having a family history of type 2 diabetes. (6).

Potassium is both an essential mineral and electrolyte that the body requires in order to maintain regular fluid levels inside the cells. This nutrient also aids in muscle contraction, blood pressure regulation, and heart rate regulation and vital functions.(7)

Normal value of potassium level in the blood is (3.2-5.2 mmol / dl) , levels below this range characterize low potassium concentration (hypokalemia), and levels above this range characterize high potassium concentration (hyperkalemia).(7)

The main source of potassium is food, especially:

1. Fruits: bananas, oranges, kiwis, apricots
2. Vegetables: spinach, leafy greens, sweet potato, mushrooms

Women should consume 2,600 mg (milligrams) of potassium per day, and men should consume about 3,400 mg of potassium per day, the body will use all of the potassium it needs, then will excrete the leftover potassium as urinary waste. (7)

Hypokalemia may be caused by low dietary potassium intake or increased potassium excretion like using of laxatives or diarrhea, and high aldosterone levels , Increased potassium excretion via urine is often caused by diuretic medications, like thiazide diuretics used to treat hypertension and higher blood pressure (8)

High blood potassium, called 'hyperkalemia', may be caused by kidney disease, excessive dietary potassium intake, uncontrolled diabetes mellitus, dehydration, or severe blood loosing , when blood serum potassium levels are higher than 5.2 mmol/L, this is called hyperkalemia. Hyperkalemia can lead to muscle cramps, serious heart problems, and paralysis.(9)

Using an ACE inhibitor (angiotensin-converting enzyme used to treat high blood pressure and heart failure) also risk of developing hyperkalemia.(9)

Hypokalemia is one of the most common electrolyte disturbances in clinical practice and is usually secondary to poor glycemic control associated with polydipsia/polyuria, in particular diabetic ketoacidosis (DKA) and hyperglycemic hyperosmolar state (HHS), gastro-intestinal loss combined with hypomagnesaemia , and diuretic use for controlling edema in chronic kidney disease (CKD) or heart failure (HF) due to cardio-renal syndrome.

A higher risk of atrial fibrillation, respiratory muscle impairment, Q-T interval increase, torsade des pointes, and ventricular fibrillation, and, ultimately, higher morbidity and mortality in diabetic individuals with HF and CKD are clinical conditions associated with hypokalemia. (10)

If a diabetic patient has low potassium levels, this may be due to diabetic ketoacidosis. Diabetic ketoacidosis occurs when the body doesn't make enough insulin to transport glucose to the cells, so it uses fat as fuel instead. The process of breaking down fat releases ketones in the blood, and high levels of ketones can poison the body (American Diabetes Association).(11)

Ketones and glucose are then transferred to the urine, where the kidneys use water to separate blood from glucose and ketones. This process dehydrates the body and reduces potassium levels, quickly worsening diabetic ketoacidosis.

Diabetic ketoacidosis is a serious complication that can be life-threatening and requires immediate attention. Symptoms include shortness of breath, weakness, nausea, extreme thirst and dehydration(11)

2. Patients and Methods

Analytic descriptive cross sectional study was done to study level of potassium in 200 diabetes mellitus patients taken from endocrine clinic of Baghdad teaching hospital in 6 months duration from 20th of June 2022 to 20th of December 2022 the clinical diagnosis was based on history which includes clinical history and diet history (recall of the last week) clinical examination including anthropometric measurements and investigations including (RBS , FBS ,Hb A1c, Lipid profile , Renal function test, s. potassium level , Hb)

Depending on normal value of table (1)

Table (1) normal value of the patients biochemical analysis.

FBS	<126 mg/dl	S. Creatinine	0.7-1.3 mg/dl
RBS	<200 mg/dl	S. Cholesterol.	<200 mg/dl
Hb A1c	<6.5 %	S. Triglycerides.	<150 mg/dl
S. potassium	3.6-5.2 mmol/dl	HDL men Women	>40 mg/dl >50 mg/dl
B. urea	6-24 mg/dl	Hb. Men Women	13.2-16.6 11.6-15 g/dl

3. Statistical analysis

Analysis of data was carried out using the available statistical package of SPSS-28 (Statistical Packages for Social Sciences- version 28). Data were presented in simple measures of frequency, percentage, mean, standard deviation, and range (minimum-maximum values).

The significance of difference of different means (quantitative data) were tested using Students-t-test for difference between two independent means or Paired-t-test for difference of paired observations (or two dependent means), or ANOVA test for difference among more than two independent means. The significance of difference of different percentages (qualitative data) were tested using Pearson Chi-square test (2-test) with application of Yate's correction or Fisher Exact test whenever applicable. Statistical significance was considered whenever the P value was equal or less than 0.05.
Pearson correlation was calculated for the correlation between two quantitative variables with its t-test for testing the significance of correlation. The correlation coefficient value (r) either positive (direct correlation) or negative (inverse correlation) with value <0.3 represent no correlation, 0.3-<0.5 represent weak correlation, 0.5-<0.7 moderate strength, >0.7 strong correlation. In addition to correlation the r2 was calculated (The coefficient of determination), i.e. when value of r=0.58, then r2=0.34, this means that 34% of the variation in the values of y may be accounted for by knowing values of x or vice versa. (12,13,14,15,16,17,18,19)

4. Ethical considerations

An ethical approach obtained from a committee in the board and an official agreement document was obtained from Ministry of Health and from Baghdad Teaching Hospital .The patient were approached in the waiting room of clinic of endocrinology . All of them were informed about the aim of the study, consent was taken from them and the privacy was taken into consideration that the data used for research purpose.

5. Results

A total of 200 diabetes mellitus patients with ages ranged from 8 to 90 years with a mean age of (50.1+-17.1) years. Insulin dependent diabetes mellitus patients (DM1) were 21 patients, insulin resistance diabetes mellitus patients (DM2) were 179 , DM1 / DM2 ratio was 1/9 with potassium levels range between (2.76-6.20 mmol/dl) male were 91 And female were 109(male/female ratio were 4/5), Hypertensive patients were 36% While normotensive were 64%, these patients were 27.5%on insulin treatment and 63.5% on oral hypoglycemic drugs ,9%were on diet (table-2). From these patients were 66%poor controlled in the last 3 months according to the levels of Hb A1c % ,most of them were overweight (37%) and obese (31.5%), 61.5 %with central obesity (table-3); BMI mean was 28.7+-5.6 (table -4).
The SD mean of s. Potassium levels were 4.37+- 0.62 and the range was 2.76 – 6.20 mmol/dl , median 4.26 mmol/dl (table-5) and (figure -1)
many relationships were seen among these cases s. potassium levels and patients parameter by using statistical analysis (student t-test & ANOVA test) ; p. Value is significant with male gender and also significant with duration of hypertension and the height (table- 6,7,8). In the (table 9) the s. Potassium levels correlation with biochemical analysis positively with (FBS , RBS , s. Creatinine , s. cholesterol , HDL) especially in DM2 ; In the table (10 , 11) which shows the correlation between calories intake in the recall of the last weak and diabetes mellitus patients parameters ; p. values are significant in poor controlled both DM1 and DM2 . And also showing lower calories intake in underweight patients (SD mean 1600 +- 565 kcal / day) and higher calories intake in obese patients (SD mean 2188 +- 383 kcal/day) .

Table (2) parameter of DM patients with their %.

Parameter of the all patients and their percentages %		No	%
Age (years)	<20years	9	4.5
	20---29	12	6.0
	30---39	22	11.0
	40---49	43	21.5
	50---59	60	30.0
	60---69	40	20.0
	=>70years	14	7.0
Mean+-SD	50.1+-14.1		
Gender	Male	91	45.5
	Female	109	54.5
Duration of DM (years)	<1year	26	13.0
	1---4	43	21.5
	5---9	55	27.5
	=>10years	76	38.0
Hypertension	Yes	72	36.0
	No	128	64.0
Duration of HT (years)	<1year	2	2.8
	1---4	17	23.6
	5---9	14	19.4
	=>10years	39	54.2
Blood pressure control	Hypertensive	42	21.0
	Normotensive	158	79.0
Insulin treatment	Yes	55	27.5
	No	145	72.5
OHD treatment	Yes	127	63.5
	No	73	36.5

Table (3) diabetes mellitus patients risk features.			
Diabetes mellitus risk features		Total	
		No	%
Measured by HbA1C	Poor control (=>8.0)	132	66.0
	Good control (<8.0)	68	34.0
BMI (Kg/m2)	Underweight (<18.5)	8	4.0
	Normal (18.5-24.9)	37	18.5
	Overweight (25-29.9)	74	37.0
	Obese (30-34.9)	63	31.5
	Morbid Obese (=>35)	18	9.0
Waist circumf. (cm)	Normal (<102M & <88F)	77	38.5
	Central obese	123	61.5

Table (4) mean of the patients anthropometric measurements.	
Patients parameter	Total
BMI (Kg/m2)	28.7±5.6 (12.72-44.44)
Weight (Kg)	78.1±17.0 (21.5-126.0)
Height (cm)	164.5±8.7 (130-190)
Waist circumference (cm)	95.24±13.03 (52-136)
MAC (cm)	32.91±5.89 (17.0-45.0)
Wrist circumference (cm)	18.18±2.04 (12.0-26.0)

Table (5) serum potassium levels of diabetes mellitus patients.	
Serum potassium levels	Total
Mean±SD	4.37±0.62
Standard Error of Mean	0.044
Range	2.76-6.20
Mode	4.20
Percentile 05th	3.47
25th	4.00
50th (Median)	4.26
75th	4.70
95th	5.61
99th	6.06

Table (6) p. value of s. Potassium levels for all diabetes mellitus patients parameter.			
		Serum K (mmol/L)	P. Value
Age (years)	< 20years	4.54±0.50	0.784
	20---29	4.11±0.55	
	30---39	4.41±0.65	
	40---49	4.39±0.57	
	50---59	4.34±0.59	
	60---69	4.40±0.72	
	=>70years	4.32±0.81	
Gender	Male	4.48±0.63	0.020#
	Female	4.27±0.61	
Diabetes type	T1DM	4.35±0.66	0.896
	T2DM	4.37±0.62	
Duration of DM (years)	<1year	4.37±0.67	0.054
	1---4	4.17±0.54	
	5---9	4.52±0.65	
	=>10years	4.36±0.62	
Hypertension	Yes	4.30±0.60	0.289
	No	4.40±0.64	
Duration of HT (years)	<1year	4.53±0.37	0.024#
	1---4	3.93±0.50	
	5---9	4.51±0.59	
	=>10years	4.38±0.59	
Blood pressure control	Hypertensive	4.32±0.55	0.574
	Normotensive	4.38±0.64	
Insulin treatment	Yes	4.43±0.61	0.359
	No	4.34±0.63	
OHD treatment	Yes	4.37±0.58	0.768
	No	4.35±0.70	
Diabetes control	Poor control (HbA1C=>8)	4.39±0.65	0.518
	Good control	4.33±0.58	
-Data were presented as Mean±SD			
#Significant difference between two independent means using Students-t-test at 0.05 level.			
^Significant difference among more than two independent means using ANOVA-test at 0.05 level.			

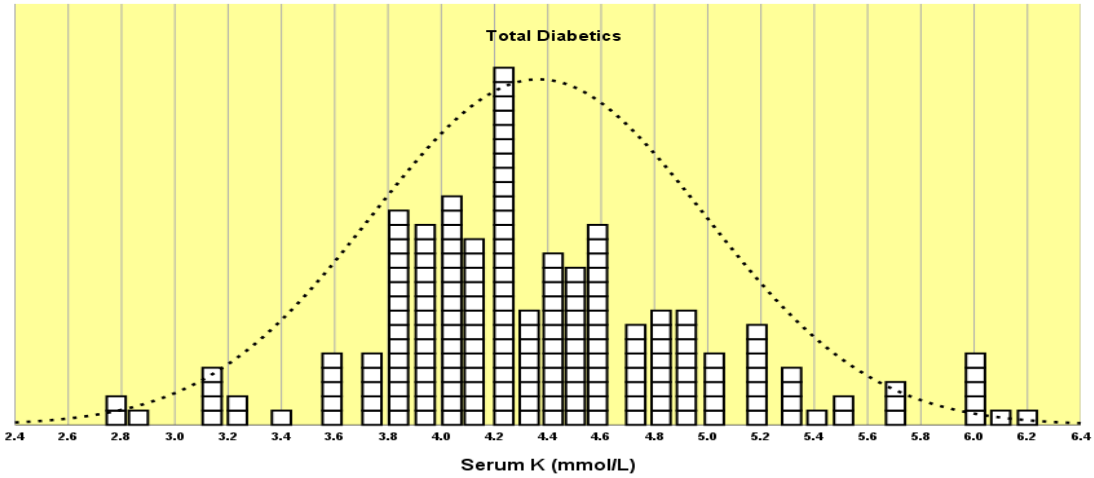

Figure (1) level of potassium in all diabetes mellitus patients

Table (7) relationship between diabetes mellitus patients parameter features and serum potassium levels using student t-test and ANOVA test.			
Diabetes mellitus patients parameter features		Serum K (mmol/L)	P value
BMI (Kg/m2)	Underweight (<18.5)	4.47±0.96	0.878
	Normal (18.5-24.9)	4.42±0.68	
	Overweight (25-29.9)	4.35±0.61	
	Obese (30-34.9)	4.36±0.61	
	Morbid Obese (=>35)	4.25±0.45	
Waist circumference (cm)	Normal (<102M &<88F)	4.42±0.66	0.366
	Central obese	4.33±0.60	
Cal/day	Low	4.46±0.64	0.319
	Normal (2-3M; 1.6-2.4F)	4.33±0.62	
	Excess	4.55±0.68	
Carbohydrates (%)	Low	-	-
	Normal (45-65%)	4.37±0.62	
	Excess	-	
Protein (%)	Low	-	-
	Normal (10-35%)	4.37±0.62	
	Excess	-	
Fat (%)	Low	5.31±	0.130
	Normal (20-35%)	4.36±0.62	
	Excess	-	
-Data were presented as Mean±SD			
#Significant difference between two independent means using Students-t-test at 0.05 level.			
^Significant difference among more than two independent means using ANOVA-test at 0.05 level.			

TABLE (8) : The correlation of serum K with diabetes mellitus patients parameter features				
		Serum K (mmol/L)		
		T1DM (n=21)	T2DM (n=179)	Total (n=200)
Age (years)	r	-0.138	0.049	0.032
	P	0.552	0.517	0.658
Duration of DM (years)	r	-0.302	0.049	0.012
	P	0.184	0.517	0.869
Duration of HT (years)	r	-0.999**	0.230	0.213
	P	0.0001	0.056	0.072
Weight (Kg)	r	0.067	0.016	0.024
	P	0.771	0.833	0.740
Height (cm)	r	0.023	0.158*	0.132
	P	0.922	0.035	0.062
BMI (Kg/m2)	r	0.088	-0.076	-0.046
	P	0.704	0.313	0.515
Waist circumference (cm)	r	0.008	0.111	0.086
	P	0.973	0.140	0.225
MAC (cm)	r	0.105	0.016	0.027
	P	0.651	0.832	0.699
Wrist circumference (cm)	r	0.129	0.092	0.094
	P	0.576	0.221	0.187
*Correlation is significant at 0.05 level. **Correlation is highly significant at 0.001 level				

Table (9) : The Correlation of serum K with diabetes mellitus patients biochemical analysis and their caloric and macronutrient intake				
Biochemical analysis and calories and macronutrient intake		Serum K (mmol/L)		
		T1DM (n=21)	T2DM (n=179)	Total (n=200)
Haemoglobin (g/dL)	r	-0.012	0.127	0.108
	P	0.960	0.090	0.129
FBS (mg/dL)	r	0.191	0.221**	0.209**
	P	0.406	0.003	0.003
RBS (mg/dL)	r	0.207	0.243**	0.232**
	P	0.367	0.001	0.001
HbA1C (%)	r	0.133	0.003	0.016
	P	0.567	0.965	0.827
Blood urea (mg/dL)	r	-0.098	0.086	0.074
	P	0.671	0.253	0.296
Serum creatinine (mg/dL)	r	0.340	0.267**	0.271**
	P	0.131	0.0001	0.0001
Serum cholesterol (mg/dL)	r	0.115	0.164*	0.159*
	P	0.618	0.028	0.024
Triglycerides (mg/dL)	r	-0.061	0.112	0.093
	P	0.793	0.134	0.192
HDL (mg/dL)	r	0.159	0.194**	0.187**
	P	0.490	0.009	0.008
Cal/day	r	0.098	0.097	0.097
	P	0.673	0.197	0.173
Carbohydrates (%)	r	-0.009	-0.145	-0.129
	P	0.968	0.053	0.068
Protein (%)	r	0.294	0.066	0.080
	P	0.196	0.383	0.259
Fat (%)	r	-0.175	0.138	0.102
	P	0.448	0.066	0.150
*Correlation is significant at 0.05 level. **Correlation is highly significant at 0.001 level				

Table (10) : The relationships of Cal/day intake with diabetes mellitus patients type one (insulin dependent) parameter features				
T1DM (n=21)		No	Cal/day Mean±SD	P value
Diabetes control	Poor control (HbA1C=>8)	18	1816.7±386.9	0.029#
	Good control	3	2366.7±208.2	
BMI (Kg/m2)	Underweight (<18.5)	6	1650.0±378.2	0.145
	Normal (18.5-24.9)	12	1941.7±394.2	
	Overweight (25-29.9)	2	2000.0±282.8	
	Obese (30-34.9)	-	-	
	Morbid Obese (=>35)	1	2600.0±	
Waist circumference (cm)	Normal (<102M &<88F)	20	1860.0±389.9	0.080
	Central obese	1	2600.0±	
-Data were presented as Mean±SD				
#Significant difference between two independent means using Students-t-test at 0.05 level.				
^Significant difference among more than two independent means using ANOVA-test at 0.05 level.				

Table (11): the relationships of Cal/day intake and diabetes mellitus patients type two (insulin resistance) parameter features				
T2DM (n=179)		No	Cal/day Mean±SD	P value
Diabetes control	Poor control (HbA1C=>8)	114	2226.8±401.4	0.022#
	Good control	65	2080.0±419.5	
BMI (Kg/m2)	Underweight (<18.5)	2	1600.0±565.7	0.404
	Normal (18.5-24.9)	25	2180.0±458.3	
	Overweight (25-29.9)	72	2179.9±432.7	
	Obese (30-34.9)	63	2188.9±383.2	
	Morbid Obese (=>35)	17	2147.1±346.6	
Waist circumference (cm)	Normal (<102M &<88F)	57	2193.9±419.4	0.653
	Central obese	122	2163.9±411.4	
-Data were presented as Mean±SD				
#Significant difference between two independent means using Students-t-test at 0.05 level.				
^Significant difference among more than two independent means using ANOVA-test at 0.05 level.				

6. Discussion

Potassium is micronutrient which is important in maintaining body health; both situations hyperkalemia or hypokalemia is dangerous and life threatening which can cause cardiac arrhythmias and cardiac arrest, in diabetes mellitus patients there are many complications associated with abnormal potassium level .

in our study we found direct correlations between poorly controlled diabetes mellitus in both types (DM1 and DM2) and serum potassium levels ; the same was discussed by George Liamis (20) who found that electrolyte imbalance in poorly controlled diabetes mellitus especially serum potassium levels and its direct relationship with poorly controlled diabetes mellitus .

Also we found the patients with higher BMI and central obesity have strong direct correlations with serum potassium level as in the study was done by Xianlei Cai (21) , who found an association between central obesity and abnormal S. Potassium level , he found the patients with abnormal S. Potassium level had more liability for developing metabolic syndrome (hypertension, dyslipidemia and diabetes mellitus).

Also in cases with diabetes mellitus with hypercholesterolemia there is positive correlation with serum potassium levels, also Camille Noe Pagán(22) found correlation between poor controlled diabetes mellitus and high level of serum cholesterol caused by increase synthesis of cholesterol from higher serum level of glucose and this hyperglycemic state lead to biochemical abnormalities including s. K level .

We found there's strong direct correlations between S. Creatinine level and S. Potassium level , which mean that the relation was with renal function because the S. creatinine is affected by decrease renal function(diabetic nephropathy)as in the study of Kleber Goia-Nishide (23) , who study the relationships between potassium levels and renal function in diabetes mellitus patients and the effect of renal impairment on the electrolyte homeostasis like S. Potassium level and also the study which done by Andy KH Lim (24) about diabetic nephropathy and biochemical analysis impairment as hyperkalemia and increase S. Creatinine level (renal function test) .

on the other hand we found a newly diagnosed diabetes mellitus patients have a low level of serum potassium which could be as a cause for diabetes mellitus type 2 as discussed by Yang Peng (25) in meta-analysis study show the risk of low serum potassium levels for diabetes mellitus type 2 development.

The patients with diabetes mellitus type one have inverse correlation between S. Potassium levels and duration of hypertension which could be due to Hypertensive drugs effect as in the study of Lucas Coregliano-Ring (26) who found the relationships between s. Potassium levels and antihypertensive drugs effect and the effect of insulin treatment which lead to intracellular potassium shifting with glucose.

And also we found the direct correlations between S. Potassium level with height of patients with diabetes mellitus type two , while in the Eun-Jung Rhee (27) study he found that the height of the diabetes mellitus patients inversely correlated with diabetes mellitus type two and its complications (abnormal S. Potassium levels) .

Also we found that direct correlations between S. Potassium levels and lipid profile especially HDL which also have been studied by Nabil A. Hasona (28) who found correlation between S. Electrolyte imbalance (potassium) and lipid profile of diabetes mellitus patients.

We found also relationships between poorly controlled diabetes mellitus both types (DM1,DM2) and calories intake when doing recall for last week and most of the patients didn't followed by dietitian and poor knowledge about food glycemic index which compatible with study have done by Juma Al-Kaabi (29) who found the poor knowledge and follow up of diabetes mellitus patients and most of them didn't know about calories counting or glycemic index of the food and no one was followed by dietitian .

7. Conclusions

Electrolyte abnormalities are common in diabetic patients and may be associated with increased morbidity and mortality. These disturbances are particularly common in decompensated DM who are poorly managed and controlled by using proper dieting and drugs as well as in the presence of renal impairment , in this study we have measured the level of potassium in diabetic patients and found strong direct correlations between level of potassium and poorly controlled DM patients especially with higher BMI and central obesity , height and also with biochemical analysis like higher level Hb A1c ; higher RBS , FBS , cholesterol , S. creatinine , HDL (mean increase level of potassium with increasing level of these parameters) , while S. Potassium level have inverse correlation with duration of hypertension in diabetes mellitus type one (mean with prolonged duration of hypertension the S. Potassium level becoming low) could be due antihypertensive drugs effect .

Electrolyte imbalance has a significant effect upon the risk of contracting many diseases. Also, early diagnosis, good glycemic control, and dietary modification are usually enough for prevention and treating complications in diabetes mellitus.

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