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Original Article

Disturbance of Electrolytes (Na, K and Cl) Homeostasis among Patients with Type II Diabetes Mellitus

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Abstract:

Diabetes Mellitus is a common metabolic disorder, which causes an imbalance in the electrolytes that regulate crucial metabolic mechanisms of the body. Derangement of water and electrolyte balances may occur in patients with diabetes mellitus caused by insulin deficiency and hyperglycemia. The objective of the study was to evaluate the electrolytes status (Na, K and Cl) in patients with type II diabetes mellitus and investigate their relations to glycemic control. A total of 104 participants aged between 35-60 years for both sexes (males and females) were included in the study; 64 type II diabetic patients and 40 healthy participants. Both groups were matched in age and sex. Blood glucose, HbA1c, Sodium, Potassium and Chloride parameters were biochemically estimated in the study. All the results were statistically analyzed using SPSS version 20 for applying the one-way ANOVA test. Total mean glucose was 172.84 28.88 and 92.6 10.22 for case and control groups, respectively. The mean level of HbA1c was 7.56 1.79 and 5.15 0.73 for case and control subjects, respectively. The mean of electrolyte levels (Na, K and Cl) was 124.95 7.21, 7.13 1.54 and 115.15 10.32 for diabetic patients, respectively and 140.37 3.12, 4.13 0.51 and 98.95 3.20 for healthy subjects, respectively. All the results were statistically significant between the case and control groups. Hyponatremia, hyperkalemia, and hyperchloremia were more common in diabetic patients with uncontrolled diabetes (HbA1c < 6.5%) than those with controlled diabetes (HbA1c > 6.5%). The study revealed that diabetes mellitus could cause electrolyte imbalance, morbidity and mortality in patients. Good glycemic control and regular evaluation of electrolyte levels among diabetic patients can reduce the morbidity and fatalities associated with electrolyte rearrangements.

Key words: Diabetes mellitus, electrolytes, disturbances and glycemic control

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Introduction:

Diabetes mellitus (DM) is a heterogeneous group of metabolic disorders characterized by high glucose levels (hyperglycemia) and disturbances in carbohydrate, fat and protein metabolism [1, 2]. Currently, diabetes is the biggest pandemic and an alarming issue worldwide because of its increasing prevalence rate. According to International Diabetes Federation, diabetes is a global health concern affecting 425 million people, and it is expected to reach 629 million by 2045 [3]. Type 2 diabetes mellitus is characterized by both insulin resistance and relative insulin deficiency [4]. Electrolytes play an important role in many of the body's processes, such as controlling fluid levels, maintenance of acid-base balance (pH), nerve conduction, blood clotting, and muscle contraction. Imbalance in the electrolyte levels that results from kidney disease, dehydration, fever, diarrhoea and vomiting has been implicated as one of the contributing factors towards the development of complications that is observed in diabetes mellitus and other related endocrine disorders [5, 6]. Moreover, electrolytes play an important role in intermediary metabolism and cellular function, including enzyme activities and maintenance of electrical gradients [7]. Disturbances of some electrolytes can be correlated with diabetes mellitus [8, 9]. This correlation may be due to impaired and reduction in insulin action which causes the movement of electrolytes between intra- and extracellular [10]. Furthermore, hyperglycemia causes the disturbance of cell surface receptors and transport channels which move the fluid and electrolytes from the intracellular to the extracellular space which will cause cellular dehydration and changes in the metabolism machinery of cells and contribute to the progress of diabetes mellitus complications. [11, 12]. Na+ K+ ATPase pump in the red blood cells plays an essential role in the maintenance and regulation of intracellular and extracellular electrolyte homeostasis [13]. The alterations of this transport enzyme activity in diabetic patients are associated with the progression and pathogenesis of diabetes mellitus which ultimately leads to the complications of diabetes mellitus [8, 10, 14]. Therefore, the objectives of the study were to estimate some electrolytes (Na, K and Cl) status among patients with type II diabetes mellitus and healthy participants and evaluate the significant differences between the two groups (case and control group). Finally, evaluating the effect of glycemic control on electrolytes homeostasis among diabetic patients.

Study Population:

A case-control study was conducted from March to May 2022 at Albalsam Clinic, Garma, Southwest region of Libya. A total of 104 participants aged between 35-60 years for both sexes (males and females) were included in the study, 64 type II diabetic patients and 40 healthy participants. Both groups were matched in age and sex. All the participants were informed about the purpose of the study, were free to ask questions throughout the

study and signed an informed consent form as an ethical approval.

Sample Collection:

Five ml of blood was collected after overnight fasting of 8-12 hours from all diabetes mellitus patients for the measurement of glucose, HbA1c, Sodium (Na), Potassium (K) and Chloride (Cl). The blood was collected in sodium fluoride to detect glucose and Ethylene Diamine Tetra Acetic Acid (EDTA) to detect glycosylated haemoglobin (HbA1c). The serum was made to detect Na, K and Cl. Demographic characteristics of the study population, including (name, age and sex), family history, medical history, medication, occupation, physical activity and lifestyle patterns such as smoking were all obtained by a structured questionnaire.

Biochemical Parameters:

Blood glucose, HbA1c, Sodium, Potassium and Chloride parameters were biochemically estimated in the study. • Serum glucose: The method used was the GOD-PAP method by photometer 4040 Fulfils. Plasma glycosylated haemoglobin (HbA1c): The method used was the sandwich immunodetection method by Ichroma made in Korea. Na+, K+ and Cl- were analysed using ISE in Beckman Coulter AU 680 analyser.

Inclusion criteria:

Group 1: confirmed cases of type II diabetes mellitus aged between 35-60 years under medication metformin or insulin. Group 2: Apparently healthy individuals without a history of any diseases.

Exclusion criteria:

Type 1 or gestational diabetic patients, breastfeeding and pregnant women were excluded from the study. Patients suffering from vomiting and diarrhoea or any kind of chronic diseases affecting electrolyte imbalance such as kidney, heart and endocrine diseases. Taking any kind of medications or supplementations that affect the levels of electrolytes such as thiazide diuretics.

Statistical analysis:

The results were expressed as mean and standard deviation and were statistically analyzed by using Statistical Package for Social Sciences (SPSS version 20). An analysis of variance (one-way-ANOVA) test was used to compare the means of the variables among the groups.

Results:

The results of the current study have been presented and summarized in the form of tables. The study included 104 participants aged between 35-60 years for both sexes (males and females), 64 type II diabetic patients and 40 healthy participants. Both groups were matched in age and sex.

Table 1 shows means and standard deviations of age and biochemical parameters of blood glucose, HbA1c, Na, K and Cl levels for both groups (cases and control groups). The mean age was 44.29 ± 7 and 44.55 ± 7.29 for the cases and control group, respectively. The total mean and standard deviation of blood glucose levels was 172.84 ± 28.88 mg/dl and 92.6 ± 10.22 for the cases and control group, respectively. The mean level of HbA1c was 7.56 1.79 and 5.15 0.73 for case and control subjects, respectively. The mean of electrolyte levels (Na, K and Cl) was 124.95 7.21, 7.13 1.54 and 115.15 10.32 for diabetic patients, respectively

and 140.37 3.12, 4.13 0.51 and 98.95 3.20 for healthy subjects, respectively. An analysis of the data by using one-way ANOVA showed a statistically significant difference in biochemical variables (blood glucose, HbA1c, Na, K and Cl) between case and control groups at a *P*-value of less than 0.01.

In Table 2, the results have been divided into two groups as per HbA1c levels. The first group in which HbA1c > 6.5% is considered a controlled blood glucose group and the second group where HbA1c > 6.5% is for uncontrolled blood glucose. The table reveals means and standard deviations of biochemical parameters of blood glucose, HbA1c, Na, K and Cl levels for both groups (controlled and uncontrolled blood glucose groups). The total mean and standard deviation of blood glucose levels was 144.04 ± 12.14 and 186.90± 23.75 in controlled and uncontrolled groups, respectively. The mean of HbA1c levels were 5.8 ± 1.09 and 8.43± 1.38 in controlled and uncontrolled blood glucose levels, respectively. The mean level of Na in controlled blood glucose subjects was 131.52 ± 3.99, whereas, in uncontrolled subjects was 121.74± 6.19. The mean of K in controlled blood glucose was 5.53 ± 0.51, while, in uncontrolled subjects was 7.91± 1.24. The mean of Cl levels in controlled and uncontrolled blood glucose was 105.13 ± 7.78 and 120.05± 7.49, respectively. An analysis of the data by using one-way ANOVA revealed a statistically significant difference in biochemical parameters (blood glucose, HbA1c, Na, K and Cl) between controlled and uncontrolled blood glucose groups at a *P*-value of less than 0.01.

Table 1: Comparison of the results between case and control groups.

Parameters	Group I (Cases) (Diabetic patients)	Group II (Control) (Healthy individuals)	*P* Value
Age years	44.29 ± 7	44.55 ± 7.29	0.8
Blood glucose levels mg/dl	172.84 ± 28.88	92.6 ± 10.22	< 0.01
HbA1c Levels %	7.56 ± 1.79	5.15 ± 0.73	< 0.01
Na mmol/ L	124.95 ± 7.21	140.37 ± 3.12	< 0.01
K mmol/ L	7.13 ± 1.54	4.13 ± 0.51	< 0.01
Cl mg/ dl	115.15 ±10.32	98.95 ± 3.20	< 0.01

Table 2: Distribution of cases' results according to glycemic control.

Parameters	Controlled blood sugar HbA1c < 6.5%	Uncontrolled blood sugar HbA1c > 6.5%	*P* Value
Blood glucose levels mg/dl	144.04 ± 12.14	186.90 ± 23.75	< 0.01
HbA1c Levels %	5.8 ± 1.09	8.43 ± 1.38	< 0.01
Na mmol/ L	131.52 ± 3.99	121.74 ± 6.19	<0.01
K mmol/ L	5.53 ± 0.51	7.91 ± 1.24	< 0.01

Cl mg/ dl	105.13 ± 7.78	120.05 ± 7.49	< 0.01

Discussion:

The relationship of diabetes mellitus with minerals including Na+, K+ and Cl- has been reported by many studies [17, 18, 19, 20].

The present study showed that there is a decrease in serum sodium level 124.95 ± 7.21 among diabetic patients when compared to the control group 140.37 ± 3.12. The result was consistent with many studies which all revealed a reduction in serum sodium levels among type II diabetic patients [21, 22, 23]. In contrast to the current study, a study showed that there are no significant changes in sodium levels among type II diabetic patients [24].

Hyperglycemia in diabetes causes osmotic diuresis leading to changes in electrolytes between intra and extracellular spaces. Increases in osmolality results in the movement of water from intracellular space to extracellular space which dilutes the extracellular Na+ leading to lower serum Na+ level. Furthermore, Alteration in the rennin angiotensin system in diabetes leads to a change in serum sodium concentration [25, 26]. It is proposed that the association between diabetes mellitus and lowered serum sodium may be due to the altered vasopressin regulation [27].

The study also reported that there is a significant elevation in serum potassium 7.13 ± 1.54 in type II diabetic patients as compared to the control group 4.13 ± 0.51. The study was in agreement with other studies that showed an increase in potassium levels among diabetic patients compared to the control group [8, 28]. Conversely, some studies showed a decrease in serum potassium levels [29, 30] and another study showed that there are no significant changes in potassium study [24, 31].

Impaired insulin secretion causes an increase in potassium levels by promoting potassium influx into hepatic cells and skeletal muscle cells leading to an increase in the activity of Na+ and K+ ATPase pump [32]. Alterations to this transport system are linked to several complications of types of diabetes mellitus disorders [27].

In this study, the serum chloride was significantly higher in diabetic patients (115.15 ±10.32) than in the control group (98.95 ± 3.20). These findings were in agreement with other studies' findings [22, 33]. Elevated chloride in diabetic patients could be due to ketoacidosis. Ketoacidosis decreases the pH of blood leading to disturbing acid-base balance which causes an elevation in chloride [32 and33].

Moreover, our findings showed significant changes in Na (decrease), K (increase) and Cl (increase) among uncontrolled diabetic patients (HbA1c > 6.5%) when compared to the controlled diabetic patients (HbA1c > 6.5%) which could be due to hyperglycemia or insulin deficiency. A similar study reported significant changes in Na, K and Cl among uncontrolled diabetic patients [34].

Conclusion: Diabetes mellitus is associated with disturbances of electrolyte levels (Na, K and Cl). Hyponatremia, hyperkalemia, and hyperchloremia are more common in

diabetic patients with uncontrolled diabetes (HbA1c < 6.5%) than those with controlled diabetes (HbA1c > 6.5%). Good glycemic control and regular evaluation of electrolyte levels among diabetic patients can reduce the fatalities associated with electrolyte rearrangements.

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