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ORIGINAL RESEARCH

Serum Electrolytes Levels in Patients with Diabetes Mellitus: An Experience from a Tertiary Care Hospital of Northern India

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ABSTRACT

Background: Blood glucose and electrolytes have a complicated relationship that is influenced by a number of other factors such as age and concomitant conditions. As there is paucity of such studies in India, so present study was to determine the most prevalent electrolyte disturbances among diabetic in-patients and to explore an association between blood sugar and electrolyte imbalances.

Materials and Methods: The present cross-sectional study was carried for a duration of two years among 271 adult patients with diabetes mellitus admitted to the wards and ICU in a tertiary care centre. Patient-specific information was collected in a structured schedule and blood sample was collected for laboratory investigations after obtaining written informed consent. All tests were performed at a 5% level of significance; thus, an association was significant if the p value was less than 0.05.

Results: In present study (Table 1), the mean age of study subjects was 58.92 ± 13.15 years, with nearly equal representation from males (49.4%) and females (50.6%). The mean duration of diabetes among subjects was 9.72 ± 6.57 years. The mean HbA1C was 7.65 ± 1.23 % which reflect uncontrolled diabetes. The most common electrolyte imbalance among enrolled subjects was hyponatremia (33.6%). The mean levels of serum sodium (group A: 132.82 ± 3.99 vs group B: 135.62 ± 5.12), were statistically different ($p<0.05$).

Conclusion: The importance of evaluating serum electrolytes in patients with type 2 diabetes was presented in the study. Electrolytes, particularly sodium, chloride, and potassium, become significantly disturbed as fasting blood glucose rises.

Keywords: Blood Glucose, Diabetes Mellitus, Electrolytes

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INTRODUCTION

Diabetes mellitus is a major and growing public health concern around the world. Chronic hyperglycaemia is a symptom that occurs as a result of abnormal insulin action, secretion, or both. Chronic complications in people with diabetes can impact numerous organ systems and are responsible for a number of morbidity and mortality related with the diabetes. Renal failure, cardiovascular disease, and retinopathy are all commonly associated with it. Patients are at a higher risk of developing numerous consequences as the disease progresses, such as metabolic imbalances, blood vessel degeneration, electrolyte concentration effects, and electrolyte proportion offset.[1,2]

Maintaining acid-base balance, membrane potential, blood clotting, muscle contraction, nerve conduction, and maintaining body fluids are all critical functions of electrolytes. Its imbalances have become a major cause of human health complications. Potassium, magnesium, phosphate, and sulphate are the major electrolytes found in intracellular fluid, while sodium, chloride, and bicarbonate are found in extracellular fluid. Sodium is primarily involved in acid-base regulation, osmoregulation, and the uniform distribution and conservation of body fluid. Potassium is important for neuromuscular excitability, acid-base balance, and myocardial activity, as well as serving as a cofactor for the enzyme pyruvate kinase. Chloride aids in fluid balance both inside and outside cells, blood volume regulation, and acid-base balance.[3]

Disturbance in electrolyte distribution may have an impact on the course of diabetes and how it is managed. Blood glucose and electrolytes have a complicated relationship that is influenced by a number of other factors such as age and concomitant conditions.[4] Furthermore, diabetic nephropathy, which is defined by reduced renal function and is one of the consequences of diabetes, can cause electrolyte imbalance because high blood glucose damages the nephrons, affecting electrolyte absorption and reabsorption.[5-7] A number of research from developed counties have found an association between electrolytes and diabetes.[8-11] Electrolytes must be evaluated in diabetes patients, and the relationship between electrolytes and glucose control must be understood. As there is paucity of such studies in India, so present study was conducted with an to determine the most prevalent electrolyte disturbances among diabetic in-patients at a tertiary care hospital, Delhi. Additionally an association between blood sugar and electrolyte imbalances was explored in the present study.

MATERIALS & METHODS

Study setting and Design

The present cross-sectional study was carried for a duration of two years (May 2019 to April 2021) in the Department of Pulmonary Medicine of a tertiary care teaching and referral hospital, Delhi, India, after obtaining ethical approval from Institutional Ethics Committee (IEC/IRB No.; LHMC, Delhi).

Study subjects and sample size

The present study included the confirmed cases of type 2 diabetes mellitus patients (18 years or above) admitted to the wards and ICU as study subjects. Diagnosis of diabetes mellitus was based on the WHO criteria using fasting blood glucose, postprandial blood glucose, and random blood glucose. Two groups were formed: group A (RBS > 300mg/dL) and group B (RBS $\leq$ 300mg/dL) on the basis of previous studies.[12,13] The minimum sample size was calculated as 97 for each group considering the prevalence of electrolyte imbalance in diabetes as 50% (no particular studies found in Delhi) and taking absolute precision as 10%. Prior to enrolling of subjects into the study, written informed consent was obtained either from patient or relatives after explaining in detail regarding the purpose of study, and consecutive sampling method was used to enrol the study subjects, so a total of 271 patients were enrolled in the study during defined study duration. Pregnant women and subjects with were excluded from the study.

Data and Sample collection

After admission, clinical history was taken and patient-specific and relevant information was collected in a structured data collection schedule through interviews. At the time of admission 5 mL of blood sample was collected from each patient for laboratory investigations such as fasting, postprandial and random blood glucose levels (done by GOD-POD method), HbA1C

(done by nephelometry method), electrolytes such as sodium, potassium, chloride and bicarbonate (done by direct and indirect Ion Selective Electrodes [ISEs] method).[14-16] The cut off defined for hyponatremia was sodium concentration < 135 mmol/L. The cut offs defined for hypochloremia and hyperchloremia were chloride ion < 97 mEq/L and chloride level > 107 mEq/L respectively. The cut offs defined for hyperkalemia and hypokalemia were potassium level > 5 mEq/L and potassium level < 3.5 mEq/L respectively.

Statistical analysis

The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 28. Results were analysed with baseline demographic and clinical, laboratory parameters of each group of study patients. Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD. Normality of data were tested by Kolmogorov-Smirnov test. If the normality was rejected, then non parametric test was used. Mean of electrolyte disturbances between the groups were compared using Unpaired t-test. Frequency of electrolyte disturbances between the groups were compared using Chi-Square test /Fisher's exact test. All tests were performed at a 5% level of significance; thus, an association was significant if the p value was less than 0.05.

RESULTS

In present study [Table 1], the mean age of study subjects was 58.92 ± 13.15 years, with nearly equal representation from males (49.4%) and females (50.6%). The means of weight, height and BMI among subjects were 67.22 ± 18.87 Kg, 161.34 ± 11.45 cms, and 25.93 ± 6.2 Kg/m^2 respectively. Among enrolled subjects more than one tenth were hypertensives (11.1%). The mean duration of diabetes among subjects was 9.72 ± 6.57 years.

Table 1: Baseline characteristics of study subjects (N=271).

Variables	Number (%)/ Mean+SD
Gender	
Male	134 (49.4)
Female	137 (50.6)
Age (in years)	58.92 ± 13.15
Age group	
<45 years	42 (15.5)
45-60 years	199 (73.4)
>60 years	30 (11.1)
Anthropometric measures	
Weight (Kg)	67.22 ± 18.87
Height (cms)	161.34 ± 11.45
BMI (Kg/m^2)	25.93 ± 6.2
Comorbidity	
Hypertension	30 (11.1)
Hypertension and ischemic heart disease	14 (5.3)
None	227 (83.6)
Duration of diabetes (in years)	9.72 ± 6.57

The means of pulse rate, systolic blood pressure, diastolic blood pressure and respiratory rate among subjects were 90.01 ± 17.21 bpm, 137.11 ± 26.53 mmHg, 83.97 ± 13.34 mmHg and 22.67 ± 4.18 rpm respectively [Table 2]. The retinopathy was observed in 8.9% of subjects

and nearly two fifth of subjects were having neuropathy (17.3%). Only one tenth of patients were either on oral hypoglycaemic agents (11.4%) or insulin (12.9%) for management of diabetes. The ongoing treatment drugs for hypertensives (including IHD) among subjects were calcium channel antagonist (18.2%), beta blockers (11.4%), loop diuretics (50.0%) and potassium sparing diuretics (11.4%).

Table 2: Clinical characteristics of study subjects (N=271).

Variables	Number (%)/ Mean+SD
Vitals	
Pulse rate (bpm)	90.01 ± 17.21
Systolic B.P (mmHg)	137.11 ± 26.53
Diastolic B.P (mmHg)	83.97 ± 13.34
Respiratory rate (rpm)	22.67 ± 4.18
Retinopathy	
Present	24 (8.9)
Absent	247 (91.1)
Neuropathy	
Present	47 (17.3)
Absent	224 (82.7)
Oral hypoglycaemic agents	
Yes	31 (11.4)
No	240 (88.6)
Insulin	
Yes	35 (12.9)
No	236 (87.1)
Calcium channel antagonist (n=44)	
Yes	8 (18.2)
No	36 (81.8)
Beta blockers (n=44)	
Yes	5 (11.4)
No	39 (88.6)
Loop diuretics (n=44)	
Yes	22 (50.0)
No	22 (50.0)
Potassium sparing diuretics (n=44)	
Yes	5 (11.4)
No	39 (88.6)

The means of FBS, PPBS, and RBS, among subjects were 176.87 ± 66.76 mg/dL, 217.54 ± 71.23 mg/dL and 205.29 ± 70.47 mg/dL respectively [Table 3]. The means for serum sodium, potassium and chloride among subjects were 134.22 ± 4.34 mEq/L, 4.42 ± 0.56 mEq/L and 100.41 ± 6.92 mEq/L respectively. The mean HbA1C was 7.65 ± 1.23 % and patients with HbA1C level > 7% were considered as uncontrolled diabetics. The most common electrolyte imbalance among enrolled subjects was hyponatremia (33.6%) followed by hypochloraemia (19.9%) and hypokalaemia (16.2%) whereas hyperkalaemia (5.9%) and hyperchloremia (1.8%) were among least occurring electrolyte imbalance among subjects.

The mean levels of serum sodium (group A: 132.82 ± 3.99 vs group B: 135.62 ± 5.12), potassium (group A: 4.32 ± 0.61 vs group B: 4.62 ± 0.52) and chloride (group A: 101.08 ± 12.63 vs group B: 98.56 ± 4.20) were statistically different in group A and group B

(p<0.05). The frequency of hyponatremia (group A: 38.5% vs group B: 27.0%) and hypochloraemia (group A: 22.4% vs group B: 16.5%) was higher among group A as compared to group B, but events of hyperkalaemia (group A: 4.5% vs group B: 7.8%) and hyperchloremia (group A: 1.3% vs group B: 2.6%) was higher among group B as compared to group A.

Table 3: Laboratory parameters of study subjects (N=271).

Parameters	Number (%)/ Mean+SD
Blood sugar	
FBS (mg/dL)	176.87 ± 66.76
PPBS (mg/dL)	217.54 ± 71.23
RBS (mg/dL)	205.29 ± 70.47
Serum Electrolytes	
Serum sodium (mEq/L)	134.22 ± 4.34
Serum potassium (mEq/L)	4.42 ± 0.56
Serum chloride (mEq/L)	100.41 ± 6.92
HbA_{1C} (%)	7.65 ± 1.23
Type of electrolyte imbalance	
Hyponatremia (<135 mEq/L)	91 (33.6)
Hypokalaemia (<3.5 mEq/L)	44 (16.2)
Hyperkalaemia (>5 mEq/L)	16 (5.9)
Hypochloraemia (<97 mEq/L)	54 (19.9)
Hyperchloremia (> 107 mEq/L)	5 (1.8)

Table 4: Analysis of laboratory parameters among study subject groups (N=271).

Parameters	Number (%)/ Mean+SD		P-value
	Group A (n=156)	Group B (n=115)	
Serum Electrolytes			
Serum sodium (mEq/L)	132.82 ± 3.99	135.62 ± 5.12	P<0.0001
Serum potassium (mEq/L)	4.32 ± 0.61	4.62 ± 0.52	P<0.0001
Serum chloride (mEq/L)	101.08 ± 12.63	98.56 ± 4.20	P=0.040
Type of electrolyte imbalance			
Hyponatremia (<135 mEq/L)	60 (38.5)	31 (27.0)	P=0.047
Hypokalemia (<3.5 mEq/L)	25 (16.0)	19 (16.5)	P=0.912
Hyperkalemia (>5 mEq/L)	7 (4.5)	9 (7.8)	P=0.249
Hypochloremia (<97 mEq/L)	35 (22.4)	19 (16.5)	P=0.228
Hyperchloremia (> 107 mEq/L)	2 (1.3)	3 (2.6)	P=0.422

DISCUSSION

Patients with type 2 diabetes mellitus frequently have electrolyte imbalances. The reason is generally multifaceted, but insulin inadequacy in diabetic ketoacidosis and hyperglycemia are the most common causes.[11] The present study showed significant reduction in serum sodium and chloride levels with increasing fasting blood glucose (group A [RBS>300 mg/dL]): 132.82 ± 3.99 vs group B [RBS ≤ 300mg/dL]: 135.62 ± 5.12). This decreasing pattern of change in serum sodium levels as fasting blood glucose rises is mostly supported by a study conducted by Parmar et al., which found that serum sodium and chloride levels decreased as fasting blood glucose raised.[17]

Osmotic diuresis is a well-known physiological cause of dysnatremia in diabetes. Serum sodium levels in people with uncontrolled diabetes fluctuate due to a balance between

hyperglycemia-induced water transport out of cells, which lowers sodium, and glucosuria-induced osmotic diuresis, which raises sodium. Hyponatremia is caused by an increase in blood glucose levels, which pushes water out of the cells into the extracellular space. Studies have shown that serum sodium levels have an inverse connection with urine microalbumin levels, implying that when renal function degrades, serum sodium levels decline as well.[11,18,19] The stimulation of the renal renin-angiotensin system is responsible for the development of diabetic nephropathy, a primary cause of end-stage renal disease, according to Giacchetti et al.[20]

Hyponatremia was the most prevalent electrolyte imbalance identified in this study, with nearly a third of the participants (33.6%) reporting sodium levels below 135 mEq/L. The incidence of hyponatremia among hospitalised patients varies significantly, ranging from 5 to 35 percent.[21] Hyponatremia has been linked to an increased risk of death in hospitalised patients in previous studies. Hyponatremia as a risk factor for mortality in diabetic people may have been reversed if sodium levels were corrected during hospitalisation.

In the present study, hypochloremia was occurring along with the hyponatremia which was comparable to the findings of a study conducted by Al Jameil et al.[24] These findings were consistent with the research that revealed a prevalence of 35 percent of hypochloremia among critically ill individuals with septic shock.[25]

In the present study, glycaemic factors had a substantial impact on serum potassium levels, which was consistent with the findings of Saito et al. and Parmar et al., who found a decreasing pattern in serum and potassium levels with increased fasting blood glucose.[10,21] However a recent study that found no significant differences in serum potassium levels in individuals with both controlled and uncontrolled blood glucose levels.[26] Hypokalemia was found to be 13 percent of the population in a big Swedish health care system with data from 364,955 cases, and hyperkalemia was shown to be 7 percent of the population.[27]

Limitations

Since the current study did not test for changes in electrolyte concentration during hospitalisation, patients who had electrolyte imbalances after a few days were not detected. The study did not assess electrolyte concentrations in the urine, and having these parameters would allow us to better classify patients.

CONCLUSION

The importance of evaluating serum electrolytes in patients with type 2 diabetes was presented in the study. Electrolytes, particularly sodium, chloride, and potassium, become significantly disturbed as fasting blood glucose rises. As a result, electrolyte measurements in type 2 diabetic patients should be part of routine patient care.

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