ORIGINAL ARTICLE

ASSOCIATION OF RISK FACTORS FOR DIABETES MELLITUS AND SERUM ELECTROLYTES

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ABSTRACT

OBJECTIVE: The purpose of the study was to examine the imbalance of selected serum electrolytes and the associated factors in diabetic patients.

METHODOLOGY:
This was a cross-sectional study, carried out in diabetic patients attending their follow-up appointments at the Polyclinic Hospital Islamabad. To include 155 patients with diabetes mellitus in the study, a convenience technique of sampling was used. A questionnaire was utilized to comprise all necessary information from each patient with diabetes mellitus. 5mL of venous whole blood was extracted from each participant and ion-selective electrode (ISE) device and automated chemistry analyzer were processed and tested for determination of serum electrolyte and serum glucose respectively. In order to determine the association and meaningful link between irregular electrolytes in serum and independent parameters, the model of Pearson's correlation coefficient and regression for multivariate logistic were performed respectively.

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RESULTS: In diabetic patients, an increased prevalence rate of disturbed electrolytes in the serum was prominent. The total prevalence rate was 45.80% (n=71/155), with hyponatraemia being the largest (46.47%), followed by hypochloraemia and hypercalcaemia (19.48% and 14.28% respectively. There were strong positive associations between type of medication, age and high body mass index (BMI) and elevated serum concentrations of sodium (Na^+) (r=0.712, P=0.003), potassium (K^+) (r=0.817, P=0.002) and chloride (Cl-) (r=0.518, P=0.003). In diabetic patients, risk factors for serum electrolyte disorders were statistically defined as being employed (AOR: 3.879, 95%, P-value: (0.044), treated with various drugs (AOR: 2.988, 95% C.I, P value: 0.012) and not able to regulate the level of blood glucose or increased level of glucose (hyperglycaemic) (AOR: 3.18, 95% C.I, P value: <0.001).

CONCLUSION: In patients with diabetes mellitus, the concentration of serum electrolyte was abnormal significantly. In advanced patients of diabetes mellitus, incidence of imbalanced concentrations was more prevalent, with some parameters had a clear strong association with deranged electrolytes in the serum in patients with diabetes mellitus.

KEYWORDS: Electrolytes, Risk factors, Diabetes Mellitus, Hyperkalaemia, Hyponatraemia

INTRODUCTION

Body fluid is an electrolyte- and non-electrolyte-containing aqueous solution having two compartments i.e. extracellular and intracellular. [1-2] Most of the metabolic processes take place mainly inside intracellular fluid (ICF), as a result of which there may be major changes in the strength of the ion with detrimental influences on functions of the body. Extracellular fluid (ECF) acts as a channel efficiently that controls the volume intracellularily and its strength of the ion, requiring most favourable volume maintenance. Whichever change in osmolality extracellularily is followed by equal variation in osmolality intracellularily, followed by a mutual alteration in the cell volume since there is an osmotic balance between extracellular fluid and cells. [1, 3-6]

The electrolytes are compounds which in solution turn into ions and develop ability to carry electricity. [7-8] In several processes, electrolytes work as integral part, including the amount of fluid of the body and regulation of osmosis, rhythmicity and contractility of the myocardial, excitability of the neuromuscular junction and acid-base balance. [1, 8] Important electrolytes in extracellular fluid are sodium (Na^+) and chloride (Cl^-) ions, though phosphate, potassium and magnesium are essential electrolytes in intracellular fluid. Trans-membrane electrical gradients trigger the cellular K^+ diffusion out of the cells and Na^+ into the cells. Stimulated through insulin and catecholamine hormones, the Na^+-K^+ pump overturns the progression of electrolytes to preserve their homeostasis intracellularity and extracellularily.[1, 4, 8-10] Changes in catecholamine and insulin levels influence the amount of serum electrolytes. [5] The mechanisms well thought-out by which solutes and fluid anomalies arise in patients with hyperglycaemia are variations in total quantity of solute extracellularily, osmotic diuresis, thirst-driven intake of water, and influences from related conditions. [11-13]

The most common electrolyte condition is hypo- and hyper-secretion in hospitalised patients. The hyperkalaemia and hypokalaemia occur when the potassium levels in serum is <3.5 mmol/L and >5.1 mmol/L, respectively. The hyponatraemia is called when the serum sodium concentration is <135 mmol/L, and the hypernatraemia is called when the serum sodium concentration is >50 mmol/L. Mechanisms through which enhancement of the serum may happen are the transfer to the extracellular fluid of electrolytes from the cells or into the cells from extracellular fluid, more intake and decreased renal excretion. (14-19) The diabetes is chronic disease that happens when blood glucose level is elevated as body is not efficiently manufacturing any or adequate insulin or utilize insulin. (20-21) Of the immediate complications of diabetes mellitus caused due to insufficient intake of fluid and total insulin deficiency is the hyperglycaemic hyperosmolar condition, which is characterised by de-hydration, hypotension and hyperosmolarity and can cause disorders of the electrolytes in patients with diabetes mellitus having various periods of hyperglycaemia after several weeks of polyuria. (22-25)

Therefore, the purpose of the research was to evaluate abnormalities of electrolytes in the serum and factors related to abnormalities in diabetic patients.

PATIENTS AND METHODS

The research was performed from February 2019 to June 2019, at Polyclinic Hospital Islamabad. The research was performed on patients of diabetes mellitus (both type 1 and type 2). A cross-sectional study conducted and a comfort sampling was utilized to provide a number of 155 patients with diabetes mellitus. A questionnaire was used for the collection of clinical history, socio-demographic, and drug use etc. Patients with diabetes mellitus with a record of renal complications or disease as well as patients undergoing care with diuresis while the time of data collection were disqualified from the research. Blood pressure tests were carried out on the basis of recommendations from the World Health Organization (WHO) and patients with diabetes mellitus were deemed hypertensive having elevated diastolic and systolic blood pressure tests. For each study participant, anthropometric assessment was carried out on the basis of WHO guidelines and the body mass index (BMI) was determined using the formula, Body Mass Index = weight over height square and patients with diabetes mellitus were categorised as irregular and average weight (18.5-24.9 kg/m^2), obese ≥ 30 kg/m^2), overweight (25.0-29.9 kg/m^2), underweight (<18.5 kg/m^2) according to World Health Organization guideline group.

Every study participant collected five millilitres of over-night fasting blood samples and underwent the requisite standardised methods to isolate the serum from obtained whole blood utilized for determining blood glucose and serum electrolyte. For the determination of serum electrolytes and blood glucose, ion-selective electrode (ISE) device and automated chemistry analyzers were used respectively. To distinguish electrolyte values above and below the standard range, the International Federation of Clinical Chemistry (IFCC) has proposed finishing levels. Reference interval of sodium concentration in the blood is therefore 136-145 mmol/L. Subjects with concentration of sodium (Na^+) in serum is <135 mmol/L and >146 mmol/L were classified as hyponatraemic and hypernatraemic, respectively. Same was for concentration of both chloride (Cl^-) and potassium (K^+) levels in the serum, the reference period is 98-107 mmol/L and 3.5-5.1 mmol/L, respectively. Hypochloraemic and hyperchloraemic individuals were known to be diabetic patients with serum chloride concentrations <98 mmol/L and >107 mmol/L. Similarly, those research participants were classified as hypokalaemic and hyperkalaemic, respectively, with concentration of serum potassium <below 3.5 mmol/L and >5.1 mmol/L.

Before any data review took place, all the questionnaire data was manually analyzed for comprehensiveness and transparency.

After that, all data was entered into SPSS 21.0. In order to determine the intensity of the association between irregular electrolytes in serum and independent variables, Pearson's correlation test was performed. The correlation coefficient values, r= 0.8-1.0, 0.6-0.79, 0.4-0.59, 0.2-0.39 and 0.0-0.19 were considered to be very high, high, moderate, weak and very weak, respectively, depend upon the track of the linear relationship between independent and dependent variables. In order to evaluate and classify independent predictor variables for serum electrolyte abnormality, multivariate and bivariate models of logistic regression were utilized to analyze and classify independent predictor variables for the abnormality of serum electrolyte and certain independent variables with p-values in the model of bivariate logistic were transferred to the model of multivariate logistic. At last, p-value below 0.05 was known to be statistically relevant correlation between independent variables and abnormalities of the electrolytes in serum.

RESULTS

The age of patients participated ranged from 18 to 75 years (mean age of 48.3 ± 12.9 years). Most of the participants in the sample, males were 52.90% (n= 82/155), though remaining were females. For each subject of the study, three major serum electrolytes were evaluated and in general prevalence rate irregular concentration of serum electrolyte was calculated in 45.80% (n=71/155) patients with diabetes mellitus. Hyponatraemia was the foremost irregular serum electrolyte in patients with diabetes mellitus, accompanied by hypochloraemia (46.47% vs. 19.48%) and only about 14.28% of patients with diabetes mellitus were hyperkalaemic.

Using the Pearson correlation coefficient model, the correlation between the degree of electrolyte concentration in the serum and independent variables was measured. Depend on the evaluation, the amount of potassium (K^+), chloride (Cl^-) and sodium (Na^+) serum electrolyte concentration elevates in period of diabetes mellitus and diastolic hypertension. Age of patients with diabetes mellitus had an effective positive association with concentration of abnormal serum sodium (r=0.712, P=0.003) and weak positive association with concentration of abnormal serum chloride (r=0.081, P=0.311) and a very weak negative correlation with serum potassium abnormal concentration (r=-0.514, P=0.80). The nature of drugs utilized in patients with diabetes mellitus had a clear association to concentration of abnormal potassium in the serum (r=0.911, P=0.001), while the concentration of abnormal sodium in the serum had somewhat poor negative and positive association with the type of drug utilized in patients with diabetes mellitus (r=0.049, P=0.41 vs. r=-0.019, P=0.801). Elevated concentration of potassium in the serum had a clear association with increased BMI (r=-0.008, P=0.141), while concentration of serum chloride and sodium had a somewhat poor association with diabetic patients' elevated BMI (Table 1).

In order to distinguish independent predictor parameters which may contain statistically important correlation with abnormalities of serum electrolyte, regression of multivariate and bivariate logistic was tested after variables whose P values were moved to multivariate logistic regression below 0.25 in regression of binary logistic. Three parameters were classified as containing significant statistically in association with irregular electrolytes in the serum, depends upon regression of multivariate logistic statistical evaluation. Compared to unemployed diabetic patients, working diabetic patients were more likely than unemployed diabetic patients to produce irregular serum electrolytes (AOR: 3.879, 95 % C.I: 1.061–10.49, P-value: 0.044). Likewise, patients with diabetes mellitus who were treated with both insulin and oral anti-hyperglycaemic agents were more likely than patients with diabetes mellitus treated with insulin alone to establish serum electrolyte abnormality to regulate their blood level of glucose (AOR: 2.988, 95% C.I: 1.301–6.881, P-value: 0.012). In addition, patients with diabetes mellitus with no control in their levels of blood glucose in regular were more likely than patients whose fasting level of blood glucose level was not controlled well or with hyperglycaemics throughout the period of study to experience elevated serum electrolyte levels (AOR: 3.18, 95 % C.I: 2.321-5.812, P-value <0.001) (Table 2).

Table 1: Association of Serum Electrolytes with Independent Variables (n=155)

Predictor Variables	Sodium (Na^+)		Potassium (K^+)		Chloride (Cl^-)	
	r-value	p-value	r-value	p-value	r-value	p-value
Gender	0.042	0.481	0.361	0.557	-0.02	0.713
Age	0.712	0.003	-0.514	0.419	0.081	0.311
Education Level	0.003	0.814	-0.084	0.181	-0.003	0.881
Occupation,	0.201	0.091	-0.008	0.949	0.028	0.481
Duration of Diabetes Mellitus	0.094	0.202	0.0623	0.413	0.041	0.591
Type of Medication	0.049	0.412	0.911	0.001	0.019	0.801
Hypertension	-0.091	0.381	-0.001	0.861	0.581	0.510
Body Mass Index (BMI)	0.218	0.018	-0.008	0.141	0.041	0.719
Systolic Blood Pressure (SBP)	0.210	0.081	-0.006	0.817	0.061	0.003
Diastolic Blood Pressure (DBP)	0.071	0.418	0.007	0.002	0.841	0.318
Alcohol	-0.019	0.781	0.014	0.881	0.119	0.076
Cigarette Smoking	0.078	0.219	-0.071	0.431	0.118	0.071
Fasting Blood Glucose (FBG)	-0.312	<0.001	0.118	0.071	-0.319	0.002

Table 2: Multivariate & Bivariate Logistic Regression and Related Factors in Patients with Diabetes Mellitus (n=155)

Variable	Category	COR	C.I. (95%)	p-value	AOR	C.I. (95%)	p-value
Gender	Male Female	0.841 0.983	0.441 – 1.210	0.288	1.661 0.981	0.951 – 2.991	0.089
Age (years)	18-29	1	-	-	1	-	-
	30-39	1.077	0.371 – 3.101	0.901	1.498	1.374 – 3.018	0.778
	40-49	1.441	0.588 – 2.719	0.419	1.440	0.606 – 2.771	0.411
	50-59	0.891	0.414 – 1.810	0.804	0.901	0.441 – 1.771	0.776
	≥ 60	0.601	0.322 – 1.081	0.803	0.558	0.304 – 1.055	0.805
Occupation	Employed Unemployed	0.401 1	0.099 – 1.021	0.055	3.879 1	1.061 – 10.49	0.044
Diabetes Mellitus Type	Type 1 Type 2	1 1.081	0.659 – 1.781	0.658	1 0.778	0.798 – 4.771	0.704
Duration of Diabetes (years)	5-15 ≤5	1 0.804	0.388 – 1.771	0.541	0.778	0.378 – 1.887	0.776
Type of Medication	Mixed (Insulin + Oral) Insulin	0.704 1	0.369 – 1.019	0.06	2.988 1	1.301 – 6.881	0.012
Hypertension	Yes No	1.201 1	0.767 – 1.910	0.474	1.28 1	0.756 – 1.887	0.501
Body Mass Index (BMI)	Abnormal Normal	1.189 1	0.746 – 1.904	0.524	1.204 1	0.841 – 1.984	0.588
Alcohol	Yes No	0.691 1	0.241 – 1.704	0.381	0.669 1	0.289 – 1.712	0.379
Cigarette Smoking	Yes No	1.401 1	0.199 – 9.811	0.798	1.401 1	0.189 – 8.998	0.803
Fasting Blood Sugar (FBS)	Hyperglycaemic Normoglycaemic	2.98 1	0.180 – 0.681	<0.001	3.18 1	2.321 – 5.812	<0.001

DISCUSSION

By controlling fluid balance, distribution of oxygen, balance of the acid-base, neurological and cardiac mechanisms, electrolytes participate in maintenance of homeostasis of the body. The electrolyte level in body, however, can be very high or very low, ultimately causing imbalance of electrolyte. In this study, there was a increased prevalence in diabetic patients with one or more electrolyte abnormalities. Of the serum electrolytes measured, most common irregularity in patients with diabetes mellitus was hyponatraemia or low serum sodium concentration. [26-31] Decreased sodium ion concentration in serum of patients with diabetes mellitus may be because of hypovolaemia caused by osmotic diuresis. It is to be implied that glucose has high activity of osmosis, so high concentration of glucose contributes to high osmolality of the serum which allows the water to pass exterior of the cells and leads to dilution of hyponatraemia. Second most common electrolyte deficiency in patients with diabetes mellitus was hypokalaemia. Low serum level of potassium abnormally in patients with diabetes mellitus has also been found in other studies. [32-35] Insulin therapy may be the primary explanation for the elevated level of potassium. Potassium crosses along cell membrane with glucose as insulin is given and the glucose is occupied by cells, reducing the potassium concentration in intracellular fluid as well as in blood. Na^{+}-K^{+} pump, that overturns diffusion of cellular potassium from cells and sodium inside cells triggered by electrical gradients of the transmembrane, is the other possible explanation for hypokalaemia. Two hormones, insulin and catecholamine, stimulate this sodium-potassium pump via β-2-adrenergic receptors, therefore changes in concentration of such hormones may influence convey of K^{+} and its level in the serum. Third irregular electrolyte in serum tested in current study was diabetic hyperchloraemia or elevated serum chloride ion concentration levels in diabetics. From different research, similar results were published. [23, 26]

We also tested the association between the abnormality of serum electrolytes and independent variables. Depend on results, few factors such as smoking, irregular body mass index and age showed a positive association with hyponatraemia, and medication also showed a positive association with hypokalaemia, while smoking was associated with hyperchloraemia. In order to test the relationship between independent and dependent variables, multivariate and bivariate regression of logistic statistics were analysed. Depend on such evaluation, 3 independent variables were established as independent predictor variables for the abnormality of serum electrolyte, specifically diverse medication, elevated fasting level of blood glucose, being used. [31]

CONCLUSION

The average level of serum concentration of electrolytes was significantly deranged in patients with diabetes mellitus and incidence of abnormalities was highest in advanced-age patients with diabetes mellitus. There was a considerable difference in extent of association between irregular concentration of serum electrolyte and independent variables in patients with diabetes mellitus

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