ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Electrolyte Imbalance-A Better Predictor For Onset Of Metabolic Derangements In Patients With Type 2 Diabetes Mellitus.

Chitra Siva Sankari G[1], Vinodha J[2]*, and Jemima Ajitha P[3].

[1]Assistant Professor of Biochemistry, Govt. Madras Medical College, Chennai, Tamil Nadu, India.
[2]Assistant Professor of Biochemistry, Govt. Kilpauk Medical College, Chennai, Tamil Nadu, India.
[3]Post Graduate Student, Govt. Madras Medical College, Chennai, Tamil Nadu, India.

ABSTRACT

Diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose leading to serious damage to the heart, blood vessels, eyes, kidneys and nerves over time. Diabetic patients frequently develop a constellation of electrolyte disorders. Several body mechanisms are regulated by electrolytes such as maintenance of acid base balance, body fluid maintenance, muscle contraction, membrane potential and nerve conduction. Alterations in these electrolytes homeostasis leads to physiologic disorders. Serum sodium and potassium levels are altered in patients with diabetes mellitus due to the shift of water and due to effect of hyperglycemia. These electrolyte disturbances cause various acute and chronic metabolic derangements. This study aims in establishing electrolyte imbalance as a better predictor for onset of metabolic derangements in patients with type 2 diabetes mellitus. This Observational Cross- Sectional Study was conducted on 120 Type 2 Diabetes Mellitus patients within 30 to 70 years of age. Pearson correlation was done between serum glucose levels and serum osmolality, serum corrected sodium and serum potassium levels statistically significant p value was obtained. The results show that corrected serum sodium and serum potassium are better implications of metabolic derangements and early markers of cellular impairment in type 2 diabetes mellitus.

Keywords: Diabetes mellitus, Corrected serum sodium, Serum potassium, Hyperglycemia

https://doi.org/10.33887/rjpbcs/2023.14.2.11

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder which leads to various alterations in metabolism of carbohydrates, proteins and fats. In 2021, estimation showed that 537 million diabetic cases were reported. This estimate is calculated that it would reach 643 million by 2030 and by 2045 it would reach 783 million[1]. Major background of Diabetes mellitus(DM) includes defective insulin secretion by pancreatic cells and insulin resistance by tissues.

The major complications due to metabolic derangements in diabetes mellitus include micro and macrovascular complications. Microvascular complications include diabetic nephropathy, retinopathy and neuropathy. Macrovascular complications include cardiovascular disease leading to myocardial infarction and peripheral vascular disease leading to diabetic foot[2]. Early identification and prevention of these complications is essential. Hence an early marker for detecting the metabolic derangements in diabetes mellitus is important.

Diabetes mellitus is commonly associated with electrolyte disturbances and is the result of an altered distribution of electrolytes related to osmotic fluid shifts which is hyperglycemia induced or osmotic diuresis due to total-body deficits. Therapies in the management of diabetes and complications from end-organ injury used in may also contribute to electrolyte disturbances [3].

Hyperglycemia in diabetic patients leads to hypertonicity which causes osmotic extracellular shift of potassium leading to hyperkalemia. Redistribution of potassium from the intracellular to the extracellular compartment causes hyperkalemia with no net total body K+ increase. Hyperglycemia causes raise in serum osmolality which causes movement of water out of cells. This intracellular water loss leads to an increase in intracellular potassium concentration which causes a gradient for potassium to move out of the cells. Simultaneously, forces causes potassium to be carried along with water through the pores in cell membrane Hyperkalemia is also caused due to hyporeninemic hypoaldosteronism causing reduced tubular secretion of potassium[4]. Hyperkalemic renal tubular acidosis is seen in paients with overt diabetic nephropathy.

Serum sodium levels is altered in diabetic patients and it causes various effects. Hyponatermia is more common in diabetic patients[5].Hyponatremia is due to osmotic dilutional effect or osmotic diuresis. Hence pseudohyponatemia is to be watched before diagnosing and treating a patient as electrolyte imbalance. To eliminate this effect, corrected serum sodium levels are used[6].It is the measured serum sodium adjusted with osmotic dilutional effect due to hyperglycemia. It is the measured serum sodium adjusted with osmotic dilutional effect due to hyperglycemia. The corrected [Na+] is calculated by adding 1.6 mmol/L for every 100 mg/dL increment of serum glucose above normal to measured [Na+] .When serum glucose concentration is higher than 400 mg/dL a correction factor by 2.4 mmol/L is used[7]. Corrected sodium after adjustment for hyperglycemic dilutional effects should be is an effective tool for the monitoring of treatment in hyperglycemic states[8].Studies show that diabetes mellitus per se (independently of drugs or hyperglycemia) is associated with hyponatremia[9]. The magnitude of the deficit of sodium and water can be assessed by correcting the plasma sodium concentration in patients with glycemia and it provides a reasonable initial estimate of the required tonicity of replacement fluids for treatment.

Electrolyte abnormalities are associated with increased morbidity and mortality[10].Early detection of electrolyte imbalance helps in prevention of metabolic derangements in diabetic patients.Due to the high prevalence of diabetes mellitus,It is essential to limit the morbidity caused in the community by early detection of metabolic derangements which can be done by monitoring the serum electrolytes.

Aim

- To identify and evaluate electrolyte abnormalities in patients with Type 2 Diabetes Mellitus.

Objectives

- To measure serum glucose, sodium, potassium, urea, creatinine levels in diabetic patients.
- To calculate Corrected Serum Sodium, estimated GFR(e GFR) and Serum Osmolality levels.
- To evaluate electrolyte imbalance as a better predictor for onset of metabolic derangements in patients with type 2 diabetes mellitus.

ISSN: 0975-8585

MATERIALS AND METHODS

This Cross sectional study was carried out in the Department of Biochemistry and Diabetology in Rajiv Gandhi Government General Hospital, Chennai-03 after obtaining institutional ethical committee approval and informed consent from the participants.

Study Population

Inclusion Criteria

Type 2 Diabetes Mellitus patients attending Diabetology OPD within 3 months of diagnosis between 30 to 70 years of age

Exclusion Criteria

Known cases of hypertension, patients on medications which alter serum electrolytes, known cases of autoimmune diseases and tumours, Known cases of renal impairment.

Sample Collection

5ml of fasting venous blood sample was obtained from the study participants using sterile vacutainer tubes. Blood sample was centrifuged, serum separated and electrolytes, urea, creatinine were analysed. Blood for Plasma glucose was collected in a different container. The analysis was done using fully automated clinical chemistry random access analyser roche COBAS c501.

Laboratory Investigations

PARAMETERS	METHOD
Plasma Glucose	Glucose Oxidase Peroxidase method
Serum Sodium & Potassium	Indirect Ion Selective Electrode method
Serum Urea	Glutamate Dehydrogenase - Urease method
Serum Creatinine	Modified Jaffe's method
CALCULATED VALUES	
Corrected Serum Sodium	Measured Sodium + (1.6 (Glucose-100) / 100)
e GFR: Cockcroft and Gault formula	((140-age) x weight) / (72 x Serum Creatinine)) x 0.85(if female)
Serum Osmolality	$(2 \times \text{sodium}) + \frac{\text{Glucose}}{18} + \frac{\text{BUN}}{2.8} + 9$

OBSERVATIONS AND RESULTS

Tables 1 to 6

All the patients were known cases of type 2 diabetes mellitus.

DISCUSSION

The purpose of the study was to evaluate and establish electrolyte imbalance as a better predictor for onset of metabolic derangements in patients with type 2 diabetes mellitus. Our study showed that serum osmolality in our study subjects were within the reference range.

Our study subjects has the eGFR of 101.37 ± 38.17(table 1) indicating that the renal function is preserved in our study subjects and electrolytes have been correlated in normal renal functioning cases

ISSN: 0975-8585

of diabetes mellitus.

Table 1

	Mean	Std. Deviation (±)	Minimum	Maximum
Glucose	260.44	44.94	180	383
Serum Osmolality	288.9	8.27	257.51	303.79
Corrected serum Sodium	133.1	3.95	118.05	138.53
eGFR	101.37	38.17	35.22	249.98
Potassium	5.17	0.3	4	5.9

Table 2: Pearson Spearman Correlation With Serum Glucose

Analytes	r value	P value
Serum osmolality	**0.365**	**0.000***
Corrected sodium	**0.219**	**0.016***
eGFR	-0.101	0.274
Potassium	**0.596**	**0.000***

*Significance < 0.05

Table 3: Correlation Of Serum Glucose And Serum Osmolality

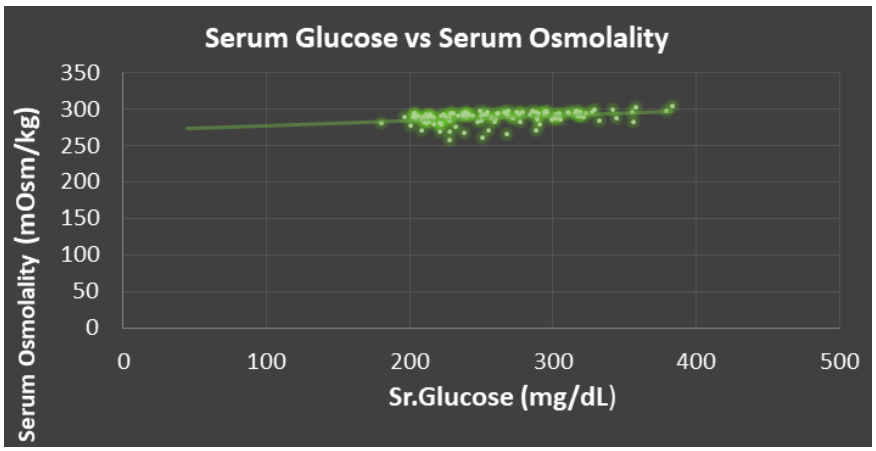
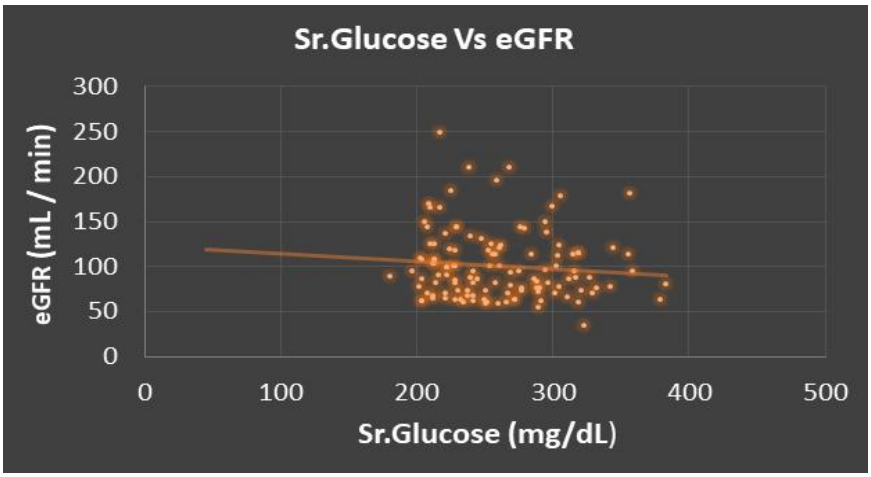


Table 4: Correlation Of Serum Glucose And e GFR



ISSN: 0975-8585

Table 5: Correlation Of Serum Glucose And Corrected Serum Sodium

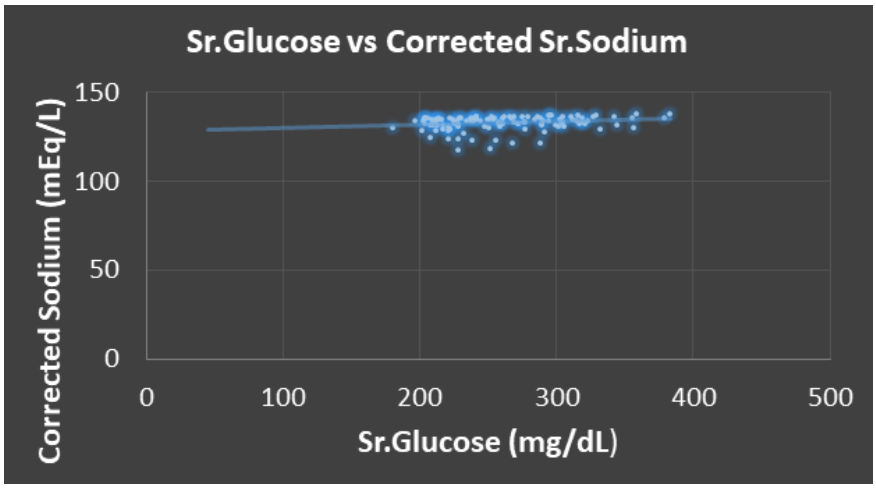
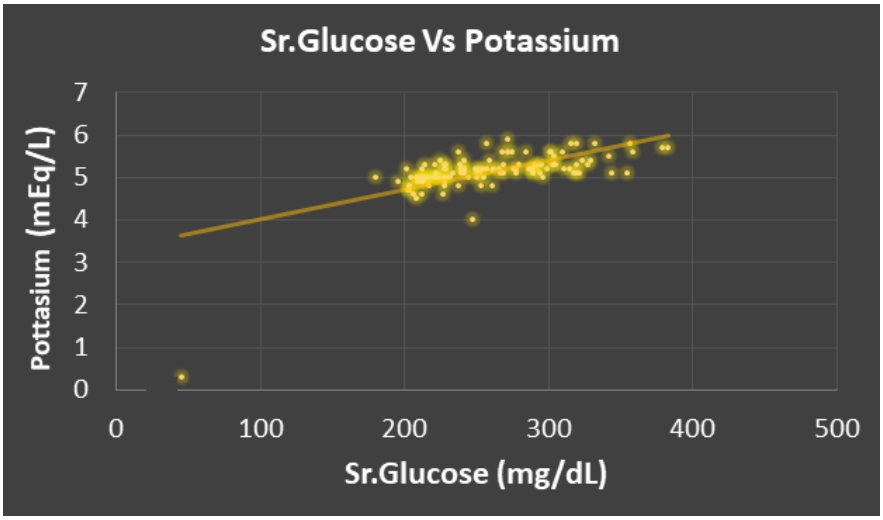


Table 6: Correlation Of Serum Glucose And Potassium



The mean of serum Sodium was 130.5 ± 3.91 mEq/L(table 1) and the mean of corrected serum sodium was 133.1 ± 3.95 mEq/L as shown in table 1. There was significant hyponatremia in diabetic patients. This is in concurrence to the study done by Yongze Zhang et al [5].

Hyponatremia was detected after using the formula for correction of serum sodium levels with the osmotic effect of hyperglycemia. Measured serum sodium levels were found to be lower than that of the corrected serum sodium levels indicating the osmotic effect og hyperglycemia. Therapies to treat hyponatremia must be followed by the use of the corrected serum sodium levels to prevent hyperkalemia due to over treatment.The corrected serum sodium levels were found to be lower than the reference range indicating true hyponatremia in our study subjects.

The mean serum potassium level was 5.17 **±** 0.3 mEq/L (table 1). There was significant hyperkalemia in diabetic patients with normal renal function and normal serum osmolality. This is in congruence with the study done by Kleber Goia-Nishide et al[12] and T Saito et al [13].

Hyperkalemia in diabetic patients occurs due to various causes including renal insufficiency to excrete potassium and due to fall in GFR. It is also due to extracellular shift of potassium. The cause of which is distinguished by the calculation of e GFR. Our study subjects have normal e GFR indicating that the hyperkalemia is due to true extracellular shift of potassium.

Correlation studies were done. Pearson spearman correlation study showed significant positive

correlation between serum glucose and serum osmolality(table2, 3) which is congruent with the study done by G Oztürk et al[14]. The mean value of serum osmolality in diabetic patients was within the reference range.

Correlation was assessed between plasma glucose levels and e GFR. Pearson spearman correlation analysis showed that there is no significant correlation between serum glucose levels and e GFR (table 2,4).This indicated that the cases had normal e GFR with dyselectrolytemia.

Pearson spearman correlation study shows significant correlation between corrected serum sodium levels and serum glucose levels with r value 0.219 and significant p value(table 2,5). This is in congruence with the study done by Matthew B Wolf et al[15]. Correlation studies done by Pearson spearman correlation study showed significant positive correlation between serum glucose levels and serum potassium levels with the r value of 0.59(table 2,6).This is similar to the study done by P McNair et al [16].

The results of the study show that there is significant dyselectrolytemia in patients with normal serum osmolality and normal e GFR. This indicates that dyelectrolytemia can be used as an early indicator for metabolic derangements in diabetic patients. This on early detection will be helpful in early management and prevention of morbidity and mortality.

CONCLUSION

There is significant dyselectrolytemia in patients with diabetes mellitus with normal serum osmolality and estimated glomerular filtration rate. Hyponatremia and hyperkalemia have been found to be an early and better predictor for onset of metabolic derangements in patients with type 2 diabetes mellitus and can be useful in prevention of early morbidity and mortality of diabetic patients.

REFERENCES

[1] Home, Resources, diabetes L with, Acknowledgement, FAQs, Contact, et al. IDF Diabetes Atlas | Tenth Edition [Internet]. [cited 2023 Feb 5]. Available from: https://diabetesatlas.org/

[2] Unnikrishnan R, Anjana RM, Mohan V. Diabetes mellitus and its complications in India. Nat Rev Endocrinol. 2016 Jun;12(6):357–70.

[3] Palmer BF, Clegg DJ. Electrolyte and Acid–Base Disturbances in Patients with Diabetes Mellitus. Ingelfinger JR, editor. N Engl J Med [Internet]. 2015 Aug 6 [cited 2023 Mar 2];373(6):548–59. Available from: http://www.nejm.org/doi/10.1056/NEJMra1503102

[4] Uribarri J, Oh MS, Carroll HJ. Hyperkalemia in diabetes mellitus. J Diabet Complications. 1990;4(1):3–7.

[5] Zhang Y, Li C, Huang L, Shen X, Zhao F, Wu C, et al. Relationship between Hyponatremia and Peripheral Neuropathy in Patients with Diabetes. J Diabetes Res [Internet]. 2021 Aug 19 [cited 2023 Mar 1];2021:9012887. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8397566/

[6] Chuang C, Guo YW, Chen HS. Corrected sodium levels for hyperglycemia is a better predictor than measured sodium levels for clinical outcomes among patients with extreme hyperglycemia. J Chin Med Assoc [Internet]. 2020 Sep [cited 2023 Feb 28];83(9):845–51. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7478195/

[7] Hillier TA, Abbott RD, Barrett EJ. Hyponatremia: evaluating the correction factor for hyperglycemia. Am J Med. 1999 Apr;106(4):399–403.

[8] Liamis G, Gianoutsos C, Elisaf MS. Hyperosmolar nonketotic syndrome with hypernatremia: how can we monitor treatment? Diabetes Metab. 2000 Nov;26(5):403–5.

[9] Beukhof CM, Hoorn EJ, Lindemans J, Zietse R. Novel risk factors for hospital-acquired hyponatraemia: a matched case?control study. Clin Endocrinol (Oxf) [Internet]. 2007 Mar [cited 2023 Mar 2];66(3):367–72. Available from: https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2265.2007.02741.x

[10] Liamis G, Liberopoulos E, Barkas F, Elisaf M. Diabetes mellitus and electrolyte disorders. World J Clin Cases WJCC [Internet]. 2014 Oct 16 [cited 2023 Mar 1];2(10):488–96. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4198400/

[11] Rao GM. Serum electrolytes and osmolality in diabetes mellitus. Indian J Med Sci. 1992 Oct;46(10):301–3.

[12] Goia-Nishide K, Coregliano-Ring L, Rangel ÉB. Hyperkalemia in Diabetes Mellitus Setting. Diseases [Internet]. 2022 Mar 28 [cited 2023 Mar 1];10(2):20. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9036284/

[13] Saito T, Ishikawa S, Higashiyama M, Nakamura T, Rokkaku K, Hayashi H, et al. Inverse distribution of serum sodium and potassium in uncontrolled inpatients with diabetes mellitus. Endocr J. 1999 Feb;46(1):75–80.

[14] Oztürk G, Erdoğan E, Oztürk M, Cengiz N, Him A. Differential analysis of effect of high glucose level in the development of neuropathy in a tissue culture model of diabetes mellitus: role of hyperosmolality. Exp Clin Endocrinol Diabetes Off J Ger Soc Endocrinol Ger Diabetes Assoc. 2008 Nov;116(10):582–91.

[15] Wolf MB. Hyperglycemia-induced hyponatremia: Reevaluation of the Na+ correction factor. J Crit Care. 2017 Dec;42:54–8.

[16] McNair P, Madsbad S, Christiansen C, Christensen MS, Transbøl I. Hyponatremia and hyperkalemia in relation to hyperglycemia in insulin-treated diabetic out-patients. Clin Chim Acta Int J Clin Chem. 1982 Apr 8;120(2):243–50.