Effects of Hyperglycemia on Electrolyte Indices in Type 2 Diabetes Mellitus

PARNEET KAUR[1], MANRAJ SINGH[2]
[1, 2]*Department of medical lab Technology, Khalsa College of Pharmacy & Technology Amritsar, Punjab, India.*

Abstract— Background: Type 2 Diabetes Mellitus (T2DM) is primarily characterized by insulin resistance and relative insulin deficiency. While the endocrine dysfunction of the pancreas in T2DM (type 2 diabetes mellitus) is well-documented, emerging evidence suggests that pancreatic exocrine functions are also significantly impacted. Electrolyte imbalance is commonly present in patients with type-2 diabetes mellitus. Introduction: Due to hyperglycemia plasma osmolality and impaired renal function is rise which contributing to a change in electrolyte levels. Diabetic patients are more likely develop electrolytes imbalance then control or healthy patients. Material and Methods: In this hospital based study120 subjects between the healthy and diabetic patients. The electrolyte profile was assessed using standard methodologies. Statistical analysis was performed using the GraphPad Prism9 stat® Software. Analysis of data was done using one-way ANOVA employing Tukey's test, after analysis. p<0.05 was found to be statistically significant. Results: In our study population Phosphate was seen higher in diabetic patients as compared with all electrolyte parameters except magnesium which was observed normal with healthy patients. Rest of the parameters like calcium, chloride, sodium and potassium were observed difference in their level (p < 0.005) as compared with the healthy patients. Conclusion: Therefore, it can be concluded that diabetes mellitus also be responsible for the imbalance of electrolytes in the body. High phosphate level and low magnesium level might be associated with the insulin resistance. Low sodium level might be dehydration of cells and low calcium might be due to low calcium absorption in the diabetes mellitus

Index Terms- (DM) Diabetes Mellitus, Electrolyte Imbalance, Pancreas, Renal Function, Endocrine, Exocrine.

I. INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is primarily characterized by insulin resistance and relative insulin deficiency. While the endocrine dysfunction of the pancreas in T2DM (type 2 diabetes mellitus) is well-documented, emerging evidence suggests that pancreatic exocrine functions are also significantly impacted [1-2]. Electrolyte imbalance is commonly present in patients with type-2 diabetes mellitus. The cause is usually multifactorial, but usually results from insulin deficiencies in diabetic ketoacidosis and hyperglycemia [3]. Due to hyperglycemia plasma osmolality and impaired renal function is rise which contributing to a change in electrolyte levels. Diabetes Mellitus is directly linked with the hyper and hypo-natremia reflecting the coexistence of hyperglycemia related mechanism which change the serum sodium to different directions [4]. The pancreas may not produce enough insulin to compensate for the resistance. The risk factors include Obesity, sedentary lifestyle, poor diet, genetics, and aging and the symptoms are Increased thirst, frequent urination, fatigue, blurred vision, slow healing of wounds, and unexplained weight loss. The body fluid is divided into the two components and the components are: Intracellular fluid and Extracellular fluid [5-6].

II. PURPOSE

The purpose of this study is to assess the electrolyte imbalance with type 2 diabetes mellitus.

In light of this, the study was taken up with the following objectives:
1.) Measurement of weight, height, age and BMI.
2.) To determine the serum fasting blood glucose and HbA1c level of control and diabetic subjects.
3.) To determine the serum of Calcium, Potassium, Magnesium, Phosphate, Sodium and Chloride in levels of control and diabetic subjects.

III. MATERIAL AND METHODS

Blood samples were collected from Arora Hospital, Sacred Heart Hospital and Neel Kanth Hospital, Amritsar and a test was performed in Khalsa Diagnostic Lab, Amritsar. About 120 samples were taken out of which 20 samples served as Healthy subjects and 100 samples were served as type 2 diabetic patients. Serum electrolyte level of all samples were determined by CLIA method using 9180 Electrolyte Analyzer with the help of serum estradiol kit. HbA1c and Fasting Blood Glucose level were determined by semi-biochemistry autoanalyzer with of kit (Erba).

- Blood Sample Collection

For the collection of samples, a prominent vein was selected and tourniquet was applied and anterior cubital vein area was cleaned with a sterilized cotton swab dipped in spirit. Needles and syringes were properly inspected and then sampling was performed. A cotton swab was held firmly over the vein puncture site as soon as the needle is removed. After removing the needle, the collected blood was dispensed in the tubes. After obtaining the blood, the serum sample was separated for further biochemical analysis. Serum sample was obtained from blood for the evaluation of HbA1c, Fasting Blood Glucose (FBG), Calcium (Ca), Chloride (Cl), Magnesium (Mg), Potassium (K), Sodium (Na) and Phosphate (Po4).

- Biochemical Investigation

Determination of HbA1c in blood by Particle Enhancement Immunoturbidimetric Method.

The blood HbA1c level was estimated by using biochemistry analyzer with commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

- Determination of Glucose in blood by GOD/POD method.[10]

The glucose level was estimated by semi biochemistry analyzer using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/ Germany)

- Determination of Serum Sodium

The serum sodium was estimated in 9180 Electrolyte Analyzer (Roche) by using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

- Determination of Serum Potassium

The serum potassium was estimated in 9180 Electrolyte Analyzer (Roche) by using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

- Determination of Serum Calcium

The serum calcium was estimated in 9180 Electrolyte Analyzer (Roche) by using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

- Determination of Serum Magnesium

The serum magnesium was estimated in 9180 Electrolyte Analyzer (Roche) by using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

- Determination of Serum Chloride

The serum chloride was estimated in 9180 Electrolyte Analyzer (Roche) by using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

- Determination of Serum Phosphate

The serum phosphate was estimated in 9180 Electrolyte Analyzer (Roche) by using a commercially available kit (ERBA diagnostics Mannheim GmbH, Mannheim/Germany)

Fig No.1: Data of Description

Total Population (n=120)	
Healthy Subjects (n=20)	Diabetic Subjects (n=100)

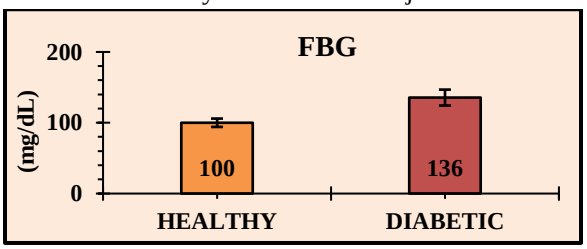
Table No.1: Data of Fasting Blood Sugar (FBS) in Healthy and Diabetic Subjects

S. No.	Subjects	FBS (mg/dL)
1.	Healthy Subjects	100.50±5.92

2.	Diabetic Subjects	135.36±11.23

(Data represented as mean ± S.D.)

Fig No.2: Bar graph of Fasting Blood Sugar in Healthy and Diabetic Subjects



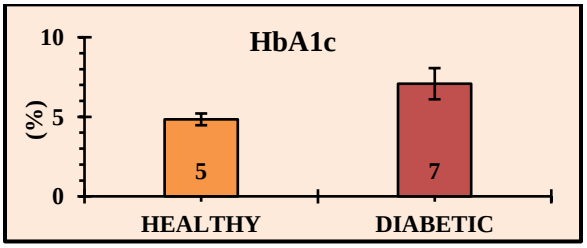
This data and bar graph represent the average Fasting Blood Sugar (FBS) in Healthy and Diabetic subjects. In this data, the average FBS was observed 100.50±5.92 mg/dL in healthy subjects and 135.36±11.23 mg/dL were seen in diabetic patients.

Table No.2: Data of HbA1c in Healthy and Diabetic Subjects

S. No.	Subjects	HbA1c (%)
1.	Healthy Subjects	4.84±0.87
2.	Diabetic Subjects	7.08±0.98

(Data represented as mean ± S.D.)

Fig No.3: Bar graph of HbA1c in Healthy and Diabetic Subjects



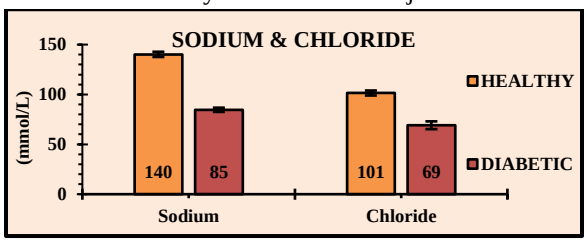
The Bar graph and data represent the HbA1c level in healthy and diabetic subjects. Begin with the healthy subjects shown 4.84±0.87 % and the diabetic were observed 7.08±0.98 %.

Table No.3: Data of Sodium and Chloride in Healthy and Diabetic Subjects

S. No.	Subjects	Sodium (mmol/L)	Chloride (mmol/L)
1.	Healthy Subjects	120.40±2.61	101.46±2.49
2.	Diabetic Subjects	84.62±2.11	69.12±3.91

(Data represented as mean ± S.D.)

Fig No.4: Bar graph of Sodium and Chloride in Healthy and Diabetic Subjects



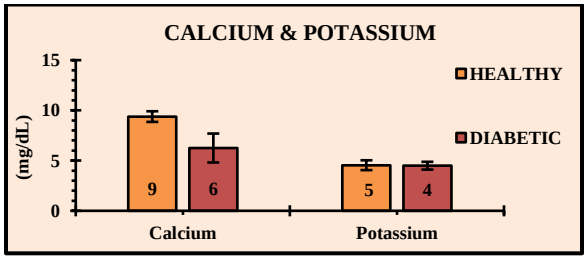
This data and bar graph represents the average value of sodium was 120.40±2.61 mmol/L and 84.62±2.11 mmol/L in healthy and diabetic patients. Furthermore, average level of chloride was observed 101.46±2.49 mmol/L in heathy and 69.12±3.91 mmol/L in diabetic patients. The sodium and chloride each level was significantly lower (p=0.0001) p<0.005 in diabetic than in the healthy subjects.

Table No.4: Data of Calcium and Potassium in Healthy and Diabetic Subjects

S. No.	Subjects	Calcium (mg/dL)	Potassium (mg/dL)
1.	Healthy Subjects	9.38±0.53	4.54±0.49
2.	Diabetic Subjects	6.25±1.44	4.49±0.39

(Data represented as mean ± S.D.)

Fig No.5: Bar graph of Calcium and Potassium in Healthy and Diabetic Subjects



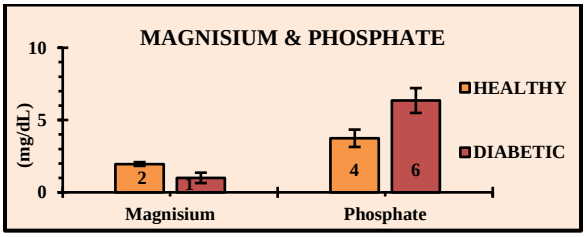
The bar graph and data represent the healthy subject's calcium level 9.38±0.53 mg/dL and 6.25±1.44 mg/dL in diabetic subjects. Moreover, the level of potassium 4.54±0.49 mg/dL were seen in healthy subjects and 4.49±0.39 mg/dL was observed in diabetic patients. There were no significant changes was seen in potassium but quite decline (p=0.0001) p<0.005 was observed in calcium level.

Table No.5: Data of Magnesium and Phosphate in Healthy and Diabetic Subjects

S. No.	Subjects	Magnesium (mg/dL)	Phosphate (mg/dL)
1.	Healthy Subjects	1.96±0.13	3.74±0.60
2.	Diabetic Subjects	1.00±0.36	6.35±0.86

(Data represented as mean ± S.D.)

Fig No.6: Bar graph of Magnesium and Phosphate in Healthy and Diabetic Subjects



This data and bar graph represents the comparison of healthy and diabetic patients with magnesium and phosphate level. The average value of magnesium was 1.96±0.13 mg/dL and 1.00±0.36 mg/dL in healthy and diabetic patients. Furthermore, average level of phosphate was observed 3.74±0.60 mg/dL in heathy and 6.35±0.86 mg/dL in diabetic patients. There was decline($p=0.0001$) $p<0.005$ observed in magnesium level. However, sharp increase ($p=0.0360$) $p<0.005$ was seen in phosphate level.

CONCLUSION

It has been concluded from the study that hyperglycemia produced changes in electrolyte constituents. The five electrolyte parameters Sodium, Chloride, Calcium, Magnesium and Phosphate were found significantly associated with fasting blood sugar. The higher Phosphate count in a range between 6.30 to 7.10 mg/dL was observed in the diabetes patients. Magnesium level were found reduced in diabetic patients. The count was found to be 1.00 mg/dL having bad glycemic index as compared to healthy controls. Low Magnesium level are associated with the insulin resistance. Uncontrolled diabetes can cause the kidneys to eliminate excess glucose through urine, which can also lead to magnesium imbalance. Glycosylated haemoglobin is an important diagnostic indicator of diabetes. HbA1c concentrations lead to difficulties in releasing oxygen to cells and reduced oxygen transporting functions of erythrocytes. Hyperglycemia, increased osmosis and oxidative stress in patients with diabetes alter the concentration of iron and protein inside and outside the erythrocytes and activate eryptosis pathway. The lowest Sodium value around 84 mmol/L were found in the patients with bad glycemic index which might be cause water to move out from the cell which dilutes the sodium level. Patients having diabetes was also observed lower chloride value around 69 mmol/L. The level of calcium was decreased about 6 to 7 mg/dL in diabetic group, which might be due to bone metabolism, partly from impaired intestinal calcium absorption. Our findings demonstrated that control of abnormal electrolyte levels in the early stage of diabetes mellitus may help the patients to raise quality of life.

REFERENCES

[1] Petersmann, A., Nauck, M., Müller-Wieland, D., Kerner, W., Müller, U. A., Landgraf, R., … & Heinemann, L. (2018). Definition, classification and diagnostics of diabetes mellitus. Journal of Laboratory Medicine, 42(3), 73-79.

[2] Balcı, A. K., Koksal, O., Kose, A., Armagan, E., Ozdemir, F., Inal, T., & Oner, N. (2013). General characteristics of patients with electrolyte imbalance admitted to emergency department. World journal of emergency medicine, 4(2), 113.

[3] Khan, R. N., Saba, F., Kausar, S. F., & Siddiqui, M. H. (2019). Pattern of electrolyte imbalance in Type 2 diabetes patients: Experience from a tertiary care hospital. Pakistan Journal of Medical Sciences, 35(3), 79

[4] Fried, L. F., & Palevsky, P. M. (1997). Hyponatremia and hypernatremia. Medical Clinics of North America, 81(3), 585-609.

[5] Fletcher, B., Gulanick, M., & Lamendola, C. (2002). Risk factors for type 2 diabetes mellitus. Journal of Cardiovascular Nursing, 16(2), 17-23.

[6] Conway, E. J., & McCormack, J. I. (1953). The total intracellular concentration of mammalian tissues compared with that of the extracellular fluid. The Journal of Physiology, 120(1-2), 1.