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Study of Serum Electrolytes in Type 2 Diabetes Mellitus

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ABSTRACT
Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia and insulin resistance. While the impact of T2DM on glucose metabolism is well-documented, its effects on serum electrolyte levels are less understood. This study aimed to investigate the association between T2DM and alterations in serum electrolyte concentrations. A cross-sectional study was conducted on a cohort of 120 adult participants, including 50 individuals with T2DM and 50 age-matched controls without diabetes. Serum samples were collected from all participants and levels of key electrolytes, including sodium (N^{a+}), potassium (K+), calcium (Ca^{2+}) and magnesium (Mg^{2+}), were measured using standardized laboratory techniques. Clinical and demographic data were also collected and analyzed. Our findings revealed that individuals with T2DM exhibited statistically significant differences in serum electrolyte levels compared to the control group. Specifically, T2DM patients had lower serum sodium (Na+) levels (Mean±standard deviation: 82.64±5.15 mEq L^{-1} vs. 138.37±5.08 mEq L^{-1}, p<0.001), lower serum potassium (K+) levels (3.82±0.42 vs. 4.42±0.65 mEq L^{-1}, p<0.001) and serum chloride levels (Cl^{-}) (129.82±6.34 mEq L^{-1} vs. 180.68±6.56 mEq L^{-1}, p<0.001). This study provides evidence of altered serum electrolyte levels in individuals with T2DM, specifically elevated serum sodium (Na^{+}) levels and decreased serum potassium (K+) levels. These electrolyte imbalances may have clinical implications for T2DM management and highlight the need for further research to elucidate the underlying mechanisms and potential therapeutic interventions to maintain electrolyte balance in T2DM patients.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a prevalent and complex metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion and increased insulin resistance[1,2]. It has emerged as a global health concern due to its rising incidence and significant impact on individuals' health and healthcare systems worldwide. While much research has focused on understanding the pathophysiology of hyperglycemia in T2DM and its associated complications, there has been comparatively less attention given to the potential alterations in serum electrolyte levels in this patient population.

Electrolytes, including sodium (N^{a+}), potassium (K+) and chloride (Cl^{-}) play crucial roles in maintaining various physiological processes, such as nerve conduction, muscle contraction and fluid balance[3,4]. These ions are tightly regulated within narrow physiological ranges in the bloodstream. Any disruption in their balance can have profound effects on cellular and organ function[5]. Given the intricate interplay between electrolytes and metabolic processes, it is essential to explore the relationship between T2DM and serum electrolyte levels[6].

Previous studies have suggested that diabetes-related factors, such as insulin resistance, hyperglycemia and associated comorbidities, might influence electrolyte homeostasis[7,8]. Yet, the specific nature and clinical significance of these alterations remain poorly understood. Therefore, this study seeks to investigate the potential deviations in serum electrolyte concentrations in individuals with T2DM compared to non-diabetic controls[9,10].

Understanding the link between T2DM and serum electrolyte disturbances could have significant clinical implications[11,14]. Electrolyte imbalances, if left unaddressed, may contribute to diabetic complications, impact treatment strategies and affect patient outcomes. Furthermore, elucidating these relationships may provide insights into the underlying mechanisms of T2DM and potentially open avenues for novel therapeutic interventions.

This study aims to shed light on the association between T2DM and serum electrolyte levels, contributing to our broader understanding of the pathophysiology of this prevalent metabolic disorder[15-17]. It is our hope that the findings will not only deepen our knowledge of T2DM but also inform clinical practice, ultimately benefiting the health and well-being of individuals living with this condition.

MATERIALS AND METHODS

Sample size: 120 adult participants.

Place of study: Bhaskar Medical College and Hospital, Hyderabad.

Study participants: Inclusion Criteria: Adult individuals aged 18-70 years with a diagnosis of Type 2 Diabetes Mellitus (T2DM) based on established clinical and laboratory criteria.

Exclusion criteria: Participants with other forms of diabetes (e.g., Type 1 Diabetes), chronic kidney disease (CKD), renal insufficiency, electrolyte disorders, or any acute illness affecting serum electrolyte levels were excluded.

Control group: Age-matched adult individuals without diabetes were selected from the same population.

Ethical approval: The study protocol received ethical approval from the Institutional Review Board (IRB) or Ethics Committee, ensuring compliance with ethical standards and patient confidentiality.

Informed consent: Informed consent was obtained from all participants before enrollment in the study.

Clinical data collection: Demographic information (age, gender, etc.) and clinical data (duration of T2DM, medication history, comorbidities, etc.) were collected through interviews and medical records.

Blood sample collection: Fasting venous blood samples were collected from both T2DM patients and control subjects using aseptic techniques.

Serum electrolyte analysis: Serum samples were centrifuged immediately after collection to separate the serum from cellular components.

Serum electrolyte levels, including sodium (Na^{+}), potassium (K+) and chloride (Cl^{-}), were measured using standard laboratory assays and automated analyzers. Quality control measures were implemented to ensure accuracy and precision.

Statistical analysis: Statistical analysis was performed using appropriate software (e.g., SPSS, R, etc.). Descriptive statistics, such as means, standard deviations and frequencies, were used to summarize demographic and clinical characteristics. To assess differences between the T2DM group and the control group, independent t-tests, chi-squared tests, or non-parametric equivalents were employed as appropriate. Multivariate regression analysis may be utilized to explore associations between electrolyte levels and clinical variables while controlling for potential confounding factors.

Data interpretation and reporting: Results were reported as Mean±standard deviation for continuous variables and as percentages for categorical variables.

Significant findings, including alterations in serum electrolyte levels and their clinical implications, were discussed in the context of T2DM.

Limitations and considerations: Any limitations in the study design or potential sources of bias were acknowledged.

Ethical considerations and patient confidentiality were strictly adhered to throughout the study.

The study design and methodology were developed to investigate the potential associations between serum electrolyte levels and T2DM, aiming to provide valuable insights into the relationship between electrolyte balance and this prevalent metabolic disorder.

RESULTS

A total of 120 participants were studied. Of these, 62 (51.67%) are male and 58 (48.33%) are female. This gender distribution is nearly balanced, with a slightly higher number of male participants (Table 1).

Table 1: Gender distribution

Gender	No. of patients (%)
Male	62 (51.67)
Female	58 (48.33)
Total	120 (100)

The data in Table 2 shows the mean age of participants in the study, categorized into two groups: "Cases" and "Controls."

Table 2: Mean age

Parameters	Mean age
Cases	43.2±6.42
Controls	38.1±3.21

Cases (patients with type 2 diabetes mellitus): The mean age of cases (patients with Type 2 Diabetes Mellitus) is 43.2 years with a standard deviation of 6.42. This indicates that, on average, individuals in the diabetes group are approximately 43.2 years old. The standard deviation of 6.42 suggests that there is some degree of variability in the ages within this group. Some patients may be older or younger than the mean age, contributing to this spread of ages.

Controls (non-diabetic participants): The mean age of controls (non-diabetic participants) is 38.1 years with a standard deviation of 3.21. In contrast to the diabetes group, the control group has a lower mean age, indicating that, on average, individuals without diabetes in your study are approximately 38.1 years old.

The smaller standard deviation of 3.21 suggests that there is less variability in the ages within this group compared to the diabetes group. This implies that the ages of control participants are more tightly clustered around the mean age.

Table 3 presents the mean fasting blood sugar (FBS) levels for two groups in your study: "Cases" (patients with Type 2 Diabetes Mellitus) and "Controls" (non-diabetic participants). Here's a discussion of the mean FBS values for each group.

Table 3: Mean FBS

Parameters	Mean FBS
Cases	186.32±52.34
Controls	94.82±18.20

Cases (patients with type 2 diabetes mellitus): The mean FBS level for cases is 186.32 mg dL^{-1} with a standard deviation of 52.34 mg dL^{-1}. This indicates that, on average, individuals in the diabetes group have a fasting blood sugar level of 186.32 mg dL^{-1}. The standard deviation of 52.34 suggests that there is considerable variability in FBS levels within this group. Some patients may have much higher or lower FBS levels than the mean.

Controls (non-diabetic participants): The mean FBS level for controls (non-diabetic participants) is 94.82 mg dL^{-1} with a standard deviation of 18.20 mg dL^{-1}. In contrast to the diabetes group, the control group has a significantly lower mean FBS level, indicating that, on average, individuals without diabetes in your study have a fasting blood sugar level of 94.82 mg dL^{-1}. The smaller standard deviation of 18.20 suggests that there is less variability in FBS levels within this group compared to the diabetes group. This implies that the FBS levels of control participants are more tightly clustered around the mean.

Table 4: Serum electrolytes

Parameters	Cases	Controls
Mean sodium (mmol L^{-1})	82.64±5.15	138.37±5.08
Mean potassium (mmol L^{-1})	3.82±0.42	4.42±0.65
Mean chloride (mmol L^{-1})	129.82±6.34	180.68±6.56

The provided data in Table 4 presents the mean levels of several serum electrolytes (sodium, potassium and chloride) for two groups in your study: "Cases" (patients with Type 2 Diabetes Mellitus) and "Controls" (non-diabetic participants). The mean electrolyte values for each group is given below:

Sodium (N^{a+}):

Cases (patients with type 2 diabetes mellitus): The mean serum sodium level for cases is 82.64 mmol L^{-1} with a standard deviation of 5.15 mmol L^{-1}. This indicates that, on average, individuals in the diabetes group have a lower serum sodium level of 82.64 mmol L^{-1}. The standard deviation of 5.15 suggests that there is some variability in sodium levels within this group.

Controls (non-diabetic participants): The mean serum sodium level for controls (non-diabetic participants) is 138.37 mmol L^{-1} with a standard deviation of

5.08 mmol L^{-1}. In contrast to the diabetes group, the control group has a significantly higher mean serum sodium level, indicating that, on average, individuals without diabetes in your study have a serum sodium level of 138.37 mmol L^{-1}. The standard deviation of 5.08 suggests that there is some variability in sodium levels within this group as well but it's relatively close to the mean.

Potassium (K+)

Cases (patients with type 2 diabetes mellitus): The mean serum potassium level for cases is 3.82 mmol L^{-1} with a standard deviation of 0.42 mmol L^{-1}. This indicates that, on average, individuals in the diabetes group have a lower serum potassium level of 3.82 mmol L^{-1}. The standard deviation of 0.42 suggests that there is some variability in potassium levels within this group.

Controls (non-diabetic participants): The mean serum potassium level for controls (non-diabetic participants) is 4.42 mmol L^{-1} with a standard deviation of 0.65 mmol L^{-1}. In contrast to the diabetes group, the control group has a significantly higher mean serum potassium level, indicating that, on average, individuals without diabetes in your study have a serum potassium level of 4.42 mmol L^{-1}. The standard deviation of 0.65 suggests that there is more variability in potassium levels within this group compared to the diabetes group.

Chloride (Cl^-)

Cases (patients with type 2 diabetes mellitus): The mean serum chloride level for cases is 129.82 mmol L^{-1} with a standard deviation of 6.34 mmol L^{-1}. This indicates that, on average, individuals in the diabetes group have a lower serum chloride level of 129.82 mmol L^{-1}. The standard deviation of 6.34 suggests some variability in chloride levels within this group.

Controls (non-diabetic participants): The mean serum chloride level for controls (non-diabetic participants) is 180.68 mmol L^{-1} with a standard deviation of 6.56 mmol L^{-1}. In contrast to the diabetes group, the control group has a significantly higher mean serum chloride level, indicating that, on average, individuals without diabetes in your study have a serum chloride level of 180.68 mmol L^{-1}. The standard deviation of 6.56 suggests some variability in chloride levels within this group as well.

Electrolyte imbalances in type 2 diabetes: The data reveals significant differences in mean serum sodium, potassium and chloride levels between individuals with Type 2 Diabetes Mellitus (cases) and those without diabetes (controls). These differences suggest that electrolyte imbalances may be associated with Type 2 Diabetes.

Clinical Implications: Altered electrolyte levels can have clinical implications, affecting various physiological processes. In diabetes, these imbalances might be related to complications or comorbidities and should be investigated further.

Mechanisms and risk factors: Discuss potential mechanisms and risk factors associated with these electrolyte imbalances in individuals with Type 2 Diabetes. Explore how diabetes-related factors such as hyperglycemia and insulin resistance might contribute.

Management considerations: Consider how these electrolyte imbalances might influence the management and treatment of Type 2 Diabetes. Electrolyte management may be an important aspect of diabetes care.

DISCUSSIONS

The study of serum electrolytes in Type 2 Diabetes Mellitus (T2DM) is of considerable importance, as it sheds light on the potential alterations in electrolyte balance associated with this prevalent metabolic disorder[18]. Electrolytes are vital for maintaining various physiological functions and any disturbances in their levels can have significant clinical implications[19,20]. The following are the key findings and implications of the study.

- **Alterations in serum electrolytes:** The study revealed significant differences in serum electrolyte levels between individuals with T2DM (cases) and those without diabetes (controls)

  Cases had lower serum sodium levels, lower serum potassium levels and lower serum chloride levels compared to controls. The obtained result was consistent with previous studies by Ahmed R *et al*[21] Das A *et al*,[22] and Rajagambeeran *et al* [23].

- **Clinical Significance:** The findings underscore the clinical significance of monitoring electrolyte levels in individuals with T2DM. Electrolyte imbalances can affect nerve function, muscle contractions and overall health.
- **Potential mechanisms:** Discuss potential mechanisms underlying the observed electrolyte imbalances in T2DM. Factors such as hyperglycemia, insulin resistance and

diabetesrelated complications may contribute to these alterations.

- **Sodium (N^{a+}):** In cases, serum sodium levels were lower. This could be associated with increased urinary sodium excretion or other factors related to diabetes. Low sodium levels may have implications for blood pressure regulation and fluid balance.
- **Potassium (K+):** Cases exhibited lower serum potassium levels. This may be related to insulin resistance, as insulin plays a role in potassium uptake by cells. Low potassium levels can lead to muscle weakness and cardiac arrhythmias.
- **Chloride (ClG):** Lower serum chloride levels were observed in cases. The reasons for this phenomenon should be explored further. Chloride imbalances can affect acid-base balance and contribute to metabolic acidosis.

  The significantly lower mean chloride level among T2DM patients compared to non-diabetics in the current study is consistent with the significantly lower chloride levels among T2DM patients as reported in Prabha AT [26] where changes in serum electrolytes, including hypochloremia, were widespread in diabetic patients as renal function deteriorated. However, the current study's findings contradict
- **Clinical management:** Discuss how these findings may impact the clinical management of individuals with T2DM. Healthcare providers should consider electrolyte monitoring and interventions to correct imbalances..
- **Implications for complications:** Electrolyte imbalances can contribute to diabetic complications. For example, hypokalemia may exacerbate cardiovascular issues, while hyponatremia may affect cognition and balance.
- **Future research:** Highlights the need for further research to investigate the causal relationships and underlying mechanisms between T2DM and serum electrolyte imbalances. Explores whether specific interventions targeting electrolyte balance can improve diabetes management and outcomes.
- **Limitations:** Acknowledge any limitations of the study, such as sample size, selection bias, or confounding variables. Addressing these limitations can provide a more accurate interpretation of the findings.

CONCLUSION

In this study, we investigated the serum electrolyte profiles of individuals with Type 2 Diabetes Mellitus (T2DM) and compared them to a control group without diabetes. Our findings reveal significant differences in serum electrolyte levels between the two groups, shedding light on the clinical relevance of electrolyte balance in diabetes management. Individuals with T2DM exhibited lower serum sodium levels compared to the control group. This suggests the presence of hyponatremia in T2DM patients, which may have implications for blood pressure regulation and fluid balance. T2DM patients displayed lower serum potassium levels. This electrolyte imbalance, often associated with insulin resistance, highlights the importance of monitoring and managing potassium levels in diabetes care to prevent complications such as cardiac arrhythmias. Lower serum chloride levels were observed in T2DM patients. The underlying mechanisms require further investigation. Chloride imbalances may affect acid-base balance and metabolic status in individuals with T2DM. These findings underscore the clinical significance of monitoring electrolyte levels in T2DM and recognizing the potential impact of electrolyte imbalances on diabetes management and complications. In summary, our study contributes to our understanding of the relationship between T2DM and serum electrolyte levels. It emphasizes the importance of recognizing and managing electrolyte imbalances as an integral component of diabetes care. Further research in this area holds the potential to enhance our ability to optimize the health and well-being of individuals living with Type 2 Diabetes Mellitus.

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