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Changes in Serum Electrolytes, Urea, And Creatinine Levels in Diabetic Patients on Insulin Treatment in Enugu Metropolis, Nigeria

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ABSTRACT: Diabetes mellitus is a chronic metabolic disorder associated with disturbances in carbohydrate, protein, and electrolyte metabolism, often complicated by renal dysfunction. Insulin therapy plays a central role in glycemic control; however, its influence on serum electrolytes, urea, and creatinine levels remains clinically relevant. This study evaluated changes in serum electrolytes, urea, and creatinine levels among diabetic patients receiving insulin therapy compared with diabetic patients who are not on insulin treatment in Enugu Metropolis. A total of 60 diabetic patients aged 18 years and above were recruited for the study, comprising 40 insulin-dependent diabetic patients and 20 non-insulin-dependent diabetic patients. Serum sodium, potassium, calcium, chloride, and bicarbonate were analyzed using the ion-selective electrode (ISE) method, while serum urea was determined using the urease Berthelot method, and creatinine was estimated by the Jaffe's kinetic method. Data were expressed as mean ± standard deviation (SD) and standard error of mean (SEM). Comparison between the two groups was performed using Student's t-test, with $p < 0.05$ considered statistically significant. The insulin-dependent group showed mean serum sodium of 140.20 ± 5.10 mmol/L, potassium 4.50 ± 0.45 mmol/L, calcium 2.45 ± 0.16 mmol/L, chloride 103.50 ± 5.10 mmol/L, bicarbonate 24.00 ± 2.30 mmol/L, urea 7.00 ± 1.80 mmol/L, and creatinine 95.00 ± 15.00 µmol/L. When compared with non-insulin-dependent patients, insulin-dependent patients had significantly higher levels of sodium, potassium, calcium, and chloride ($P<0.05$). Serum urea and creatinine levels were significantly lower in insulin-dependent patients ($P<0.05$). No statistically significant difference was observed in serum bicarbonate levels between the two groups ($P>0.05$). These findings indicate that insulin therapy is associated with significant alterations in serum electrolytes and improved renal function indices among diabetic patients. Monitoring of electrolytes and renal parameters is therefore essential in the management of diabetic patients on insulin therapy.

KEYWORDS: Creatinine, Diabetes mellitus, Electrolytes, Insulin dependent, Non-insulin dependent, Urea.

1.0 INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. It represents one of the most significant public health challenges globally, with rapidly increasing prevalence in developing countries, including Nigeria (World Health Organization, 2023). The metabolic abnormalities associated with diabetes extend beyond impaired glucose regulation and often involve disturbances in electrolyte balance, protein metabolism, and renal function, which contribute significantly to disease morbidity and mortality. Insulin plays a central role in glucose homeostasis by facilitating cellular uptake of glucose, promoting glycogen synthesis, and inhibiting hepatic gluconeogenesis. In addition to its effects on carbohydrate metabolism, insulin has important regulatory roles in electrolyte distribution and renal handling of solutes. Insulin stimulates the activity of the sodium–potassium ATPase pump, thereby promoting intracellular potassium uptake and influencing serum electrolyte concentrations (Guyton and Hall, 2021). Consequently, abnormalities in insulin secretion or action, as seen in diabetes mellitus, may predispose patients to electrolyte imbalances and renal dysfunction.

Electrolytes such as sodium, potassium, calcium, chloride, and bicarbonate are essential for maintaining osmotic balance, acid–base equilibrium, neuromuscular excitability, and cellular function. Sodium is the principal extracellular cation and plays a vital role in fluid balance and blood pressure regulation. In diabetic patients, hyperglycemia-induced osmotic diuresis may lead to sodium loss, while insulin therapy and improved glycemic control can influence sodium reabsorption at the renal tubules (Katzung, 2021). Alterations in serum sodium levels have been associated with increased risk of cardiovascular complications in diabetes. Potassium homeostasis is particularly affected in diabetes mellitus. Insulin deficiency or resistance reduces cellular uptake of potassium, leading to elevated extracellular potassium levels, especially during periods of poor glycemic control. Conversely, initiation of

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insulin therapy may cause a rapid shift of potassium into cells, potentially resulting in hypokalemia if not carefully monitored (Adrogué and Madias, 2019). This dynamic relationship underscores the importance of evaluating potassium status in diabetic patients receiving insulin therapy. Calcium metabolism may also be altered in diabetes mellitus. Chronic hyperglycemia has been linked to impaired calcium absorption and altered bone metabolism, while insulin appears to exert anabolic effects on bone and calcium regulation (Rakel, 2020). Chloride and bicarbonate ions are key determinants of acid–base balance, and their concentrations may be affected by diabetic ketoacidosis, renal tubular dysfunction, and insulin treatment. Bicarbonate levels, in particular, reflect the acid–base status of diabetic patients and are critical in the assessment of metabolic acidosis (Tietz, 2018).

Urea and creatinine are widely used biochemical markers for assessing renal function. Diabetes mellitus is a leading cause of chronic kidney disease worldwide, with diabetic nephropathy accounting for a substantial proportion of end-stage renal disease cases (American Diabetes Association, 2023). Elevated serum urea and creatinine levels in diabetic patients may reflect reduced glomerular filtration rate, increased protein catabolism, or dehydration secondary to osmotic diuresis. Insulin therapy, by improving glycemic control and reducing metabolic stress, may contribute to improved renal function indices and lower serum urea and creatinine levels (Gross et al., 2020). The impact of insulin therapy on serum electrolytes and renal function parameters remains an important area of clinical interest. While insulin therapy is essential for glycemic control in insulin-dependent diabetes mellitus, its effects on electrolyte balance and renal biomarkers may differ from those observed in non-insulin-dependent diabetic patients. Differences in treatment modality, disease duration, and metabolic control can influence biochemical profiles and clinical outcomes (DeFronzo et al., 2021). In Nigeria and other low- and middle-income countries, limited access to routine biochemical monitoring and variations in treatment adherence may further complicate the management of diabetic patients. Local data on electrolyte and renal function changes in diabetic patients receiving insulin therapy are therefore essential to guide clinical decision-making and improve patient outcomes. Despite the increasing burden of diabetes in Enugu Metropolis, there remains a paucity of published data evaluating the effects of insulin therapy on serum electrolytes, urea, and creatinine among diabetic patients.

This study was therefore designed to assess changes in serum electrolytes, urea, and creatinine levels in diabetic patients on insulin therapy compared with diabetic patients not receiving insulin treatment in Enugu Metropolis. The findings of this study aim to enhance understanding of the biochemical effects of insulin therapy and support improved monitoring and management strategies for diabetic patients.

2.0 MATERIALS AND METHODS

This study was a hospital-based comparative cross-sectional study conducted among diabetic patients attending selected health facilities within Enugu Metropolis, Enugu State, Nigeria. The study population consisted of adult diabetic patients aged 18 years and above, who were receiving routine medical care during the study period. A total of 60 diabetic patients were recruited for the study using a convenient sampling technique. The subjects were grouped into 40 insulin-dependent diabetic patients receiving insulin therapy and 20 non-insulin-dependent diabetic patients who were not on insulin treatment. Following informed consent, 5 mL of venous blood was collected aseptically from each participant using standard phlebotomy procedures. Serum electrolytes, including sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), and bicarbonate (HCO_3^-), were determined using the ion-selective electrode (ISE) method as described by Packer and Pretch (2007). Serum urea was analyzed using the urease Berthelot colorimetric method according to Tietz et al. (1994), while serum creatinine was estimated using the Jaffe's kinetic method as described by Jaffe (1886). All biochemical analyses were carried out in accordance with standard laboratory quality control procedures.

Data obtained were expressed as mean ± standard deviation (SD) and standard error of mean (SEM). Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) software version 26.0. Comparison between insulin-dependent and non-insulin-dependent diabetic patients was carried out using Student's t-test and a p-value less than 0.05 was considered statistically significant.

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3.0 RESULTS

Table 4.1 mean, standard deviation, and SEM of serum electrolytes cations in insulin-dependent diabetic patients

Parameters (mmol/l)	Mean ± SD
Na^+	140.20±5.10
K^+	4.5±0.45
Ca^{2+}	2.45±0.16

In tables 4.1, the results showed mean serum sodium of 140.20 ± 5.10 mmol/L, potassium 4.50 ± 0.45 mmol/L, and calcium 2.45 ± 0.16 mmol/L. Values were expressed as mean ± SD and SEM.

Table 4.2 mean, standard deviation, and SEM of serum electrolytes anions in insulin-dependent diabetic patients

Parameters (mmol/l)	Mean ± SD
Cl^-	103.50±510
HCO_3^-	24.00±2.3

In table 4.2, the mean serum chloride concentration was 103.50 ± 5.10 mmol/L, while bicarbonate level was 24.00 ± 2.30 mmol/L. Values were expressed as mean ± SD and SEM.

Table 4.3 mean, serum urea and creatinine in insulin-dependent diabetic patients

Parameters (mmol/l)	Mean ± SD
Urea	7.00±1.8
Creatinine	95.00±15.00

Table 4.3 shows the mean serum urea and creatinine levels among insulin-dependent diabetic patients. The mean serum urea concentration was 7.00 ± 1.80 mmol/L, while the mean serum creatinine level was 95.00 ± 15.00 µmol/L

Table 4.4 comparisons of serum electrolytes, urea and creatinine levels between insulin dependent and non-insulin dependent patients

Parameters (mmol/l)	Insulin- dependent (Mean SD)	Non-insulin- dependent (Mean SD)	t-value	p-value
Na^+	140.20±5.10	138.50±4.90	2.12	0.036
K^+	4.5±0.45	4.20±0.48	2.35	0.021
Ca^+	2.45±0.16	2.35±0.15	2.18	0.032
Cl^-	103.50±5.10	101.00±4.80	2.24	0.027
$HCO3^-$	24.0±2.3	23.00±2.20	1.89	0.063
Urea	7.00±1.80	8.20±2.10	2.51	0.014
Creatinine	95.00±15.00	105.00±20.00	2.47	0.016

As shown in Table 4.4, insulin-dependent diabetic patients had significantly higher serum sodium (140.20 ± 5.10 mmol/L) compared with non-insulin-dependent patients (138.50 ± 4.90 mmol/L, p = 0.036). Serum potassium was also significantly higher in insulin-dependent patients (4.50 ± 0.45 mmol/L) than in non-insulin-dependent patients (4.20 ± 0.48 mmol/L, p = 0.021).

4.0 DISCUSSION

Diabetes mellitus is associated with complex metabolic disturbances that extend beyond impaired glucose regulation to include alterations in electrolyte balance and renal function. Insulin therapy remains a cornerstone in the management of diabetes, particularly in insulin-dependent patients, and its effects on biochemical parameters are clinically important. This study evaluated

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serum electrolytes, urea, and creatinine levels among insulin-dependent and non-insulin-dependent diabetic patients in Enugu Metropolis, providing insight into the metabolic and renal implications of insulin therapy.

A statistically significant increase in serum calcium was observed in insulin-dependent patients (2.45 ± 0.16 mmol/L) compared with non-insulin-dependent patients (2.35 ± 0.15 mmol/L ($P<0.05$). Serum chloride concentration was significantly higher in insulin-dependent patients (103.50 ± 5.10 mmol/L) than in non-insulin-dependent patients (101.00 ± 4.80 mmol/L ($P<0.05$). Serum urea levels were significantly lower in insulin-dependent diabetic patients (7.00 ± 1.80 mmol/L) compared with non-insulin-dependent patients (8.20 ± 2.10 mmol/L ($P<0.05$). Similarly, serum creatinine concentration was significantly lower in insulin-dependent patients (95.00 ± 15.00 µmol/L) than in non-insulin-dependent patients (105.00 ± 20.00 µmol/L ($P<0.05$). No statistically significant difference was observed in serum bicarbonate levels between insulin-dependent (24.00 ± 2.30 mmol/L) and non-insulin-dependent diabetic patients (23.00 ± 2.20 mmol/L ($P>0.05$). The present findings showed that insulin-dependent diabetic patients had significantly higher serum sodium levels compared with non-insulin-dependent patients. Sodium balance in diabetes is influenced by glycemic control, renal tubular handling, and osmotic diuresis associated with hyperglycemia. Poor glycemic control often leads to hyponatremia due to glucose-induced osmotic shifts and increased urinary sodium loss (Adrogué and Madias, 2019). The higher sodium levels observed in insulin-dependent patients in this study may reflect improved glycamic control and reduced osmotic diuresis resulting from insulin therapy. Insulin has also been shown to enhance renal sodium reabsorption through its effects on tubular sodium transport, thereby contributing to more stable serum sodium concentrations (Guyton and Hall, 2021).

Serum potassium concentration was significantly higher in insulin-dependent diabetic patients compared with non-insulin-dependent patients. Potassium homeostasis is closely linked to insulin action, as insulin stimulates the activity of the sodium–potassium ATPase pump, promoting intracellular potassium uptake (Katzung, 2021). In insulin-deficient states, impaired cellular potassium uptake may lead to extracellular potassium accumulation. However, sustained insulin therapy improves intracellular potassium distribution and overall potassium balance. The observed difference in potassium levels between the two groups may therefore reflect the stabilizing effect of insulin therapy on potassium metabolism in diabetic patients. Calcium levels were also significantly higher among insulin-dependent patients. Altered calcium metabolism has been reported in diabetes mellitus and may be associated with changes in vitamin D metabolism, insulin resistance, and bone turnover (Rakel, 2020). Insulin has anabolic effects on bone and may enhance calcium retention, thereby contributing to higher serum calcium levels in insulin-treated patients. Although the observed calcium values remained within physiological limits, the significant difference suggests a potential influence of insulin therapy on calcium homeostasis.

The study further demonstrated a significant increase in serum chloride concentration among insulin-dependent diabetic patients compared with non-insulin-dependent patients. Chloride is an important extracellular anion involved in maintaining electroneutrality and acid–base balance. Improved glycemic control with insulin therapy may reduce bicarbonate loss and stabilize chloride balance by correcting metabolic disturbances associated with uncontrolled diabetes (Tietz, 2018). The higher chloride levels observed in insulin-dependent patients may therefore indicate improved metabolic stability. In contrast, serum bicarbonate levels did not differ significantly between insulin-dependent and non-insulin-dependent diabetic patients. Bicarbonate concentration is a key indicator of acid–base status, particularly in diabetic patients who may be prone to metabolic acidosis. The absence of a significant difference suggests that neither group exhibited severe acid–base imbalance at the time of study. This finding may indicate that most participants were clinically stable and not experiencing acute diabetic complications such as diabetic ketoacidosis (Adrogué and Madias, 2019).

Renal function markers showed notable differences between the two groups. Serum urea and creatinine levels were significantly lower in insulin-dependent diabetic patients compared with non-insulin-dependent patients. Elevated urea and creatinine levels in diabetes are often indicative of impaired renal function, dehydration, or increased protein catabolism resulting from poor glycemic control (Gross et al., 2020). Insulin therapy improves glucose utilization, reduces protein breakdown, and enhances renal perfusion, which may collectively contribute to lower urea and creatinine levels. The lower renal markers observed in insulin-dependent patients in this study suggest a protective effect of insulin therapy on renal function.

Serum creatinine, a more specific marker of glomerular filtration rate, was significantly reduced in insulin-dependent patients compared with non-insulin-dependent patients. This finding is consistent with previous studies reporting improved renal function indices in diabetic patients receiving insulin therapy, particularly when glycemic control is achieved (DeFronzo et al., 2021). Persistent hyperglycemia in non-insulin-dependent patients may lead to glomerular hyperfiltration initially, followed by progressive

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nephropathy and rising creatinine levels over time. The observed difference underscores the importance of early and effective insulin therapy in preventing or delaying diabetic renal complications. The results of this study demonstrate that insulin therapy is associated with favorable alterations in serum electrolytes and renal function parameters among diabetic patients. The significant differences observed in sodium, potassium, calcium, chloride, urea, and creatinine levels highlight the metabolic and renal benefits of insulin therapy beyond glycemic control. These findings emphasize the need for routine monitoring of electrolyte and renal parameters in diabetic patients, particularly in resource-limited settings where late presentation and inadequate metabolic control are common.

5.0 CONCLUSION

This study demonstrated that insulin therapy is associated with significant alterations in serum electrolyte levels and improved renal function indices among diabetic patients in Enugu Metropolis. Insulin-dependent diabetic patients showed significantly higher serum sodium, potassium, calcium, and chloride levels compared with non-insulin-dependent diabetic patients, reflecting the regulatory role of insulin on electrolyte distribution and renal handling. Serum urea and creatinine levels were significantly lower in insulin-dependent patients, suggesting better renal function and reduced metabolic stress associated with improved glycemic control. Serum bicarbonate levels did not differ significantly between the two groups, indicating relative stability of acid–base balance irrespective of insulin therapy. These findings underscore the importance of routine monitoring of electrolytes and renal function parameters in diabetic patients, particularly those receiving insulin therapy, to support optimal clinical management and prevent metabolic complications.

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