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Electrolyte Disturbances and Membrane Potential Alterations in Newly Diagnosed and Treated Pulmonary Tuberculosis Patients in Imo State

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Abstract: **Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide. Beyond pulmonary manifestations, TB is associated with metabolic disturbances that may contribute to disease severity and treatment outcomes. Electrolyte abnormalities and alterations in membrane potential have been reported among pulmonary tuberculosis patients, but their clinical significance remains inadequately characterized.**

Keywords: **Pulmonary tuberculosis, Electrolytes, Membrane potential, Sodium, Potassium, Calcium, Hyponatremia, Hypokalemia.**

1. INTRODUCTION

Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis* and remains a major public health concern worldwide. In 1993, the World Health Organization (WHO) declared tuberculosis a global public health emergency due to its increasing burden and associated mortality (World Health Organization, 2023). Approximately one-third of the world's population is estimated to be infected with *M. tuberculosis*, and about 10% eventually develop active disease (Sharma and Sarkar, 2018).

Nigeria is among the countries with the highest burden of tuberculosis globally, with a substantial proportion of cases occurring alongside HIV infection (Olalekan *et al.*, 2014). Pulmonary tuberculosis is the most common form of the disease and is characterized by prolonged cough, weight loss, fever, night sweats, and progressive deterioration of health.

In addition to pulmonary manifestations, tuberculosis is associated with several metabolic abnormalities, particularly disturbances in electrolyte balance. Hyponatremia, hypokalemia, hypochloremia, and reduced bicarbonate concentrations have been reported among pulmonary tuberculosis patients (Patil and Mrudula, 2019). These abnormalities may arise from adrenal insufficiency, syndrome of inappropriate antidiuretic hormone secretion (SIADH), renal electrolyte wasting, malnutrition, excessive sweating, vomiting, and diarrhea (Berggren, 2015).

Electrolytes are critical for maintaining cellular homeostasis, neuromuscular function, acid-base balance, and membrane excitability. Sodium and potassium play central roles in generating membrane potential, while calcium serves as an important intracellular signaling molecule involved in immune activation and macrophage function (Gupta *et al.*, 2013). Alterations in electrolyte concentrations may therefore influence immune responses and disease progression.

Although several studies have investigated the immunological and clinical aspects of tuberculosis, limited information exists regarding electrolyte disturbances and membrane potential changes among pulmonary tuberculosis patients receiving treatment. This study therefore evaluated serum electrolyte concentrations and membrane potential among newly diagnosed pulmonary tuberculosis patients, pulmonary tuberculosis patients on therapy, and healthy controls.

2. METHODOLOGY

Study Design

This was a comparative cross-sectional study involving newly diagnosed pulmonary tuberculosis patients, pulmonary tuberculosis patients receiving anti-tuberculosis therapy, and apparently healthy controls in Imo State.

Study Population

The study population comprised:

- Newly diagnosed pulmonary tuberculosis patients (n = 50)
- Pulmonary tuberculosis patients on therapy (n = 50)
- Apparently healthy controls (n = 50)

Inclusion Criteria

- Confirmed pulmonary tuberculosis diagnosis.
- Patients receiving anti-tuberculosis therapy.
- Apparently healthy individuals without evidence of tuberculosis.

Sample Collection and Analysis

Venous blood samples were collected under aseptic conditions. Serum sodium, potassium, chloride, bicarbonate, calcium, and membrane potential were determined using standard laboratory procedures.

Statistical Analysis

Data were analyzed using SPSS version 21.0 statistical software. Results were expressed as mean ± standard deviation. Comparisons among groups were performed using analysis of variance (ANOVA). Statistical significance was accepted at $p < 0.05$.

3. RESULTS

Table 1: Serum Electrolyte Levels in Study Groups

Parameter	Newly Diagnosed TB (n=50)	TB on Therapy (n=50)	Controls (n=50)	P-value
Sodium (mmol/L)	132.15 ± 2.16	133.04 ± 4.11	136.40 ± 3.07	0.0001
Potassium (mmol/L)	3.44 ± 0.42	3.51 ± 0.30	3.87 ± 0.41	0.0001
Bicarbonate (mmol/L)	20.40 ± 2.11	21.38 ± 2.42	23.60 ± 2.12	0.033
Chloride (mmol/L)	100.26 ± 4.00	103.11 ± 5.30	99.06 ± 4.11	0.0001

The mean serum sodium concentration was significantly lower among newly diagnosed and treated TB patients than controls. Potassium and bicarbonate concentrations also demonstrated significant reductions among TB patients.

Table 2: Calcium and Membrane Potential in Study Groups

Parameter	Newly Diagnosed TB	TB on Therapy	Controls	P-value
Calcium (mg/dL)	8.13 ± 0.41	8.97 ± 0.33	9.28 ± 0.40	0.0001
Membrane Potential (mV)	11.98 ± 0.22	11.93 ± 0.21	11.76 ± 0.24	0.0001

Calcium concentrations were significantly reduced among TB patients, while membrane potential values were significantly elevated compared with controls.

4. DISCUSSION

This study demonstrated significant electrolyte abnormalities among pulmonary tuberculosis patients. Hyponatremia was observed among both newly diagnosed and treated TB patients. Similar findings have been reported by Adrogué and Madias (2000), who identified hyponatremia as one of the most common electrolyte abnormalities associated with chronic infectious diseases. The reduced sodium concentration observed in this study may result from SIADH, adrenal insufficiency, renal dysfunction, and excessive fluid loss.

Potassium concentrations were also significantly reduced among TB patients. Kaur *et al.*, (2021) reported that hypokalemia in tuberculosis may arise from gastrointestinal losses, renal potassium wasting, and inadequate dietary intake. Chronic inflammation and increased metabolic demands may further contribute to potassium depletion.

The observed reduction in bicarbonate concentrations may reflect compensatory mechanisms aimed at maintaining acid-base balance in response to electrolyte disturbances. Similar findings have been reported among pulmonary tuberculosis patients with chronic inflammatory disease (Patil and Mrudula, 2019).

Calcium levels were significantly lower among TB patients than controls. This finding agrees with Hendy and El-Nagger (2019), who reported increased prevalence of hypocalcemia among pulmonary tuberculosis patients. Reduced calcium levels may be related to vitamin D deficiency, poor nutritional status, impaired renal activation of vitamin D, and chronic inflammatory processes.

Membrane potential was significantly elevated among pulmonary tuberculosis patients. Alterations in sodium, potassium, and calcium concentrations may contribute to changes in transmembrane ionic gradients, resulting in altered membrane excitability. Calcium-mediated intracellular signaling pathways are known to play important roles in macrophage activation and host defense against *M. tuberculosis* (Gupta *et al.*, 2013).

The persistence of electrolyte abnormalities among patients receiving anti-tuberculosis therapy suggests that metabolic disturbances may continue despite treatment and therefore warrant ongoing monitoring.

5. CONCLUSION

Pulmonary tuberculosis is associated with significant electrolyte disturbances characterized by:

- Hyponatremia
- Hypokalemia
- Reduced bicarbonate levels
- Hypocalcemia
- Elevated membrane potential

These abnormalities occur in both newly diagnosed and treated tuberculosis patients and may contribute to disease morbidity. Routine assessment of electrolyte status should therefore be incorporated into tuberculosis management protocols.

6. RECOMMENDATIONS

1. Routine electrolyte monitoring should be included in TB patient management.
2. Nutritional interventions should be provided to reduce electrolyte deficiencies.
3. Patients receiving anti-tuberculosis therapy should undergo periodic biochemical assessment.
4. Further longitudinal studies should investigate the impact of electrolyte correction on treatment outcomes.

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