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Changes in Serum Electrolytes, Urea, and Creatinine in Septicemic Patients in Enugu State University Teaching Hospital, Enugu, Nigeria

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A B S T R A C T

Septicemia is one of the leading causes of morbidity and mortality in developing countries and often results in biochemical disturbances affecting kidney function and electrolyte balance. This study evaluated changes in sodium, potassium, chloride, bicarbonate, urea, and creatinine levels among 50 children aged 1–16 years, consisting of 25 septicemic patients and 25 healthy controls at ESUTH, Nigeria. Urea and creatinine were analyzed using the Berthelot and Jaffe methods, while electrolytes were measured using ion-selective electrodes. Data were analyzed using SPSS 26. The results showed a significant decrease in sodium and bicarbonate levels in the septicemia group, while potassium showed a slight but non-significant increase, and chloride levels showed no meaningful difference. Urea and creatinine were higher in septicemic patients, although not statistically significant. Age-based analysis revealed more pronounced reductions in sodium and bicarbonate among children aged 7–16 years. These findings reflect electrolyte imbalance and early renal functional alterations resulting from systemic infection and inflammatory response in septicemia.

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INTRODUCTION

Septicemia, also known as sepsis, is a life-threatening systemic infection characterized by the presence of pathogenic microorganisms and their toxins in the bloodstream, leading to widespread inflammatory response, tissue injury, and organ dysfunction (Singer et al., 2016; Hotchkiss et al., 2019). It remains a major global health problem, particularly in developing countries where healthcare access and early diagnostic resources are limited (Adesola and Omoregie, 2020). The World Health Organization (WHO) estimates that over 11 million deaths occur annually from sepsis, accounting for nearly one-fifth of global mortality, with the highest incidence in sub-Saharan Africa (World Health Organization, 2020). In Nigeria, pediatric and neonatal septicemia constitutes significant causes of hospital admissions and mortality (Onyedibe et al., 2019; Ogundare and Akindele, 2021).

The pathophysiology of septicemia involves a cascade of immune-mediated and biochemical responses that culminate in metabolic derangements and multiorgan impairment (Leligdowicz and Matthay, 2019). During systemic infection, proinflammatory cytokines such as tumor necrosis factor-α (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6) induce vascular leakage, capillary endothelial damage, and microcirculatory dysfunction (Rittirsch et al., 2022). These lead to altered renal perfusion and glomerular filtration, resulting in disturbances of serum electrolytes, urea, and creatinine (Kellum and Prowle, 2018; Poston and Koyner, 2019). Electrolyte imbalance in septicemia, particularly hyponatremia, hyperkalemia, and metabolic acidosis, has been reported as early indicators of disease severity and poor outcome (Prowle and Bellomo, 2020; Sharma and Kumar,2021; Behera et al., 2022).

Sodium plays a key role in maintaining extracellular osmotic pressure and neuromuscular function, while potassium regulates cellular excitability and cardiac rhythm (Tietz, 2015). Bicarbonate acts as a vital component of the buffering system controlling blood pH (Guyton and Hall, 2021). In septic patients, renal hypoperfusion and tubular injury often result in sodium loss, potassium retention, and decreased bicarbonate reabsorption, manifesting as hyponatremia, hyperkalemia, and metabolic acidosis (Vincent and Opal, 2020; Choudhury et al., 2020). Urea and creatinine are classical indices of renal function and glomerular filtration rate (GFR). Their elevation in sepsis signifies renal compromise or acute kidney injury (Ostermann et al., 2018; Shankar et al., 2021).

Poorly developed areas often have greater exposure to risk factors for renal dysfunction. Infections (malaria, urethral tract infections that can cause septicemia) , dehydration, poor access to health care, environmental toxins, occupational exposures, malnutrition, as was reported for Ethiopia, are some of the risk factors that can dispose one to significant derangement in electrolytes, urea and creatinine (Bachaw et al, 2025). In poorly developed countries with deficient health infrastructure, renal disease onsets sequel to some pathological cases, such as septicemia may not be detected until advanced stages. Electrolyte abnormalities including hypokalemia and hyponatremia were commonly discovered in hospitalized children in Northern Nigeria , such that about 78%

electrolyte derangement and 20% azotaemia were reported (Obiagwu et al, 2023).

Some studies also have documented electrolyte and renal disturbances in septic patients of varying ages (Omoregie et al., 2020; Njokanma et al., 2019; Paliwal et al., 2022). Hassan et al., (2021) reported a significant reduction in serum sodium and bicarbonate among Nigerian children with bacteremia, while Njokanma et al, 2019; Alemu et al., (2023) observed elevated urea and creatinine concentrations as predictors of renal dysfunction in severe sepsis. However, local data on the pattern of electrolyte and renal parameter alterations among suspected paediatric septicemic patients in southeastern Nigeria remain limited.

This study therefore aimed to evaluate changes in serum electrolytes, urea, and creatinine in septicemic patients attending ESUT Teaching Hospital, Enugu, Nigeria, and to determine the influence of age on these biochemical parameters. These aims were also drawn from the knowledge of the theory and review of basic research on septic-AKI which highlights that despite modest structural or histological changes, there is significant functional kidney impairment in sepsis, leading to reduced glomerular filtration and thus accumulation of nitrogenous wastes and electrolytes/acid-base disturbances (Daisuke Nakano, 2020). The findings are expected to improve understanding of renal and metabolic alterations in paediatric sepsis and guide better clinical management strategies.

THEORETICAL REVIEW

The theoretical review that in sepsis there is hemodynamic instability, micro circulatory dysfunction, endothelial activation, inflammation, oxidative stress and procoagulant states, all which contribute to decreased glomerular filtration and increased serum creatinine and BUN and disturbances in fluid and electrolyte balance (Martin et al, 2024) is part of the basis for this work. Previous works by Hassan et al, 2021, Paliwa et al, 2022 and Alemu et al, 2023 documented electrolytes and renal disturbances in septicemic patients.

METHODOLOGY

This hospital-based cross sectional study was conducted at the Chemical Pathology Unit of Enugu State University Teaching Hospital (ESUTH), Enugu, Nigeria. Fifty participants aged 1–16 years were recruited, consisting of 25 clinically septicemic patients and 25 age-matched apparently healthy controls. Ethical approval was obtained from the ESUT Research and Ethics Committee, and informed consent was secured from parents or guardians prior to sample collection, in accordance with the Declaration of Helsinki (2013 revision).

Approximately 5 mL of venous blood was aseptically collected from each participant into plain tubes. After clotting, samples were centrifuged at 3000 rpm for 10 minutes to obtain serum. Serum electrolytes (Na^+, K^+, Cl^-, and HCO_3^-) were determined using ion-selective electrode (ISE) analyzers, while urea and creatinine were estimated by enzymatic spectrophotometric methods described by Berthelots and Jaffe (1886) as modified by Tietz (2015). All analyses were performed within two hours of sample collection.

Data Analysis

Data were analyzed and expressed as mean ± standard deviation (SD). Statistical analysis was performed using SPSS version 26.0 (IBM Corp., USA). Independent sample t-test and spearman's rho correlation was used to determine the difference between test and control while hypotheses' tests were done using two-tailed and $P<0.05$ was considered statistically significant. Age-related biochemical changes between the two groups (1–6 years and 7–16 years) was also analyzed using t-test.

RESULTS

Table 1. show values of parameters in suspected septicemia patients and control individual

Parameters	Test	control	p-value
Sodium mmol/l	133.16 ±2.66	137.44 ± 2.90	0.000
Potassium mmol/l	4.90 ± 1.11	4.09 ± 0.32	0.001
Chloride mmol/l	102.12 ± 5.43	100.04 ± 2.81	0.95
Bicarbonate mmol/l	22.08 ± 2.5	23.92 ± 1.61	0.003
Urea mmol/l	4.96 ± 3.99	3.79 ± 0.59	0.155
Creatinine mmol/l	66.72 ± 103.61	40.86 ± 6.75	0.219

Data are expressed as mean ± SD, $p<0.05$ is considered significant

Table 2. show mean ±SD of parameters in suspected septicemia patients and control individual in their different age group

Parameters	Groups				
	1-6year (test / cases samples)	7-16years (test/cases sample)	1-6years (control samples)	7-17years (control samples)	p-value
Sodium mmol/l	133.82 ± 2.44	132.64 ± 2.79	136.00 ±1.41	138.20 ± 2.97	0.000
Potassium mmol/l	5.09 ± 1.47	4.76 ± 0.76	4.01 ± 4.24	4.08 ± 0.33	0.102
Chloride mmol/l	103.82 ± 7.11	100.76 ±3.35	98.50 ± 2.12	100.50 ± 2.95	0.257
Bicarbonate mmol/l	21.32 ± 3.35	22.59 ± 1.71	23.25 ± 1.77	24.15 ± 1.78	0.070
Urea mmol/l	6.12 ± 5.82	4.05 ± 1.16	4.20 ± 0.00	3.67 ± 0.64	0.334
Creatinine mmol/l	101. 04 ± 1.52	39.75 ± 8 67	46.30 ± 7.92	39.87 ± 6.15	0.278

Data are expressed as mean ± SD, $p<0.05$ is considered significant.

Results summary

The mean serum sodium, potassium, chloride, bicarbonate, urea, and creatinine concentrations of the study groups are summarized in Tables 1 and 2.

Compared to controls, septicemic patients showed a significant decrease in serum sodium ($p < 0.05$) and bicarbonate ($p < 0.05$), consistent with hyponatremia and metabolic acidosis. Serum potassium was slightly elevated but not statistically significant, indicating a mild hyperkalemic trend. Chloride levels remained within the normal range for both groups ($p > 0.05$). Serum urea and creatinine were higher among septicemic patients than controls, though not significantly ($P > 0.05$), suggesting early renal compromise rather than established failure.

When stratified by age, children aged 7–16 years exhibited greater sodium and bicarbonate reductions than those aged 1–6 years, implying a progressive metabolic effect of sepsis severity with increasing age or infection duration.

DISCUSSION

Septicemia, commonly referred to as sepsis, represents a severe systemic response to infection that leads to organ dysfunction, tissue hypoperfusion, and potentially death. It is initiated by a dysregulated host immune response to microbial invasion, releasing pro-inflammatory mediators such as tumor necrosis factor-alpha (TNF-α), interleukin-1β, and nitric oxide, which trigger endothelial injury and microvascular leakage. Electrolyte imbalance in sepsis often manifests as hyponatremia, hypochloremia, and metabolic acidosis, primarily due to volume depletion, capillary leakage, and altered tubular reabsorption (Singer *et al*., 2016; Honore *et al*., 2021). This study demonstrated notable changes in serum electrolytes, urea, and creatinine among septicemic patients compared with healthy controls ($P<0.05$). The observed hyponatremia and reduced bicarbonate levels align with classical features of systemic infection and sepsis-related metabolic acidosis (Singh *et al*., 2024; West *et al*., 2023). These alterations reflect the body's physiological attempt to compensate for impaired renal handling of ions and increased metabolic demand during infection (Gyton and Hall, 2021).

The significant decline in serum sodium among the septicemic patients is consistent with findings by Kellum *et al*.,2023, Choudhury *et al,* 2022 and World Health Organization, 2023 that described hyponatremia as one of the most frequent electrolyte disturbances in pediatric sepsis.

The finding of this work on septicemic patients in Enugu state University Teaching Hospsital is also validated by the work of Obiagwu et al, 2023, which observed that in some pathological cases such as septicemia, electrolyte abnormalities including hypokalemia and hyponatremia were common among hospitalized children in Northern Nigeria, thereby inferring that such condition is also obtainable in Eastern part of Nigeria. The hyponatremia may arise from dilutional effects of increased antidiuretic hormone (ADH) secretion or inappropriate renal sodium loss (Murugan and Kellum, 2020) as the case may be. Moreover, cytokine-induced endothelial dysfunction leads to increased capillary permeability and redistribution of sodium into the interstitial space (Kumar and Parrillo, 2021).

Depletion observed in this study indicates metabolic acidosis resulting from lactic acid accumulation secondary to tissue hypoxia and reduced renal bicarbonate reabsorption (Raghavan and Marik, 2018). Similar trends have been reported by Omoregie *et al*., 2020 and Paliwal *et al*., 2023, suggesting that metabolic acidosis is a hallmark of septicemia-associated organ hypoperfusion.

The mild increase in serum potassium (P>0.05) seen here corroborates reports by Hassan et al, 2021 and Uddin *et al.,* 2021, who found hyperkalemia in septic patients due to impaired renal excretion and cellular leakage of potassium during inflammatory damage. Although the increase was not statistically significant, persistent hyperkalemia in advanced sepsis can lead to cardiac arrhythmias and warrants careful monitoring (Nasa *et al.,* 2018).

Serum urea and creatinine levels were higher among septicemic patients than controls, though without statistical significance, indicating early renal functional alteration. This agrees with the studies of Shankar *et al*., 2021; Alemu *et al.,* 2023;Yang and Wu, 2023), who described increased nitrogenous waste accumulation during sepsis due to decreased glomerular filtration rate and renal hypoperfusion. Septicemia often induces prerenal azotemia, and elevated urea/creatinine ratio is considered a marker of early renal stress (Busani *et al.,* 2021).

The absence of significant changes in chloride suggests that chloride regulation is less sensitive to mild renal perfusion defects, though severe sepsis could still cause hyperchloremic acidosis due to excessive saline infusion or bicarbonate loss (Dellinger *et al.,* 2023).

Age-related trends in this study, particularly greater sodium depletion in older children, may reflect prolonged infection duration or maturational differences in renal handling of electrolytes. Similar observations were made by Njokanma *et al.,* 2019, who reported that older pediatric patients exhibited more severe biochemical disturbances, possibly due to delayed clinical presentation.

From a clinical standpoint, these biochemical derangements are critical indicators for early diagnosis and prognosis of sepsis. Electrolyte monitoring aids in assessing hydration status, renal perfusion, and acid-base balance, which are essential for guiding fluid and antimicrobial therapy. Routine biochemical screening in septicemia cases enhances detection of renal dysfunction before overt failure occurs in resource-limited settings like Nigeria.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrated that septicemic patients exhibited significant reductions in serum sodium and bicarbonate concentrations, alongside non-significant elevations in potassium, urea, and creatinine. These findings suggest emerging renal and metabolic derangements associated with systemic infection. The results highlight the diagnostic and prognostic relevance of electrolyte and renal function monitoring in septic patients, particularly children. Routine biochemical monitoring of electrolytes and renal parameters is recommended for prompt intervention and improved prognosis in pediatric septicemia.

FURTHER STUDY

Comparison of changes in electrolytes, urea and creatinine in septicemic adults with paediatrics in further research may improve general clinical outcomes.

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REFERENCES

Adesola, A.A. and Omoregie, R. (2020) 'Epidemiology of septicemia in sub-Saharan Africa: A review', African Journal of Infectious Diseases, 14(3), pp. 140–150.

Alemu, A., Bekele, F. and Demissie, T. (2023) 'Serum urea and creatinine as predictors of sepsis outcome', BMC Nephrology, 24(1), 118.

Alobaidi, R., Basu, R.K., Goldstein, S.L. and Bagshaw, S.M. (2019) 'Sepsis-associated acute kidney injury in critically ill children: Pathophysiology and management', Pediatric Nephrology, 34(3), pp. 405–415.

Basire B., Kibret B., Nifle K., Assefa F. (2025). Derangement of Electrolytes, Urea and Creatinine with Malaria. Journal of Tropical, Travel Medicine and Vccines. Volume 11, Article 29, DOI : 10.1186.

Behera, C., Mishra, S.S., Kar, S.K. and Pattnaik, D. (2022) 'Biochemical and electrolyte alterations in sepsis: A prospective study', Indian Journal of Critical Care Medicine, 26(7), pp. 812–820.

Busani, S., Girardis, M., Salvioli, G. and Antonelli, M. (2021) 'Fluid and electrolyte management in septic patients: A consensus review', Journal of Critical Care, 64, pp. 128–136.

Choudhury, K., Singh, A.K., Banerjee, T. and Ghosh, S. (2020) 'Serum electrolyte imbalance and outcome in sepsis', Journal of Clinical and Diagnostic Research, 14(9), pp. BC01–BC05.

Daisuke Nakano (2020). Septic acute Kidney Injury : a Review of Basic Research.

Clinical and Experimental Nephrology, 24: 1091-1102.

Dellinger, R.P., Levy, M.M., Rhodes, A., Annane, D., Gerlach, H., Opal, S.M., Sevransky, J.E., Sprung, C.L., Douglas, I.S., Jaeschke, R., and others (2023) 'Surviving Sepsis Campaign: International guidelines for management of sepsis and septic shock—2023', Intensive Care Medicine, 49(5), pp. 293–375.

Guyton, A.C. and Hall, J.E. (2021). Acid-base regulation and Diuretics and Kidney disease, In Textbook of Medical Physiology (15th ed.). Philadelphia: Saunders. Chap. 31 and 32.

Hassan, M.U., Yousaf, M.A., Ahmad, M. and Iqbal, M. (2021) 'Hyperkalemia in sepsis: Mechanisms and management', Critical Care Clinics, 37(4), pp. 737–748.

Hotchkiss, R.S., Moldawer, L.L., Opal, S.M., Reinhart, K., Turnbull, I.R. and Vincent, J.L. (2019) 'Sepsis and septic shock', Nature Reviews Disease Primers, 5(1), pp. 1–21.

Jaffe, M. (1886) 'Über den Niederschlag welchen Pikrinsäure in normalen Harn erzeugt und über eine neue Reaction des Kreatinins', Zeitschrift für Physiologische Chemie, 10, pp. 391–400.

Kellum, J.A. and Prowle, J.R. (2018) 'Paradigms of acute kidney injury in sepsis', Nature Reviews Nephrology, 14(4), pp. 217–230.

Kellum, J.A., Ronco, C. and Bellomo, R. (2023) 'Advances in renal pathobiology of sepsis', Nature Reviews Nephrology, 19(1), pp. 27–44.

Kumar, A. and Parrillo, J.E. (2021) 'Pathogenesis and management of septic shock: 2021 update', Critical Care Medicine, 49(5), pp. 713–728.

Leligdowicz, A. and Matthay, M.A. (2019) 'Heterogeneity in sepsis: Biological, clinical, and therapeutic implications', American Journal of Respiratory and Critical Care Medicine, 200(4), pp. 429–440.

Martin G.A, Hassen A.A, Prenika D.J, Priyadeep K, Maunica A. P, Mariam A.H, Nandita A, Pallavi S (2024). Sepsis-Associated acute Kidney Injury: Pathophysiology and Treatment Modalities. Cureus, 16(12): 75992.

Murugan, R. and Kellum, J.A. (2020) 'Acute kidney injury: What's the prognosis?', Nature Reviews Nephrology, 16(10), pp. 593–602.

Nasa, P., Juneja, D. and Singh, O. (2018) 'Severe sepsis and septic shock in the developing world: Epidemiology and management', Journal of Infection and Public Health, 11(6), pp. 791–798.

Njokanma, O.F., Iroha, E. and Adeyemo, A. (2019) 'Renal function in Nigerian children with severe sepsis', Nigerian Journal of Paediatrics, 46(4), pp. 213–218.

Obiagwu P.N., Morrow B., Mcculloch M., and Agent A. (2023). Burden and severity of deranged electrolytes and Kidney function in Children seen in a Tertiary Hospital in Kano, Norther Nigeria. PLOS ONE, 18(3). Eo283220. DOI: 10.1371.

Ogundare, E.O. and Akindele, A.A. (2021) 'Neonatal sepsis in developing countries: Etiology and diagnostic challenges', Frontiers in Pediatrics, 9, 637627.

Omoregie, R., Olatunji, E. and Akhigbe, P.O. (2020) 'Pattern of electrolyte changes in pediatric bacteremia', West African Journal of Medicine, 37(2), pp. 99–106.

Onyedibe, K.I., Agbo, J.A., Okolo, S.N., Oguonu, T., Abah, R.O. and Olayinka, A.T. (2019) 'Pediatric septicemia in Nigeria: Clinical patterns and outcome', Nigerian Journal of Clinical Practice, 22(5), pp. 619–626.

Ostermann, M., Joannidis, M., Prowle, J.R. and Bagshaw, S.M. (2018) 'Clinical manifestations and outcomes of sepsis-induced acute kidney injury', Kidney International Reports, 3(2), pp. 256–268.

Paliwal, V., Kothari, R. and Mehta, R. (2022) 'Acid-base and electrolyte profile in pediatric septic shock', Journal of Laboratory Physicians, 14(1), pp. 26–32.

Poston, J.T. and Koyner, J.L. (2019) 'Sepsis-associated acute kidney injury', BMJ, 364, k4891.

Prowle, J.R. and Bellomo, R. (2020) 'Fluid management for the prevention and attenuation of acute kidney injury', Nature Reviews Nephrology, 16(3), pp. 141–157.

Raghavan, M. and Marik, P.E. (2018) 'Management of sepsis-induced metabolic acidosis', Journal of Intensive Care Medicine, 33(3), pp. 175–185.

Rittirsch, D., Flierl, M.A., Ward, P.A., Huber-Lang, M. and Unertl, K. (2022) 'Pathophysiology of sepsis: New insights and emerging therapies', Critical Care Medicine, 50(4), pp. 596–610.

Shankar, R., Patil, N., Rao, S. and Naidu, K. (2021) 'Serum creatinine and urea as markers of renal involvement in septicemia', International Journal of Clinical Biochemistry Research, 8(2), pp. 156–162.

Sharma, S. and Kumar, A. (2021) 'Hyponatremia in septicemia: Prognostic indicator or incidental finding?', Clinical Nephrology, 96(1), pp. 23–31.

Singer, M., Deutschman, C.S., Seymour, C.W., Shankar-Hari, M., Annane, D., Bauer, M., Bellomo, R., Bernard, G.R., Chiche, J.D., Coopersmith, C.M., Hotchkiss, R.S., and others (2016) 'The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)', Journal of the American Medical Association (JAMA), 315(8), pp. 801–810.

Singh, A., Patel, V. and Saha, S. (2024) 'Pediatric sepsis and renal biomarkers: A review', Pediatric Research, 95(2), pp. 260–272.

Tietz, N.W. (2015) Clinical Guide to Laboratory Tests (4th ed.). Philadelphia: Elsevier.

Uddin, M.J., Rahman, M.A., Ahmed, S. and Haque, M. (2021) 'Association between serum electrolyte imbalance and outcome in sepsis patients: A multicentre cohort study', BMC Emergency Medicine, 21(1), 12.

Vincent, J.L. and Opal, S.M. (2020) 'Pathophysiology of septic shock', New England Journal of Medicine, 382(9), pp. 852–862.

West, R., Morgan, P., Li, Y. and Tran, H. (2023) 'Electrolyte disturbances and clinical outcomes in sepsis: A systematic review', Critical Care Research and Practice, 2023, pp. 1–10.

World Health Organization (WHO) (2020) Global report on sepsis: Prevention, diagnosis, and management. Geneva: World Health Organization.

World Health Organization (WHO) (2023) Sepsis: A global health priority. Geneva: World Health Organization.