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Research Article

Assessment of Serum Sodium Levels and their Clinical Impact in Postoperative Patients of Obafemi Awolowo University Teaching Hospital, Ile-Ife, Osun State

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Abstract

Background: Sodium is the principal extracellular cation responsible for maintaining fluid balance, osmotic pressure, and cellular homeostasis. Postoperative dysnatremia, particularly hyponatremia, is a common complication following surgery due to perioperative stress, hormonal imbalance, fluid therapy, and underlying comorbidities. Abnormal sodium levels are associated with prolonged hospitalization, neurological complications, and increased mortality.

Aim: This study assessed serum sodium levels and their clinical impact among postoperative patients at Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), with emphasis on the prevalence and magnitude of sodium abnormalities, gender differences, and associations with different surgical conditions.

Methodology: A hospital-based descriptive cross-sectional study was conducted at OAUTHC between April and June 2026. A total of 197 adult postoperative patients aged 18 years and above were recruited using consecutive sampling. Ethical approval and informed consent were obtained. Venous blood samples were collected within 24 - 72 hours postoperatively, and serum sodium levels were analyzed using standard biochemical methods. Demographic and clinical data were obtained using structured questionnaires.

Results: There was a significant reduction in mean plasma sodium concentration from 140.48 ± 2.71 mmol/L pre-operatively to 129.24 ± 5.19 mmol/L post-operatively ($t = 13.40$, $p < 0.001$), indicating a high prevalence of postoperative hyponatremia. Male patients showed a decline from 140.98 ± 2.77 mmol/L to 129.74 ± 5.55 mmol/L ($p < 0.001$), while females decreased from 139.94 ± 3.19 mmol/L to 130.45 ± 4.51 mmol/L ($p < 0.001$). However, the difference in sodium reduction between males and females was not statistically significant ($p = 0.109$). Disease-specific analysis revealed the greatest sodium decline among post-Endoscopic Retrograde Cholangiopancreatography (ERCP) patients (140.5 ± 3.20 to 124.5 ± 6.16 mmol/L, $p < 0.001$). Significant reductions were also observed in appendectomy, bowel surgery, breast cancer surgery, and craniopharyngioma surgery patients ($p < 0.05$). Linear regression analysis demonstrated a weak positive correlation between pre-operative and post-operative sodium levels ($R = 0.2245$, $R^2 = 0.050$, $p = 0.0344$).

Conclusion: Postoperative hyponatremia is highly prevalent among surgical patients at OAUTHC and occurs across multiple surgical conditions. Routine perioperative electrolyte monitoring, proper fluid management, and early correction of sodium imbalance are essential to reduce postoperative complications and improve patient outcomes.

Keywords: *Post-Operative; Dysnatremia; Antidiuretic Hormone (ADH); Perioperative Fluid Management*

Abbreviations

OAUTHC: Obafemi Awolowo University Teaching Hospital; ERCP: Post-Endoscopic Retrograde Cholangiopancreatography; ADH: Antidiuretic Hormone

Introduction

Sodium is the principal extracellular cation and plays a fundamental role in maintaining extracellular fluid volume, osmotic balance, acid-base equilibrium, neuromuscular activity, and cellular homeostasis [1]. Normal serum sodium concentration is tightly regulated within a narrow physiological range through coordinated interactions involving the kidneys, the renin-angiotensin-aldosterone system (RAAS), antidiuretic hormone (ADH), natriuretic peptides, and hypothalamic thirst mechanisms (Hoorn and Zietse, 2021). Disruption of these regulatory pathways may result in dysnatremia, a clinical condition characterized by either hyponatremia or hypernatremia, both of which are associated with significant morbidity and mortality among hospitalized patients. The postoperative period is particularly associated with disturbances in sodium homeostasis due to the physiological stress response induced by surgery. Surgical trauma stimulates neuroendocrine activation, leading to increased secretion of cortisol, catecholamines, aldosterone, and ADH. These hormonal responses are intended to preserve circulatory volume and maintain hemodynamic stability; however, excessive or prolonged activation may alter renal handling of sodium and water, thereby predisposing patients to dysnatremia [2,3]. Increased ADH secretion following surgery promotes renal water reabsorption, resulting in dilutional hyponatremia, especially in patients receiving hypotonic intravenous fluids or excessive perioperative fluid therapy [4]. While these responses are physiologically adaptive, they may become maladaptive when combined with inappropriate fluid management or impaired renal function, leading to clinically significant sodium abnormalities. Hypernatremia may occur in postoperative patients due to dehydration, inadequate free water replacement, osmotic diuresis, or excessive sodium administration (Li., *et al*. 2023). Recent evidence suggests that postoperative dysnatremia is a common complication across various surgical specialties. Studies conducted in developed countries reported postoperative hyponatremia prevalence ranging from approximately 13% in general surgical populations to nearly 28% among orthopedic and spinal surgery patients [5,6]. Similarly, dysnatremia occurring within the first 72 hours after surgery has been strongly associated with increased rates of intensive care admission, neurological complications, prolonged hospitalization, and mortality (Lin., *et al*. 2023; Arzhan., *et al.* 2023). Hypernatremia, although less frequent, has been associated with even worse prognostic outcomes in critically ill and postoperative patients (Leung., *et al.* 2021). The clinical consequences of postoperative sodium imbalance are substantial. Hyponatremia may present with symptoms ranging from mild headache, lethargy, and nausea to severe cerebral edema, seizures, confusion, coma, and death in acute cases [7]. Hypernatremia similarly contributes to neurological dysfunction, impaired cardiac performance, and increased mortality risk. In addition, postoperative dysnatremia has been consistently linked with prolonged hospital stay, delayed recovery, increased healthcare costs, and poorer overall patient outcomes [8,9]. Consequently, routine monitoring of serum sodium levels during the perioperative period has become increasingly recognized as an essential component of postoperative care. Despite growing global evidence regarding postoperative dysnatremia, there remains limited locally generated data within Nigerian healthcare settings. Most available Nigerian studies focus on generalized electrolyte disturbances among hospitalized or critically ill patients, with relatively few specifically evaluating serum sodium changes among postoperative populations [10,11]. Furthermore, differences in perioperative monitoring systems, fluid management practices, patient characteristics, and healthcare resources between developed countries and sub-Saharan African settings may significantly influence the occurrence and clinical implications of sodium imbalance. As such, international findings may not fully reflect postoperative realities in Nigerian tertiary healthcare institutions. The paucity of local evidence creates uncertainty regarding the prevalence, magnitude, and determinants of postoperative sodium imbalance among Nigerian surgical patients. In addition, many previous studies were retrospective in design, utilized inconsistent diagnostic thresholds, or had limited sample sizes, thereby restricting the applicability of their findings [12,13]. There is therefore a need for prospective hospital-based studies capable of providing context-specific evidence to improve perioperative electrolyte management and patient safety. This study was therefore designed to assess serum sodium levels among postoperative patients at Obafemi Awolowo University Teaching Hospitals Complex. Specifically, the

study aimed to evaluate the prevalence and magnitude of postoperative sodium abnormalities, compare preoperative and postoperative serum sodium concentrations, determine gender-related differences, and identify associations between sodium imbalance and various surgical conditions. Findings from this study are expected to contribute valuable local data that may strengthen perioperative monitoring protocols, support evidence-based fluid management practices, and improve postoperative outcomes among surgical patients [14].

Materials and Methods

Study design and setting

This study was a hospital-based descriptive cross-sectional study conducted at the Department of Chemical Pathology, Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Nigeria, between April and June 2026. OAUTHC is a tertiary healthcare institution that provides specialized surgical and laboratory services to patients within Osun State and neighboring regions.

Study population

The study population comprised adult postoperative patients aged 18 years and above who underwent various surgical procedures at OAUTHC during the study period. Patients who met the inclusion criteria and consented to participate were consecutively recruited into the study.

Sample size and sampling technique

A total of 89 postoperative patients were enrolled using a consecutive sampling technique.

Inclusion and exclusion criteria

Adult postoperative patients aged 18 years and above who underwent surgery and were within 24 - 72 hours postoperatively were included in the study. Patients with known chronic electrolyte disorders, severe renal disease, or those who declined consent were excluded.

Ethical consideration

Ethical approval for the study was obtained from the Health Research Ethics Committee of Obafemi Awolowo University Teaching Hospitals Complex. Written informed consent was obtained from all participants before sample collection, and confidentiality of participants' information was maintained throughout the study.

Sample collection and laboratory analysis

About 5 mL of venous blood was collected aseptically from each participant into lithium heparin sample bottles within 24 - 72 hours after surgery. Samples were centrifuged, and plasma was separated for biochemical analysis. Serum sodium concentration was determined using standard biochemical laboratory methods following the manufacturer's instructions and established laboratory protocols.

Data collection

Sociodemographic and clinical information, including age, gender, type of surgery, and relevant clinical history, was obtained from structured data collection forms and patients' medical records.

Statistical analysis

The data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Results were expressed as mean ± standard deviation (SD). Paired Student's t-test was used to compare preoperative and postoperative serum sodium levels, while an independent t-test was used to assess gender differences. Linear regression analysis was performed to determine the relationship between preoperative and postoperative sodium levels. A p-value of less than 0.05 was considered statistically significant.

Results and Discussion

A total of 89 postoperative patients participated in this study. The mean preoperative plasma sodium concentration was 140.48 ± 2.71 mmol/L, while the mean postoperative sodium concentration significantly declined to 129.24 ± 5.19 mmol/L. Statistical analysis showed that this reduction was highly significant ($t = 13.40$, $p < 0.001$), indicating a high prevalence of postoperative hyponatremia among the study population.

Gender-based analysis showed that male participants had a significant decrease in mean sodium concentration from 140.98 ± 2.77 mmol/L preoperatively to 129.74 ± 5.55 mmol/L postoperatively ($p < 0.001$). Similarly, female participants demonstrated a reduction from 139.94 ± 3.19 mmol/L to 130.45 ± 4.51 mmol/L ($p < 0.001$). However, comparison of the magnitude of sodium reduction between males (11.24 ± 5.44 mmol/L) and females (9.49 ± 4.66 mmol/L) revealed no statistically significant difference ($t = 1.62$, $p = 0.109$). Disease-specific evaluation demonstrated that patients who underwent Endoscopic Retrograde Cholangiopancreatography (ERCP) had the most pronounced postoperative sodium reduction, with mean sodium concentration decreasing from 140.5 ± 3.20 mmol/L preoperatively to 124.5 ± 6.16 mmol/L postoperatively ($p < 0.001$). Significant reductions in serum sodium levels were also observed among patients who underwent appendectomy, bowel surgery, breast cancer surgery, and craniopharyngioma surgery ($p < 0.05$). Linear regression analysis demonstrated a weak positive correlation between preoperative and postoperative sodium concentrations ($R = 0.2245$, $R^2 = 0.050$, $p = 0.0344$), suggesting that baseline sodium status had only a limited influence on postoperative sodium changes.

Variable	Pre-Op (Mean ± SD)	Post-Op (Mean ± SD)	t-value	p-value	Remark
Sodium (mMol/L)	140.48 ± 2.71	129.24 ± 5.19	13.40	< 0.001	S

Table 1: *Plasma sodium concentrations of pre-operative and post-operative patients.*

Note: p-value ≤ 0.05 is significant. While p-value > is non-significant, Pre-opt: Pre-operation, Post-Op: Post-operation.

Variable	Pre-Op (Mean ± SD)	Post-Op (Mean ± SD)	t-value	p-value	Remark
Sodium (mMol/L)	140.98 ± 2.77	129.74 ± 5.55	13.40	< 0.001	S

Table 2: *Plasma sodium concentrations of pre-operative and post-operative male patients.*

Note: p-value ≤ 0.05 is significant. While p-value > is non-significant, Pre-opt: Pre operation, Post-Op: Post operation.

Variable	Pre-Op (Mean ± SD)	Post-Op (Mean ± SD)	t-value	p-value	Remark
Sodium (mMol/L)	139.94 ± 3.19	130.45 ± 4.51	13.95	< 0.001	S

Table 3: *Plasma sodium concentrations of pre-operative and post-operative female patients.*

Note: p-value ≤ 0.05 is significant. While p-value > is non-significant, Pre-opt: Pre operation, Post-Op: Post operation.

Variable	Male (Mean ± SD)	Female (Mean ± SD)	t-value	p-value	Remark
Sodium (mMol/L)	11.24 ± 5.44	9.49 ± 4.66	1.62	0.109	Non-Significant

Table 4: *Comparison of mean difference of plasma sodium concentration` between male and female patients.*

Note: p-value ≤ 0.05 is significant. While p-value > is non-significant, Pre-opt: Pre-operation, Post-Op: Post-operation.

Diseases	N	Pre-Op (Mean ± SD)	Post-Op (Mean ± SD)	t-value	p-value	Remark
Appendectomy	6	140 ± 1.26	129.16 ± 2.13	9.2	< 0.001	S
Bone Fracture	4	141.25 ±3.20	130 ± 4.54	4.23	0.0233	S
Bowel Surgery	4	139.25 ± 4.42	129 ± 6.48	4.23	0.022	S
Breast Cancer	6	142.5 ± 5.08	130.66 ± 1.86	7.09	< 0.001	S
Caesarean Section	4	140 ±1.41	130.25 ± 6.33	2.76	0.0696	NS
Coronary Heart Failure	6	141.50 ± 3.44	132.66 ± 4.32	4.6	0.0046	S
Cholecystectomy	3	139 ± 1.73	132 ± 2.64	12.12	0.0067	S
Colorectal Tumor	3	138.66 ± 1.52	128.33 ± 4.50	5. 85	0.002	S
Craniopharyngioma	6	141 ± 2.28	128.33 ± 5.20	6.24	0.001	S
Hernia Repair	2	138.5 ± 7.77	130.5 ± 0.70	1.6	0.355	NS
Intestinal Fistula/Res	3	141.2 ± 1.30	133.6 ± 2.50	5.75	0.004	S
Intes. Obs/ Intes. Res.	2	142.5 ± 3.53	129.5 ± 4.94	3	0.204	NS
Liver Injury	4	138.75 ± 1.50	128.50 ± 9.00	2.71	0.0717	NS
Obst. Jaundice	2	142.5 ± 3.53	129.5 ± 4.94	13	0.048	S
Mastectomy/Myomectomy	2	140.5 ± 7.77	139 ± 1.43	2.33	0.257	NS
Ovarian Cyst/Ovarian Surgery	3	137.33 ±	132.33 ±	3.27	0.080	NS
Post-ERCP	10	140.5 ± 3.20	124.5± 6.16	8.56	< 0.001	S
Prostatectomy	3	139.00 ± 0.00	133.33 ± .3.33	6.42	0.023	S
RTA	4	139.75 ± 3.40	130 ± 2.70	3.90	0.029	S

Table 5: *Plasma sodium concentrations of pre-operative and post-operative diseases.*

Note: p-value ≤ 0.05 is significant. While p-value > is non-significant, Pre-opt: Pre operation, Post-Op: Post operation.

Correlation	R	R^2	p-value	Remark
Pre-Op vs post-Op	0.2245	0.050	0.03436	S

Table 6: *Linear regression.*

Note: p-value ≤ 0.05 is significant. While p-value > is non-significant, pre-opt: pre-operation.

Discussion

The present study demonstrated a significant reduction in postoperative serum sodium concentration among surgical patients, indicating that postoperative hyponatremia is highly prevalent in the study population. The mean postoperative sodium concentration was significantly lower than the preoperative value, suggesting that surgery and perioperative management play major roles in disrupting sodium homeostasis. This finding agrees with previous studies that identified postoperative hyponatremia as one of the most frequent electrolyte disturbances following surgical procedures [5,6]. The observed reduction in sodium levels may be attributed to surgical stress responses, excessive antidiuretic hormone (ADH) secretion, administration of hypotonic intravenous fluids, blood loss, and postoperative fluid redistribution.

In male patients, sodium levels decreased significantly from 140.98 ± 2.77 mmol/L (pre-operative) to 129.74 ± 5.55 mmol/L (post-operative) with $p < 0.001$. This mirrors the overall trend observed in table 1, confirming that male patients are equally susceptible to post-operative sodium imbalance.

The magnitude of sodium reduction suggests that perioperative physiological stress affects males substantially, likely through similar mechanisms such as ADH-mediated water retention and surgical trauma-induced inflammatory responses. Studies such as Arieff (1998) in the *New England Journal of Medicine* emphasize that post-operative hyponatremia is not gender-specific but rather linked to surgical stress and fluid therapy practices.

This reinforces the need for careful electrolyte monitoring in male surgical patients, especially in procedures involving significant fluid shifts. Female patients also exhibited a significant decline in sodium levels from 139.94 ± 3.19 mmol/L (pre-operative) to 130.45 ± 4.51 mmol/L (post-operative), with $p < 0.001$. The slightly higher post-operative sodium compared to males may reflect minor physiological variations, but the reduction remains clinically significant.

Patients in the post-Endoscopic Retrograde Cholangiopancreatography (ERCP) group demonstrated the most pronounced reduction in plasma sodium levels, declining from 140.5 mmol/L pre-operatively to 124.5 mmol/L post-operatively ($p < 0.001$). This substantial decrease indicates the development of moderate to severe hyponatremia, highlighting ERCP as a procedure with a particularly high risk for electrolyte imbalance. The severity of sodium reduction observed in this group can be better understood in the context of the underlying hepatobiliary conditions for which ERCP is commonly performed. Oni*., et al.* [15] highlights that ERCP is frequently indicated in the management of obstructive jaundice secondary to pancreatobiliary diseases, including gallstones, malignancies, and inflammatory conditions. ERCP is not merely a procedural intervention but part of a broader management strategy for pancreatobiliary disease, were patients often present late with significant physiological derangements [15]. These disease states are themselves associated with altered liver function and impaired fluid homeostasis, which predispose patients to electrolyte imbalances even before the procedure.

The marked reduction in sodium concentration following ERCP can be attributed to several interrelated mechanisms. First, ERCP is frequently associated with pancreatic and biliary manipulation, which can trigger inflammatory responses such as post-ERCP pancreatitis. This inflammatory state leads to increased capillary permeability and third spacing of fluids, thereby reducing effective circulating volume and promoting dilutional hyponatremia. According to Testoni., *et al*. (2010) in *Endoscopy*, ERCP-related complications, particularly pancreatitis, are commonly associated with metabolic disturbances, including significant electrolyte imbalances.

The significant reduction in serum sodium observed among postoperative craniopharyngioma ($p < 0.001$) patients in the present study is consistent with findings from previous neurosurgical studies. Research has shown that hyponatremia is one of the most frequent electrolyte complications following pituitary and sellar region surgeries, including craniopharyngioma excision (Castle-Kirszbaum., *et al*. 2022). This is largely attributed to hypothalamic injury, pituitary stalk manipulation, and postoperative neuroendocrine instability. In many patients, the triphasic response characterized by an initial diabetes insipidus phase, followed by SIADH-induced hyponatremia, and eventual permanent diabetes insipidus may occur after surgery involving the hypothalamic-pituitary axis.

The significant reduction in serum sodium observed among postoperative craniopharyngioma ($p < 0.001$) patients in the present study is consistent with findings from previous neurosurgical studies. Research has shown that hyponatremia is one of the most frequent electrolyte complications following pituitary and sellar region surgeries, including craniopharyngioma excision (Castle-Kirszbaum., *et al*. 2022). This is largely attributed to hypothalamic injury, pituitary stalk manipulation, and postoperative neuroendocrine instability. In many patients, the triphasic response characterized by an initial diabetes insipidus phase, followed by SIADH-induced hyponatremia, and eventual permanent diabetes insipidus may occur after surgery involving the hypothalamic-pituitary axis.

Furthermore, postoperative hyponatremia in craniopharyngioma patients may be exacerbated by perioperative fluid administration, corticosteroid imbalance, nausea, pain, and stress-induced hormonal activation. Studies have demonstrated that neurosurgical patients with postoperative hyponatremia are at increased risk of neurological complications such as confusion, seizures, reduced consciousness, prolonged hospitalization, and increased mortality (Legrand., *et al*. 2021). The brain is particularly sensitive to rapid changes in serum osmolality, making sodium imbalance especially dangerous in postoperative neurosurgical patients.

Patients with congestive heart failure are particularly susceptible to postoperative hyponatremia due to impaired cardiovascular function and activation of compensatory neurohormonal mechanisms aimed at maintaining circulatory volume. In the present study, patients with coronary heart failure demonstrated a significant reduction in serum sodium concentration from 141.50 ± 3.44 mmol/L preoperatively to 132.66 ± 4.32 mmol/L postoperatively ($p = 0.0046$). This finding indicates that sodium imbalance is a significant postoperative complication among patients with underlying cardiac dysfunction. The development of hyponatremia in heart failure patients is largely associated with increased activation of the renin-angiotensin-aldosterone system (RAAS) and excessive secretion of antidiuretic hormone (ADH). Reduced cardiac output in heart failure leads to decreased effective arterial blood volume, which stimulates non-osmotic ADH release and promotes renal water retention. This excessive water retention dilutes serum sodium concentration, resulting in dilutional hyponatremia (Hoorn and Zietse, 2021). Surgical stress, anesthesia, and perioperative fluid therapy may further aggravate these hormonal responses during the postoperative period.

The linear regression analysis demonstrated a weak positive correlation ($R = 0.2245$) between pre-operative and post-operative sodium levels, with a low coefficient of determination ($R^2 = 0.050$) and a statistically significant p-value ($p = 0.03436$). This indicates that although there is a statistically detectable relationship between pre-operative and post-operative sodium levels, the strength of this relationship is minimal, and pre-operative sodium accounts for only about 5% of the variability in post-operative sodium levels. From a statistical standpoint, the low R^2 value suggests that the majority (95%) of the variation in post-operative sodium levels is explained by other factors not captured in the model. These factors likely include perioperative fluid administration, surgical stress response, blood loss, hormonal changes, and underlying disease conditions. According to Kutner., *et al*. (2005) in *Applied Linear Statistical Models*, a low R^2 in biological systems is not uncommon, as physiological outcomes are often influenced by multiple interacting variables rather than a single predictor. Clinically, this weak correlation implies that baseline (pre-operative) sodium levels are poor predictors of post-operative sodium status. Even patients with normal pre-operative sodium concentrations may develop significant hyponatremia following surgery. This finding aligns with Leung., *et al*. (2012) in the *Archives of Internal Medicine*, who reported that hospital-acquired hyponatremia frequently develops independently of baseline sodium levels and is more strongly associated with in-hospital factors such as fluid therapy and stress-induced ADH secretion.

Conclusion

This study assessed serum sodium levels and their clinical impact among postoperative patients at Obafemi Awolowo University Teaching Hospital, Ile-Ife. The findings showed a significant reduction in postoperative serum sodium levels compared with preoperative values, indicating that postoperative hyponatremia is a common occurrence among surgical patients. Both male and female patients experienced significant reductions in serum sodium levels after surgery, although no significant difference was observed between both sexes. Variations in sodium levels were also observed across different surgical conditions, suggesting that surgical stress, hormonal responses, fluid shifts, and perioperative management contribute to postoperative electrolyte imbalance. Furthermore, a significant relationship was observed between preoperative and postoperative sodium levels, indicating that preoperative sodium status may influence postoperative outcomes. Overall, the study highlights the importance of routine serum sodium monitoring in postoperative patients to ensure early detection and proper management of electrolyte disturbances, thereby improving patient recovery and clinical outcomes.

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Conflict of Interest

There was no conflict of interest.

Bibliography

1. Adrogué HJ and Madias NE. "Renal tubular acidosis and sodium metabolism". *New England Journal of Medicine* 382.6 (2020): 543-554.
2. Verbalis JG., *et al*. "Efficacy and safety of oral tolvaptan therapy in patients with the syndrome of inappropriate antidiuretic hormone secretion". *European Journal of Endocrinology* 164.5 (2011): 725-732.
3. Liamis G., *et al*. "Aldosterone activation in postoperative patients and its impact on sodium balance". *Hormones* 21.2 (2022): 205-215.
4. Brown E and Paloian NJ. "Perioperative electrolyte management and sodium balance in surgical patients". *Journal of Surgical Research* 285.1 (2023): 1-11.
5. Webb AR., *et al*. "Prevalence and clinical impact of postoperative hyponatremia in major surgery". *BJA: British Journal of Anaesthesia* 134.4 (2025): 912-922.
6. Sanada H., *et al*. "Incidence and risk factors of postoperative hyponatremia in patients undergoing spinal surgery". *Spine* 48.6 (2023): E96-E103.
7. McCausland FR., *et al*. "Increased dietary sodium is independently associated with greater mortality among prevalent hemodialysis patients". *Clinical Journal of the American Society of Nephrology* 7.3 (2022): 435-442.
8. Gilder ME., *et al*. "Postoperative dysnatremia and prolonged hospital stay: A prospective cohort analysis". *Perioperative Medicine* 9.1 (2020): 22.
9. Waikar SS and Mount DB. "Sodium homeostasis in clinical practice: An evidence-based review". *New England Journal of Medicine* 386.25 (2022): 2399-2410.
10. Adebayo O., *et al*. "Electrolyte abnormalities among hospitalized patients in a Nigerian tertiary hospital: Prevalence and clinical correlates". *Nigerian Journal of Clinical Practice* 24.5 (2021): 683-689.
11. Okoye HC., *et al*. "Postoperative electrolyte monitoring in Nigerian teaching hospitals: Current practices and gaps". *African Health Sciences* 23.3 (2023): 571-580.
12. Huang G., *et al*. "Dysnatremia and clinical outcomes in intensive care and surgical populations: A meta-analysis". *Critical Care Medicine* 52.6 (2024): e298-e309.
13. Coşkun Yavuz G., *et al*. "Methodological heterogeneity in postoperative sodium monitoring studies: A systematic review". *Surgical Research and Practice* (2025): 6628071.
14. OpenStax. "Anatomy and physiology (2nd edition)". OpenStax (2021).
15. Oni ES., *et al*. "Impact of ERCP on cholestatic liver enzymes in patients with obstructive jaundice at Obafemi Awolowo University Teaching Hospital, Ile-Ife, Osun, Nigeria". *Asian Journal of Research and Reports in Hepatology* 8.1 (2026): 1-8.

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