ORIGINAL ARTICLE

SERUM SODIUM IN ACUTE STROKE AND ITS CLINICAL CORRELATION

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ABSTRACT

Introduction: *Hyponatremia is a frequent electrolyte disturbance in acute stroke, associated with poor clinical outcomes. This study examines the correlation between serum sodium levels and clinical outcomes in acute stroke patients.*

Materials and methods: *A cross-sectional study of 100 adult stroke patients confirmed by CT/MRI was conducted at a tertiary care hospital. Demographic and clinical data were collected, with stroke severity assessed using the Glasgow Coma Scale (GCS) and Modified Rankin Scale (mRS). Statistical analysis evaluated the association between serum sodium levels and stroke parameters.*

Results: *The cohort included 63% males and 37% females, with a mean age of 64 years. Ischemic strokes (58%) were more common than hemorrhagic strokes (41%), and 1% had mixed findings. Right-sided strokes (55%) slightly exceeded left-sided strokes (45%). Dysnatremia was present in 31%, comprising 28% hyponatremia and 3% hypernatremia. Hyponatremia was significantly associated with hypertension (p = 0.010), lower GCS scores (p < 0.001), and worse mRS outcomes (p = 0.005). No significant correlations were found between sodium levels and stroke type (p = 0.241), laterality (p = 0.244), or diabetes (p = 0.246). Middle circulation strokes were the most prevalent (90%), with no sodium-related differences by territory.*

Conclusion: *Hyponatremia correlates with increased stroke severity and poorer functional outcomes, emphasizing its prognostic value. Its association with hypertension highlights the importance of monitoring sodium levels in hypertensive stroke patients. These findings highlight serum sodium's role in acute stroke management to potentially improve clinical outcomes.*

Keywords: *Acute Stroke, Electrolyte imbalance, Hyponatremia, Modified Rankin Scale (mRS)*

INTRODUCTION

Stroke is a leading global health issue, ranking as the second most common cause of death worldwide, with an estimated annual mortality of 5.5 million. Beyond its high mortality, stroke imposes a significant burden of morbidity, leaving up to 50% of survivors chronically disabled, thereby creating profound economic and social challenges for public health systems worldwide.[1] Recognizing its widespread impact, stroke is regarded as a critical health condition requiring focused attention and intervention.

The World Health Organization (WHO) defines stroke as "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer, or leading to death, with no apparent cause other than of vascular origin"[2] Strokes are broadly categorized into ischemic and hemorrhagic types. Ischemic strokes result from an interruption of the cerebral blood supply, leading to the sudden loss of neurological function, while hemorrhagic strokes are caused by the rupture of a blood vessel or an abnormal vascular structure, resulting in intracerebral bleeding.[3] The global burden of stroke is particularly evident in low- and middle-income countries (LMICs), where its incidence and associated mortality are steadily rising.[4]

Among the many complications of acute stroke, electrolyte imbalances are frequent and can significantly influence disease progression and outcomes. Hyponatremia, the most common electrolyte disturbance, occurs frequently alongside other abnormalities such as hypokalemia, hypocalcemia, and hypomagnesemia in stroke patients.[5] Hyponatremia, defined as a plasma sodium concentration of less than 135 mEq/L, can lead to profound neurological dysfunction. When plasma sodium levels fall rapidly (over 1 to 3 days), cerebral edema may develop due to osmotic swelling of brain cells, causing a cascade of neurological symptoms. Early manifestations include nausea and malaise, typically observed when sodium levels drop below 125-130 mEq/L, while severe symptoms such as seizures, coma, and respiratory arrest may occur when levels fall below 115-120 mEq/L. In the context of stroke, hyponatremia is a critical contributor to altered sensorium and poor neurological outcomes. It may present with seizures or exacerbate consciousness disturbances, further complicating the clinical picture. Several factors predispose stroke patients to hyponatremia, including dietary sodium restriction for hypertension control, diuretic use, and complications like aspiration pneumonia.

Given the critical role of serum sodium in neurological function, this study aims to investigate the correlation between serum sodium levels and clinical outcomes in patients diagnosed with acute stroke in a tertiary care center. Specifically, we attempted to assess how serum sodium levels at the time of admission relate to stroke severity, as measured by GCS scores, and functional outcomes, assessed by mRS scores at discharge. By understanding these relationships, we aimed to provide insights that could enhance clinical management and improve prognostic assessments for acute stroke patients. This study's findings could add to the growing body of literature on the significance of electrolyte management in stroke care.

MATERIALS AND METHODS

This study is a cross-sectional observational design conducted at National Academy of Medical Sciences- Bir Hospital, aimed at investigating the correlation between serum sodium levels and clinical outcomes in patients diagnosed with acute stroke. The study was carried out over a period of one year. The study included 100 adult patients (≥18 years) with acute ischemic or hemorrhagic stroke confirmed by neuroimaging (CT/MRI) and presenting within 24 hours of symptom onset.

Inclusion Criteria:

- Adults (≥18 years).
- Acute stroke confirmed by neuroimaging.
- Onset within 24 hours.
- Informed consent.

Exclusion Criteria:

- Head injury, acute renal failure, heart failure, or chronic liver disease.
- Pregnancy or significant non-sodium electrolyte imbalances.
- Recent diuretic use (within 48 hours), infections, sepsis, or severe psychiatric disorders

Data analysis was conducted using SPSS version 20.0. Descriptive statistics (mean, standard deviation, frequencies) were calculated. Chi-Square and Fisher's Exact Tests assessed associations between serum sodium levels and clinical outcomes (GCS, mRS). A p-value < 0.05 indicated statistical significance.Ethical approval was obtained from the institutional review board, NAMS. Informed consent was acquired from all participants prior to their enrollment in the study.

RESULTS

100 adult patients diagnosed with acute stroke, confirmed through neuroimaging techniques such as computed tomography (CT) or magnetic resonance imaging (MRI) were studied. In the study, 63% were males, and 37% were females, indicating a higher prevalence of stroke among males.The age of the patients ranged from 20-99 years, with the mean age of the patients being 64 years.

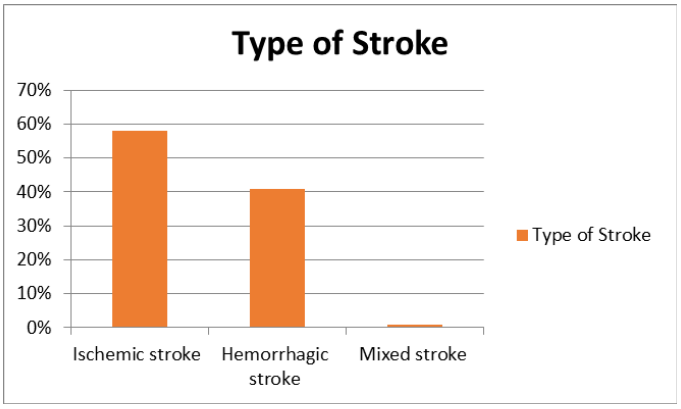

Figure 1: Bar graph showing the types of stroke in the study

The study showed prevalence of ischemic stroke at 58%, Hemorrhagic stroke at 41% and Mixed stroke at 1%. Among the 100 patients enrolled in the study, right sided stroke was found to be more common than left sided stroke.

Among the 100 patients included in our study, 31% patient had dysnatremia, hyponatremia being major (28%) and hypernatremia in only 3 percent of patient as shown in figure 2.

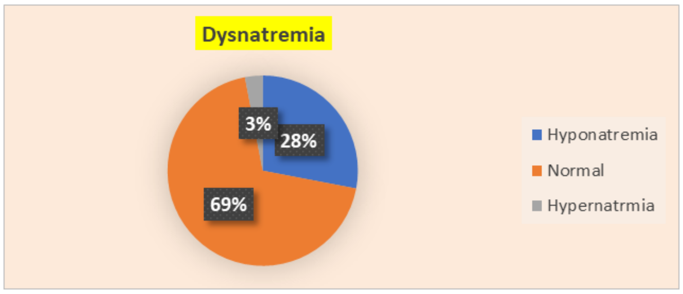

Figure 2: Prevalence of Dysnatremia in Patients with Stroke

Table 1 shows that 90% of patients had middle circulation strokes (65% eunatremic, 25% hyponatremia), while posterior circulation (5%) and anterior/mixed strokes (5%) were less common. The association between stroke type and sodium levels was not statistically significant (p = 0.241).

Table 1: Stroke Diagnosis and Serum Sodium Levels

Stroke Type	Euna-tremic (%)	Hypona-tremic (%)	Total (%)	p-value
Anterior Circulation	2 (2%)	0 (0%)	2 (2%)	0.241
Middle Circu-lation	65 (65%)	25 (25%)	90 (90%)	
Posterior Circulation	2 (2%)	3 (3%)	5 (5%)	
Mixed Stroke	3 (3%)	0 (0%)	3 (3%)	
Total	**72 (72%)**	**28 (28%)**	**100**	

Table 2 shows that 55% of patients had right-sided strokes (37% eunatremic, 18% Hyponatremia), while 45% had left-sided strokes (35% eunatremic, 10% Hyponatremia). No significant association was found between stroke laterality and sodium levels (p = 0.244).

Table 2: Side of Stroke and Serum Sodium Levels

Side of Stroke	Eunatremic (%)	Hyponatremic (%)	Total (%)	p-value
Right-sided	37 (37%)	18 (18%)	55 (55%)	0.244
Left-sided	35 (35%)	10 (10%)	45 (45%)	
Total	72 (72%)	28 (28%)	100	

Table 3 shows that 96% of patients had no history of stroke (71% eunatremic, 25% Hyponatremia), while 4% had a history of stroke (1% eunatremic, 3% Hyponatremia). The association between stroke history and sodium levels showed a trend but was not statistically significant (p = 0.065).

Table 3: Past History of Stroke and Serum Sodium Levels

Past History of Stroke	Eunatremic (%)	Hypona-tremic (%)	Total (%)	p-value
No	71 (71%)	25 (25%)	96 (96%)	0.065
Yes	1 (1%)	3 (3%)	4 (4%)	
Total	72 (72%)	28 (28%)	100	

Table 4 shows that 66% of patients had hypertension (42% eunatremic, 24% hyponatremic), while 34% had no hypertension (30% eunatremic, 4% hyponatremic). A statistically significant association (p = 0.010) indicates that hypertension is linked to higher rates of hyponatremia.

Table 4: Hypertension by Serum Sodium Levels

Hypertension Status	Eunatremic (%)	Hypona-tremic (%)	Total (%)	p-value
No	30 (30%)	4 (4%)	34 (34%)	0.010
Yes	42 (42%)	24 (24%)	66 (66%)	
Total	72 (72%)	28 (28%)	100	

The results in Table 5 show that among the 100 patients, 79% did not have diabetes, with 59% being eunatremic and 20% hyponatremic, while 21% had diabetes, with 13% eunatremic and 8% hyponatremic. Overall, 72% of the patients were eunatremic, and 28% were hyponatremic. The p-value (0.246) indicates no statistically significant association between diabetes status and serum sodium levels, suggesting that sodium levels were not meaningfully correlated with diabetes in this study population.

Table 5: Diabetes and Serum Sodium Levels

Diabetes Status	Eunatremic (%)	Hyponatremic (%)	Total (%)	p-value
No	59 (59%)	20 (20%)	79 (79%)	0.246
Yes	13 (13%)	8 (8%)	21 (21%)	
Total	72 (72%)	28 (28%)	100	

Table 6 shows that 41% of patients had hemorrhagic strokes (37% eunatremic, 18% hyponatremic), 58% had ischemic strokes (37% eunatremic, 18% hyponatremic), and 1% had mixed findings (hyponatremic). Overall, 72% were eunatremic, and 28% hyponatremic. The association between stroke type and sodium levels was not statistically significant (p = 0.121).

Table 6: CT/MRI Findings and Serum Sodium Levels

CT/MRI Findings	Eunatremic (%)	Hyponatremic (%)	Total (%)	p-value
Hemorrhagic	37 (37%)	18 (18%)	41 (41%)	0.121
Ischemic	37 (37%)	18 (18%)	58 (58%)	
Mixed	0 (0%)	1 (1%)	1 (1%)	
Total	72 (72%)	28 (28%)	100	

Table 7 shows the distribution of serum sodium levels by Glasgow Coma Scale (GCS) categories among 100 patients. Severe cases (GCS ≤ 8) included 1% hyponatremic patients, with no eunatremic cases. Moderate cases (GCS 9–12) comprised 6% eunatremic and 11% hyponatremic patients. Most patients (82%) were in the mild category (GCS 13–15), with 66% eunatremic and 16% hyponatremic. A statistically significant association (p < 0.001) highlights that lower GCS scores are correlated with higher hyponatremia rates.

Table 7: GCS Category and Serum Sodium Levels

GCS Category	Euna-tremic (%)	Hypona-tremic (%)	Total (%)	p-value
Severe (GCS ≤ 8)	0 (0%)	1 (1%)	1 (1%)	<0.001
Moderate (GCS 9-12)	6 (6%)	11 (11%)	17 (17%)	
Mild (GCS 13-15)	66 (66%)	16 (16%)	82 (82%)	
Total	**72 (72%)**	**28 (28%)**	**100**	

Table 8 shows the relationship between Modified Rankin Scale (mRS) scores and serum sodium levels among 100 patients. Moderately severe (mRS = 4) and severe disability (mRS = 5) were most common, comprising 43% (34% eunatremic, 9% hyponatremic) and 33% (20% eunatremic, 13% hyponatremic), respectively. Deaths (mRS = 6) occurred in 6% of cases, with hyponatremia (5%) significantly more frequent than eunatremia (1%). The association between mRS scores and serum sodium levels was statistically significant (p = 0.005), showing hyponatremia as a potential marker of stroke severity and poor recovery.

Table 8: mRS Scale and Serum Sodium Levels

mRS Score	Euna-tremic (%)	Hypona-tremic (%)	Total (%)	p-value
No symptoms	0 (0%)	0 (0%)	0 (0%)	0.005
No significant disability	1 (1%)	0 (0%)	1 (1%)	
Slight disability	5 (5%)	0 (0%)	5 (5%)	
Moderate disability	11 (11%)	1 (1%)	12 (12%)	
Moderately severe disability	34 (34%)	9 (9%)	43 (43%)	
Severe disability	20 (20%)	13 (13%)	33 (33%)	
Dead	1 (1%)	5 (5%)	6 (6%)	
Total	72 (72%)	28 (28%)	100	

Lower serum sodium levels are significantly linked to increased stroke severity (GCS, mRS scores). Though no significant correlations were found with stroke type or side, the strong association with hypertension highlights the need for electrolyte monitoring in acute stroke management to improve outcomes.

DISCUSSION

In our study, hyponatremia was observed in 28% of stroke patients, highlighting its significant prevalence among this population. This finding aligns with the broader literature that stresses hyponatremia as one of the most common electrolyte disturbances in acute stroke patients.

Hossain et al.[5]identified hyponatremia as the most frequent electrolyte imbalance in stroke, primarily driven by the syndrome of inappropriate antidiuretic hormone secretion (SIADH). The study further linked hyponatremia to higher mortality rates, prolonged hospital stays, and poorer functional outcomes. Similarly, Hu J et al.[6]reported that hyponatremia affected 15% of patients within the first 24 hours of stroke onset, establishing it as a frequent complication in the acute phase.

Martí-Fàbregas et al.[7] found that hyponatremia independently predicted 90-day mortality in patients with acute ischemic stroke, emphasizing its prognostic significance. A cross-sectional study by Mahesar et al.[8], conducted in Karachi, Pakistan, reported a prevalence of 39.23% for hyponatremia among ischemic stroke patients. In this study, which included 132 patients, 51 developed hyponatremia within the first 24 hours, while a smaller subset developed hypernatremia during their hospital stay, demonstrating the dynamic nature of electrolyte imbalances in stroke. Similarly, Siddiqui et al.,[9]in a cross-sectional study conducted in Bangladesh, observed hyponatremia in 32% of stroke patients, further affirming its prevalence as the most common electrolyte disturbance in this group.

Liamis et al.[10]also reported that up to 19% of patients with acute ischemic stroke presented with hyponatremia (plasma sodium <136 mmol/L), consolidating the observation that this electrolyte imbalance is a critical clinical factor in stroke management.

In our study, the mean age of patients with stroke was 64 years, which is consistent with findings from various other studies, reflecting the predominance of stroke in older age groups. Jayantee Kalita et al.[11] reported a mean age of 62 years, while Edzie EK et al.[12]observed an average age of 62.46 ± 14.74 years among stroke patients. Similarly, Devkota et al.[13]and Pathak et al.[14] found mean ages of 61 years and 61.7 years, respectively, further reinforcing the trend of stroke incidence in this age range.The similarity in age distribution across studies highlights the critical importance of targeting preventive and therapeutic strategies toward this vulnerable age group to reduce the burden of stroke-related morbidity and mortality.

In our study, the prevalence of stroke was higher in males (63%) compared to females (37%). This finding is consistent with the observations of Mahesar et al.[8], who reported a male-to-female ratio of 59.8% to 40.2%, and Edzie EK et al.[12], who found a prevalence of 54.3% in males and 45.7% in females. The higher prevalence of stroke among males in these studies may reflect gender differences in risk factors such as smoking, alcohol consumption, and hypertension.

In our study, 24 out of 66 hypertensive patients (36.4%) developed hyponatremia, and 8 out of 21 diabetic patients (38.1%) were found to have hyponatremia. These findings suggest a notable association between these comorbidities and the occurrence of hyponatremia in stroke patients. Similarly, Mahesar et al.[8] observed that 17 out of 44 hypertensive patients and 10 out of 27 diabetic patients developed hyponatremia, with a statistically significant p-value of 0.001, indicating a strong relationship between these conditions and hyponatremia.

Pathak et al.[14] reported that 65% of stroke patients had a history of hypertension, highlighting the high prevalence of this comorbidity among stroke populations. Hypertension and diabetes are well-established risk factors for stroke and are also implicated in the development of electrolyte imbalances, such as hyponatremia. The pathophysiological mechanisms linking these conditions may include alterations in renal function, vascular health, and hormonal regulation, such as the inappropriate release of antidiuretic hormone.

In our study, hyponatremia was present in 22.4% of patients with ischemic stroke and 34% of patients with hemorrhagic stroke, indicating a higher prevalence of hyponatremia in hemorrhagic stroke. This observation is consistent with the findings of Mansoor et al.[15], who reported significantly lower sodium levels in patients with ischemic stroke (129.41 ± 3.12) compared to those with hemorrhagic stroke (134.42 ± 3.46).

The higher incidence of hyponatremia in hemorrhagic stroke patients may be attributed to more profound disruptions in intracranial pressure, vascular integrity, and neurohormonal regulation, particularly through mechanisms such as the syndrome of inappropriate antidiuretic hormone secretion (SIADH) or cerebral salt-wasting syndrome (CSWS). Conversely, ischemic stroke patients might experience a lesser degree of these disruptions, explaining the relatively lower prevalence of hyponatremia.

In our study, 58% of patients had ischemic stroke, 41% had hemorrhagic stroke, and 1% had mixed stroke. These findings are comparable to those reported by Abdu et al.[16], who found ischemic stroke in 56.1% and hemorrhagic stroke in 29.2% of their study population.

Pathak et al.[17]reported a higher proportion of ischemic stroke (74.6%) compared to hemorrhagic stroke (25.4%), while Edzie EK et al.[33] observed a similar distribution, with ischemic strokes comprising 70.7% and hemorrhagic strokes 29.3%. Conversely, Mansoor et al.[15] found a higher prevalence of hemorrhagic strokes (53.7%) compared to ischemic strokes (46.3%) in their study population.

Several studies highlight the clinical impact of hyponatremia on stroke outcomes. Potasso et al.[18], in a registry-based analysis of 1995 patients, found that 7.2% had hyponatremia on admission. Patients who achieved normonatremia during their hospital stay had better functional outcomes at three months, while those who remained hyponatremic experienced worse outcomes (OR 2.46; 95% CI, 1.20-5.03).

The consistent association between hyponatremia and adverse stroke outcomes reflects the importance of early detection and correction of this electrolyte imbalance. Routine sodium monitoring, combined with targeted interventions to maintain normonatremia, could potentially improve functional outcomes and reduce mortality in stroke patients.

CONCLUSIONS

Male sex and advancing age above 60 were found to be the more prevalent groups of strokes. Ischemic stroke was more common than haemorrhagic stroke. The most common modifiable risk factors for stroke are hypertension, smoking, diabetes, alcohol consumption, dyslipidaemia, and obesity

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CONFLICT OF INTEREST: No

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