IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 7 Ser.1 (July 2025), PP 11-17
www.iosrjournals.org

Electrolyte imbalance in patients presenting with Acute Stroke admitted in Tertiary Care ICU in Eastern U.P.

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ABSTRACT

Background

Disturbances in electrolyte levels are frequently observed in patients experiencing acute stroke and may substantially influence clinical outcomes. A thorough understanding of these abnormalities and their relationship to stroke classification and prognosis is essential for improving patient care.

Objective

To assess the occurrence of electrolyte imbalances in individuals with acute stroke and to examine their distribution across various age groups and stroke categories.

Methods

This institution-based, forward-looking observational research was performed in the Intensive Care Unit of Sir Sunderlal Hospital, BHU. Fifty patients between the ages of 20 and 85, who presented within 72 hours of their initial acute stroke (validated through CT or MRI), were enrolled. Patients with potential confounding conditions, such as kidney dysfunction, hormonal disorders, or those on medications like diuretics or corticosteroids, were excluded. Clinical and laboratory data, including serum concentrations of sodium, potassium, calcium, chloride, bicarbonate, arterial blood gases, and blood glucose, were collected. Stroke classification and clinical outcomes were evaluated.

Results

Of the 50 subjects, 66% were male and 34% were female. The majority fell within the 51–70-year age range. Ischemic strokes accounted for 52%, whereas hemorrhagic strokes represented 48%. The mean serum values were: sodium 141.09 mmol/L, potassium 3.97 mmol/L, chloride 107.53 mmol/L, calcium 0.979 mmol/L, and bicarbonate 24.37 mmol/L. Mortality rates were notably higher among individuals older than 60. Prominent electrolyte anomalies, particularly low sodium (hyponatremia) and low calcium (hypocalcaemia), were associated with less favorable outcomes.

Conclusion

Electrolyte irregularities are prevalent in acute stroke and can significantly affect patient prognosis. Regular assessment and timely correction of electrolyte levels are vital components of comprehensive stroke care. Age and stroke type should also be considered when predicting clinical outcomes.

Keywords

Acute cerebrovascular accident, electrolyte disturbance, low sodium, low calcium, ischemic event, hemorrhagic event, age-based distribution, clinical prognosis.

Date of Submission: 20-06-2025 Date of Acceptance: 03-07-2025

I. INTRODUCTION:

Stroke remains a major public health concern globally. It is one of the leading causes of chronic disability and ranks as the second leading cause of death, following heart disease and preceding cancer [1]. Electrolyte disturbances have been recognized as significant contributors to poor outcomes in stroke patients. Mortality in stroke is frequently associated with complications such as cerebral edema, brainstem herniation, infections, cardiovascular events, metabolic derangements, and notably, electrolyte imbalances [2].

Electrolytes are critical in maintaining cellular homeostasis, generating electrical impulses, and supporting neuromuscular and cardiovascular function. Sodium and potassium, in particular, are essential for maintaining membrane potentials and facilitating nerve transmission [3]. Sodium is crucial for osmotic equilibrium, regulation of blood volume and pressure, and acid-base balance. Its plasma concentration is largely dependent on water balance and osmoregulation [4]. Potassium, on the other hand, is vital for neuronal integrity, cerebral perfusion, and cellular excitability [5].

Electrolytes—comprising sodium, potassium, calcium, magnesium, chloride, phosphate, and bicarbonate—serve to regulate osmotic pressure, maintain fluid balance, and stabilize pH levels. Intracellular electrolytes such as potassium, phosphate, and magnesium support critical cellular functions. Magnesium, for instance, is involved in enzymatic activity, protein synthesis, neuromuscular transmission, and muscle relaxation. Phosphate contributes to energy metabolism, acid-base homeostasis, and mineralization of bones and teeth. Calcium plays a dual role in muscle contraction and enzyme activation, and also participates in buffering pH.

Potassium specifically modulates cell excitability, nerve impulse transmission, muscle contraction, myocardial responsiveness, and intracellular osmotic balance. Sodium aids in fluid distribution via osmosis and triggers neuromuscular activation. Action potentials, essential for nerve impulse conduction, depend on the regulated movement of sodium and potassium ions across nerve cell membranes.

Among the most common electrolyte disturbances in cerebrovascular accidents (CVA) are disorders of sodium and potassium, which, if left uncorrected, can significantly increase morbidity and mortality [6]. Both hyponatremia and Hypernatremia can arise from factors such as inappropriate secretion of antidiuretic hormone (ADH), elevated levels of brain Natriuretic peptide (BNP) and Atrial Natriuretic peptide (ANP), as well as imbalances in fluid intake or loss [7]. These disturbances can lead to severe complications, including seizures and even death. The syndrome of inappropriate antidiuretic hormone secretion (SIADH) is a primary mechanism behind such imbalances [8].

In hemorrhagic strokes, symptoms like headache and vomiting are frequent, which contribute further to dyselectrolytemia [9]. Apart from neurological complications such as recurrent strokes and seizures, stroke patients are also vulnerable to several medical complications, including chest infections, urinary tract infections, bowel and bladder dysfunction, deep vein thrombosis, pulmonary embolism, gastrointestinal bleeding, aspiration pneumonia, pressure ulcers, and malnutrition [10].

Electrolyte disturbances commonly occur during the acute and post-acute phases of stroke. Hyponatremia and Hypokalemia are among the most frequently observed imbalances in both ischemic and hemorrhagic strokes. These abnormalities may adversely influence the prognosis of stroke patients. There is strong evidence supporting an association between hyponatremia or Hypokalemia and unfavorable outcomes in stroke. Therefore, early detection and appropriate management of electrolyte imbalances are essential components of stroke care.

Hyponatremia is particularly frequent among acute stroke patients and is strongly correlated with increased mortality and worse clinical outcomes. During hospitalization, inappropriate administration of hypotonic fluids, reduced solute intake, infections, and medications such as Mannitol can further lower serum sodium levels. Additionally, stroke-related mechanisms, including secondary adrenal insufficiency due to pituitary ischemia, SIADH, and cerebral salt-wasting syndrome, may contribute to persistent hyponatremia.

II. DETAILS OF PROCEDURES AND METHODS:

Materials and Methods:

This will be a hospital-based, analytical, prospective, and observational study conducted in the ICU of Sir Sunderlal Hospital, Banaras Hindu University, Varanasi, Uttar Pradesh, India. Stroke cases will be consecutively enrolled after obtaining ethical approval from the Institute Ethical Committee, Institute of Medical Sciences, Banaras Hindu University, Varanasi. Only patients presenting within 72 hours of acute stroke onset, confirmed clinically and radiological via CT or MRI, will be included.

Inclusion Criteria:

Patients of either sex, aged 20 to 85 years, diagnosed with first-ever acute stroke admitted within 72 hours of symptom onset, Stroke confirmation by CT scan or MRI, Patients not undergoing diuretic therapy, Patients not in the resuscitation phase, and the patient has no history of renal or endocrine disorders.

Exclusion Criteria:

Patients with any condition that may alter electrolyte levels will be excluded, including Neurological conditions or complications such as History of previous stroke, Transient Ischemic Attack (TIA), Syncope, or deficits secondary to head injury (e.g., SDH, EDH, ICH from trauma), Infarction due to tumors, infections, or space-occupying lesions (SOL) and Preexisting severe cognitive or physical disabilities, Medical conditions like Subarachnoid Hemorrhage (SAH), renal failure, Prior diuretic or steroid therapy and documented infections, Stroke patients with Severe hyperglycemia (>300 mg/dl) (to avoid pseudohyponatraemia), Recent diarrhea, Congestive heart failure, Cirrhosis, Nephrotic syndrome, Chronic Kidney Disease (CKD), Carcinoma and Acute or chronic pulmonary diseases (e.g., pneumonia, tuberculosis, cystic fibrosis, status Asthamaticus), Endocrine disorders, including Hypothyroidism and Use of glucocorticoids or mineralocorticoids, Central Nervous System (CNS) infections, CNS surgery, patients on a shunt, or those previously treated with Mannitol, diuretics, or other drugs affecting electrolytes and SAH or ICH with intraventricular extension or secondary SAH.

Data Collection and Analysis:
Patients aged 20–85 years, admitted within 72 hours of stroke onset, and confirmed via CT or MRI, will be included. Laboratory investigations will include measurement of Serum electrolytes (Sodium, Potassium, Calcium, Chloride, Bicarbonate), ABG, CBC, blood glucose and liver and renal function tests.

Electrolyte reference ranges:
Sodium: 136–146 mmol/L (Hyponatremia <136, Hypernatremia >146)
Potassium: 3.5–4.5 mmol/L (Hypokalemia <3.5, Hyperkalemia >4.5)
Calcium: 1.15–1.27 mmol/L (Hypocalcaemia <1.15, Hypercalcaemia >1.27)
Chloride: 98–108 mmol/L (Hypochloremia <98, Hyperchloremia >108)
Data will be systematically entered into Microsoft Excel and statistically analyzed using appropriate tools for parametric and non-parametric data. Results will be presented using tables and graphs. A p-value < 0.05 will be considered statistically significant.

III. RESULTS:

STROKETYPE	N=50	Percent
Ischemic Stroke	26	52.0
Hemorrhagic Stroke	24	48.0

Table 1: Distribution of Stroke Types among Patients

This hospital-based, prospective, observational study included 50 patients aged 20 to 85 years admitted to the ICU with a first-ever acute stroke within 72 hours of symptom onset. Of these, 26 (52%) had ischemic stroke, while 24 (48%) had hemorrhagic stroke.

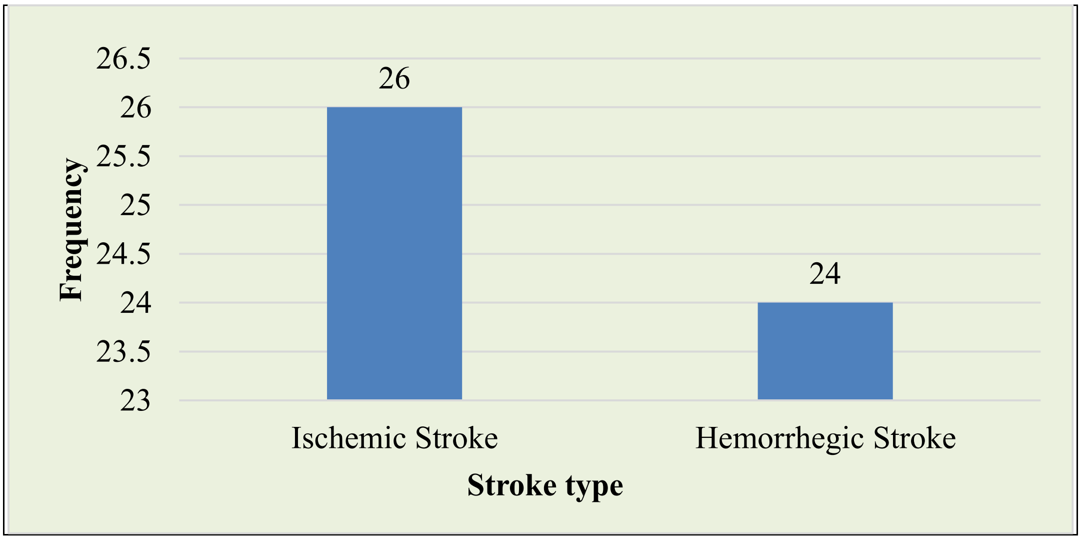

Figure 1: Bar Chart Showing Distribution of Stroke Types

The bar chart illustrates the frequency of stroke subtypes observed in the study population:
Ischemic stroke: 26 patients (52%)
Hemorrhagic stroke: 24 patients (48%)
This nearly equal distribution indicates a slight predominance of ischemic strokes in the studied cohort. Such proportions reflect a departure from the global trend, where ischemic strokes are typically more prevalent. This could be attributed to the hospital's admission pattern or regional differences in stroke risk factors.

Demographics:

Age group	(n=50)	Percent
Age 20-30	3	6.0
Age 31-40	4	8.0
Age 41-50	3	6.0
Age 51-60	14	28.0
Age 61-70	16	32.0
Age >70	10	20.0
Total	50	100.0

Table 2: Age Distribution of Stroke Patients

The mean age of patients was 58.8 years. The most affected age group was 61–70 years (32%), followed by 51–60 years (28%). A progressive increase in mortality was noted with advancing age, particularly among patients aged over 60.

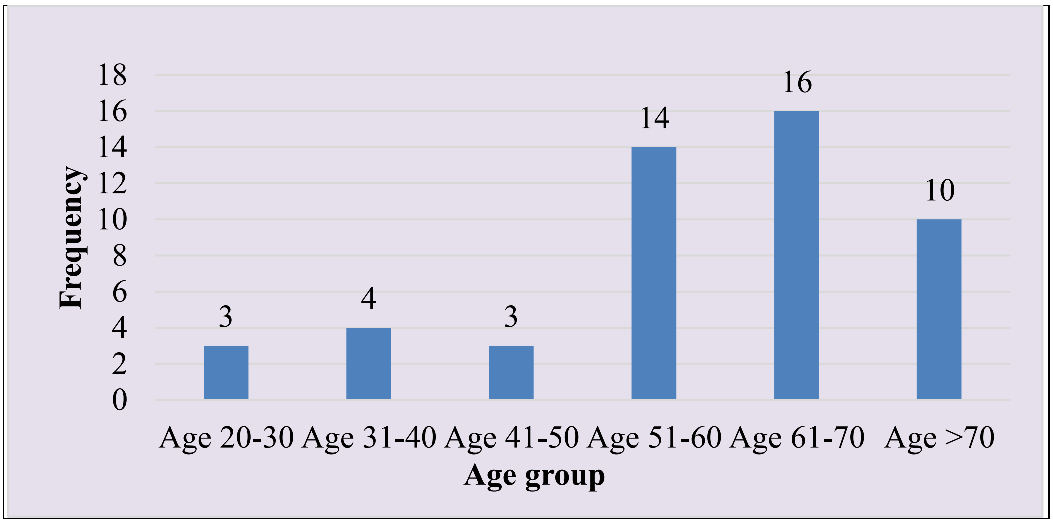

Figure 2: Bar Chart of Age group

The bar chart depicts the age-wise distribution of acute stroke cases in this study cohort. The majority of patients were within the 61–70 years (32%) and 51–60 years (28%) age groups, followed by >70 years (20%). This trend highlights that the incidence of acute stroke increases with age, particularly in individuals aged 50 years and above, which is consistent with global epidemiological patterns.

Fewer cases were observed in younger age groups:

6% in both the 20–30 and 41–50 age groups

8% in the 31–40 age groups

These findings emphasize that while stroke is predominantly a condition affecting older adults, young adults are not completely exempt, and rising cases in younger populations are of growing concern. Contributing factors could include lifestyle changes, hypertension, diabetes, smoking, and dyslipidemia beginning earlier in life.

The results are in line with previous studies that demonstrate a sharp rise in stroke incidence after the fifth decade of life, underscoring the importance of early screening and prevention strategies in middle-aged populations.

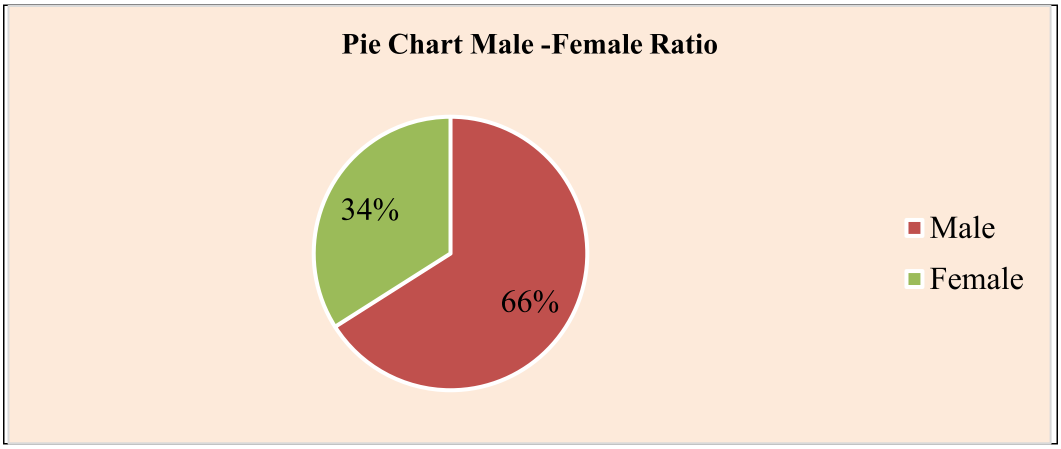

Figure 3: Gender Distribution of Stroke Patients

This pie chart shows the distribution of male and female patients included in the study. Out of the total 50 patients:
66% were male
34% were female
This indicates a male predominance among stroke patients in this cohort.

Electrolyte Distribution:

Parameters	Age	Sodium	Potassium	Chloride	Calcium	Bicarbonate
Mean	58.80	141.088	3.965	107.53	0.97940	24.368
Median	61.00	138.450	3.950	104.25	1.01000	24.000
Std. Deviation	15.456	10.6069	0.8427	8.940	0.623003	4.5651
Minimum	23	120.0	2.4	90	0.390	12.6
Maximum	82	170.0	7.0	132	4.900	35.3
Total (n)	50	50	50	50	50	50

Table 3: Mean Distribution of Age and Electrolyte Parameters in Acute Stroke Patients.

The mean sodium level was within the normal reference range (136–146 mmol/L), but the wide range (120–170) indicates that some patients experienced Hyponatremia or Hypernatremia. Potassium levels varied between 2.4 and 7.0mmol/L, suggesting both Hypokalemia and Hyperkalemia among patients. Chloride and bicarbonate values suggest acid-base imbalances in some individuals. Mean calcium level (0.979mmol/L) appears lower than standard physiological norms, pointing to potential Hypocalcaemia, which may have neurological implications.

Clinical Outcomes:

Outcomes		
Age Group	Survived with Disabilities count up to 30 days	Mortality
Age.20-30	3	0.0
Age.31-40	4	0.0
Age.41-50	1	2.0
Age.51-60	9	5.0
Age.61-70	10	6.0
Age.>70	4	6.0

Table 4: distribution of mortality and survival in comparison with age groups

Out of 50 patients, 31 survived with varying degrees of disability, while 19 succumbed to their condition within 30 days. Mortality was most prominent in the >70 age group (60%), followed by the 61–70 age group (37.5%) and the 51–60 age group (35.7%). Notably, no deaths occurred in patients under 40 years of age.

IV. DISCUSSION:

Electrolyte imbalances are frequent but often under-recognized complications in acute stroke patients and can significantly impact morbidity and mortality. In our study, conducted in a tertiary ICU setting in Eastern Uttar Pradesh, a high prevalence of electrolyte disturbances was observed, notably hyponatremia and hypocalcaemia, with a trend toward increased mortality in older age groups and among hemorrhagic stroke patients.

Our results demonstrated that 52% of patients suffered from ischemic strokes while 48% had hemorrhagic strokes. This nearly equal distribution deviates slightly from global trends, where ischemic strokes are usually more prevalent [11]. However, Indian hospital-based studies, especially those focusing on tertiary care ICUs; have shown a relatively higher proportion of hemorrhagic cases due to referral bias and late presentations [12].

Hyponatremia was the most common abnormality observed, consistent with previous reports suggesting that low serum sodium levels are prevalent in 15%–40% of stroke cases and are strongly associated with increased mortality and neurological deterioration [13, 14]. This is attributed to mechanisms such as Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH), cerebral salt wasting, and secondary adrenal insufficiency following hypothalamic or pituitary ischemia [15, 16]. Moreover, the inappropriate use of hypotonic intravenous fluids and stress-related hormonal dysregulation during acute illness may further exacerbate sodium loss [17].

Low serum calcium levels were another noteworthy finding in our cohort. Hypocalcaemia was present in several patients and has been correlated with poor clinical outcomes in other studies. Calcium plays a crucial role in synaptic transmission, vascular tone, and coagulation. Altered serum calcium levels may contribute to increased neuronal excitotoxicity, vasogenic edema, and infarct size [18]. Research by Han et al. (2015) reported that lower serum calcium levels were independently associated with increased stroke severity and worse outcomes at discharge [19].

Potassium derangements—both Hypokalemia and Hyperkalemia—were seen in our cohort, though less frequently than sodium and calcium abnormalities. Hypokalemia has been linked to increased infarct volumes and arrhythmogenic potential in stroke patients [20]. A recent prospective study by Gupta et al. (2021) found that potassium imbalance, particularly Hypokalemia, was associated with increased in-hospital complications and longer ICU stays [21].

Age appeared to be a strong determinant of prognosis. The mean patient age was 58.8 years, and mortality rates were highest in individuals over 60 years. This aligns with existing literature indicating that aging is associated with reduced physiological reserve, comorbidities, and impaired homeostatic mechanisms, which predispose to worse outcomes in acute illnesses such as stroke [22]. In fact, studies show that elderly patients often present with more profound and persistent electrolyte abnormalities following cerebral insults [23].

Our study also supports the notion that electrolyte imbalance is an early and modifiable risk factor in acute stroke. Early detection and prompt correction of these imbalances could improve neurological recovery and reduce complications. Interventions such as individualized fluid management, close monitoring of electrolytes, and avoidance of agents that exacerbate electrolyte loss are warranted [24].

In addition, this study highlights the need for routine assessment of serum calcium, which is not always part of standard stroke protocols but may provide prognostic value. Although chloride and bicarbonate imbalances were less prominent, the variation in their levels indicates acid-base disturbances, which have also been linked to increased mortality and poor neurological outcomes in ICU patients [25].

Our findings underscore the importance of integrated metabolic monitoring in stroke patients. Incorporating serum electrolyte evaluation into acute stroke management protocols—especially within the first 72 hours—can lead to early intervention and potentially better outcomes. The inclusion of calcium and potassium assessments, along with standard sodium analysis, may offer a more comprehensive risk stratification model.

Limitations:

This study was limited by its single-center nature and modest sample size (n=50), which may limit the generalizability of the results. Larger multicentric studies with a control group and longer follow-up are recommended to validate the findings and better understand causal relationships.

V. CONCLUSION:

Electrolyte imbalances are highly prevalent in patients presenting with acute stroke and represent a critical, modifiable factor influencing short-term clinical outcomes. In this study, hyponatremia and hypocalcaemia were the most frequently observed abnormalities and were associated with increased mortality, particularly among older patients and those with hemorrhagic stroke.

The results emphasize the necessity for routine monitoring of serum electrolytes—especially sodium, calcium, and potassium—within the first 72 hours of admission. Timely identification and correction of these imbalances can improve prognosis, reduce complications, and potentially decrease ICU mortality. Given the age-dependent variation in outcomes, age and stroke type should be incorporated into early risk stratification models to guide individualized management strategies.

These findings advocate for the inclusion of a comprehensive electrolyte panel in acute stroke protocols and highlight the need for broader awareness of metabolic complications in stroke care. Further large-scale, multicentric studies with extended follow-up are warranted to validate these observations and inform standardized treatment algorithms.

Conflict of Interest: The authors declare no conflict of interest related to this study. There are no financial, personal, or professional relationships that could be construed to have influenced the design, data collection, analysis, interpretation, or reporting of the findings in this research.

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