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Original Research Article

Plama Osmolality Status in Acute Stroke Patients and in Healthy Individuals in Rajshahi Medical College Hospital

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Abstract: ***Background:*** Stroke is the most prevalent neurological emergency and accounts for approximately 50% of all neurological disorders in medical college hospitals. It is the leading cause of adult neurological morbidity and the third leading cause of death globally. Changes in plasma osmolality are associated with increased complications, mortality, morbidity, and disability in stroke patients. ***Objective:*** This study aims to investigate the changes in plasma osmolality in different types of acute stroke patients and its impact on stroke outcomes. ***Method:*** The study included two groups: Group I comprised 104 acute stroke patients (mean age 58.87±13.70) as cases, and Group II consisted of 104 age- and sex-matched healthy individuals (mean age 57.55±12.60) as controls. Each stroke patient underwent cranial computed tomography within the first 24 hours. Blood tests for blood sugar, serum electrolytes, lipid profile, and blood urea were performed. The CT findings and pathological test results were analyzed using SPSS software. ***Result:*** Among the 104 stroke patients, 71 (68.27%) had ischemic stroke, and 33 (31.73%) had hemorrhagic stroke. Dyselectrolytaemia was observed in 73 (70.20%) of the stroke patients, while 31 (29.80%) had normal electrolyte levels. Hyperosmolality was present in 58 (55.77%) of the patients, and hypoosmolality was found in 3 (2.88%). ***Conclusions:*** Abnormal plasma osmolality is a significant independent risk factor for complications in acute stroke patients, both ischemic and hemorrhagic. Plasma osmolality estimation should be considered a crucial clinical investigation for evaluating acute stroke patients in the early stages.

Keywords: Acute Stroke, Plasma Osmolality, Serum Electrolytes, Ischemic Stroke, Hemorrhagic Stroke.

INTRODUCTION

Stroke is characterized by a sudden focal cerebral dysfunction of vascular origin due to the disruption of cerebral blood flow lasting for more than 24 hours or resulting in the patient's death within this period [1]. Over 80% of strokes are ischemic, caused by vascular insufficiency, while approximately 15% are hemorrhagic, due to blood vessel rupture. Stroke is the most common neurological emergency and a significant public health problem among adults [2]. It is associated with high adult mortality and morbidity, and is one of the leading causes of chronic disability and death worldwide [3]. Globally, strokes account for about

9% of all deaths and are the second most common cause of death, after heart disease and cancer. In Bangladesh, the incidence of stroke is 2.55 per 1,000 population per year, with rates increasing steadily [4]. Stroke significantly contributes to morbidity, mortality, and social burden.

Plasma osmolality is the number of osmotically active particles per kilogram of solvent, is an essential laboratory parameter for understanding clinical disorders such as electrolyte imbalance, hydration status, and exogenous intoxication. The key parameters of plasma osmolality include serum sodium, serum potassium, blood glucose, and blood urea. In this study, plasma osmolality is calculated using the equation:

Plasma osmolality= 2*[Na^+ + K^+] +blood glucose/18 + blood urea/2.8 mOsmol/kg.

Plasma osmolality is a critical physiological parameter in acute stroke patients and serves as a useful predictor of mortality, providing reliable information on short-term mortality risk [5]. Abnormal plasma osmolality, whether hypoosmolality or hyperosmolality, is associated with high morbidity, mortality, and disability in stroke patients [6]. It plays a vital role in maintaining intracellular and extracellular water balance, electrolyte balance, and hydration status. Changes in plasma osmolality, influenced by blood concentrations of Na+, K+, Cl+, glucose, and urea, are strongly associated with various body fluid imbalances, leading to dehydration, electrolyte imbalances such as hyponatremia, hypernatremia, and hypokalemia, and increased risks of cerebrovascular, cardiovascular, and renal disorders [7]. These imbalances are common in acute stroke patients and contribute to early neurological deterioration in both ischemic and hemorrhagic strokes [8].

OBJECTIVES

General Objective:

- To investigate the changes in plasma osmolality in different types of acute stroke patients and its impact on stroke outcomes.

Specific Objectives:

- To measure and compare plasma osmolality levels in ischemic and hemorrhagic stroke patients.
- To analyze the relationship between plasma osmolality and the severity of stroke outcomes, including mortality, morbidity, and disability.
- To assess the prevalence of dyselectrolytaemia in acute stroke patients and its correlation with plasma osmolality.
- To evaluate the potential of plasma osmolality as a clinical parameter for early diagnosis and prognosis in acute stroke patients.
- To determine the impact of electrolyte imbalances on the overall health and recovery of acute stroke patients.

MATERIALS AND METHODS

Study Design

This cross-sectional comparative study was conducted in the Medicine and Neuromedicine departments of Rajshahi Medical College Hospital, Rajshahi, Bangladesh, over two years from July 2017 to June 2019. The study included 104 acute stroke patients and 104 age- and sex-matched healthy controls. Stroke diagnosis was confirmed using computed tomography (CT) scans. Detailed patient histories, neurological examinations, and various pathological tests were conducted to collect data on plasma osmolality and related parameters.

Inclusion Criteria

- Patients with a confirmed diagnosis of acute stroke within the first 24 hours.
- First-ever stroke occurrence.
- Age-matched and sex-matched healthy individuals for the control group.

Exclusion Criteria

- Patients with recurrent strokes.
- Patients with known chronic renal failure.
- Patients with known chronic liver disease.
- Patients with any other significant chronic illness.
- Patients with incomplete medical records.

Data Collection

Data were collected from patients' history sheets, relevant CT scan films, and various pathological examinations, including blood sugar, blood urea, lipid profiles, and serum electrolytes. Plasma osmolality was calculated using the formula: Plasma osmolality= 2*[Na+ + K+] +blood glucose/18 + blood urea/2.8 mOsmol/kg.

Data Analysis

The collected data were entered into a computer and analyzed using SPSS version 26. Descriptive statistics were used to summarize the data, and comparative analyses were conducted to evaluate the differences between stroke patients and healthy controls. The results were presented in tables, figures, and diagrams to illustrate the findings. Statistical significance was determined using

appropriate tests, and p-values less than 0.05 were considered significant.

Ethical Considerations

The study was conducted following the ethical standards of the Helsinki Declaration and received approval from the local ethical committee of Rajshahi Medical College Hospital. Informed consent was obtained from all participants or their legal guardians before inclusion in the study. Confidentiality of patient data was strictly maintained, and all data were anonymized to protect participants' privacy. Participation was voluntary, and participants had the right to withdraw from the study at any time without any consequences.

RESULTS

The study population consisted of 204 individuals, including 104 acute stroke patients (both ischemic and hemorrhagic) and 104 age- and sex-matched healthy controls. The stroke patients were diagnosed by computed tomography (CT scan) within 24 hours of the first-ever stroke symptoms. Among the 104 stroke patients, 71 (68.27%) had ischemic strokes, while 33 (31.73%) had hemorrhagic strokes.

The mean age of the stroke patients was 59.68 (±13.43) years, with an age range of 18 to 92 years. The mean age of the healthy controls was 58.06 (±13.98) years. The highest number of stroke patients was found in the 50-60 years age group, accounting for 36 (34.62%) stroke cases. Similarly, 38 (36.54%) healthy controls were in this age group. The highest frequency of stroke patients was observed in the sixth decade of life, with 36 (34.62%) cases. The lowest frequency was observed in the <30 years age group, with 3 (2.90%) stroke patients and 3 (2.90%) healthy controls.

Age and sex distribution of the study population is depicted in Figure I and Table 2. The distribution shows that stroke incidence increases with age, with the highest prevalence in individuals aged 50 to 60 years.

Table 1: Distribution of the study patients by age and sex (N=208)

	Case					Control				
	Male (61)		Female (43)			Male (60)		Female (44)		
Age	No. of patients	%	No. of patients	%	Total	No. of patients	%	No. of patients	%	Total
<30	2	1.92%	1	0,96%	3(2.88%)	2	1.92%	1	0.96%	3(2.88%)
31-40	4	3.84%	2	1.92%	6(5.77%)	3	2.88%	3	2.88%	6(5.77%)
41-50	6	5.77%	5	4.82%	11(10.56%)	7	6.74%	5	4.82%	12(11.55%)
50-60	22	21.15%	14	13.46%	36(34.62%	21	20.19%	13	12.51%	34(32.69%)
61-70	13	12.51%	11	10.56%	24(23.08%)	12	11.55%	12	11.54%	24(23.08%)
71-80	10	9.61%	7	6.74%	17(16.35%)	11	10.56%	6	5.76%	17(16.35%)
>80	4	3.84%	3	2.88%	7(6.74%)	4	3.85%	4	3.85%	8(7.68%)
Total	**61**	**58.65%**	**43**	**41.35%**	**104 (100%)**	**60**	**57.69%**	**44**	**42.31%**	**104(100%)**

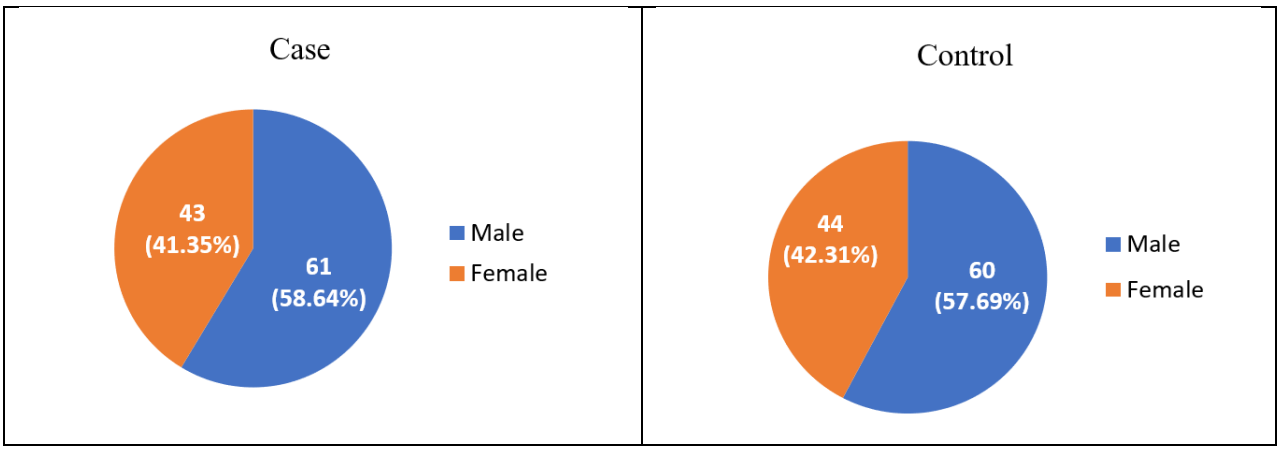

Figure 1: Gender Distribution Among Patients and Controls

Among 104 stroke patients, ischemic stroke were 71(68.27%) and haemorrhagic stroke were 33 (31.73%). Among the patients with stroke in male 47(45.19%) were ischemic stroke and 14(13.46% were haemorrhagic stroke and in female 24(23.08%) were ischemic and 19(18.27%) were haemorrhagic stroke. Among the patients with stroke 61(58.65%) were male and 43(41.35%) were female and in healthy control 60(57.70%) were male and 44(42.30%) were female.

Table 2: Distribution of the study patients by type of stroke and sex (N=104)

Sex	Ischaemic stroke N%	Hemorrhagic stroke N%	Total N%	P value
Male	47(45.19%)	14(13.46%)	61(58.65%)	0.136
Female	24(23.08%)	19(18.27%)	43(41.35%)	

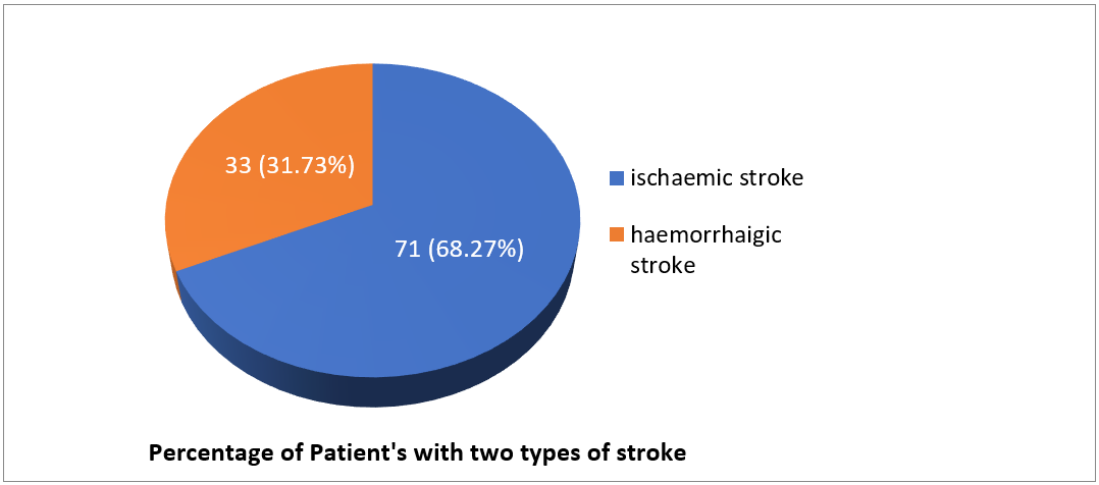

Figure 2: Frequency of plasma osmolality in the study patients (N=208)

In the case group hyperosmolality was found in 58 (55.77%) patients, hypoosmolality in 3(2.88%) and normal in 43 (41.35%). In control group, hyperosmolality was found in 15 (14.42%) patients, hypoosmolality in 1(0.96%) and normal in 88 (84.62%).

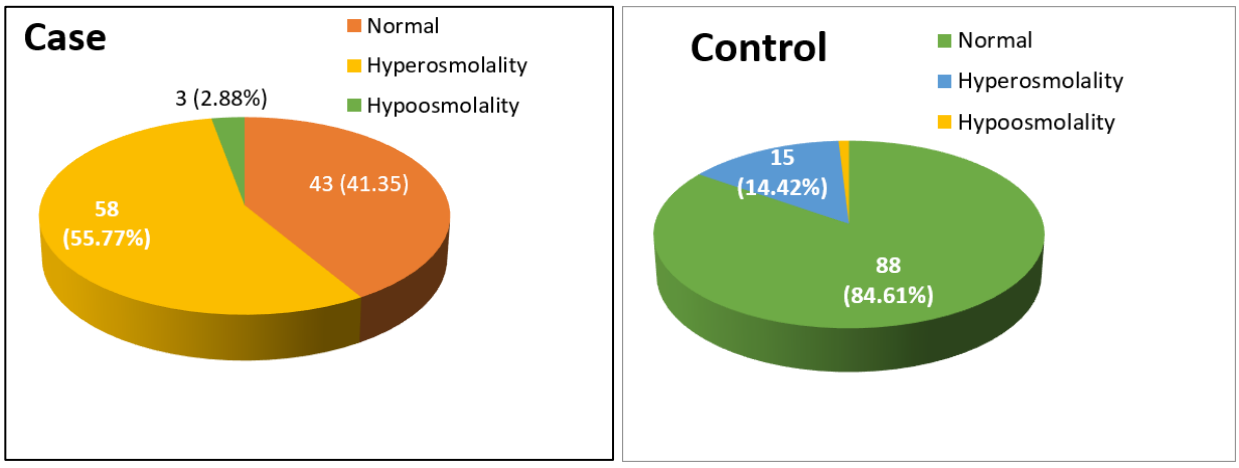

Figure 3: Plasma Osmolality in Stroke Patients and Control Group

In this study the Mean plasma osmolality was 294.93(±13.13) in case and 288.86(±8.79%) in control group. In this study Mean plasma osmolality in ischemic stroke was 296.25(±12.42%) and in haemorrhagic stroke it was 292.12(±14.31%). High plasma osmolality was found 42(40.38%) patients with ischemic stroke and 16(15.38%) patients with haemorrhagic stroke. Low or normal plasma osmolality was found in 29(25.89%) in Ischaemic stroke and 17(16.35%) patients with haemorrhagic stroke. Mean plasma osmolality in older case group (>50 years) 295.23 ±13.02 while in patients with age group (<50 years) it was 293.73±13.85, mild higher in older case group. Mean plasma osmolality in male stroke patients was 295.33±12.35 while in female stroke patients it was 292.97±14.07, mild higher in male than female.

Table 3: Frequency of Plasma Osmolality Level in Ischemic and Hemorrhagic Stroke (N=104)

Plasma Osmolality	Ischemic (N=71)	Hemorrhagic (N=33)	Total (N=104)	P value
Low/Normal	29 (27.89%)	17 (16.35%)	46 (44.23%)	p>0.05
High	42 (40.38%)	16 (15.38%)	58 (55.77%)	
Total	**71 (68.27%)**	**33 (31.73%)**	**104 (100%)**	

In this study dyselectrolytaemia was 73(70.20%) and normal electrolyte level was 31(29.81%) in acute stroke. But in control group, the dyselectrolytaemia was 75(72.20%) and normal electrolyte level was 29(27.80%). Regarding sodium hypernatraemia was 3(2.88%), hyponatraemia was 37(35.58%) and normal level was 64(61.54%) in acute stroke patients. Regarding potassium, hyperkalaemia was 11(10.58%), hypokalaemia was 22(21.15%) and normal level was 71(68.27).

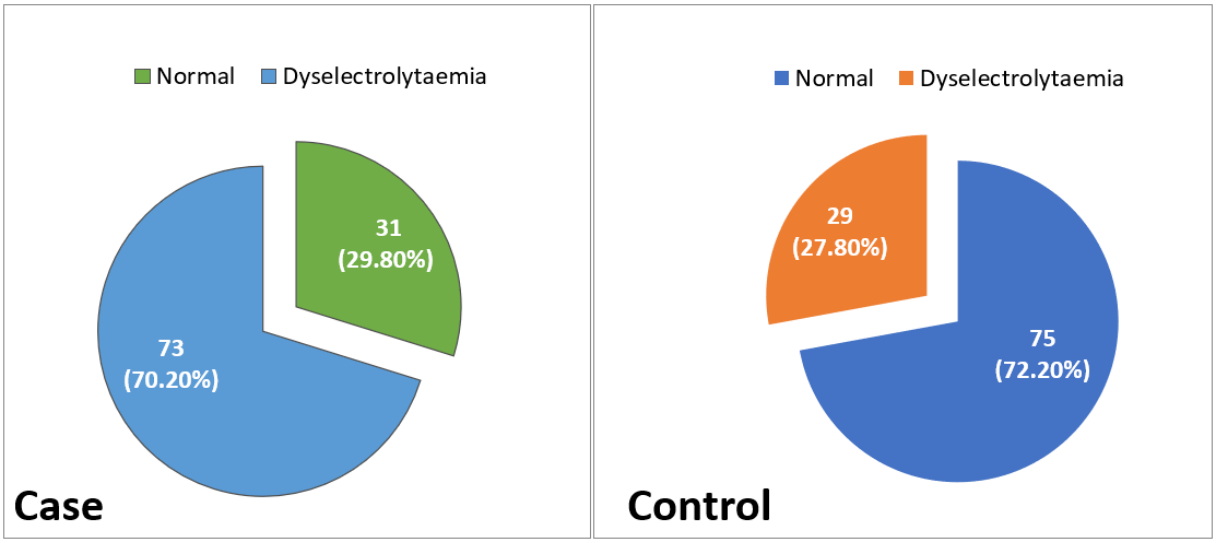

Figure 4: Frequency of dyselectrotytaem in the study subject (N=208)

In this study hypertension was found to be the most common risk factor affecting 76(73.08%) in stroke patients. Beside hypertension, dyslipidemia affecting 73(70.19%), diabetic 64(61.54%), smoking 57(54.80%), alcohol 9(8.70%). In the control group hypertension was 44(42.30%), DM was 23(22.11%), dyslipidaemia was 49(47.10%), Smoking was 54(51.90%) and Alcohol was 8(7.70%).

Table IV: Distribution of the study patients by risk factors (N=104)

	CASE					CONTROL				
	Male (61)		Female (43)			Male (60)		Female (44)		
Risk factors	**No. of patients**	**%**	**No. of patients**	**%**	**Total**	**No. of patients**	**%**	**No. of patients**	**%**	**Total**
Hypertension	46	(44.23%)	30	(28.85%)	76(73.08)	44	(23.08%)	20	(19,23%)	44(42.30%)
Diabetics mellitus	42	(40.38%)	22	(21.15%)	64(61.54%)	14	(13.46%)	9	(8.65%)	23(22.11%)
Dyslipidemia	40	(38.46%)	33	(31.73%)	73(70.19%)	29	(7.88%)	20	(19.23%)	49(47.10%)
Smoking	55	(52.88%)	2	(1.92%)	57(54.80%)	53	(50.96%)	1	(0.96%)	54(51.90%)
Family history	9	(8.65%)	0	(0 %)	9(8.70%)	7	(6.73%)	1	(0.96%)	8(7.70%)

DISCUSSION

This study investigated plasma osmolality status in acute stroke patients and aimed to elucidate the effects of plasma osmolality changes on clinical outcomes. Plasma osmolality is a critical risk factor for developing complications in stroke patients, influencing mortality, morbidity, and disability [9]. Previous studies, including one by observed that both hyperosmolality and hypoosmolality are relatively common in acute stroke patients [10]. In our study, hyperosmolality was found in 55.77% of stroke patients, compared to 14.42% in healthy controls,

while hypoosmolality was present in 2.88% of stroke patients and 1% of controls. The mean (±SD) plasma osmolality was significantly higher in stroke patients (294.93 ± 13.13) than in healthy controls (288.86 ± 8.79), aligning with findings by who reported that both hyperosmolality and hypoosmolality are associated with high mortality and disability in stroke patients. In this study, the mean (±SD) plasma osmolality in ischemic stroke patients was 296.25 (±12.42), while in hemorrhagic stroke patients, it was 292.12 (±14.31). High plasma osmolality was observed in 42.40% of ischemic stroke patients and 15.38% of hemorrhagic stroke patients. Although plasma osmolality was higher in ischemic stroke patients than in hemorrhagic stroke patients, the difference was not statistically significant. Also found that plasma osmolality was higher in ischemic stroke than in hemorrhagic stroke, consistent with our findings [11].

The mean (±SD) plasma osmolality in male stroke patients was 296.33 (±12.35) mOsm/kg, compared to 292.97 (±14.07) mOsm/kg in female stroke patients. Higher osmolality was observed in males than females, but the difference was not statistically significant ($p>0.05$). Studies by found similar results, indicating that male stroke patients tend to have higher plasma osmolality than females [12]. The mean (±SD) plasma osmolality in older patients (>50 years) was 295.23 (±13.02) mOsm/kg, while in younger patients (<50 years), it was 293.73 (±13.85) mOsm/kg. Although plasma osmolality was higher in the older age group, the difference was not statistically significant ($p>0.05$). Similar findings were reported by who observed higher plasma osmolality in older age groups than in younger age groups [13]. Conducted a retrospective observational clinical study and found that diabetes mellitus, hypertension, hypercholesterolemia, smoking, and alcohol use are risk factors for stroke patients and are associated with high osmolality. Rao *et al.,* also observed that plasma osmolality is higher in patients with hypertension, diabetes mellitus, dyslipidemia, smoking, and alcohol use [14]. In our study, high plasma osmolality was found in stroke patients with hypertension, diabetes mellitus, dyslipidemia, and smoking, corroborating these findings.

Nicholson *et al.,* studied plasma osmolality in St James Hospital, Dublin, Ireland, and found that changes in plasma osmolality increase the risk of complications in acute stroke patients [15]. This study concluded that plasma osmolality could serve as a marker for increased risk of stroke complications, with high plasma osmolality levels associated with poor prognosis and outcomes. Nag *et al.,* observed that high plasma osmolality at admission and in the ICU is associated with more complications and poorer outcomes in acute stroke patients [16]. further noted that both hypo-osmolality and hyper-osmolality significantly impact stroke patients, with high plasma osmolality during emergency presentations predicting substantially increased mortality and disability.

Our study supports these findings by demonstrating that abnormal plasma osmolality is a significant risk factor for the development of complications in acute stroke patients [17-19]. Plasma osmolality estimation should be considered an essential clinical investigation for evaluating acute stroke patients early on. Monitoring and managing plasma osmolality can potentially improve clinical outcomes by reducing mortality, morbidity, and disability. In this study highlights the critical role of plasma osmolality in acute stroke patients. Higher plasma osmolality is significantly associated with worse clinical outcomes, including increased mortality, morbidity, and disability. These findings emphasize the need for healthcare professionals to monitor plasma osmolality levels in stroke patients to manage and mitigate potential complications effectively. Future research should focus on developing targeted interventions to correct plasma osmolality imbalances and improve the prognosis for acute stroke patients.

CONCLUSION

CT scan is the gold standard for diagnosing acute stroke, but effective stroke management relies on accurately diagnosing the stroke and its complications. Alongside CT scans, comprehensive investigations, including serum electrolytes, plasma osmolality, blood sugar, lipid profiles, and serum creatinine, are essential for diagnosing stroke and its complications. Abnormal plasma osmolality is a significant independent risk factor for complications in acute stroke patients. Therefore, plasma osmolality estimation should be an imperative and potential clinical investigation, similar to CT scans, to ensure comprehensive stroke management and improve patient outcomes.

RECOMMENDATIONS

- Implement routine plasma osmolality testing for all acute stroke patients upon admission.
- Include CT scans, serum electrolytes, blood sugar, lipid profiles, and serum creatinine alongside plasma osmolality in diagnostic protocols.
- Develop targeted interventions to address abnormal plasma osmolality in stroke patients to improve clinical outcomes.

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