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***Original Research Article***

# HYPONATREMIA FOLLOWING ANEURYSMAL SUBARACHNOID HEMMORHAGE

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## ABSTRACT

***Background:*** *Hyponatremia is a frequent electrolyte disturbance in patients with aneurysmal subarachnoid hemorrhage (aSAH), often contributing to worsened neurological outcomes. Understanding its prevalence and clinical implications is crucial for timely intervention.* ***Objective:*** *To assess the frequency and severity of hyponatremia in patients with aneurysmal subarachnoid hemorrhage and evaluate its association with clinical outcomes.* ***Study Design:*** *cross-sectional study.* ***Setting:*** *The study was conducted in the neurosurgery and neurology units of a tertiary care hospital.* ***Duration of Study:*** November 2024 to May 2025. ***Methods:*** *Fifty-five patients aged above 18 years with radiologically confirmed aSAH (via CT angiography or digital subtraction angiography) were enrolled. Daily serum sodium levels were monitored and categorized as mild (<135 mmol/L), moderate (<130 mmol/L), or severe (<125 mmol/L) hyponatremia. Clinical outcomes were assessed using the Glasgow Outcome Scale (GOS) at the time of hospital discharge. Statistical analysis was performed using SPSS software, with significance defined at $p < 0.05$.* ***Results:*** *The mean patient age was 55.2 ± 3.8 years, with females comprising 60% of the study population. The most common aneurysm location was the anterior communicating artery (27.3%). Hyponatremia was observed in all patients: mild in 61.8%, moderate in 29.1%, and severe in 9.1% of cases. Severe hyponatremia showed a significant association with poorer clinical outcomes ($p = 0.01$).* ***Conclusion:*** *Hyponatremia is highly prevalent among patients with aneurysmal subarachnoid hemorrhage. Severe hyponatremia is notably associated with unfavorable neurological outcomes, underlining the importance of early detection and management in aSAH patients.*

**Keywords:** Subarachnoid Hemorrhage, Hyponatremia, Aneurysm Location, Glasgow Outcome Scale, Electrolyte Disorders

## INTRODUCTION

Aneurysmal subarachnoid haemorrhage (aSAH) governs a significant global health challenge, characterised by elevated mortality as well as rates of permanent disability. SAH constitutes a neurological emergency that requires immediate evaluation and treatment to avert life-threatening recurrent bleeding and improve patient outcomes (1, 2). Even though there has been an ongoing decrease in mortality rates from acute aSAH, decreasing from over 50%, this condition remains linked to significant morbidity as well as mortality. About one-third end up permanently reliant on nursing care, whereas only 30% manage to return to independence (3-5). The clinical outcome is influenced by several factors such as the severity of acute bleed and the presence of delayed cerebral ischaemia. Pulmonary as well as cardiac complications hold prognostic significance (6). Alongside surgical intervention for aneurysms, a different method has been established that involves the internal closure of an aneurysm through endovascular deployment of small metal coils. Between 2002 and 2008, the incidence of endovascular treatment for aneurysms went up from 17% (7).

Hyponatraemia embodies a prevalent electrolyte disturbance characterised by an excess of body water in total compared to total body sodium levels. Hyponatraemia in neurosurgical patients can lead to complications such as cerebral oedema, seizures, and death, which may result from either slow /rapid correction of the condition (8, 9). Even mild hyponatraemia has been linked to a higher mortality rate (10, 11). Prompt and suitable treatment of hyponatraemia results in normalization of patients' sodium levels without negative consequences. Hyponatraemia soon after aSAH is primarily linked to the syndrome of SIADH. Additional linked causes encompass acute cortisol insufficiency, excessive fluid therapy, and diuretic therapy. Hyponatraemia in patients with subarachnoid haemorrhage is related to extended hospital stay, increased morbidity, as well as an elevated risk for vasospasm, irrespective of underlying aetiology (12).

Hyponatremia is a common as well as clinically significant electrolyte disturbance observed following aSAH, contributing to increased morbidity and poor neurological outcomes, despite its high incidence and significant impact on recovery. There is considerable variability in reported prevalence and treatment approaches in the current literature. This study aims to investigate the frequency and clinical consequences of hyponatremia following aSAH, thereby contributing to a more nuanced understanding and guiding effective management strategies to improve patient outcomes.

## METHODOLOGY

This cross-sectional study was carried out in the department of neurosurgery from November 2024 to May 2025. This study included 55 patients with confirmed aneurysmal subarachnoid hemorrhage (SAH) with diagnosis established through CT angiography or digital subtraction angiography.

Inclusion standards comprised age >18 years having either gender, radiologically confirmed SAH and availability of complete clinical data. We did not include patients with traumatic SAH, pre-existing chronic kidney disease and adrenal insufficiency.

Demographic characteristics (age, gender, BMI), comorbidities (hypertension, diabetes) and aneurysm features were systematically recorded with daily serum sodium measurements categorizing hyponatremia as mild (<135 mmol/L), moderate (<130 mmol/L) or severe (<125 mmol/L). Clinical outcomes were assessed at discharge using the Glasgow Outcome Scale (GOS) which was stratified into good recovery (GOS 4-5), moderate/severe disability (GOS 2-3) or death (GOS 1).

For statistical analysis we employed SPSS 25, age was calculated using mean and SD for all patients. Gender, comorbidities,

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hyponatremia, Glagow score and aneurysm location were evaluated using frequency and percentages. Chi Square test was used for assessing the relation of hyponatremia with various parameters, we kept P value notable at ≤ 0.05.

## RESULTS

The study included 55 patients with a mean age of 55.18 ± 3.76 years. The gender distribution revealed that 22 (40.0%) were male while 33 (60.0%) were female. Body mass index (BMI) analysis showed that 6 (10.9%) participants were underweight, 35 (63.6%) fell within the normal range, 9 (16.4%) were overweight, and 5 (9.1%) were classified as obese (Table 1).

Aneurysm locations were diverse, with the most frequent being the anterior communicating artery (A.com) 15 (27.3%), which was followed by the middle cerebral artery (MCA) 11 (20.0%) and the posterior communicating artery (P.com) 10 (18.2%). Less common sites included the anterior cerebral artery (ACA) 4 (7.3%), the basilar tip 2 (3.6%), the internal carotid artery (ICA) 7 (12.7%), and the posterior circulation 4 (7.3%). Additionally, 2 (3.6%) participants had multiple aneurysms. (Table 2)

Hyponatremia was observed in a substantial proportion of the cohort, with mild cases (<135 mmol/L) occurring in 34 (61.8%) patients, moderate cases (<130 mmol/L) in 16 (29.1%), and severe cases (<125 mmol/L) in 5 (9.1%). (Table 3)

Outcomes assessed using the Glasgow Outcome Score (GOS) indicated that 4 (7.3%) participants died, 10 (18.2%) remained in a persistent vegetative state, and 18 (32.7%) experienced severe disability. Moderate disability was reported in 10 (18.2%) cases, while 13 (23.6%) achieved good recovery. (Table 4)

**Table 1: Demographics**

| Demographics | | n | % |
|---|---|---|---|
| Gender | Male | 22 | 40.0% |
| | Female | 33 | 60.0% |
| BMI (kg/m²) | Underweight (<18.5) | 6 | 10.9% |
| | Regular (18.5-24.9) | 35 | 63.6% |
| | Overweight (25-29.9) | 9 | 16.4% |
| | Obese (>30) | 5 | 9.1% |

**Table 2: Aneurysm Location**

| Aneurysm Location | n | % |
|---|---|---|
| A.com | 15 | 27.3% |
| ACA | 4 | 7.3% |
| Basilar tip | 2 | 3.6% |
| ICA | 7 | 12.7% |
| MCA | 11 | 20.0% |
| Multiple (2 or >2) | 2 | 3.6% |
| P.com | 10 | 18.2% |
| Posterior circulation | 4 | 7.3% |

**Table 3: Hyponatremia**

| Hyponatremia | n | % |
|---|---|---|
| Mild (<135 mmol/L) | 34 | 61.8% |
| Moderate (<130) | 16 | 29.1% |
| Severe (<125) | 5 | 9.1% |

**Table 4: Glasgow Outcome Score**

| Glasgow Outcome Score | n | % |
|---|---|---|
| 1 (Death) | 4 | 7.3% |
| 2 (Persistent vegetative state) | 10 | 18.2% |
| 3 (Severe disability) | 18 | 32.7% |
| 4 (Moderate disability) | 10 | 18.2% |
| 5 (Good recovery) | 13 | 23.6% |

**Table 5: Association of hyponatremia with various parameters**

| Parameters | | Hyponatremia | | | | | | P value |
|---|---|---|---|---|---|---|---|---|
| | | Mild (<135 mmol/L) | | Moderate (<130) | | Severe (<125) | | |
| | | n | % | n | % | n | % | |
| Gender | Male | 14 | 41.2% | 6 | 37.5% | 2 | 40.0% | 0.97 |
| | Female | 20 | 58.8% | 10 | 62.5% | 3 | 60.0% | |
| Aneurysm Location | A.com | 3 | 8.8% | 7 | 43.8% | 5 | 100.0% | 0.0001 |
| | ACA | 4 | 11.8% | 0 | 0.0% | 0 | 0.0% | |
| | Basilar tip | 2 | 5.9% | 0 | 0.0% | 0 | 0.0% | |
| | ICA | 5 | 14.7% | 2 | 12.5% | 0 | 0.0% | |
| | MCA | 11 | 32.4% | 0 | 0.0% | 0 | 0.0% | |
| | Multiple (2 or >2) | 2 | 5.9% | 0 | 0.0% | 0 | 0.0% | |
| | P.com | 3 | 8.8% | 7 | 43.8% | 0 | 0.0% | |
| | Posterior circulation | 4 | 11.8% | 0 | 0.0% | 0 | 0.0% | |
| Diabetes | Yes | 4 | 11.8% | 3 | 18.8% | 0 | 0.0% | 0.52 |
| | No | 30 | 88.2% | 13 | 81.2% | 5 | 100.0% | |
| Hypertension | Yes | 30 | 88.2% | 14 | 87.5% | 5 | 100.0% | 0.71 |
| | No | 4 | 11.8% | 2 | 12.5% | 0 | 0.0% | |
| Glasgow Outcome Score | 1 (Death) | 2 | 5.9% | 0 | 0.0% | 2 | 40.0% | 0.01 |
| | 2 (persistent vegetative state) | 5 | 14.7% | 2 | 12.5% | 3 | 60.0% | |
| | 3 (severe disability) | 12 | 35.3% | 6 | 37.5% | 0 | 0.0% | |
| | 4(moderate disability) | 5 | 14.7% | 5 | 31.2% | 0 | 0.0% | |
| | 5 (Good recovery) | 10 | 29.4% | 3 | 18.8% | 0 | 0.0% | |

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## DISCUSSION

The demographic findings of our study align with broader trends observed in the literature. The mean age of 55.18 years is consistent with other studies, such as Chaovarin et al., who reported a mean age of 56 years in their SAH cohort (13). Hannon et al. documented a median age of 53 years (14). The female predominance (60.0%) in our study mirrors the gender distribution reported by Chaovarin et al., where females accounted for 66% (13). Saramma et al in their research documented an almost equal split of male and female patients (15). This consistency across studies suggests that SAH and its complications, including hyponatremia, may disproportionately affect middle-aged and older females, possibly due to hormonal or anatomical factors influencing aneurysm formation and electrolyte regulation.

The distribution of aneurysm locations in our study, particularly the high prevalence of A.com aneurysms (27.3%), echoes findings from Chaovarin et al., who identified anterior circulation aneurysms as notable risk factors for hyponatremia. Their study reported that ACA aneurysms were associated with a fourfold increased risk of hyponatremia, which parallels our observation that A.com aneurysms were overrepresented in severe hyponatremia cases (100.0%).[13] This anatomical correlation may stem from the proximity of these aneurysms to the hypothalamus and pituitary gland structures critical for fluid and electrolyte homeostasis. Marupudi et al also highlighted the role of hypothalamic-pituitary dysfunction in hyponatremia pathogenesis, further supporting the potential link between aneurysm location and electrolyte imbalances (16). Hyponatremia severity in our study was stratified into mild, moderate, and severe categories, with mild cases being the most common (61.8%). This distribution is comparable to the findings of Hannon et al. (2014), where 71.4% of hyponatremia cases were attributed to SIADH, often presenting as mild to moderate hyponatremia (14). However, our study uniquely identified a notable association between severe hyponatremia (<125 mmol/L) and poor clinical outcomes, including higher mortality (40.0%) and persistent vegetative state (60.0%). This contrasts with Chaovarin et al. (2024), who reported that mild hyponatremia did not notably impact outcomes, suggesting that the severity of sodium imbalance may be a critical determinant of prognosis.[13] The discrepancy underscores the need for early detection and aggressive management of severe hyponatremia to mitigate adverse outcomes.

The Glasgow Outcome Score (GOS) results revealed that 23.6% of participants achieved good recovery, while 32.7% experienced severe disability. These figures are somewhat more favorable than those reported by Saramma et al., where 22.7% of hyponatremic patients had poor outcomes, including severe disability or death (15). The difference may reflect variations in sample size or management protocols. Notably, our study found that severe hyponatremia was strongly linked with worse GOS scores, reinforcing the importance of electrolyte monitoring in SAH patients.

In the light of these findings, we recommend prioritizing early and frequent electrolyte monitoring in SAH patients, particularly those with A.com aneurysms or severe presentations. Future research should explore the mechanisms linking specific aneurysm locations to hyponatremia and investigate targeted therapies to prevent or mitigate electrolyte imbalances.

## CONCLUSION

In conclusion, this study found a substantial prevalence of hyponatremia in patients with aneurysmal subarachnoid hemorrhage, and a notable association between severe hyponatremia and poor clinical outcomes in aSAH patients was noted. Early electrolyte monitoring and targeted interventions should be prioritized to mitigate adverse effects.

## DECLARATIONS

**Data Availability Statement**
All data generated or analysed during the study are included in the manuscript.

**Ethics approval and consent to participate**
Approved by the department Concerned. (IRB)

**Consent for publication**
Approved

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Not applicable

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTION

***ZIA-UR-REHMAN (Assistant Professor)***
*Conception of Study, Development of Research Methodology Design, Data Collection, Data Analysis, Review of manuscript, Manuscript Drafting, and Final Approval of Manuscript.*
***BASHIR ULLAH (Postgraduate Resident)***
*Critical Input, Review of Literature.*
***MUHAMMAD AAMIR (Postgraduate Resident)***
*Critical Input, Review of Literature.*

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