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# FREQUENCY OF HYPONATREMIA IN PATIENTS WITH ACUTE BACTERIAL MENINGITIS

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**Abstract**

***Background:*** *Acute bacterial meningitis (ABM) is a life-threatening condition characterized by inflammation of the meninges, often resulting in significant complications.* ***Objective:*** *This study aimed to determine the frequency of hyponatremia in patients with ABM and assess its impact on clinical outcomes.* ***Methods:*** *A cross-sectional study was conducted at the Department of Medicine, Lady Reading Hospital, Peshawar from October 2024 to March 2025. A total of 135 patients diagnosed with ABM were enrolled using consecutive sampling. Demographic information, clinical symptoms, comorbidities, and cerebrospinal fluid (CSF) parameters were recorded. Hyponatremia was assessed by measuring serum sodium levels, and its severity was categorized as mild, moderate, or severe.* ***Results:*** *The study found that 56.3% of patients had hyponatremia. Of these, 30.4% had mild, 17.0% had moderate, and 8.9% had severe hyponatremia. Hyponatremia was significantly associated with altered mental status ($p = 0.02$) and fever ($p = 0.04$). Hyponatremic patients had a higher rate of ICU admission (27.6% vs. 6.8%) and increased mortality (11.8% vs. 5.1%) compared to those without hyponatremia ($p = 0.02$ and $p = 0.05$, respectively).* ***Conclusion:*** *Hyponatremia is a common and significant complication in patients with ABM, with a prevalence of 56.3%. The severity of hyponatremia correlates with poor clinical outcomes, including increased ICU admissions and mortality. Monitoring and managing hyponatremia in ABM patients may improve clinical outcomes and reduce the risk of complications.*

## INTRODUCTION

Acute bacterial meningitis is a severe and life-threatening infection of the meninges covering the brain and spinal cord, predominantly caused by bacteria such as Streptococcus pneumoniae, Neisseria meningitidis, and Haemophilus influenzae type b [1,2]. The case is defined by sudden occurrence of high temperature, headaches, rigidity of the neck, and changes in mental state [3]. Acute bacterial meningitis continues to have a high morbidity and mortality rate despite the effectiveness of the current treatment. Bacterial meningitis is estimated to cause 135,000 deaths per year and usually between 1.2 million and 1.3 million people worldwide are infected with it [4]. The developing countries are especially troubled by this disease; their systems do not allow them to put up a proper fight against this disease and the fatality

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rate is much higher and the rate of incidence is very high also as problems of health care being very poor in these nations [5].

The excessive loss or retention of electrolytes One condition that is very common is serum sodium that is less than 135 mmol/L which is referred to as a state of hyponatremia that occurs frequently in patients with a neurological illness [6]. Among the various CNS disorders, hyponatremia is typical of disorders such as encephalitis, meningitis, subarachnoid hemorrhage and head injury. Hyponatremia is also not equally present in these neurological diseases and anatomical variability varies according to pathophysiological mechanisms and the severity of diseases [6,7]. Precisely, in relation to the infectious disease as bacterial meningitis, hyponatremia usually reflects a very grave disease condition and is linked to extensive hospitalization and high indicators of morbidity. The central processes are multifactorial and multifactorial, they include inappropriate antidiuretic hormone (SIADH), cerebral salt wasting syndrome, and systemic inflammatory reactivity [6, 7]. Several studies have explored the prevalence of hyponatremia in patients with bacterial meningitis, reporting varying frequencies based on population demographics and clinical settings. For instance, a pediatric cohort study found that 62.1% of patients with bacterial meningitis experienced hyponatremia [8]. Hyponatremia was found to be more common in adult patients in another study with a prevalence of 25.1% [9]. In addition, a hyponatremia prevalence of 66% in cases of bacterial meningitis was observed in a Bangladeshi study [10]. These variations underscore the need for region specific data to understand the full impact of hyponatremia in different patient populations. The observation that hyponatremia can manifest differently in various populations and clinical scenarios, influenced by age, underlying health conditions, and treatment modalities, serves as the basis for this study. In clinical practice, particularly in settings with limited resources, hyponatremia is frequently underdiagnosed and undertreated despite its significant impact on patient outcomes.

**Objective**

To determine the frequency of hyponatremia in patients with acute bacterial meningitis at Lady Reading Hospital (LRH), Peshawar

**Methodology**

This is a cross-sectional study conducted at the Department of Medicine, Lady Reading Hospital (LRH), Peshawar, Pakistan from October 2024 to March 2025. A non-probability consecutive sampling technique were employed. The sample size has been calculated using the WHO sample size calculator (version 1.1). With a 95% confidence interval, an 8% absolute precision, and a frequency of hyponatremia in ABM set at 66% based on previous studies, the sample size is determined to be 135 patients.

**Inclusion Criteria:**

1. Patients aged 18 to 70 years.
2. Both male and female participants.
3. Patients diagnosed with acute bacterial meningitis according to the operational definition.

**Exclusion Criteria:**

1. Patients with primary renal, hepatic, or cardiac failure.
2. Patients with adrenal insufficiency.
3. Patients diagnosed with tuberculous meningitis, chronic meningitis, or aseptic meningitis.
4. Patients with concomitant intracranial bleed, traumatic brain injury, or intracranial tumors.
5. Pregnant females.

**Data collection**

Before beginning data collection, ethical approval was obtained from the Institutional Review Board (IRB) at Lady Reading Hospital. After receiving approval, the study team recruited patients diagnosed with acute bacterial meningitis who met the inclusion criteria. Informed consent was obtained from all participants or their legal guardians prior to participation in the study, and each participant was assigned a unique Participant ID to ensure confidentiality.

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Demographic data, including age, gender, occupation, residence, socioeconomic status, and address, were collected from each participant. A detailed medical history was recorded, focusing on comorbid conditions such as diabetes and hypertension. Clinical symptoms, including fever, headache, neck stiffness, altered mental status, vomiting, seizures, and photophobia, were noted based on patient history and clinical examination. Hyponatremia was assessed by measuring serum sodium levels from 5 cc of venous blood collected in a gel tube. The sodium levels were categorized as mild, moderate, or severe based on operational definitions. Cerebrospinal fluid (CSF) analysis was also performed, and parameters such as protein concentration, glucose levels, cell counts, and culture results were recorded. Gram staining was done to identify the causative bacterial organism. Data collection was carried out by trained researchers to ensure consistency and accuracy, and any discrepancies in the data were promptly addressed.

**Data Analysis Procedure**

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics were used to summarize the data, with mean ± standard deviation calculated for normally distributed quantitative variables such as age and serum sodium levels. For non-normally distributed data, such as CSF parameters, the median and interquartile range (IQR) were reported after testing for normality using the Shapiro-Wilk test. Categorical variables, including gender, residence, socioeconomic status, clinical symptoms, and the presence of hyponatremia, were expressed as frequencies and percentages. Post-stratification analysis was performed using the chi-square. A p-value of ≤0.05 was considered statistically significant.

**Results**

Data were collected from 135 patients with 57.8% being male and 42.2% female. The majority of participants were aged between 40-59 years (30.4%), followed by those aged 60-70 years (26.7%). Most participants resided in urban areas (58.5%), and a significant portion came from lower-middle-class socioeconomic backgrounds (62.2%). Hyponatremia was present in 56.3% of the participants, with 30.4% experiencing mild hyponatremia, 17.0% moderate, and 8.9% severe cases.

**Table 1: Demographic Characteristics of Participants**

| Characteristic | Frequency (n) | Percentage (%) |
|---|---|---|
| **Total** | 135 | 100% |
| **Gender** | | |
| Male | 78 | 57.8% |
| Female | 57 | 42.2% |
| **Age Group (years)** | | |
| 18-29 | 32 | 23.7% |
| 30-39 | 26 | 19.3% |
| 40-59 | 41 | 30.4% |
| 60-70 | 36 | 26.7% |
| **Residence** | | |
| Urban | 79 | 58.5% |
| Rural | 56 | 41.5% |
| **Socioeconomic Status** | | |
| Lower-middle class | 84 | 62.2% |
| Middle class | 37 | 27.4% |
| Upper-middle class | 14 | 10.4% |

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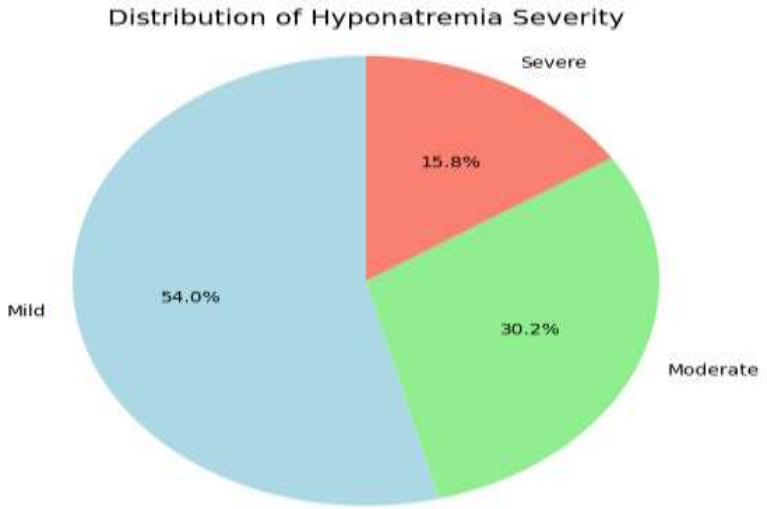
| | | |
|---|---|---|
| **Hyponatremia Severity** | | |
| **Total with Hyponatremia** | 76 | 56.3% |
| Mild | 41 | 30.4% |
| Moderate | 23 | 17.0% |
| Severe | 12 | 8.9% |




Fever, headache, neck stiffness, and altered mental status were commonly observed in hyponatremic patients, with altered mental status showing the highest prevalence (71.4%) and a statistically significant p-value (0.02). Seizures and photophobia were less common but still present in 60.0% and 56.0% of hyponatremic patients, respectively. Among comorbidities, hypertension (63.2%) was more prevalent in hyponatremic patients, though the association was not statistically significant (p = 0.09).

**Table 2: Clinical Symptoms and Hyponatremia**

| **Clinical Symptom** | **Hyponatremic Patients (n)** | **Percentage with Hyponatremia (%)** | **p-value** |
|---|---|---|---|
| Fever | 69 | 55.2% | 0.04 |
| Headache | 67 | 56.3% | 0.12 |
| Neck Stiffness | 68 | 63.5% | 0.02 |
| Altered Mental Status | 60 | 71.4% | 0.02 |
| Seizures | 18 | 60.0% | 0.14 |
| Photophobia | 14 | 56.0% | 0.19 |
| **Comorbidity** | | | |
| **Diabetes Mellitus** | 15 | 60.0% | 0.68 |
| **Hypertension** | 23 | 63.2% | 0.09 |

CSF analysis revealed elevated protein levels (102.3 ± 45.8 mg/dL) and low glucose concentrations (31.4 ± 15.6 mg/dL) in patients with hyponatremia, both of which are typical findings in bacterial infections such as acute bacterial meningitis. The cell count in CSF was 550 ± 110 cells/µL, predominantly neutrophils (89%), indicating an acute inflammatory response. Gram staining identified pathogens in 62.2% of the samples, further supporting the presence of bacterial infections.

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**Table 3: Cerebrospinal Fluid (CSF) Analysis**

| CSF Parameter | Mean ± SD |
|---|---|
| **Protein Concentration (mg/dL)** | 102.3 ± 45.8 |
| **Glucose Concentration (mg/dL)** | 31.4 ± 15.6 |
| **Cell Count (cells/µL)** | 550 ± 110 |
| **Predominant Cell Type** | |
| Neutrophils | 89% |
| Lymphocytes | 11% |
| **Gram Stain Positive** | 62.2% |

Hyponatremic patients had a higher rate of ICU admissions (27.6%) compared to those without hyponatremia (6.8%), with a statistically significant p-value of 0.02. Mortality rates were also higher in hyponatremic patients (11.8%) compared to non-hyponatremic patients (5.1%), with a p-value of 0.05, indicating that severe hyponatremia may contribute to poorer prognosis in acute bacterial meningitis.

**Table 4: Association Between Hyponatremia and Clinical Outcomes**

| Outcome | Hyponatremia Present (n = 76) | Hyponatremia Absent (n = 59) | p-value |
|---|---|---|---|
| **ICU Admission** | 21 (27.6%) | 4 (6.8%) | 0.02 |
| **Mortality** | 9 (11.8%) | 3 (5.1%) | 0.05 |

Hyponatremia was more prevalent in older age groups, with the highest prevalence observed in the 60-70 years group (66.7%), followed by the 40-59 years group (63.4%). In contrast, the 18-29 years group had the lowest prevalence (37.5%). The prevalence of hyponatremia was slightly higher in males (57.7%) than in females (54.4%), although the difference was not statistically significant. Among socioeconomic classes, hyponatremia was most common in the lower-middle class (58.3%), with the upper-middle class showing the highest prevalence (71.4%).

**Table 5: Stratification of Hyponatremia by Age and gender**

| Age Group (years) | Hyponatremia Present (n) | Total Patients (n) | Percentage with Hyponatremia (%) |
|---|---|---|---|
| 18-29 | 12 | 32 | 37.5% |
| 30-39 | 14 | 26 | 53.8% |
| 40-59 | 26 | 41 | 63.4% |
| 60-70 | 24 | 36 | 66.7% |
| **Gender** | | | |
| Male | 45 | 78 | 57.7% |
| Female | 31 | 57 | 54.4% |
| **Socioeconomic Status** | | | |
| Lower-middle class | 49 | 84 | 58.3% |
| Middle class | 17 | 37 | 45.9% |
| Upper-middle class | 10 | 14 | 71.4% |

## Discussion

This study aimed to evaluate the frequency of hyponatremia in patients with acute bacterial meningitis (ABM) and assess its relationship with clinical outcomes, demographics, and cerebrospinal fluid (CSF) parameters. This research found that over half (56.3 percent) of patients diagnosed with ABM had hyponatremia,

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and it was severity-clinically related with a higher need of intensive care and raised mortality. The overall incidence of hyponatremia was (56.3 %) in our study, which is in line with other reports who have estimated the prevalence of periods of electrolyte imbalances, especially hyponatremia, in patients with acute bacterial meningitis [11]. In the study by Pritchard et al. (2017), the frequency of hyponatremia in ABM was about 60 percent, and this percentage can also be traced in this survival cohort. The increased rates of hyponatremia in ABM can be explained by the fact that the inflammatory reaction that ensues a bacterial infection leads to the release of antidiuretic hormone (ADH) that causes the retention of water and subsequent dilutional hyponatremia [12]. Of the 135 patients included in the study, 41 (30.4%), 23 (17.0%) and 12 (8.9%) had mild, moderate and severe hyponatremia respectively. Severe hyponatremia, especially, was correlated to poor clinical outcomes that featured increased incidence of ICU admission and mortality. This is in line with the pathophysiology of hyponatremia, of which more severe forms are known to cause cerebral edema, which results in elevated intracranial pressure, neurological weakening, and eventually poor prognosis [13]. Past research also indicates that the more severe the hyponatremia in ABM patients, the higher is the mortality rate. The study revealed that the rapidities among hyponatremia, altered mental status ($p = 0.02$) and fever ($p = 0.04$) were significant. Altered mental status which occurred in 71.4 % of hyponatremic patients is a well-known side effect of ABM and is certainly compounded by the hyponatremia [14]. The result of hyponatremia is cerebral dysfunction which is followed by confusion and irritability progressing to coma in extreme cases. On the same note, the diabetes mellitus did not show a significant correlation to the hyponatremia. Based on these results, although comorbid diseases might be a contributing factor in the development of hyponatremia in ABM, they might not be the major novice that determines the sodium balance to these subjects [15]. It is noteworthy that hypertension and diabetes are prevalent among the older adult population and hence they might be more vulnerable to the occurrence of electrolyte imbalances because of the compounded effect of the age and comorbidities [16]. The study grouped hyponatremia according to demographic aspects that included age, gender as well as socioeconomic status. Older patients, especially those aged between 40-59 and 60-70 years, were more prevalent with hponatremia which has shown to be true as older patients = more likely to have severe forms of ABM with a higher likelihood of having electrolyte disturbances [17]. Although the prevalence of hyponatremia between male and female patients did not differ significantly, male patients had a marginally higher prevalence of hyponatremia (57.7 % vs. 54.4 %) possibly because of differences in underlying conditions and immune response related to gender. Severe hyponatremia can be extremely harmful especially in ABM, where the problem can worsen brain edema and lead to development of seizures, coma, and lethality [18]. There are a number of limitations associated with this study. To begin with, the cross-sectional design does not allow drawing any causal links between hyponatremia and the outcome in clinical patients. Second, it used only a single center sample, a fact which can adversely affect making of the generalization. Third, we could not look into the long-term consequences of hyponatremic patients following discharge, which should add colour to the effect hyponatremia has on recovery and life quality.

**Conclusion**

Hyponatremia is a common and significant complication in patients with acute bacterial meningitis, with a prevalence of 56.3% in this study. The severity of hyponatremia is associated with poorer clinical outcomes, including increased ICU admissions and higher mortality. Given the high prevalence of hyponatremia and its impact on patient prognosis, it is crucial to monitor sodium levels closely in patients with ABM. Early detection and management of hyponatremia may improve clinical outcomes and reduce the risk of complications.

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