ORIGINAL RESEARCH

Hyponatremia in Children Hospitalised with Community-acquired Pneumonia: A Prospective Observational Study

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ABSTRACT

Background: Community-acquired pneumonia (CAP) remains one of the leading causes of morbidity and mortality in children worldwide. Hyponatremia is a common electrolyte disturbance observed in children hospitalized with community-acquired pneumonia (CAP). This study aimed to assess the prevalence, severity, and clinical significance of hyponatremia in pediatric CAP patients and its association with disease outcomes.

Material and Methods: This prospective observational study was conducted in a tertiary care children's hospital and included 80 pediatric patients aged 1 month to 12 years, diagnosed with CAP. Patients with chronic illnesses affecting sodium balance were excluded. Serum sodium levels were measured at admission, and hyponatremia was classified as mild (130–134 mEq/L), moderate (125–129 mEq/L), or severe (<125 mEq/L). Demographic, clinical, and laboratory data were collected, including inflammatory markers and the need for oxygen therapy, ICU admission, hospital stay duration, and outcomes.

Results: Hyponatremia was present in 67 (83.8%) of the 80 patients, with mild hyponatremia in 35 (43.8%), moderate in 22 (27.5%), and severe in 10 (12.5%) cases. Hyponatremic patients had significantly higher rates of oxygen therapy (56.7% vs. 23.1%, p=0.02) and ICU admissions (22.4% vs. 7.7%, p=0.04) compared to normonatremic patients. The mean hospital stay was longer in hyponatremic patients (6.3 ± 2.1 days vs. 4.1 ± 1.2 days, p<0.01). Elevated inflammatory markers, including C-reactive protein, were significantly associated with hyponatremia (24.8 ± 6.3 mg/L vs. 12.5 ± 4.8 mg/L, p<0.01). Severe hyponatremia was associated with neurological symptoms (70.0%), and hypertonic saline therapy was required in 80.0% of these cases.

Conclusion: Hyponatremia is highly prevalent in pediatric CAP and is significantly associated with increased disease severity, prolonged hospitalization, and elevated inflammatory markers. Early recognition and appropriate management of hyponatremia are essential in improving clinical outcomes. Routine monitoring of sodium levels should be considered in hospitalized CAP patients to guide treatment strategies effectively.

Keywords: Hyponatremia, Community-acquired pneumonia, Pediatrics, Electrolyte imbalance, Disease severity

INTRODUCTION

Community-acquired pneumonia (CAP) remains one of the leading causes of morbidity and mortality in children worldwide. It is a significant public health concern, especially in developing countries, where access to medical care and early intervention may be limited. CAP is characterized by inflammation of the lung parenchyma due to infection by bacterial, viral, or atypical pathogens, often leading to respiratory distress, fever, cough, and systemic symptoms. The clinical severity of CAP varies from mild cases that can be managed on an outpatient basis to severe cases requiring hospitalization, intensive care, and advanced

respiratory support.[1]One of the less commonly discussed but clinically relevant complications of CAP is hyponatremia, a condition characterized by low serum sodium levels. Hyponatremia is a frequent electrolyte imbalance seen in hospitalized children with infections, particularly respiratory illnesses such as pneumonia. The presence of hyponatremia in children with CAP may contribute to disease severity and influence the clinical course and outcomes. Despite being a well-recognized phenomenon, the exact mechanisms, implications, and management strategies for hyponatremia in CAP remain areas of active research and clinical interest.[2]Hyponatremia is defined as a serum sodium concentration of less than 135 mEq/L. It can be classified into mild (130–134 mEq/L), moderate (125–129 mEq/L), and severe (<125 mEq/L) categories based on the degree of sodium reduction. The condition is further categorized based on serum osmolality into hypotonic, isotonic, and hypertonic hyponatremia, with hypotonic hyponatremia being the most clinically relevant. Within hypotonic hyponatremia, volume status plays a crucial role in determining the underlying cause, leading to further sub-classification into hypovolemic, euvolemic, and hypervolemic hyponatremia.[3]In the context of CAP, euvolemichyponatremia is the most frequently encountered type. It is often linked to the inappropriate release of antidiuretic hormone (ADH), leading to water retention and dilutional sodium loss. This condition, known as the syndrome of inappropriate antidiuretic hormone secretion (SIADH), is commonly associated with pulmonary infections, including pneumonia. Other contributing factors include inflammation-induced alterations in sodium homeostasis, increased renal sodium excretion, and reduced oral intake during illness.The development of hyponatremia in CAP is multifactorial and complex. One of the primary mechanisms involves the excessive release of antidiuretic hormone (ADH), which promotes water retention and dilution of sodium levels. Infections, including pneumonia, can trigger the non-osmotic release of ADH due to cytokine-mediated inflammatory responses. Increased ADH levels cause water retention in the kidneys, leading to dilutional hyponatremia.[4]Another proposed mechanism involves the inflammatory response associated with pneumonia. Inflammatory mediators such as interleukins and tumor necrosis factor (TNF) can influence renal sodium handling, leading to increased urinary sodium excretion and further exacerbation of hyponatremia. Additionally, fever and increased insensible losses from tachypnea and sweating may contribute to sodium and water imbalance in affected children.Gastrointestinal losses, commonly seen in pneumonia due to vomiting and diarrhea, can also lead to hypovolemic hyponatremia. Reduced oral intake during illness, coupled with increased fluid administration, can further disrupt sodium balance, especially if hypotonic fluids are used for intravenous hydration. These factors collectively contribute to the high prevalence of hyponatremia in children hospitalized with CAP.[5]Hyponatremia in CAP is not merely a laboratory abnormality; it has been associated with more severe disease presentations and worse clinical outcomes. The presence of hyponatremia in children with CAP may indicate a more intense inflammatory response and a higher burden of disease. Studies have shown that lower serum sodium levels correlate with an increased need for oxygen therapy, prolonged hospital stays, and a higher likelihood of requiring intensive care admission.In severe cases, hyponatremia can lead to neurological complications such as seizures, altered mental status, and coma. These manifestations occur due to cerebral edema resulting from osmotic shifts, particularly when sodium levels drop rapidly. Children with severe pneumonia complicated by hyponatremia may also be at a higher risk of developing respiratory failure and multi-organ dysfunction. Early recognition and appropriate management of hyponatremia are therefore crucial in optimizing outcomes in pediatric CAP.[6]The diagnosis of hyponatremia in hospitalized children with CAP requires routine measurement of serum sodium levels. In addition to serum sodium concentration, assessment of serum osmolality, urine sodium, and urine osmolality may provide insights into the underlying cause of hyponatremia. A thorough clinical evaluation, including assessment of volume status, is essential in distinguishing between different types of hyponatremia.In cases of euvolemichyponatremia, the presence of inappropriately high urine osmolality and urine sodium levels despite low serum sodium suggests SIADH. Hypovolemic hyponatremia, on the other hand, is characterized by low urine sodium levels and signs of dehydration, such as dry mucous membranes and hypotension. Hypervolemichyponatremia, though less common in CAP, can occur in children with

underlying cardiac or renal disease and is associated with fluid overload.[7]

AIM& OBJECTIVES: Hyponatremia is a common electrolyte disturbance observed in children hospitalized with community-acquired pneumonia (CAP). This study aimed to assess the prevalence, severity, and clinical significance of hyponatremia in pediatric CAP patients and its association with disease outcomes.

MATERIAL AND METHODS

Study Design: The current study was prospective observational cross-sectionalstudy.

Study place: This study was conducted at Department of Pediatrics, Major S.D. Singh Medical College & Hospital, Farrukhabad, Uttar Pradesh, India in collaboration with Department of Radiology, Saraswathi Institute of Medical Sciences, Hapur, Uttar Pradesh, India**.**

Study period: The study was carried out from September 2019 to January 2021.

Ethical consideration: The study was approved by the research and ethical committee of the Institute.

Study Population: A total of 80 pediatric patients aged 1 month to 12 years diagnosed with CAP. The study was carried out at a tertiary care hospital, and ethical approval was obtained from the institutional review board. Informed written consent was secured from all children parent or legal guardians before their inclusion in the study.

Inclusion Criteria:

- Children aged 1 month to 12 years.
- Clinical signs and symptoms consistent with pneumonia (e.g., fever, cough, tachypnea).
- Radiological evidence supporting the diagnosis of pneumonia.

Exclusion Criteria:

- Children with pre-existing conditions affecting sodium balance, such as:
  - Renal diseases (e.g., nephrotic syndrome, acute kidney injury).
  - Hepatic diseases.
  - Neurological disorders.
- Patients with concurrent acute gastroenteritis or diarrhea.
- Children on medications influencing sodium homeostasis.
- Cases of nosocomial or aspiration pneumonia.

Data Collection:

- **Clinical Assessment:** Detailed history and physical examination focusing on symptoms like fever, cough, and respiratory distress.
- **Laboratory Investigations:**
  - Serum sodium levels measured at admission using an automated analyzerandhyponatremia was defined as a serum sodium concentration of less than 135 mEq/L. Based on severity, hyponatremia was classified as mild (130–134 mEq/L), moderate (125–129 mEq/L), and severe (<125 mEq/L).
  - Other laboratory parameters, including complete blood counts, serum electrolytes, and inflammatory markers such as C-reactive protein (CRP), were recorded.
  - Other relevant tests to assess the severity of pneumonia and identify potential complications.
- **Radiological Evaluation:** Chest radiographs to confirm pneumonia diagnosis and assess its extent.

STATISTICAL ANALYSIS

- Statistical analysis was performed using SPSS software and Microsoft excel.
- Continuous variables were expressed as mean ± standard deviation or median with interquartile range, while categorical variables were represented as frequencies and percentages.
- Data were analyzed using appropriate statistical methods to determine the prevalence of hyponatremia among the study population.
- Comparative analyses were conducted to assess the relationship between hyponatremia and variables such as:
  - Severity of pneumonia.
  - Duration of hospital stay.
  - Patient outcomes.
- Significance levels were set at $p<0.05$ to determine statistical differences.

Detailed demographic, clinical, and laboratory data were collected at the time of admission. All patients received standard treatment for CAP according to institutional guidelines, including appropriate antibiotic therapy and supportive care. Fluid management was individualized based on the patient's hydration status and sodium levels. Patients with moderate to severe hyponatremia were closely monitored for neurological symptoms, and sodium correction was done as per standard protocols. The clinical course and response to treatment were observed until discharge.

RESULTS

The study included a total of 80 pediatric patients diagnosed with community-acquired pneumonia (CAP), as shown in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	Value
Total Patients	80
Mean Age (years)	4.8 ± 3.2
Male (%)	52 (65%)
Female (%)	28 (35%)
Mean Weight (kg)	15.2 ± 4.6
Mean Duration of Symptoms (days)	5.1 ± 2.3

Table 1 shows that the mean age of the study population was 4.8 ± 3.2 years, with a male predominance (65%, n=52), while females accounted for 35% (n=28) of the cases. The mean weight of the children was 15.2 ± 4.6 kg, reflecting a diverse representation of different age groups. The mean duration of symptoms before hospitalization was 5.1 ± 2.3 days, indicating a variable delay in seeking medical attention.

Table 2: Distribution of Hyponatremia Severity Among Patients

Severity of Hyponatremia	Number of Patients (%)
Mild (130-134 mEq/L)	35 (43.8%)
Moderate (125-129 mEq/L)	22 (27.5%)
Severe (<125 mEq/L)	10 (12.5%)
Normal Sodium Levels (≥135 mEq/L)	13 (16.2%)

Hyponatremia was a common finding among the patients, as demonstrated in Table 2. Out of 80 patients, 67 (83.8%) had hyponatremia, while only 13 (16.2%) had normal sodium levels (≥135 mEq/L). Among those with hyponatremia, mild hyponatremia (130-134 mEq/L) was the most common, affecting 35 patients (43.8%). Moderate hyponatremia(125-129 mEq/L) was present in 22 children (27.5%), while severe hyponatremia (<125 mEq/L) was seen in 10 cases (12.5%). This high prevalence of hyponatremia among hospitalized CAP patients suggests a strong association between pneumonia and sodium disturbances.

Table 3: Association BetweenHyponatremia and Clinical Outcomes

Outcome	Normal Sodium (≥135 mEq/L) (n=13)	Hyponatremia (<135 mEq/L) (n=67)	p-value
Need for Oxygen Therapy	3 (23.1%)	38 (56.7%)	0.02
ICU Admission	1 (7.7%)	15 (22.4%)	0.04
Mean Hospital Stay (days)	4.1 ± 1.2	6.3 ± 2.1	<0.01
Mortality	0 (0%)	2 (3.0%)	0.15

The association between hyponatremia and clinical outcomes is detailed in Table 3 Figure I. Patients with hyponatremia had significantly higher rates of oxygen therapy requirement (56.7%) compared to those with normal sodium levels (23.1%) (p=0.02). Similarly, ICU admissions were more frequent among hyponatremic patients (22.4%) than in those with normal sodium levels (7.7%) (p=0.04), indicating that lower sodium levels were linked to more severe disease presentations. The mean hospital stay was also significantly prolonged in patients with hyponatremia (6.3 ± 2.1 days) compared to those with normal sodium levels (4.1 ± 1.2 days) (p<0.01). Although mortality was slightly higher in the hyponatremia group (3.0%) compared to those with normal sodium (0%), the difference was not statistically significant (p=0.15).

Figure I: Association between hyp[onatremia and clinical outcomes

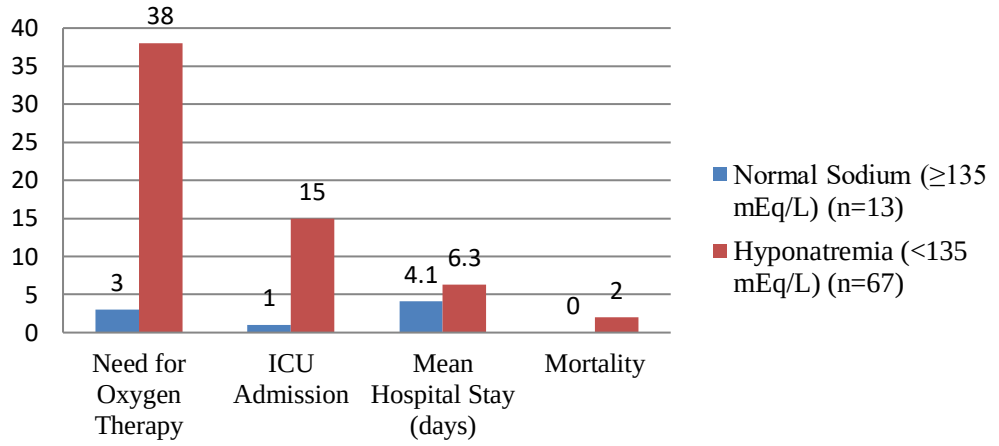

Table 4: Laboratory Findings in Patients With and Without Hyponatremia

Laboratory Parameter	Normal Sodium (≥135 mEq/L) (n=13)	Hyponatremia (<135 mEq/L) (n=67)	p-value
Mean Serum Sodium (mEq/L)	137.2 ± 1.1	129.6 ± 3.5	<0.01
Mean CRP (mg/L)	12.5 ± 4.8	24.8 ± 6.3	<0.01
Mean Hemoglobin (g/dL)	11.8 ± 1.5	10.9 ± 1.2	0.03
Mean WBC count ($x10^9$/L)	8.6 ± 2.1	11.3 ± 3.4	0.02

Table 4 presents key laboratory findings in patients with and without hyponatremia. As expected, the mean serum sodium level was significantly lower in hyponatremic patients (129.6 ± 3.5 mEq/L) compared to those with normal sodium (137.2 ± 1.1 mEq/L) ($p<0.01$). Inflammatory markers were notably elevated in hyponatremic patients, with a significantly higher mean C-reactive protein (CRP) level (24.8 ± 6.3 mg/L) compared to those with normal sodium levels (12.5 ± 4.8 mg/L) ($p<0.01$). This finding suggests that inflammation and cytokine release may play a role in the development of hyponatremia. The mean hemoglobin level was lower in the hyponatremia group (10.9 ± 1.2 g/dL) compared to the normal sodium group (11.8 ± 1.5 g/dL) ($p=0.03$), indicating a possible link between hyponatremia and anemia. Similarly, white blood cell (WBC) counts were higher in the hyponatremic group (11.3 ± 3.4 $\times 10^9$/L) compared to those with normal sodium levels (8.6 ± 2.1 $\times 10^9$/L) ($p=0.02$), further reinforcing the association between severe inflammation and hyponatremia.

Table 5: Response to Sodium Correction in Hyponatremic Patients

Severity of Hyponatremia	Mean Time to Sodium Normalization (days)	Need for Hypertonic Saline (%)	Neurological Symptoms Present (%)
Mild	1.8 ± 0.6	0 (0%)	0 (0%)
Moderate	3.2 ± 1.1	4 (18.2%)	3 (13.6%)
Severe	5.1 ± 2.0	8 (80.0%)	7 (70.0%)

The response to sodium correction in hyponatremic patients is outlined in Table 5. The mean time to sodium normalization varied based on the severity of hyponatremia. Patients with

mild hyponatremia recovered fastest, with a mean correction time of 1.8 ± 0.6 days, while those with moderate and severe hyponatremia took longer (3.2 ± 1.1 days and 5.1 ± 2.0 days, respectively). The need for hypertonic saline therapy was markedly higher in patients with severe hyponatremia (80.0%) compared to those with moderate hyponatremia (18.2%), while no patients with mild hyponatremia required hypertonic saline. Neurological symptoms such as altered mental status, seizures, and lethargy were significantly more common in children with severe hyponatremia (70.0%), whereas they were present in only 13.6% of those with moderate hyponatremia and absent in cases of mild hyponatremia.

DISCUSSION

Hyponatremia (HN) is a frequent electrolyte disturbance observed in pediatric patients with community-acquired pneumonia (CAP). In our study, we found a notably high prevalence of HN, with 83.8% of the 80 children exhibiting serum sodium levels below 135 mEq/L. This prevalence is higher than that reported in earlier studies. For instance, Don et al. (2008) identified HN in 45.4% of children with CAP, with 92% of these cases being mild (serum sodium >130 mEq/L).[8]Similarly, a study by Kaneko et al. (2009) reported that HN was common but usually mild in children with CAP. The higher prevalence in our cohort may be attributed to differences in study design, patient demographics, or criteria for hospitalization.[9]

Our findings also indicate a significant association between HN and markers of disease severity. Patients with HN had higher rates of oxygen therapy requirement (56.7% vs. 23.1%, p=0.02) and intensive care unit admissions (22.4% vs. 7.7%, p=0.04) compared to normonatremic patients. These observations align with the results of Don et al. (2008), who found that hyponatremic patients had higher body temperature, white blood cell count, neutrophil percentage, and serum C-reactive protein levels compared to normonatremic patients.[8] Another study by Singhi et al. (1992) also demonstrated a strong association between hyponatremia and the severity of lower respiratory tract infections, with a significantly higher incidence of complications in hyponatremic patients.[10]

The pathophysiology underlying HN in CAP is not fully understood, but it is believed to be multifactorial. One proposed mechanism is the syndrome of inappropriate antidiuretic hormone secretion (SIADH). However, recent studies suggest that true SIADH is relatively rare in this context. A study by Kaneko et al. (2009) concluded that HN in children with respiratory infections rarely indicates SIADH. Instead, HN in CAP may be more closely related to the severity of the inflammatory response.[9] Our study supports this notion, as we observed significantly higher levels of inflammatory markers, such as C-reactive protein, in hyponatremic patients compared to those with normal sodium levels (24.8 ± 6.3 mg/L vs. 12.5 ± 4.8 mg/L, p<0.01). These findings are in agreement with those of Nair et al. (2006), who also reported increased inflammatory markers in pediatric patients with pneumonia-associated hyponatremia.[11]

In terms of laboratory findings, our study revealed that hyponatremic patients had lower mean hemoglobin levels and higher white blood cell counts compared to normonatremicpatients. These results are consistent with those of Don et al. (2008), who reported higher white blood cell counts and neutrophil percentages in hyponatremic children with CAP.[8]

Thesehematological changes may reflect a more pronounced inflammatory response in hyponatremic patients. Similarly, Singhi et al. (1992) reported that children with severe respiratory infections and hyponatremia had a significantly higher leukocyte count and lower hemoglobin levels, supporting our findings.[10]

Regarding the management of HN in pediatric CAP, our study found that the need for hypertonic saline therapy was markedly higher in patients with severe HN (80.0%) compared to those with moderate HN (18.2%), while no patients with mild HN required hypertonic saline. This finding underscores the importance of assessing the severity of HN to guide appropriate treatment strategies. Consistent with our findings, Hanna et al. (2003) observed that severe hyponatremia required more aggressive management, including hypertonic saline therapy, and was associated with an increased risk of neurological complications such as seizures and altered consciousness.[12]

Our results also showed that neurological symptoms were significantly more common in children with severe hyponatremia (70.0%), whereas they were present in only 13.6% of those with moderate hyponatremia and absent in cases of mild hyponatremia. These findings align with those of Nair et al. (2006), who reported that the severity of hyponatremia correlated with

an increased risk of neurological complications in hospitalized children.[11]

LIMITATIONS OF THE STUDY

- Small Sample Size
- Short Follow-Up Duration

CONCLUSION

This study highlights the high prevalence of hyponatremia in children hospitalized with community-acquired pneumonia and its significant association with disease severity. Hyponatremia was linked to increased oxygen therapy requirements, longer hospital stays, and higher ICU admissions, emphasizing its role as a potential marker of severe infection. Elevated inflammatory markers and altered electrolyte levels suggest an inflammatory-driven mechanism contributing to sodium imbalance. Early recognition and appropriate management of hyponatremia are crucial in improving clinical outcomes in pediatric CAP. Routine monitoring of serum sodium levels should be considered in hospitalized children with CAP to guide optimal treatment strategies.

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