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Research Article

Evaluation of Serum Sodium Status as a Predictor of Disease Severity and Clinical Outcomes in Children with Acute Bronchiolitis Admitted To Tertiary Care Unit

Dr. Pramod Padasalimani[1*], Dr. Savitri Honakeri[2], Dr. Girish Hiremath[3]
[1*]Senior Resident, Department of Pediatrics, Koppal Institute of Medical Sciences (KIMS), Koppal, Karnataka, India.
[2]Assistant Professor, Department of Pediatric Surgery, Karnataka Institute of Medical Sciences (KMCRI), Hubballi, Karnataka, India.
[3]Associate professor, Department of Pediatrics, Koppal Institute of Medical Sciences (KIMS), Koppal, Karnataka, India.
Corresponding Author: Dr. Pramod Padasalimani
Senior resident, Department of Pediatrics, Koppal Institute of Medical Sciences (KIMS), Koppal, Karnataka, India.
Email: pramodpadasali@gmail.com
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ABSTRACT
Background & Objective: Acute bronchiolitis is the predominant cause of lower respiratory tract infections (LRTIs) and pediatric intensive care unit (PICU) admissions among infants worldwide. Hyponatremia (serum sodium <135mEq/L) is a frequent electrolyte imbalance in acute respiratory conditions, typically driven by non-osmotic release of arginine vasopressin (AVP) or dilutional fluid shifts. This study evaluated the relationship between baseline serum sodium levels on admission and disease severity, duration of PICU stay, requirement for mechanical ventilation, and overall clinical outcomes among infants with acute bronchiolitis in a resource-limited tertiary care institution in Karnataka.
Materials & Methods: A prospective cohort study was conducted over a two-year period in the PICU of Koppal Institute of Medical Sciences (KIMS), Koppal. Sixty (N=60) children aged 2 months to 2 years with a clinical diagnosis of acute bronchiolitis according to National Institute for Health and Care Excellence (NICE) guidelines were enrolled via convenience sampling. Serum sodium levels were determined within 18 hours of admission. Participants were stratified into two cohorts: Hyponatremic (<135 mEq/L) and Normonatremic (135-145mEq/L). Outcome parameters including oxygen support, mechanical ventilation, comorbid anemia, and length of stay in the PICU and hospital were recorded and analysed.
Results: Among the 60 infants evaluated, 21 (35.00%) presented with hyponatremia, whereas 39 (65.00%) were normonatremic. Hyponatremia was most frequent among infants aged under 6 months (57.14% of hyponatremic patients; 12/21). The overall male-to-female ratio was 1.9:1. Age distribution ($p = 0.834$), gender ($p > 0.05$), and gestational maturity ($p > 0.05$) showed no statistically significant differences between the two cohorts. Thirty-eight infants (63.33%) required a PICU stay of <2 days, 19 (31.67%) stayed 2–4 days, and 3 (5.00%) stayed >4 days, showing no significant association with sodium status on admission. High-Flow Nasal Cannula (HFNC) support and invasive mechanical ventilation were required in one patient each.
Conclusion: In this tertiary care setting, hyponatremia was a common finding in infants admitted with acute bronchiolitis—particularly among those under 6 months—but was not significantly associated with prolonged PICU stay, need for mechanical ventilation, or increased mortality. Baseline hyponatremia alone does not serve as an independent predictor of disease severity in acute bronchiolitis.

Keywords: Acute Bronchiolitis, Hyponatremia, Pediatric Intensive Care Unit, Respiratory Syncytial Virus, Resource-Limited Setting, Electrolyte Imbalance.

INTRODUCTION

Acute lower respiratory tract infections (LRTIs) represent a major source of childhood morbidity and hospitalization in developing nations. Children under five years of age experience an average of five acute

respiratory episodes annually, accounting for 30-50% of pediatric outpatient visits and 20-40% of hospital admissions. Among these conditions, acute bronchiolitis is the primary viral lower respiratory illness in infants under two years of age, characteristically peaking between two and six months of life. Respiratory Syncytial Virus (RSV) remains the principal causative pathogen, accounting for 30-70% of cases.

The classic clinical progression begins with upper respiratory manifestations rhinorrhea, sneezing, low-grade fever, and feeding difficulty followed within days by lower respiratory involvement characterized by tachypnea, intercostal retractions, and bilateral expiratory wheezing. Although the illness is self-limiting in most infants, approximately 1-3% require hospitalization, with 10-15% of hospitalized cases deteriorating into severe respiratory distress requiring care in the Pediatric Intensive Care Unit (PICU).

Electrolyte abnormalities, mainly hyponatremia (serum sodium <135mEq/L), are frequently recognized in critically ill children with pulmonary infections. In acute lower respiratory tract disease, non-osmotic stimuli including hypoxia, hypercapnia, systemic stress, nausea, and fluid administration trigger the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH), leading to impaired renal free-water excretion and dilutional hyponatremia. Severe hyponatremia can precipitate neurological complications including cerebral edema, altered consciousness, seizures, and increased risk of mortality.

While international literature from well-resourced tertiary centers offers conflicting evidence regarding the prognostic significance of hyponatremia in bronchiolitis, data from rural public healthcare institutions in India remain limited. Establishing whether serum sodium at admission correlates with disease severity is critical for risk stratification and resource allocation in settings where advanced diagnostic testing and invasive monitoring are constrained.

This study was conducted at Koppal Institute of Medical Sciences (KIMS), Koppal to evaluate serum sodium status on admission as a prognostic marker for severity and outcomes in infants admitted with acute bronchiolitis.

METHODOLOGY & STUDY DESIGN

Study Design and Setting

This prospective cohort study was conducted over a two-year period in the Pediatric Intensive Care Unit (PICU), Department of Pediatrics, Koppal Institute of Medical Sciences (KIMS College), Koppal, Informed written consent was obtained from the parents or legal guardians of all participating infants prior to enrollment after providing a detailed explanation in their native language.

Study Population and Eligibility

Sixty (N=60) children admitted to the PICU with a clinical diagnosis of acute bronchiolitis were enrolled sequentially using convenience sampling. The clinical diagnosis was established according to National Institute for Health and Care Excellence (NICE) guidelines (first episode of acute wheezing and/or fine inspiratory crackles in children <2 years of age preceded by viral upper respiratory symptoms).

Inclusion Criteria:

1. Children aged 2 months to 2 years admitted to the PICU with acute bronchiolitis based on NICE criteria.
2. Clinical evaluation and initial blood sampling completed within 18 hours of hospital admission.
3. Informed written consent from parents or legal guardians.

Exclusion Criteria:

1. Referral cases who received intravenous fluid resuscitation or prior medical management at outside facilities.
2. Hypernatremia on admission (serum sodium >145 mEq/L).
3. Pre-existing chronic comorbidities: Congenital heart disease, chronic lung disease, neuromuscular disease, or known immunodeficiencies.
4. Renal failure, primary gastrointestinal electrolyte losses (e.g., severe vomiting/diarrhea), or metabolic disorders.

Clinical & Laboratory Assessment

Baseline demographic data (age, sex, gestational age at birth, birth weight, seasonal trend) and clinical histories were collected using a pre-structured proforma. Within 18 hours of admission, a 3 mL venous blood sample was drawn under minimal stasis for serum electrolyte estimation (sodium and potassium) using an automated direct analyzer, alongside a complete blood count.

Based on initial serum sodium levels, participants were classified into two study

cohorts:

- **Hyponatremic Cohort:** Serum sodium <135mEq/L.
- **Normonatremic Cohort:** Serum sodium 135-145mEq/L.

Outcome Measures

Primary outcomes measured included:

1. Duration of PICU stay (<2 days, 2-4 days, >4 days).
2. Total length of hospital stay.
3. Respiratory support requirements (Supplemental oxygen, High-Flow Nasal Cannula [HFNC], Mechanical Ventilation).
4. Co-occurrence of anemia (hemoglobin <11g/dL).
5. In-hospital mortality.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS Version 25.0 Categorical variables are expressed as frequencies and percentages, and continuous variables as mean standard deviation (SD). Comparisons between categorical variables were performed using the Pearson Chi-Square test. Continuous outcome variables were evaluated using Analysis of Variance (ANOVA), with Wilcoxon-Mann-Whitney tests used for non-parametric distributions. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 60 infants meeting all eligibility criteria were included in the final analysis. Hyponatremia (serum sodium <135mEq/L) was identified on admission in 21 children (35.00%), while 39 children (65.00%) were normonatremic.

Baseline Demographics and Age Distribution

The study population comprised 26 infants (43.33%) under 6 months of age, 29 infants (48.33%) aged 6–12 months, and 5 infants (8.33%) aged >12 months. Hyponatremia occurred most frequently in the <6 months age bracket (12/21; 57.14%). There was no statistically significant difference in overall age distribution between the hyponatremic and normonatremic groups (p = 0.834).

Table 1: Age Distribution and Serum Sodium Status (N=60)

Age Category	Hyponatremia (<135mEq/L})	Normonatremia (135-145mEq/L})	Total (N)	Percentage (%)	p-value
< 6 months	12	14	26	43.33%	
6-12 months	7	22	29	48.33%	0.834
> 12 months	2	3	5	8.33%	
Total	21 (35.00%)	39 (65.00%)	60	100.00%	

Gender and Gestational Maturity Analysis

Male children predominated in the study, with an overall male-to-female ratio of 1.9:1. Among female patients (n=22), 8 were in the hyponatremic group (4 aged <6 months, 3 aged 6-12 months, 1 aged >12 months) and 14 in the normonatremic group (7 aged <6 months, 6 aged 6-12 months, 1 aged >12 months). Gender differences showed no statistical significance between the two groups (p = 0.120 for males, p = 0.906 for females).

Regarding gestational age, 2 out of 21 children in the hyponatremic cohort were born preterm, compared to 9 out of 39 in the normonatremic cohort. Gestational maturity was not significantly associated with the development of hyponatremia (p = 0.110 for hyponatremia, p = 0.566 for normonatremia).

Duration of PICU Stay

Overall, 38 patients (63.33%) required a PICU stay of less than 2 days, 19 patients (31.67%) stayed between 2 and 4 days, and 3 patients (5.00%) required PICU admission for more than 4 days.

In the hyponatremic cohort, 13 cases (61.90%) required a PICU stay <2 days, 7 cases (33.33%) stayed 2–4 days, and 1 case (4.76%) stayed >4 days. In the normonatremic cohort, 25 cases (64.10%) stayed <2 days, 12 cases (30.77%) stayed 2–4 days, and 2 cases (5.13%) stayed >4 days. No statistically significant difference in PICU length of stay was observed between the two cohorts across any age subgroup.

Table 2: Length of PICU Stay Stratified By Age and Serum Sodium Group

PICU Length of	Age Category	Hyponatremia	Normonatremia	Total (N=60)

Stay		(n=21)	(n=39)	
< 2 Days	< 6 months	9 (69.2%)	9 (36.0%)	18 (47.4%)
	6-12 months	3 (23.1%)	14 (56.0%)	17 (44.7%)
	> 12 months	1 (7.7%)	2 (8.0%)	3 (7.9%)
	Subtotal	13 (100.0%)	25 (100.0%)	38 (100.0%)
2-4 Days	< 6 months	3 (42.9%)	3 (25.0%)	6 (31.6%)
	6-12 months	3 (42.9%)	8 (66.7%)	11 (57.9%)
	> 12 months	1 (14.3%)	1 (8.3%)	2 (10.5%)
	Subtotal	7 (100.0%)	12 (100.0%)	19 (100.0%)
> 4 Days	< 6 months	0 (0.0%)	2 (100.0%)	2 (66.7%)
	6-12 months	1 (100.0%)	0 (0.0%)	1 (33.3%)
	> 12 months	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Subtotal	1 (100.0%)	2 (100.0%)	3 (100.0%)

Clinical Outcomes, Interventions, and Comorbidities

Advanced respiratory interventions were infrequently required in this population. High-Flow Nasal Cannula (HFNC) therapy was administered to 1 patient in the normonatremic group, and invasive mechanical ventilation was required for 1 patient in the hyponatremic group (ventilation duration: 22 hours).

Co-existing anemia (hemoglobin <11g/dL}) was identified in 14 children (66.67%) in the hyponatremic group (7 aged <6 months, 6 aged 6-12 months, 1 aged >12 months) and 30 children (76.92%) in the normonatremic group (11 aged <6 months, 17 aged 6-12 months, 2 aged >12 months). Anemia was concentrated primarily in infants under 1 year of age, but the intergroup difference was not statistically significant ($p > 0.05$).

Table 3: Clinical Outcomes, Interventions, and Comorbidities

Clinical Outcome / Variable	Hyponatremia (n=21)	Normonatremia (n=39)	Total (N=60)	p-value
Invasive Mechanical Ventilation	1 (4.76%)	0 (0.00%)	1 (1.67%)	> 0.05
High-Flow Nasal Cannula (HFNC)	0 (0.00%)	1 (2.56%)	1 (1.67%)	> 0.05
Co-existing Anemia (<11g/dL})	14 (66.67%)	30 (76.92%)	44 (73.33%)	> 0.05
In-hospital Mortality	0 (0.00%)	0 (0.00%)	0 (0.00%)	N/A

DISCUSSION

Acute bronchiolitis remains a primary reason for acute hospital admission among infants during early life. In regional tertiary settings like Koppal, managing viral lower respiratory tract disease involves addressing background nutritional deficits, delayed health-seeking behavior, and environmental exposure. Electrolyte abnormalities, particularly hyponatremia, are frequently documented during severe acute lower respiratory tract infections.

The prevalence of hyponatremia in our study was 35.00% (21/60). This finding aligns with prevalence rates reported by Milani et al. (28%) and broader pediatric LRTI literature where hyponatremia frequency ranges from 25% to 45%. Hyponatremia occurred predominantly in infants under 6 months of age (57.14% of hyponatremic cases). Younger infants are physiologically pre-disposed to electrolyte derangements due to higher total body water composition, immature renal tubular capacity for free-water clearance, and heightened susceptibility to non-osmotic AVP secretion triggered by fever, respiratory distress, and pulmonary stretch receptor activation.

In our study, baseline serum sodium status was not significantly associated with duration of PICU stay, need for mechanical ventilation, or mortality. These findings mirror the

prospective observations of Gaurav and Kumar (2023), who similarly demonstrated that mild-to-moderate hyponatremia on admission did not independently drive clinical deterioration or prolonged PICU care in Indian children with acute bronchiolitis.

Conversely, studies by Luu et al., Seifert et al., and Hasegawa et al. documented significant associations between hyponatremia and unfavorable outcomes, including longer ICU stay and higher mechanical ventilation rates. These discrepancies may stem from variations in admission thresholds, baseline disease severity, viral strain differences, and institutional fluid protocols (e.g., standard isotonic versus hypotonic fluid administration).

Anemia was identified as a prevalent co-morbidity in our study population (73.33\% overall), reflecting the high background burden of iron deficiency anemia in rural Karnataka. As described by Hussain et al., nutritional anemia compromises tissue oxygenation and immune function, predisposing infants to severe LRTIs. Although anemia was common across both cohorts, it did not significantly influence serum sodium dynamics or PICU length of stay ($p > 0.05$).

Limitations to the Study Design

Several methodological and resource-related limitations should be noted:

1. **Single-Center Design & Sample Size:** The study was conducted at a single tertiary center with a sample size of 60 children. While suitable for cohort evaluation, the sample size limits statistical power to detect small differences in rare clinical outcomes such as mechanical ventilation or mortality.
2. **Resource-Limited Setting Constraints:** Diagnostic tests for viral identification (e.g., multiplex PCR panels) could not be routinely performed due to financial and laboratory resource constraints.
3. **Etiologic Biomarker Evaluation:** Diagnostic markers needed to differentiate dilutional hyponatremia (SIADH) from depletional hyponatremia—such as serum osmolality, urine osmolality, urinary sodium concentration, and plasma vasopressin levels—were unavailable in this clinical setting.
4. **Convenience Sampling Bias:** Non-probability convenience sampling in a single PICU setting may introduce selection bias, limiting external generalizability to primary or secondary healthcare facilities.
5. **Pre-referral Hydration Data:** Although fluid administration protocols were standardized upon admission, granular records regarding total fluid volume and fluid tonicity administered prior to arrival were unavailable for referred patients.

CONCLUSION

In infants hospitalized with acute bronchiolitis in tertiary care PICU, hyponatremia is a common laboratory finding, particularly in infants under six months of age. However, baseline serum sodium levels on admission showed no statistically significant association with disease severity, requirement for mechanical ventilation, or PICU length of stay. Serum sodium status alone should not be relied upon as a primary prognostic indicator for adverse outcomes in acute bronchiolitis. Comprehensive clinical monitoring, validated scoring systems, and meticulous fluid management remain the primary standard of care in resource-limited pediatric intensive care settings.

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