

Prevalence and Clinical Correlates of Electrolyte Abnormalities in Adults with Enteric Fever: A Retrospective Study from Kerala, India

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ABSTRACT

Background: Enteric fever remains a major public health concern in developing countries, including India, despite advances in sanitation, vaccination, and antimicrobial therapy. Electrolyte disturbances frequently accompany systemic infections and may increase morbidity and prolong hospitalization. However, data on electrolyte abnormalities among adults with enteric fever in South India remain limited. This study evaluated the prevalence, pattern, clinical significance, and predictors of serum electrolyte abnormalities, particularly hyponatremia.

Methods: This retrospective observational study was conducted in the Department of General Medicine, Amala Institute of Medical Sciences, Thrissur, Kerala. Medical records of 186 adults (≥ 18 years) with laboratory-confirmed enteric fever admitted between November 2024 and March 2026 were reviewed. Demographic, clinical, and laboratory data, including admission serum electrolyte levels, were analyzed using descriptive statistics, comparative analyses, and multivariate logistic regression. A p -value < 0.05 was considered statistically significant.

Results: The mean age was 34.8 ± 13.6 years, and 53.8% of patients were female. Hyponatremia was the most common electrolyte abnormality (58.1%), followed by low serum bicarbonate (54.3%). Among patients with hyponatremia, 59.3% had mild, 28.7% moderate, and 12.0% severe hyponatremia. Hyponatremia was significantly associated with older age, fever duration > 7 days, vomiting, diarrhea, and longer hospital stay ($p = 0.003$). Multivariate analysis identified fever duration > 7 days (OR 2.14), vomiting (OR 1.96), diarrhea (OR 1.82), and age > 45 years (OR 1.73) as independent predictors.

Conclusion: Hyponatremia and reduced serum bicarbonate are common among adults hospitalized with enteric fever. Routine electrolyte assessment at admission may facilitate early identification of high-risk patients, timely correction of electrolyte abnormalities, and improved clinical outcomes.

Key-words: Enteric fever, Typhoid fever, Electrolyte abnormalities, Hyponatremia, Bicarbonate, Hospitalization, Retrospective study

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INTRODUCTION

Enteric fever, caused predominantly by *Salmonella enterica* serovars Typhi and Paratyphi, remains a major public health challenge in low- and middle-income countries, particularly in South Asia, despite improvements in sanitation, vaccination, and antimicrobial therapy.^[1,2] The disease continues to impose substantial morbidity and socioeconomic burden,



with India contributing significantly to the global disease burden and reporting a large number of hospitalizations each year.^[2-6] Although advances in diagnosis and antimicrobial therapy have improved survival, delayed diagnosis and disease-related complications continue to contribute to adverse clinical outcomes.^[7-9]

Enteric fever is a systemic bacterial infection with a broad spectrum of clinical manifestations ranging from uncomplicated febrile illness to severe multisystem disease.^[4,5] Patients commonly present with prolonged fever, headache, abdominal pain, anorexia, nausea, vomiting, diarrhea or constipation, and hepatosplenomegaly. Severe disease may lead to intestinal perforation, gastrointestinal hemorrhage, encephalopathy, septic shock, and other life-threatening complications.^[4,5,8,9] These manifestations reflect dissemination of *Salmonella* organisms through the reticuloendothelial system, resulting in widespread inflammatory responses and systemic involvement.^[4,5]

Electrolyte disturbances are frequently observed in hospitalized patients with acute infectious diseases and may significantly influence disease severity and clinical outcomes.^[10-13] Alterations in serum sodium, potassium, chloride, and bicarbonate concentrations may occur secondary to persistent fever, reduced oral intake, gastrointestinal fluid losses, dehydration, renal dysfunction, and systemic inflammatory responses associated with severe infection.^[12,13] Among these abnormalities, hyponatremia is one of the most frequently encountered electrolyte disorders and is commonly attributed to extracellular volume depletion and inappropriate antidiuretic hormone secretion, whereas reduced serum bicarbonate levels may indicate dehydration and underlying metabolic disturbances.^[13] These abnormalities may contribute to neurological manifestations, cardiovascular instability, prolonged hospitalization, and delayed recovery.^[13]

Despite the clinical importance of electrolyte disturbances, studies specifically evaluating their prevalence and pattern among adults hospitalized with enteric fever remain limited, particularly in the Indian setting.^[8,9] Most available evidence is derived from pediatric populations or relatively small observational studies, and information regarding the association of electrolyte abnormalities with disease severity, duration of illness, gastrointestinal manifestations, and length of hospital stay remains inadequate.^[8,9]

Kerala continues to report sporadic cases of enteric fever despite improvements in healthcare infrastructure and public health measures.^[3,7,9] Regional variations in disease epidemiology, healthcare-seeking behavior, and clinical presentation highlight the need for locally generated evidence to support patient management.^[4,8,9] Therefore, the present study was undertaken in the Department of General Medicine, Amala Institute of Medical Sciences, Thrissur, Kerala, to determine the prevalence and pattern of serum electrolyte abnormalities among adults admitted with laboratory-confirmed enteric fever and to evaluate their association with selected clinical characteristics, particularly factors associated with hyponatremia.

MATERIALS AND METHODS

Study Design and Setting- This retrospective observational study was conducted to evaluate the prevalence and pattern of serum electrolyte abnormalities among adult patients admitted with enteric fever. The study was carried out in the Department of General Medicine, Amala Institute of Medical Sciences, Thrissur, Kerala, India, a tertiary care teaching hospital serving patients from central Kerala and neighboring districts. Medical records of patients admitted between November 2024 and March 2026 were retrospectively reviewed and analyzed.

Study Population and Eligibility Criteria- Adult patients admitted to the Department of Internal Medicine with a diagnosis of enteric fever during the study period were screened for eligibility. Patients aged ≥ 18 years with laboratory-confirmed enteric fever, defined by positive blood culture for *Salmonella Typhi* or *Salmonella Paratyphi* or positive serology with compatible clinical features, were included. Patients with available complete admission serum electrolyte profiles including sodium, potassium, chloride, and bicarbonate levels, along with complete demographic and clinical records, were eligible for inclusion.

Patients with chronic kidney disease (Stage 4 or 5), chronic diuretic therapy, congestive heart failure, chronic liver disease or cirrhosis, endocrine disorders affecting electrolyte balance such as adrenal insufficiency or thyroid disorders, incomplete medical records, missing electrolyte data, or pregnancy were excluded from the study.

Sample Size- A total of 186 eligible patients were included in the final analysis. This represented all consecutive eligible admissions fulfilling inclusion criteria during the study period.

Data Collection- Data were collected from the institutional electronic medical record system using a standardized data collection proforma. Demographic variables included age and sex. Clinical variables included duration of fever, presence of vomiting, diarrhea, abdominal pain, headache, relative bradycardia, and length of hospital stay. Laboratory variables included admission serum electrolyte values obtained within the first 24 hours of hospitalization, specifically sodium, potassium, chloride, and bicarbonate levels.

Definitions of Variables- Hyponatremia was defined as serum sodium <135 mmol/L and further classified into mild (130–134 mmol/L), moderate (125–129 mmol/L), and severe (<125 mmol/L). Potassium abnormalities included hypokalemia (<3.5 mmol/L) and hyperkalemia (>5.0 mmol/L). Chloride abnormalities were defined as hypochloremia (<98 mmol/L) and hyperchloremia (>107 mmol/L). Low bicarbonate was defined as serum bicarbonate <22 mmol/L.

Outcome Measures- The primary outcome of the study was to determine the prevalence and pattern of serum electrolyte abnormalities among adults hospitalized with enteric fever. Secondary outcomes included severity distribution of hyponatremia, age and sex-wise differences in electrolyte abnormalities, association between duration of illness and electrolyte disturbances, relationship between gastrointestinal symptoms and electrolyte imbalance, impact on length of hospital stay, and identification of independent predictors of hyponatremia.

Statistical Analysis- Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean \pm standard deviation, while categorical variables were expressed as frequency and percentage. Student's t-test was used for comparison of continuous variables between two groups, while Chi-square test or Fisher's exact test was used for categorical variables. Analysis of variance (ANOVA) was used for

comparison among more than two groups. Variables found significant in univariate analysis were entered into multivariate logistic regression analysis to identify independent predictors of hyponatremia. Adjusted odds ratios with 95% confidence intervals were calculated, and a p-value <0.05 was considered statistically significant.

Ethical Considerations- The study protocol was approved by the Institutional Ethics Committee of Amala Institute of Medical Sciences, Thrissur. As this was a retrospective record-based study using anonymized patient data, informed consent was waived. Confidentiality of patient information was strictly maintained, and all analyses were performed on de-identified data in accordance with the Declaration of Helsinki.

RESULTS

Table 1 presents the baseline demographic characteristics and mean laboratory parameters of the study population. A total of 186 adult patients with laboratory-confirmed enteric fever were included, with a slight female predominance (53.8%). The mean duration of fever before admission was 8.1 ± 3.4 days, and the mean hospital stay was 5.8 ± 2.6 days. The mean serum sodium level was mildly reduced (133.1 ± 5.9 mmol/L), whereas the mean potassium, chloride, and bicarbonate levels were within or near the normal reference ranges.

Table 1: Baseline Characteristics and Mean Laboratory Values

Variable	Value
Total patients	186
Mean age (years)	34.8 ± 13.6
Male	86 (46.2%)
Female	100 (53.8%)
Mean duration of fever before admission (days)	8.1 ± 3.4
Mean hospital stay (days)	5.8 ± 2.6
Sodium (mmol/L)	133.1 ± 5.9
Potassium (mmol/L)	4.2 ± 0.5
Chloride (mmol/L)	100.8 ± 3.8
Bicarbonate (mmol/L)	20.7 ± 4.5

Table 2 summarizes the frequency and severity of electrolyte abnormalities among the study participants. Hyponatremia was the most common abnormality, affecting 108 (58.1%) patients, followed by low bicarbonate levels in 101 (54.3%) patients. Potassium and chloride abnormalities were relatively uncommon,

occurring in 14 (7.5%) and 11 (5.9%) patients, respectively. Among patients with hyponatremia, mild hyponatremia (130–134 mmol/L) was the most frequent (59.3%), followed by moderate (125–129 mmol/L) in 28.7% and severe (<125 mmol/L) in 12.0%, indicating that most cases were of mild to moderate severity.

Table 2: Frequency and Severity of Electrolyte Abnormalities

Parameter	N	%
Hyponatremia	108	58.1
Low bicarbonate	101	54.3
Potassium abnormality	14	7.5
Chloride abnormality	11	5.9
Severity of Hyponatremia		
Mild (130–134 mmol/L)	64	59.3
Moderate (125–129 mmol/L)	31	28.7
Severe (<125 mmol/L)	13	12.0

The prevalence of hyponatremia increased progressively with age, from 51.4% among patients aged 18–30 years to 66.7% in those aged >60 years. Patients with fever duration of more than 7 days showed a higher prevalence of hyponatremia (66.4%) and low bicarbonate levels (61.2%) compared with those having fever for ≤7 days (48.2% and 43.9%, respectively).

Multivariable logistic regression identified fever duration >7 days (adjusted OR: 2.14, 95% CI: 1.19–3.84; $p=0.011$), vomiting (adjusted OR: 1.96, 95% CI: 1.08–3.56; $p=0.026$), diarrhea (adjusted OR: 1.82, 95% CI: 1.01–3.29; $p=0.043$), and age >45 years (adjusted OR: 1.73, 95% CI: 1.02–2.94; $p=0.041$) as independent predictors of hyponatremia (Table 3).

Table 3: Age-wise prevalence, fever duration–related electrolyte abnormalities, and independent predictors of hyponatremia

Age Group (Years)	Total Patients	Hyponatremia n (%)
18–30	72	37 (51.4)
31–45	58	35 (60.3)
46–60	38	24 (63.2)
>60	18	12 (66.7)
Fever Duration	Hyponatremia (%)	Low Bicarbonate (%)
≤7 days	48.2	43.9
>7 days	66.4	61.2
Variable	Adjusted OR (95% CI)	p-value
Fever >7 days	2.14 (1.19–3.84)	0.011
Vomiting	1.96 (1.08–3.56)	0.026
Diarrhea	1.82 (1.01–3.29)	0.043
Age >45 years	1.73 (1.02–2.94)	0.041

Table 4 compares electrolyte abnormalities between male and female patients. Hyponatremia was observed in 55.8% of males and 60.0% of females, while low bicarbonate levels were present in 51.2% and 57.0%, respectively. Potassium abnormalities (8.1% vs. 7.0%) and chloride abnormalities (7.0% vs. 5.0%) were

infrequent in both groups. None of the sex-wise differences were statistically significant (all $p > 0.05$), indicating that the prevalence of electrolyte abnormalities was comparable between male and female patients.

Table 4: Sex-wise Comparison

Variable	Male (n=86)	Female (n=100)	p-value
Hyponatremia	48 (55.8%)	60 (60.0%)	0.56
Low bicarbonate	44 (51.2%)	57 (57.0%)	0.42
Potassium abnormality	7 (8.1%)	7 (7.0%)	0.78
Chloride abnormality	6 (7.0%)	5 (5.0%)	0.59

Table 5 presents gastrointestinal manifestations along with hospital outcomes based on sodium status in patients with enteric fever. Among symptoms, headache was the most frequent, followed by abdominal pain and vomiting. Hospital stay showed a progressive increase

with worsening sodium levels, with patients having severe hyponatremia requiring the longest duration of hospitalization compared to those with normal sodium levels.

Table 5: Gastrointestinal Symptoms and Clinical Outcome According to Sodium Status

Variable	Category	Value
Gastrointestinal symptoms	Vomiting	42.5%
	Diarrhea	34.4%
	Abdominal pain	46.8%
	Headache	67.2%
	Relative bradycardia	21.5%
Hospital stay (according to sodium status)	Normal sodium	4.9 ± 1.8 days
	Hyponatremia	6.7 ± 2.8 days
	Severe hyponatremia	8.1 ± 3.1 days

DISCUSSION

The present study demonstrated that electrolyte abnormalities are common among adults hospitalized with enteric fever, with hyponatremia (58.1%) and reduced serum bicarbonate (54.3%) being the predominant biochemical abnormalities. These findings emphasize the importance of routine electrolyte assessment at admission, particularly in patients with prolonged illness and gastrointestinal symptoms, as early recognition may facilitate timely correction and improve clinical outcomes.^[14–16]

Hyponatremia was the most frequent electrolyte disturbance observed in our cohort, consistent with previous reports describing it as a common manifestation of systemic bacterial infections.^[17,18]

The pathogenesis is multifactorial and includes persistent fever, poor oral intake, vomiting, diarrhea, excessive insensible losses, and non-osmotic secretion of antidiuretic hormone, resulting in dilutional hyponatremia.^[14,17,18–21] Most patients had mild hyponatremia, while moderate and severe forms were less common but clinically important because severe sodium depletion may lead to altered sensorium, seizures, and encephalopathy if left untreated.^[17–20]

Reduced serum bicarbonate was the second most common abnormality. This finding probably reflects metabolic acidosis secondary to dehydration, gastrointestinal bicarbonate loss, tissue hypoperfusion, and increased metabolic demand associated with systemic infection.^[21,25] In contrast, potassium and



chloride abnormalities were relatively uncommon, suggesting that sodium and bicarbonate disturbances are the predominant biochemical derangements in enteric fever and therefore deserve greater clinical attention during hospitalization.^[21,22]

The frequency of hyponatremia increased with advancing age, with older patients showing a greater susceptibility to electrolyte imbalance. Age-related reductions in physiological reserve, impaired renal concentrating ability, and an increased tendency toward dehydration may explain this observation.^[17-20] Similarly, patients presenting after more than seven days of fever had significantly higher rates of hyponatremia and low bicarbonate levels, indicating that prolonged illness may result in cumulative electrolyte losses and worsening metabolic disturbances.^[17,18,21]

Gastrointestinal symptoms were strongly associated with electrolyte abnormalities in the present study. Patients with vomiting and diarrhea exhibited significantly lower serum sodium concentrations, supporting the role of gastrointestinal sodium and bicarbonate losses in the development of hyponatremia.^[14,17,21] Similar electrolyte abnormalities have also been reported in other infectious diseases, emphasizing that systemic inflammation and fluid loss are important contributors to hyponatremia.^[22] Salmonella infections are well known to produce multisystem manifestations, and electrolyte disturbances may accompany severe invasive disease, highlighting the need for careful biochemical monitoring.^[23-25]

An important clinical finding of this study was the association between hyponatremia and prolonged hospitalization. Patients with hyponatremia required longer hospital stays than normonatremic patients, suggesting that sodium imbalance may serve as a marker of disease severity and increased healthcare utilization.^[16,19,20] Multivariate logistic regression further identified age >45 years, fever duration >7 days, vomiting, and diarrhea as independent predictors of hyponatremia, indicating that both patient-related and disease-related factors contribute to electrolyte disturbances.^[17,18,21]

Although this study was limited by its retrospective single-center design and the absence of serial electrolyte measurements, it provides valuable regional data on electrolyte abnormalities in adults with enteric fever. Overall, hyponatremia and reduced serum bicarbonate

were the predominant biochemical abnormalities, while increasing age, prolonged illness, and gastrointestinal symptoms were significant predictors of hyponatremia. Routine electrolyte monitoring and timely correction should therefore be considered an integral component of the management of hospitalized patients with enteric fever.^[14,17,21,25]

CONCLUSIONS

This study concludes that electrolyte abnormalities, particularly hyponatremia and reduced serum bicarbonate levels, are highly prevalent among adults hospitalized with enteric fever. Hyponatremia was observed in more than half of the patients, indicating it as the most common biochemical disturbance associated with the disease. Increasing age, prolonged duration of fever, vomiting, and diarrhea were identified as significant predictors of hyponatremia, highlighting the role of both disease severity and gastrointestinal losses in its development. Patients with electrolyte abnormalities experienced longer hospital stays, suggesting that these disturbances may serve as useful markers of clinical severity and prognosis. Potassium and chloride abnormalities were comparatively uncommon, indicating that routine clinical monitoring should primarily focus on sodium and bicarbonate levels. Early identification and timely correction of electrolyte disturbances can improve patient management and reduce complications. Routine electrolyte assessment should therefore be an integral part of the evaluation of all patients admitted with enteric fever.

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