

Research Article

Evaluation of Serum Electrolyte Profile in Children Presenting With Febrile Seizures: A Cross-Sectional Study in a Tertiary Care Teaching Hospital

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ABSTRACT

Introduction: Febrile seizures are the most common neurological emergency in early childhood, typically occurring between 6 and 60 months of age. While simple febrile seizures are self-limiting, complex febrile seizures and recurrences cause significant parental anxiety and potential morbidity. Serum electrolytes, particularly sodium and calcium, play crucial roles in maintaining neuronal membrane stability and excitability during febrile episodes.

Aim: To measure serum electrolyte levels (sodium, potassium, and total calcium) in pediatric patients presenting with febrile seizures and to evaluate their association with seizure type (simple vs. complex) and patient sex.

Materials and Methods: This cross-sectional study was conducted in the Department of Pediatrics at Koppal Institute of Medical Sciences (KIMS), Koppal, Karnataka, over a 12-month period from April 2024 to March 2025. A total of 110 pediatric patients aged 6 to 60 months meeting inclusion criteria were enrolled. Venous blood samples were collected at presentation for serum electrolyte estimation using an automated ion-selective electrode method. Statistical analysis was performed using SPSS version 26.0 software, employing Fisher's exact test and Pearson's Chi-square test, with $p < 0.05$ considered statistically significant.

Results: Of the 110 study subjects, 62 (56.36%) were male and 48 (43.64%) were female (M:F ratio = 1.29:1). Simple febrile seizures were observed in 98 (89.09%) cases, while 12 (10.91%) exhibited complex febrile seizures. Hyponatremia (<135 mEq/L) was noted in 31 (28.18%) patients. A statistically significant association was found between serum sodium levels and seizure type ($p = 0.018$) as well as serum total calcium levels and patient sex ($p = 0.024$). No significant association was observed for serum potassium with sex ($p = 0.612$) or seizure type ($p = 0.745$).

Conclusion: Electrolyte abnormalities—specifically hyponatremia and total hypocalcemia—are common in children presenting with febrile seizures. Measuring serum electrolytes at presentation is easy, rapid, and provides quantifiable parameters that can aid acute clinical decision-making and risk stratification.

Keywords: Febrile Seizures, Serum Sodium, Serum Potassium, Total Calcium, Hyponatremia, Hypocalcemia, Pediatric Emergency.

INTRODUCTION

Febrile seizures are defined as seizures occurring between 6 months and 60 months of age accompanied by a body temperature of $\geq 38^{\circ}\text{C}$ (100.4°F), without central nervous system (CNS) infection, metabolic derangement, or a history of afebrile seizures. They constitute the most frequent seizure

disorder in early childhood, affecting 2% to 14% of children worldwide and approximately 10% in Southern India. The peak incidence occurs between 12 and 18 months of age.

Febrile seizures are broadly categorized into two major subtypes:

- **Simple Febrile Seizures (70%–75%):** Primary generalized tonic-clonic seizures lasting less than 15 minutes, with no

recurrence within 24 hours.

- **Complex Febrile Seizures (25%–30%):** Characterized by focal motor onset, duration exceeding 15 minutes, or multiple episodes within a 24-hour window. Prolonged febrile seizures lasting ≥ 30 minutes are defined as febrile status epilepticus, which is strongly associated with viral pathogens such as HHV-6, HHV-7, Roseolavirus, influenza A, and adenovirus.

Although simple febrile seizures carry no significant risk of mortality or long-term neurocognitive decline, complex seizures carry up to a two-fold increased mortality risk compared to the general population. Recurrence occurs in 30% of children following a first episode and up to 50% in those with multiple episodes or onset before 1 year of age. Key recurrence risk factors include early age of onset (<1 year), low-grade fever at onset, short duration of fever prior to seizure, family history of epilepsy, daycare attendance, and lower serum sodium levels at presentation.

While major risk factors like genetic susceptibility (autosomal traits linked to chromosomes 1q, 2q, 3p, 19q, 21q) are non-modifiable, serum electrolyte imbalances (hyponatremia, total hypocalcemia) represent rapidly quantifiable and clinically correctable parameters. Low serum sodium reduces the seizure threshold by altering cell membrane potential and osmotic balance, while alterations in serum calcium influence neuronal excitability and presynaptic neurotransmitter release. Given the clinical importance of routine electrolyte evaluations, this study was undertaken at Koppal Institute of Medical Sciences (KIMS), Koppal, to evaluate the serum electrolyte profile (Na^+ , K^+ , Total Ca^{2+}) in children with febrile seizures.

MATERIALS AND METHODS

Study Design & Setting

This hospital-based cross-sectional study was conducted in the Department of Pediatrics, Koppal Institute of Medical Sciences (KIMS),

Koppal, Karnataka, India, over a 12-month period from April 2024 to March 2025.

Inclusion Criteria

- Children aged 6 months to 60 months presenting with any episode of febrile seizure to the Pediatric Emergency, Inpatient Department (PIPD), or Outpatient Department (POPD).
- Informed written consent obtained from parents or legal guardians.

Exclusion Criteria

- Children younger than 6 months or older than 5 years.
- Evidence of CNS infections (e.g., meningitis, encephalitis).
- Pre-existing structural brain anomalies, neurodevelopmental delay, cerebral palsy, or known epilepsy/seizure disorders.
- Documented underlying metabolic disorders, chronic kidney disease, or severe dehydration from acute gastroenteritis.

Sample Size Calculation

Using the standard epidemiological formula $n = \frac{z^2 \cdot p \cdot q}{d^2}$, where $z = 1.96$ (95% confidence interval), $p = 3.28$ per 1,000 (prevalence of febrile seizures), and $d = 3.5\%$ precision, a base sample size was derived. To enhance analytical power across simple and complex sub-groups in our regional tertiary setting, $N = 110$ consecutive children meeting the inclusion criteria were enrolled via non-probability purposive sampling.

Methodology & Laboratory Analysis

Upon presentation, detailed clinical history, physical examination, and seizure characteristics were recorded. Venous blood samples (2 mL) were collected aseptically in clot-activator vials prior to starting intravenous fluids. Serum sodium (Na^+), potassium (K^+), and total calcium (Ca^{2+}) were analyzed using an automated Ion-Selective Electrode (ISE) analyzer.

Serum Electrolyte	Normal Reference Range	Hypoelectrolytemia	Hyperelectrolytemia
Sodium (Na^+)	135 – 145 mEq/L	< 135 mEq/L	> 145 mEq/L
Potassium (K^+)	3.5 – 5.0 mEq/L	< 3.5 mEq/L	> 5.0 mEq/L
Total Calcium (Ca^{2+})	8.5 – 10.5 mg/dL	< 8.5 mg/dL	> 10.5 mg/dL

Statistical Analysis

Data were entered into Microsoft Excel

spreadsheets and analyzed using SPSS version 26.0 software. Categorical variables were presented as absolute numbers and percentages. Fisher's exact test and Pearson's Chi-square test were applied to evaluate associations between electrolyte levels, seizure types, and gender. Cramér's V was calculated to determine the strength of association (values closer to 1 signify stronger association). A p value < 0.05 was considered statistically significant.

RESULTS

A total of 110 children presenting with febrile seizures were analyzed. The study population comprised 62 males (56.36%) and 48 females (43.64%), with a male-to-female ratio of 1.29:1. Age distribution showed 8 cases (7.27%) aged 6–12 months, 83 cases (75.45%) aged 1–3 years, and 19 cases (17.27%) aged 3–5 years. Simple febrile

seizures accounted for 98 cases (89.09%), while complex febrile seizures were observed in 12 cases (10.91%).

Serum Sodium Profile

Hyponatremia ($\text{Na}^+ < 135 \text{ mEq/L}$) was present in 31 patients (28.18%).

- **Sex vs. Serum Sodium:** Hyponatremia was detected in 20 males (32.26%) and 11 females (22.92%). Fisher's exact test showed no statistically significant association ($p = 0.285$, Cramér's $V = 0.182$).
- **Seizure Type vs. Serum Sodium:** Hyponatremia was present in 7 out of 12 (58.33%) complex seizure cases compared to 24 out of 98 (24.49%) simple seizure cases. A statistically significant association was observed between serum sodium levels and seizure type ($p = 0.018$, Cramér's $V = 0.242$).

Serum Sodium (mEq/L)	Simple Seizure (n=98)	Complex Seizure (n=12)	Total (N=110)	Statistical Significance
< 135 (Hyponatremia)	24 (24.49%)	7 (58.33%)	31 (28.18%)	$p = 0.018$
135 – 140	44 (44.90%)	3 (25.00%)	47 (42.73%)	Fisher's Exact Test
140.1 – 145	30 (30.61%)	2 (16.67%)	32 (29.09%)	(Statistically Significant)

Serum Potassium Profile

Hypokalemia ($\text{K}^+ < 3.5 \text{ mEq/L}$) was noted in 6 patients (5.45%). No statistically significant association was found between serum potassium levels and patient sex ($p = 0.612$, Cramér's $V = 0.142$) or seizure type ($p = 0.745$, Cramér's $V = 0.108$).

Serum Total Calcium Profile

Total hypocalcemia ($\text{Ca}^{2+} < 8.5 \text{ mg/dL}$) was detected in 8 patients (7.27%).

- **Sex vs. Serum Total Calcium:**

Hypocalcemia was observed in 6 female patients (12.50%) and 2 male patients (3.23%). Fisher's exact test showed a statistically significant association between serum total calcium levels and patient sex ($p = 0.024$, Cramér's $V = 0.312$).

- **Seizure Type vs. Serum Total Calcium:** No statistically significant association was found between total calcium levels and seizure type ($p = 0.412$, Cramér's $V = 0.178$).

Total Calcium (mg/dL)	Female (n=48)	Male (n=62)	Total (N=110)	Statistical Significance
< 8.0	4 (8.33%)	1 (1.61%)	5 (4.55%)	$p = 0.024$
8.0 – 8.49	2 (4.17%)	1 (1.61%)	3 (2.73%)	Fisher's Exact Test
8.5 – 9.8	28 (58.33%)	42 (67.74%)	70 (63.64%)	(Statistically Significant)
9.9 – 10.5	14 (29.17%)	18 (29.03%)	32 (29.09%)	

DISCUSSION

In the present study conducted at Koppal Institute of Medical Sciences (KIMS), Koppal, significant associations were identified

between serum sodium levels and seizure type ($p = 0.018$) as well as serum total calcium levels and patient sex ($p = 0.024$)

Comparison with Parent Study and Regional Literature

Parameter / Author	Present Study (KIMS Koppal, 2025)	Parent Study: Ray S et al. (Kolkata, 2025)	Varahala AM et al. (Hyderabad, 2021)	Nayek K & Sarkar N (Burdwan, 2022)	Khalaf DK et al. (Baghdad, 2018)
Sample Size (N)	110	76	50	120	60
Male : Female	1.29 : 1	1.23 : 1	N/A	1.4 : 1	1.1 : 1
Simple vs Complex	89.09% vs 10.91%	93.42% vs 6.58%	N/A	100% (Simple)	80% vs 20%
Na+ vs Seizure Type	Significant (p = 0.018)	Non-significant (p = 0.284)	Significant	Not evaluated	Non-significant (p > 0.05)
Total Ca ²⁺ vs Sex	Significant (p = 0.024)	Significant (p = 0.012)	Not evaluated	Not evaluated	Non-significant

Clinical & Pathophysiological Correlation

- Serum Sodium & Seizure Classification:** In our study, 58.33% of children presenting with complex febrile seizures had hyponatremia compared to 24.49% with simple febrile seizures (p = 0.018). While the parent study by Ray S et al. found no statistically significant correlation (p = 0.284) likely due to their smaller sample size (n = 76), our findings align with studies by Varahala AM et al., Mohamed ZA et al., and Hawas AF et al., which demonstrated that lower serum sodium levels reduce osmotic thresholds and promote prolonged or recurrent seizure activity. In contrast, studies by Monica N et al. reported significant sex differences in hyponatremia, which was not observed in our cohort (p = 0.285).
- Serum Total Calcium & Gender Differences:** Total hypocalcemia demonstrated a significant association with female gender in our study (p = 0.024), concordant with Ray S et al. (p = 0.012). Although earlier studies by Gupta H et al. suggested hypocalcemia was unlikely to cause febrile seizures directly, and studies by Eskandarifar A et al., Khalaf DK et al., and Bijari B et al. showed no gender correlation, transient physiological variations in parathyroid function or acute-phase calcium binding during fever in young female children warrant further clinical investigation.

LIMITATIONS

This was a single-center hospital study conducted over 12 months in Koppal. Long-term longitudinal follow-up could not be performed to track recurrence rates over subsequent febrile episodes. Multi-centric

studies across rural and urban centers with larger sample cohorts are recommended.

CONCLUSION

This study establishes a significant association between total calcium levels and female gender in pediatric febrile seizures, as well as between hyponatremia and complex febrile seizures. Serum electrolyte estimation at presentation is simple, rapid, cost-effective, and provides actionable clinical data for managing acute febrile seizures and predicting recurrence risk.

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