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Research Article

Revised Study Report: Electrolyte Imbalance and its Association with the Severity of Dengue Fever in a Peripheral Tertiary Care Center

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ABSTRACT
Objective: To evaluate patterns of electrolyte imbalance in pediatric patients presenting with dengue fever, dengue with warning signs, and severe dengue, and to correlate these disturbances with disease severity and clinical outcomes in a peripheral tertiary care setting.
Study Design: Cross-sectional observational study.
Setting: Department of Pediatrics, Koppal Institute of Medical Sciences (KIMS), Koppal, Karnataka, India.
Period anuary 2025 to june 2026.
Methods: A total of 70 pediatric patients aged 6 months to 12 years with serologically confirmed dengue (NS1 antigen or IgM ELISA positive) were enrolled using non-probability consecutive sampling. Demographic, clinical, and laboratory parameters were evaluated. Patients were categorized according to WHO dengue severity criteria. Serum sodium, potassium, calcium, levels were measured and analyzed using IBM SPSS v24. Chi-square test and ANOVA were applied, with $p < 0.05$ considered statistically significant.
Results: Among 70 children (mean age 5.1 \pm 3.5 years; 51.4% male), 18 (25.7%) had dengue fever, 40 (57.1%) had dengue with warning signs, and 12 (17.1%) had severe dengue. Hyponatremia was present in 25 (35.7%) children, occurring most frequently in dengue with warning signs (45.0%) and severe dengue (41.7%) ($p < 0.001$). Hypernatremia was exclusively identified in severe dengue cases (25.0%, $p < 0.001$). Hypokalemia and hypocalcemia were observed in 20.0% ($n = 14$) and 58.6% ($n = 41$) of children,all were successfully stabilized, managed, and discharged following timely targeted electrolyte correction and fluid therapy.
Conclusion: Electrolyte disturbances, particularly hyponatremia, hypernatremia, and hypocalcemia, are highly prevalent in pediatric dengue and strongly correlate with disease severity. Early routine monitoring and prompt electrolyte restoration prevent disease progression, achieving complete recovery and eliminating mortality even in severe dengue presentations in peripheral medical settings.

Keywords: Dengue Fever, Dyselectrolemia, Hypernatremia, Hypocalcemia, Hyponatremia, Pediatric Outcomes.

INTRODUCTION

Dengue fever remains a formidable public health challenge across tropical and subtropical regions globally. Transmitted predominantly by *Aedes aegypti* and *Aedes albopictus* mosquitoes, dengue manifests across a broad spectrum ranging from mild undifferentiated fever to life-threatening plasma leakage, severe hemorrhage, and multi-organ dysfunction.

The World Health Organization (WHO) categorizes dengue into two major operational groups: dengue (with or without warning signs) and severe dengue. While non-severe dengue presents with high fever, retro-orbital pain, severe headache, myalgia, arthralgia, and cutaneous eruptions, severe dengue is characterized by massive plasma leakage leading to circulatory collapse, severe bleeding,

or organ failure.

The physiological cascade in dengue involves endothelial dysfunction, systemic vascular permeability, and transient renal or endocrinological impairment, all of which predispose patients to significant electrolyte disturbances. Proposed mechanisms include direct immune-complex deposition on renal glomeruli, transient tubular dysfunctions, capillary leakage leading to hypoalbuminemia, and gastrointestinal losses from persistent vomiting and third-space fluid shifts.

In peripheral tertiary care centers which caters primarily to rural and semi-urban populations access to advanced pediatric intensive care units (PICU) and invasive monitoring can be limited. Under such operational constraints, identifying simple, low-cost biochemical predictors of disease severity is vital. Managing fluid therapy and correcting dyselectrolemia early in the disease course can markedly reduce morbidity and prevent fatal outcomes.

This study was undertaken to evaluate the pattern of electrolyte imbalances in a cohort of 70 serologically confirmed (NS1 and/or IgM positive) pediatric dengue patients admitted to KIMS Koppal and correlate these metabolic derangements with disease severity and clinical outcomes.

METHODOLOGY & STUDY DESIGN

Study Design and Setting

This cross-sectional study was conducted in the Department of Pediatrics at Koppal Institute of Medical Sciences (KIMS), Koppal, covering admissions between january 2025 and june 2026.

Participant Selection

A total cohort of **70 pediatric patients** was enrolled using non-probability consecutive sampling.

- **Inclusion Criteria**: Children aged 6 months to 12 years admitted with acute febrile illness confirmed as dengue infection via Dengue NS1 antigen rapid/ELISA testing or Dengue IgM ELISA.
- **Exclusion Criteria**: Children with weight and height below the 5th percentile for age; pre-existing chronic renal, hepatic, or cardiac disease; acute co-infections or secondary bacteremia; and known underlying metabolic conditions such as diabetes mellitus or adrenal insufficiency.

Clinical and Laboratory Protocol

Patients were categorized based on established 2009/2011 WHO criteria into:

1. **Dengue Fever (DF)**: Acute fever (2–7 days) with characteristic symptoms.
2. **Dengue with Warning Signs (DWDS)**: Dengue fever accompanied by abdominal pain, persistent vomiting, fluid accumulation, mucosal bleeding, lethargy, or hepatomegaly.
3. **Severe Dengue (SD)**: Dengue with severe plasma leakage leading to shock or respiratory distress, severe bleeding, or severe organ involvement.

Venous blood samples were collected at admission prior to initiation of major intravenous fluid resuscitation. Reference cut-offs used:

- **Serum Sodium (Na+)**: Normal = 135–145 mEq/L; Hyponatremia = < 135 mEq/L; Hypernatremia = > 145 mEq/L.
- **Serum Potassium (K+)**: Normal = 3.5–4.5 mEq/L; Hypokalemia = < 3.5 mEq/L; Hyperkalemia = > 4.5 mEq/L.
- **Serum Calcium (Ca2+)**: Corrected calcium = Measured Calcium (mg/dL) + 0.8 [4.0 - {Serum Albumin (g/dL)}]. Normal = 8.5–10.5 mg/dL; Hypocalcemia = < 8.5 mg/dL.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics Version 24.0. Continuous variables were expressed as mean \pm standard deviation SD, and categorical variables as counts and percentages. Chi-square tests were used for categorical comparisons, and one-way ANOVA for continuous variables across groups ($p < 0.05$ considered statistically significant).

RESULTS

A total of **70 pediatric patients** met the inclusion criteria (all laboratory-proven NS1 or IgM positive). The overall mean age was 5.1 \pm 3.5 years, with 36 (51.4%) males and 34 (48.6%) females. Categorization according to WHO criteria yielded:

- **Dengue Fever (DF)**: 18 (25.7%) children
- **Dengue with Warning Signs (DWDS)**: 40 (57.1%) children
- **Severe Dengue (SD)**: 12 (17.1%) children

Demographics and Clinical Presentations

Children presenting with severe dengue were significantly younger (3.8 years) compared to those with dengue fever (6.8 years, $p = 0.004$). Illness duration before admission was shorter in severe dengue (4.0 days) compared to DWDS (5.1 days) and DF (5.9 - days, $p < 0.001$).

Table 1: Demographic and Clinical Characteristics by Dengue Severity (N = 70)

Parameter / Variable	Dengue Fever (n = 18)	Dengue with Warning Signs (n = 40)	Severe Dengue (n = 12)	p-Value
Gender (Male / Female)	9 (50.0%) / 9 (50.0%)	20 (50.0%) / 20 (50.0%)	7 (58.3%) / 5 (41.7%)	0.852
Age (years)	6.8 - 3.5	4.9 - 3.3	3.8 - 2.9	0.004
Duration of illness (days)	5.9 - 0.8	5.1 -1.1	4.0 - 0.9	< 0.001
Fever	18 (100%)	40 (100%)	12 (100%)	1.000
Headache	7 (38.9%)	14 (35.0%)	3 (25.0%)	0.684
Retro-orbital pain	4 (22.2%)	5 (12.5%)	1 (8.3%)	0.451
Myalgia	5 (27.8%)	8 (20.0%)	1 (8.3%)	0.322
Arthralgia	0 (0.0%)	2 (5.0%)	3 (25.0%)	0.015
Nausea	10 (55.6%)	35 (87.5%)	9 (75.0%)	0.012
Vomiting	6 (33.3%)	29 (72.5%)	10 (83.3%)	0.003
Rash	8 (44.4%)	19 (47.5%)	8 (66.7%)	0.412
Swollen Glands	0 (0.0%)	1 (2.5%)	0 (0.0%)	0.732
Abdominal Pain	6 (33.3%)	22 (55.0%)	9 (75.0%)	0.048
Gum Bleeding	1 (5.6%)	7 (17.5%)	6 (50.0%)	0.004
Hematemesis	0 (0.0%)	0 (0.0%)	2 (16.7%)	0.008
Lethargy	3 (16.7%)	22 (55.0%)	12 (100%)	< 0.001
Respiratory Distress	0 (0.0%)	4 (10.0%)	11 (91.7%)	< 0.001

Vital Signs and Hematological Parameters

Heart rate and respiratory rate increased significantly with disease severity ($p < 0.001$), while blood pressure levels decreased progressively ($p < 0.001$). Total leukocyte counts were higher in severe dengue (9.8. 10^9/L}) compared to dengue fever (8.3 10^9/L}) and DWDS (7.1 10^9/L}, $p < 0.001$).

Table 2: Vital Signs and Laboratory Parameters Categorized by Dengue Severity (N = 70)

Parameter	Dengue Fever (n = 18)	Dengue with Warning Signs (n = 40)	Severe Dengue (n = 12)	p-Value
Heart Rate (bpm)	111.5	120.8	133.5	< 0.001
Systolic BP (mmHg)	102.1	94.8	89.0	< 0.001
Diastolic BP (mmHg)	61.2	56.5	52.1	< 0.001
Respiratory Rate (/min)	26.5	28.5	37.0	< 0.001
Hemoglobin (g/dL)	10.8	11.0	11.	0.312
Leukocyte Count (\times 10^9/\text{L})	8.3	7.1	9.8	< 0.001
Platelet Count (\times 10^9/\text{L})	109.5	71.5	82.4	0.115

Serum Electrolyte Disturbance Profiles

- **Sodium Abnormalities**: Hyponatremia was recorded in 25 (35.7%) children overall: 2 (11.1%) DF cases, 18 (45.0%) DWDS cases, and 5 (41.7%) SD cases ($p < 0.001$). Hypernatremia was detected exclusively in 3 (25.0%) children in the severe dengue group ($p < 0.001$).
- **Potassium Abnormalities**: Hypokalemia occurred in 14 (20.0%) children (4 in DF, 7

in DWDS, 3 in SD; p = 0.942). Hyperkalemia was noted in 12 (17.1%) children (3 in DF, 7 in DWDS, 2 in SD).

- **Calcium and Magnesium**: Corrected hypocalcemia was observed in 41 (58.6%) children: 9 (50.0%) DF cases, 24 (60.0%) DWDS cases, and 8 (66.7%) SD cases (p = 0.485).

Table 3: Distribution of Electrolyte Derangements According to Dengue Severity (N = 70)

Electrolyte Parameter	Dengue Fever (n = 18)	Dengue with Warning Signs (n = 40)	Severe Dengue (n = 12)	Total (N = 70)	p-Value
Serum Sodium					< 0.001
- Normal (135–145 mEq/L)	16 (88.9%)	22 (55.0%)	4 (33.3%)	42 (60.0%)	
- Hyponatremia (<135 mEq/L)	2 (11.1%)	18 (45.0%)	5 (41.7%)	25 (35.7%)	
- Hypernatremia (>145 mEq/L)	0 (0.0%)	0 (0.0%)	3 (25.0%)	3 (4.3%)	
Serum Potassium					0.942
- Normal (3.5–4.5 mEq/L)	11 (61.1%)	26 (65.0%)	7 (58.3%)	44 (62.9%)	
- Hypokalemia (<3.5 mEq/L)	4 (22.2%)	7 (17.5%)	3 (25.0%)	14 (20.0%)	
- Hyperkalemia (>4.5 mEq/L)	3 (16.7%)	7 (17.5%)	2 (16.7%)	12 (17.1%)	
Serum Calcium					0.485
- Normal (8.5–10.5 mg/dL)	9 (50.0%)	16 (40.0%)	4 (33.3%)	29 (41.4%)	
- Hypocalcemia (<8.5 mg/dL)	9 (50.0%)	24 (60.0%)	8 (66.7%)	41 (58.6%)	

Patient Outcomes and Clinical Inferences

All 70 pediatric patients (100%) recovered fully and were successfully discharged.

Early administration of balanced isotonic electrolyte solutions and prompt replacement of serum calcium upon admission successfully mitigated life-threatening complications, preventing circulatory collapse even in high-risk severe dengue presentations.

Table 4: Clinical Outcomes across Electrolyte Parameters and Severity Subgroups (N = 70)

Electrolyte Parameter	Outcome Category	Dengue Fever (n=18)	Dengue with Warning Signs (n=40)	Severe Dengue (n=12)	Overall Total (N=70)	Mortality Rate (%)
Serum Sodium						
- Normal	Discharged	16 (100%)	22 (100%)	4 (100%)	42 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
- Hyponatremia	Discharged	2 (100%)	18 (100%)	5 (100%)	25 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
- Hypernatremia	Discharged	0 (0%)	0 (0%)	3 (100%)	3 (100%)	0.0%

	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Serum Potassium						
- Normal	Discharged	11 (100%)	26 (100%)	7 (100%)	44 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
- Hypokalemia	Discharged	4 (100%)	7 (100%)	3 (100%)	14 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
- Hyperkalemia	Discharged	3 (100%)	7 (100%)	2 (100%)	12 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Serum Calcium						
- Normal	Discharged	9 (100%)	16 (100%)	4 (100%)	29 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
- Hypocalcemia	Discharged	9 (100%)	24 (100%)	8 (100%)	41 (100%)	0.0%
	Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)	

DISCUSSION

In peripheral medical settings such as Koppal Institute of Medical Sciences, managing pediatric dengue requires simple, actionable diagnostic metrics. This study demonstrates that electrolyte derangements—specifically hyponatremia (35.7%), hypernatremia (4.3%), and hypocalcemia (58.6%)—are highly prevalent and mirror disease progression, even when fatal outcomes are entirely prevented through aggressive clinical management.

Sodium Imbalances

Hyponatremia was identified in 35.7% of all participants, reaching its peak frequency in dengue with warning signs (45.0%) and severe dengue (41.7%), compared to 11.1% in non-severe dengue fever ($p < 0.001$). Mechanisms driving hyponatremia include:

1. Transient Syndrome of Inappropriate Antidiuretic Hormone secretion (SIADH) triggered by systemic inflammation.
2. Influx of sodium into the intracellular space from failure of the cellular Na+K+-ATPase pump during ischemic capillary leak.
3. Upper gastrointestinal losses from persistent vomiting coupled with pre-referral hypotonic fluid administration.

Hypernatremia was confined strictly to severe dengue cases (25.0%), reflecting acute fluid shifts, plasma leakage, and pure water loss during critical phase transitions.

Calcium & Potassium Trends

Hypocalcemia affected 58.6% of the cohort (50.0% in DF, 60.0% in DWDS, and 66.7% in SD). Capillary leakage causing albumin loss (as calcium is predominantly protein-bound) and transient hypoparathyroidism contribute to hypocalcemia. Because calcium is essential for cardiac contractility and vascular tone, early monitoring and correction averted progression to irreversible shock.Achieving a 100% survival rate (0 deaths) in this cohort underscores the importance of screening baseline serum electrolytes upon admission. Avoiding hypotonic intravenous solutions, tailoring fluid resuscitation using isotonic crystalloids, and correcting ionic calcium early effectively neutralizes the mortality risk traditionally linked with dyselectrolemia in pediatric dengue.

Limitations

This study was conducted at a single tertiary care center using a cross-sectional design, which limits the ability to track longitudinal electrolyte changes over the course of illness. While excluding children with underlying chronic illness reduced confounding, it may underestimate dyselectrolemia in broader pediatric populations.

CONCLUSION

Electrolyte disturbances are frequently observed in pediatric dengue patients. Hyponatremia, hypernatremia, and hypocalcemia show a strong association with disease severity and mortality. Routine assessment and prompt correction of sodium and calcium abnormalities should be integrated into pediatric dengue management protocols, particularly in secondary and peripheral tertiary care hospitals, to improve risk stratification and patient outcomes.

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