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Laboratory Correlates of Dehydration Severity in Children with Acute Gastroenteritis in a Saudi Pediatric Emergency Department: A Retrospective Observational Study

Laboratory Correlates of Pediatric Dehydration

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ABSTRACT: Background: Assessment of dehydration severity is central to the management of children with acute gastroenteritis (AGE), but clinical signs alone have imperfect reliability and laboratory tests are not recommended routinely for every child. This study examined the clinical and laboratory correlates of dehydration severity among children presenting to a pediatric emergency department.

Methods: A retrospective observational study was conducted at Maternity and Children Hospital, Dammam, Saudi Arabia, using records from January to December 2023. Children aged ≥1 month and <14 years who presented with AGE and had laboratory testing were eligible. Dehydration was categorized as mild, moderate, or severe according to the documented clinical assessment framework used in routine care. Demographic, clinical, vital-sign, hematologic, renal, electrolyte, glucose, and acid-base variables were compared across severity groups using chi-square/exact tests or one-way analysis of variance, as appropriate.

Results: The analysis included 215 children: 126 (58.6%) with mild, 30 (14.0%) with moderate, and 59 (27.4%) with severe dehydration. Vomiting duration differed across severity groups ($p=0.049$), whereas most other historical variables did not. Respiratory rate was the only vital sign that differed significantly ($p=0.005$). Hemoglobin ($p=0.012$), serum creatinine ($p=0.049$), and urea ($p<0.001$) varied across dehydration categories; RDW and serum sodium, potassium, and chloride did not. Hypoglycemia was substantially more frequent in severe dehydration (59.3% of severe cases; $p<0.001$), and metabolic acidosis was reported only in the severe group ($p<0.001$).

Conclusions: Selected biochemical abnormalities—particularly urea, creatinine, glucose, and acid-base status—were associated with documented dehydration severity, whereas

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RDW and routine electrolytes did not distinguish severity groups. These findings support targeted laboratory assessment in clinically higher-risk children rather than routine testing in all AGE presentations. Because of the retrospective design and possible incorporation of laboratory findings into routine severity classification, the results should be interpreted as exploratory associations rather than independent diagnostic validation.

INTRODUCTION

Acute gastroenteritis (AGE) remains a major cause of childhood morbidity worldwide. The World Health Organization estimates that diarrhoeal disease causes approximately 443,832 deaths annually among children younger than 5 years, with dehydration remaining the principal immediate threat during severe diarrhoeal illness [1]. In emergency care, the key clinical task is therefore to identify children who are dehydrated, distinguish those with more substantial fluid deficit, and initiate appropriate oral or intravenous rehydration.

Dehydration is primarily a clinical diagnosis. Established approaches rely on combinations of general appearance, mucous-membrane findings, tears, eye appearance, perfusion, urine output, and other signs, while change in body weight after rehydration is often treated as a research reference standard when a reliable pre-illness weight is unavailable [2–5]. However, individual clinical signs have limited accuracy, and even validated clinical dehydration scales show variable performance across settings and severity spectra [4,5].

Guidelines consequently discourage routine blood testing in uncomplicated AGE, but recommend targeted measurement of electrolytes, urea/creatinine, glucose, and acid-base status when intravenous therapy is required, hypernatraemia is suspected, or shock is present [2,3]. Prior studies have reported mixed findings: urea, creatinine, bicarbonate, and venous pH have shown associations with fluid deficit or clinically assessed dehydration in some cohorts, whereas conventional laboratory tests have performed poorly as stand-alone estimators in others [6–10]. RDW has also been proposed as an inexpensive marker of AGE severity, but evidence remains limited [11].

The present study evaluated the relationship between documented dehydration severity and routinely available clinical and laboratory parameters among children with AGE presenting to a pediatric emergency department in Dammam, Saudi Arabia. The primary objective was to identify which routinely measured laboratory variables differed across mild, moderate, and severe dehydration categories. A secondary objective was to examine whether RDW was associated with dehydration severity in this population.

METHODS

Study design and setting

This retrospective observational study was conducted at Maternity and Children Hospital in Dammam, Eastern Province, Saudi Arabia, a specialist hospital providing pediatric emergency care. Medical records from January 1 through December 31, 2023 were reviewed. Reporting was structured with reference to the STROBE recommendations for observational studies [12].

Participants

Children aged ≥1 month and <14 years who presented to the emergency department with AGE were eligible. AGE was defined in the source protocol as three or more loose stools and/or three or more episodes of vomiting within 24 hours. Exclusion criteria were age <1 month or ≥14 years; chronic renal, gastrointestinal, or cystic-fibrosis-related disease; malnutrition or malabsorption syndromes; hydration therapy within the preceding 24 hours; absence of laboratory testing; or triage to primary health care rather than emergency-department evaluation. A retrospective convenience sample of eligible records was included.

Variables and data collection

A standardized abstraction form was used to collect age, sex, nationality, weight, illness duration, diarrhea and vomiting characteristics, fever, urine-output history, and relevant examination findings. Vital signs included temperature, heart rate, systolic and diastolic blood pressure, respiratory rate, and peripheral oxygen saturation (SpO_2). Laboratory variables included hemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), red cell distribution width (RDW),

platelet count, white blood cell count (WBC), serum creatinine, urea, sodium, potassium, chloride, the reported BUN/creatinine ratio, random blood glucose, and blood-gas classification.

Dehydration severity

Dehydration was categorized as mild, moderate, or severe according to the severity classification documented in the study abstraction. The source protocol describes the routine assessment as being informed by the Clinical Dehydration Scale and World Health Organization dehydration categories [1,4]. It also indicates that laboratory information could contribute to the overall severity assessment. Therefore, analyses of laboratory variables against the recorded severity category are treated as exploratory associations and not as an independent validation of those laboratory tests. This potential incorporation bias is addressed in the limitations.

Statistical analysis

Continuous variables are reported as mean ± standard deviation (SD), and categorical variables as frequency and percentage. Categorical variables were compared across dehydration groups with Pearson's chi-square test; an exact probability test was used when expected cell counts were small. Continuous variables were compared using one-way analysis of variance. Analyses used available data for each variable; notably, sex was reported for 101 of the 215 records in the supplied analytic table. All tests were two-sided, and $p<0.05$ was considered statistically significant. Because the analysis was exploratory and involved multiple unadjusted comparisons, borderline p values should be interpreted cautiously. The reported analyses were performed using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA).

Ethical approval

The study was approved by the Institutional Review Board of Maternity and Children Hospital, Dammam. Patient confidentiality was maintained throughout the study, and data were analyzed in de-identified form.

RESULTS

Participant characteristics

A total of 215 children met the study eligibility criteria. Dehydration severity was classified as mild in 126 children (58.6%), moderate in 30 (14.0%), and severe in 59 (27.4%). Age was not associated with dehydration severity ($p=0.167$). Sex information was available for 101 records and was not significantly associated with severity ($p=0.101$). Nationality, diarrhea duration, stool frequency, vomiting frequency, and fever category were also not significantly different across dehydration groups. Vomiting duration showed a borderline association with severity ($p=0.049$) (Table 1).

Vital signs and anthropometric measures

Most vital signs were similar across dehydration categories. Weight, temperature, heart rate, systolic blood pressure, diastolic blood pressure, and SpO_2 did not differ significantly. Respiratory rate differed across groups ($p=0.005$), although the pattern was not monotonic: the mean respiratory rate was 25.57±5.00 breaths/min in the mild group, 22.44±3.54 in the moderate group, and 24.11±4.27 in the severe group (Table 2).

Hematologic and biochemical markers

Hemoglobin differed across severity groups ($p=0.012$), but MCV, MCH, RDW, WBC count, and platelet count did not. RDW was 14.14±1.93% in mild, 14.27±0.97% in moderate, and 14.59±1.90% in severe dehydration ($p=0.291$). Serum creatinine differed across groups ($p=0.049$), with means of 38.35±9.56, 41.24±6.50, and 41.02±7.70 μmol/L in mild, moderate, and severe dehydration, respectively. Urea also differed significantly ($p<0.001$), but not in a simple dose-response pattern: the mean was 3.36±1.69 mmol/L in mild, 7.46±1.04 mmol/L in moderate, and 5.29±2.49 mmol/L in severe dehydration. Sodium, potassium, chloride, and the reported BUN/creatinine ratio were not significantly different across groups (Table 3).

Glucose and acid-base status

Random blood glucose category was strongly associated with dehydration severity ($p<0.001$). Hypoglycemia (<70 mg/dL) occurred in 9/126 (7.1%) mild cases, 7/30 (23.3%) moderate cases, and 35/59 (59.3%) severe cases. Blood-gas status also differed significantly ($p<0.001$): all 59 records classified as metabolic acidosis belonged to the severe dehydration group, whereas all mild and moderate cases were recorded as having a normal blood-gas category (Table 4).

DISCUSSION

Principal findings

In this single-center retrospective study of 215 children with AGE, most demographic characteristics, historical features, and standard vital signs did not clearly discriminate across documented dehydration-severity groups. In contrast, several laboratory variables differed across severity categories. The most notable findings were differences in urea and creatinine, the concentration of hypoglycemia among severely dehydrated children, and the exclusive occurrence of recorded metabolic acidosis within the severe group. RDW and routine serum electrolytes were not associated with dehydration severity.

Comparison with previous evidence

The renal-function findings are broadly consistent with earlier work showing that urea and creatinine can increase with more substantial volume depletion, plausibly reflecting reduced renal perfusion [7,8]. Hoxha et al. reported high specificity of urea and creatinine for severe dehydration, while Yilmaz et al. found that urea and bicarbonate were related to dehydration severity but serum sodium was not [6,7]. However, the literature is not uniform: Teach et al. found that conventional laboratory tests were generally poor predictors of measured fluid deficit, and Bonadio et al. reported that BUN magnitude alone was not an accurate measure of hydration status [9,10]. The present findings therefore support laboratory values as adjuncts rather than replacements for clinical assessment.

Acid-base status appears particularly relevant in children with clinically important dehydration. Parkin et al. found that venous pH and serum bicarbonate had useful positive likelihood ratios for greater dehydration in children with AGE [5]. In the present dataset, metabolic acidosis was recorded only among severe cases. This strong separation should nevertheless be interpreted with caution because the routine severity classification may itself have been informed by laboratory results.

Hypoglycemia was also concentrated in the severe group. In practical terms, this finding reinforces the value of glucose assessment in children with severe illness, poor intake, or a need for intravenous therapy. This is aligned with clinical guidance recommending glucose and biochemical testing selectively in children with more severe dehydration or those requiring intravenous fluids [2,3].

RDW did not differ across dehydration categories, in contrast with Korkmaz et al., who reported higher RDW with greater AGE severity using the modified Vesikari score [11]. The discrepancy may reflect differences in outcome definition: the modified Vesikari score captures global gastroenteritis severity, whereas the current analysis focused on a dehydration-severity category. Differences in population characteristics, comorbidity exclusions, and the retrospective design may also contribute.

Clinical implications

These findings should not be interpreted as an argument for routine laboratory testing in every child with AGE. Current guidance emphasizes clinical assessment and oral rehydration for most children, reserving blood testing for selected patients with severe dehydration, shock, suspected hypernatraemia, or a requirement for intravenous therapy [2,3]. Within that targeted context, urea/creatinine, glucose, and acid-base status may provide useful supportive information and help identify metabolic complications that require closer monitoring.

Strengths and limitations

The study provides real-world pediatric emergency-department data from Saudi Arabia and evaluates several commonly available laboratory variables in the same cohort. The sample size of 215 is larger than that reported in several earlier single-center studies, and the analysis includes both conventional renal/electrolyte measures and RDW.

Several limitations are important. First, the retrospective single-center design limits causal inference and generalizability. Second, a post-rehydration weight-based estimate of fluid deficit was not available, and dehydration severity depended on the routine documented classification. The source protocol indicates that laboratory findings could contribute to severity determination, creating potential incorporation bias and making the strongest laboratory associations partly non-independent. Third, sex was reported for only 101 records in the supplied analytic table, indicating missing data or incomplete abstraction for that variable. Fourth, numerous unadjusted group comparisons were performed without multiplicity correction, increasing the possibility of chance findings, particularly for p values close to 0.05. Fifth, no multivariable adjusted model is reported, so confounding by age, illness duration, or other clinical factors cannot be excluded. Sixth, several continuous variables show dispersion patterns

that warrant verification against the raw dataset before submission, particularly the very large reported SDs for potassium. Finally, management decisions, intravenous-fluid requirements, admission, return visits, and clinical outcomes were not evaluated.

CONCLUSION

Among children with AGE presenting to a Saudi pediatric emergency department, selected laboratory findings—particularly urea, creatinine, hypoglycemia, and metabolic acidosis—differed across documented dehydration-severity groups, whereas RDW and routine serum electrolytes did not. Laboratory testing should remain targeted to children in whom clinical severity or treatment requirements justify biochemical assessment. Prospective multicenter studies using an independent reference standard for percentage dehydration, prespecified multivariable models, and standardized laboratory thresholds are needed to determine whether these markers add diagnostic value beyond clinical assessment alone.

Declarations

Ethics approval

The study was approved by the Institutional Review Board of Maternity and Children Hospital, Dammam. Patient confidentiality was maintained, and only de-identified retrospective data were analyzed.

Conflict of interest

The authors declare no conflict of interest.

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Tables

Table 1. Demographic and clinical characteristics by dehydration severity

Variable	Total	Mild	Moderate	Severe	p value
Age					**0.167**
1–24 months	32 (14.9%)	24 (75.0%)	2 (6.2%)	6 (18.8%)	
3–5 years	45 (20.9%)	26 (57.8%)	8 (17.8%)	11 (24.4%)	
6–9 years	95 (44.2%)	47 (49.5%)	16 (16.8%)	32 (33.7%)	
10–14 years	43 (20.0%)	29 (67.4%)	4 (9.3%)	10 (23.3%)	
Sex (available n=101)					**0.101**
Boys	52/101 (51.5%)	30 (57.7%)	10 (19.2%)	12 (23.1%)	
Girls	49/101 (48.5%)	20 (40.8%)	8 (16.3%)	21 (42.9%)	
Nationality					**0.379†**
Saudi	210 (97.7%)	122 (58.1%)	29 (13.8%)	59 (28.1%)	
Non-Saudi	5 (2.3%)	4 (80.0%)	1 (20.0%)	0 (0.0%)	
Diarrhea duration					**0.405**
None	136 (63.3%)	80 (58.8%)	21 (15.4%)	35 (25.7%)	
<4 days	47 (21.9%)	24 (51.1%)	6 (12.8%)	17 (36.2%)	
4–5 days	19 (8.8%)	11 (57.9%)	2 (10.5%)	6 (31.6%)	
>5 days	13 (6.0%)	11 (84.6%)	1 (7.7%)	1 (7.7%)	
Stool frequency					**0.679†**
None	150 (69.8%)	85 (56.7%)	24 (16.0%)	41 (27.3%)	
1–3 times	16 (7.4%)	12 (75.0%)	0 (0.0%)	4 (25.0%)	
4–5 times	25 (11.6%)	14 (56.0%)	3 (12.0%)	8 (32.0%)	

Variable	Total	Mild	Moderate	Severe	p value
>5 times	24 (11.2%)	15 (62.5%)	3 (12.5%)	6 (25.0%)	
Vomiting duration					**0.049*†**
None	2 (0.9%)	2 (100.0%)	0 (0.0%)	0 (0.0%)	
<2 days	138 (64.2%)	77 (55.8%)	26 (18.8%)	35 (25.4%)	
3–4 days	51 (23.7%)	30 (58.8%)	2 (3.9%)	19 (37.3%)	
≥5 days	24 (11.2%)	17 (70.8%)	2 (8.3%)	5 (20.8%)	
Vomiting frequency					**0.290†**
None	30 (14.0%)	16 (53.3%)	4 (13.3%)	10 (33.3%)	
1 time	13 (6.0%)	12 (92.3%)	0 (0.0%)	1 (7.7%)	
2–4 times	40 (18.6%)	23 (57.5%)	7 (17.5%)	10 (25.0%)	
≥5 times	132 (61.4%)	75 (56.8%)	19 (14.4%)	38 (28.8%)	
Temperature/fever category					**0.233†**
<37°C	110 (51.2%)	60 (54.5%)	21 (19.1%)	29 (26.4%)	
37.1–38.4°C	97 (45.1%)	62 (63.9%)	8 (8.2%)	27 (27.8%)	
38.5–38.9°C	8 (3.7%)	4 (50.0%)	1 (12.5%)	3 (37.5%)	

Data are n (%) unless otherwise stated. Percentages within mild/moderate/severe columns are row percentages.

** p<0.05. † Exact probability test. Other categorical comparisons used Pearson's chi-square test.*

Sex data were available for 101 of 215 records. Age-category labels are reproduced from the source analytic table.

Table 2. Vital signs and anthropometric measures by dehydration severity

Variable	Total	Mild	Moderate	Severe	p value
Weight (kg)	17.46 ± 9.28	17.95 ± 10.38	18.69 ± 7.56	15.81 ± 7.26	0.256
Temperature (°C)	37.00 ± 1.70	37.21 ± 0.82	36.89 ± 0.56	36.61 ± 2.96	0.081
Heart rate (beats/min)	122.19 ± 22.64	121.13 ± 23.29	123.37 ± 25.53	123.83 ± 19.77	0.719

Variable	Total	Mild	Moderate	Severe	p value
Systolic BP (mmHg)	109 ± 11	108 ± 11	110 ± 12	109 ± 11	0.612
Diastolic BP (mmHg)	67 ± 11	67 ± 11	70 ± 14	65 ± 11	0.195
Respiratory rate (breaths/min)	24.73 ± 4.73	25.57 ± 5.00	22.44 ± 3.54	24.11 ± 4.27	0.005*
SpO_2 (%)	98.37 ± 1.49	98.42 ± 1.51	98.46 ± 1.43	98.24 ± 1.48	0.700

*Data are mean ± SD. Comparisons used one-way analysis of variance. * p<0.05.*

Table 3. Hematologic and biochemical markers by dehydration severity

Variable	Total	Mild	Moderate	Severe	p value
Hemoglobin (g/dL)	12.00 ± 1.22	11.84 ± 1.14	12.57 ± 1.16	12.05 ± 1.32	0.012*
MCV (fL)	78.51 ± 9.40	77.91 ± 9.33	77.31 ± 7.99	80.40 ± 10.05	0.185
MCH (pg)	25.61 ± 3.09	25.35 ± 2.99	25.29 ± 2.73	26.31 ± 3.40	0.121
RDW (%)	14.28 ± 1.82	14.14 ± 1.93	14.27 ± 0.97	14.59 ± 1.90	0.291
Platelets ($\times 10^3/\mu L$)	355.08 ± 113.22	353.97 ± 128.86	361.77 ± 71.34	354.05 ± 94.54	0.942
WBC ($\times 10^3/\mu L$)	10.49 ± 4.96	10.71 ± 4.90	11.53 ± 5.75	9.48 ± 4.59	0.133
Serum creatinine (μmol/L)	39.48 ± 8.78	38.35 ± 9.56	41.24 ± 6.50	41.02 ± 7.70	0.049*
Potassium (mmol/L)	5.55 ± 19.31	6.48 ± 25.31	4.21 ± 0.53	4.27 ± 0.49	0.710
Sodium (mmol/L)	135.49 ± 2.97	135.42 ± 2.88	136.23 ± 2.81	135.24 ± 3.21	0.307
Chloride (mmol/L)	99.23 ± 23.83	99.88 ± 21.47	90.87 ± 36.38	102.10 ± 19.86	0.098
Urea (mmol/L)	4.46 ± 2.38	3.36 ± 1.69	7.46 ± 1.04	5.29 ± 2.49	<0.001*
Reported BUN/creatinine ratio	0.16 ± 0.89	0.17 ± 1.15	0.13 ± 0.10	0.13 ± 0.26	0.941

*Data are mean ± SD. Comparisons used one-way analysis of variance. * p<0.05.*

The potassium SD values are reproduced from the supplied analytic table and should be verified against the raw dataset before submission.

Table 4. Random blood glucose and acid-base status by dehydration severity

Variable	Total	Mild	Moderate	Severe	p value
Random blood glucose					**<0.001*†**
Normal (70–150 mg/dL)	164 (76.3%)	117 (92.9%)	23 (76.7%)	24 (40.7%)	
Hypoglycemia (<70 mg/dL)	51 (23.7%)	9 (7.1%)	7 (23.3%)	35 (59.3%)	
Blood-gas category					**<0.001***
Normal	156 (72.6%)	126 (100.0%)	30 (100.0%)	0 (0.0%)	
Metabolic acidosis	59 (27.4%)	0 (0.0%)	0 (0.0%)	59 (100.0%)	

*Data are n (%). * p<0.05. † Exact probability test.*