Hematological Changes in Acute gastroenteritis in pediatrics: A single-center Case-Control Study

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Abstract

Background: Several hematologic parameters are involved in inflammatory processes through leukocyte and platelet activity, yet their diagnostic and prognostic role in acute gastroenteritis (AGE) remains unclear.

Objective: To evaluate different hematological parameters in children with AGE and determine their association with AGE severity.

Methods: A case–control study was conducted at Fayoum University Children's Hospital from February to July 2025, including 100 children aged under five years old, who attended the emergency department and the outpatient clinics of pediatric and family medicine with AGE, and 100 age-matched healthy controls. Complete blood count (CBC) indices were assessed in relation to disease severity using the Vesikari score.

Results: According to the Vesikari score, 10% of cases were severe. Among AGE patients, 64% required ward admission, 11% were admitted to the PICU, and 25% were managed at home. Compared with controls, AGE patients demonstrated significantly lower mean hemoglobin and MCH, a lower median MCV, and higher RDW and PMI values. CRP was significantly associated with higher Vesikari severity ($p = 0.036$). The Vesikari score also showed predictive accuracy for survival outcomes, with a sensitivity of 93.5% and a specificity of 57.1%.

Conclusion: Children with AGE exhibited distinct hematological alterations, most notably elevated RDW and PMI. CRP served as an independent predictor of Vesikari severity and prolonged hospitalization. These results emphasize the possible role of hematological and inflammatory markers in risk stratification and management of pediatric AGE.

Keywords: Acute gastroenteritis, complete blood count, Vesikari, Platelet mass index

Introduction

One of the most prevalent infectious diseases and a major reason for pediatric morbidity and mortality globally is acute gastroenteritis (AGE). Both the pathogen and the host are important risk factors that influence the severity of gastroenteritis. Rotavirus has been identified as the primary cause of severe and chronic diarrhea among other pathogens. The severity of diarrhea is influenced by host-related factors such as age, chronic illnesses, and immune deficiencies (1)**.**

Higher degrees of severity of dehydration and mild dehydration associated with social factors are common reasons for hospitalization in children with AGE. Accurately evaluating the level of dehydration in infants and children is crucial for forming informed treatment decisions (2)**.**

The Vesikari Scoring System (VSS) is an intensity rating scale initially designed to assess the efficacy and effectiveness of rotavirus vaccines, using a 20-point scoring system (3).

In recent studies, several blood-based parameters have been introduced to assess inflammatory activity across various diseases. The following parameters are useful in reflecting inflammatory burden and disease activity in numerous disorders: platelet-to-lymphocyte ratio (PLR), mean platelet volume (MPV), red cell distribution width (RDW), platelet distribution width (PDW), and neutrophil-to-lymphocyte ratio (NLR). Regretfully, little data confirmed the usefulness of these hematologic markers in AGE patients (4).

Given this context, our research was intended to assess the diagnostic utility of different hematological parameters and other routine laboratory investigations, and to correlate them with the severity of dehydration using the Vesikari scoring system

Methods

Ethical Considerations

All of the included children's legal guardians or parents signed consent forms. The current study (code number: R-671) was approved by the Local Ethics Committee of the Faculty of Medicine at Fayoum University in February 2025 and is consistent with the Declaration of Helsinki. The patient had the right to keep the results or to refuse to participate in the study.

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Competing interests: The authors declare no competing financial or non-financial interests.

Data and/or Code availability: The datasets produced and/or analyzed in this study are available from the corresponding author upon reasonable request.

Study design: This case-control study was performed at Fayoum University Children's Hospital in Fayoum, Egypt, from February to July 2025. The study comprised 100 patients with AGE and 100 healthy controls. All cases presented with AGE during the study period were included in the study. Sex and age were used to match the study groups.

Sample size calculation

Sample size measured employing G-Power© software version 3.1.7 (Institute of experimental psychology, Heinrich Heine University, Dusseldorf, Germany). Sample size of patients will be 100 patients in every group. Based on preceding research findings, a two-sided type I error rate of 0.05 and a power of 90% were used, with an effect size of 0.463.

Inclusion criteria

The case group included infants and children of both sexes, aged under five years old, who attended the emergency department and the outpatient clinics of pediatric and family medicine with AGE (described in children who suffered from at least three watery or loose stools in the preceding 24 hours, with or without vomiting or abdominal pain, for less than seven days (1)(3)(4)). The control group included healthy children that are age- and sex-matched.

Exclusion criteria

Patients with malnutrition, chronic hematological diseases, immunodeficiency, and chronically ill children with known GIT conditions were excluded.

Tools

All patients were subjected to the following:

I. **Full history taking** focusing on the patient's age, sex, nutritional history, residence, previous history of gastroenteritis, and duration of vomiting and diarrhea episodes.

II. **Thorough clinical evaluation.** Vesikari scoring system was used to asses severity of dehydration among cases as illustrated in table 1 **Severity assessment (The Vesikari score)**

The Vesikari score was calculated based on patient data retrieved from history and examination (3).

Table (1) Vesikari scoring system.

Severity assessment (Vesikari score)			
	1	**2**	**3**
Diarrhea			
Number of motions per day	1-3	4-5	≥6
Duration of diarrhea (days)	1-4	5	>6
Vomiting			
Max number per day	1	2-4	>5
Duration (days)	1	2	>3
Max body temp	37-38.4	38.5-38.9	>39
Severity of dehydration (%)	N/A	1–5	≥6
Treatment	rehydration	Hospitalization	N/A
Severity rating scale	<7mild	7-10 moderate	≥11severe

III. **Laboratory investigations:**

Laboratory investigations included Complete Blood Count, serum electrolytes, liver, kidney function, and ABG. Blood samples were gathered in two-milliliter EDTA tubes and analyzed at the hospital's central biochemistry laboratory using the same Sysmex Xn 1000, USA automated analyzer. PDW (%), RDW (pg), neutrophil count (2−12 × 10^3/μL), white blood cell count (4−10 × 10^3/μL), platelet count (156 to 373 × 10^3/μL), MPV (6.9 to 10.8 fl), and lymphocyte count (1−4.9 × 10^3/μL; 14.3%) were all measured. The NLR was obtained by dividing the total neutrophil count by the lymphocyte count derived from the differential analysis, whereas the PLR was determined by calculating the ratio of platelet count to

lymphocyte count. The platelet count was divided by the MPV to calculate the PMI. Serum electrolytes, liver, kidney function, and ABG were analyzed using Cobas c 311 (Roche Diagnostics, Switzerland), and ABG were analyzed using GEM 3500 Premier, USA.

Statistical analysis

Data were analyzed applying the Statistical Package for Social Sciences (SPSS), version 22 Descriptive statistics were reported as percentages and frequencies for categorical variables. For quantitative parametric variables, the arithmetic mean and standard deviation were computed, while for non-parametric variables, the median and range were reported. To compare quantitative variables across two independent groups, the independent-samples t-test was applied. For comparisons among more than two independent groups, one-way ANOVA was conducted. The Kruskal–Wallis test was employed to evaluate differences in non-parametric variables across more than two groups, whereas the Mann–Whitney U test compared two non-parametric independent groups. Categorical variables were analyzed utilizing the Chi-square test. Diagnostic performance was evaluated through specificity, sensitivity, and Receiver Operating Characteristic (ROC) curve analysis. Logistic regression was used to examine associations among dependent and independent variables and to identify predictors of risk. Statistical significance was defined as a p-value < 0.05.

Results

A total of 200 children were registered between February 2025 and July 2025 to participate in the research. One hundred patients with AGE were enrolled in the case group. Sixty-two of the cases were males (62%) with a median age of 12 months. Additionally, 100 healthy children (65 male patients, 65%) were enrolled (Table 2).

Table (2): Comparisons of demographic and clinical characteristics in the studied groups.

Variables	**Cases (N=100)**		**Control (N=100)**		**P-value**
	Median	**Range**	**Median**	**Range**	
Age (years)	12	1-48	12	3-46	0.07
Sex	**No.**	**%**	**No.**	**%**	
Male	62	62%	65	65%	0.76
Female	38	38%	35	35%	
Variables (n=100)	**Frequency**				
	Number		**%**		
Type of feeding					
Breast feeding	21		21%		
Artificial	35		35%		
Mixed	19		19%		
Weaning	25		25%		
Vesikari score					
Mild	41		41%		
Moderate	49		49%		
Severe	10		10%		
Site of management					
Ward	64		64%		
PICU	11		11%		
Home	25		25%		
Survival					
Discharged	93		93%		
Died	7		7%		
	Mean ±SD		**Median (Range)**		
Hospital stays (D)	2.4±1.8		2(0-7)		

SD: standard deviation; PICU: Pediatric intensive care unit. According to the Vesikari score severity, 49% had a moderate degree of dehydration, and 10% had a severe degree of dehydration. The mortality rate among cases was 7% (Table 2).

Table (3): Comparisons of laboratory investigations in distinct study groups.

Variables		**Cases** (N=100)		**Control** (N=100)		**P-value**
		Mean	**SD**	**Mean**	**±SD**	
HB g/dl		10.1	1.5	12.01	±1.5	**<0.001***
MCH pg		22.6	3.7	25.5	±3.2	**<0.001***
RDW fl		**16.7**	3.2	14.9	±1.7	**<0.001***
PLT 10^3 / µL		392.6	132.3	365.2	±128.6	0.14
MPV fl		8.9	1.2	8.7	±1.1	0.41
PMI		**3475.9**	1236.5	3152.5	±981.2	**0.04***
PDW %		10.5	1.3	10.5	±1.2	0.90
AST U/L		**35.4**	8.4	32.1	±10.8	**0.02***
ALT U/L		**25.5**	9.4	19.2	±6.7	**<0.001***
Na^+ mmol/l		135.3	3.3	137.5	±2.5	**<0.001***
K^+ mmol/l		**4.2**	0.45	3.9	±0.57	**0.002***
		Median	**Range**	**Median**	**Range**	
MCV		71	59-86	80.2	71-731	**<0.001***
TLC		10	3.4-28	9.1	4.8-16.4	0.06
L/M		5.4	0.195-133.7	7.1	3-18	0.14
N/L		0.78	0.24-6.6	0.73	0.22-4.2	0.98
M count		**940**	3.8-8200	617.4	234-1548	**<0.001***
N count		3575	24.5-16590	3065	1185.01-11497.3	0.72
L count		4711.8	62.7-14000	4536.8	1312.4-8424.1	0.69
MPV/PLT		0.022	0.01-0.063	0.024	0.009-0.059	0.12
P/L		85.8	16.1-7461.7	78.04	21.1-338.2	0.25
CRP mg\l		**22**	0-78	2	1-12	**<0.001***
Stool Leucocyte (/HPF)		**20**	10-50	2	1-4	**<0.001***
ABG	Normal	91	91%	100	100%	**0.003***
	Acidic	**9**	**9%**	0	0%	

SD: standard deviations; HB: hemoglobin level; MCH: Mean corpuscular hemoglobin; RDW: red cell distribution width; PLT: platelet count; MPV: mean platelet volume; PMI: platelet mass index; PDW: platelet distribution width; AST: Aspartate aminotransferase; ALT: alanine aminotransferase; MCV: Mean corpuscular volume; TLC: Total leucocytic count; L/M: Lymphocyte monocyte ratio; N/L: neutrophil-to-lymphocyte ratio; M count: monocyte count; N count: neutrophil count; L count: Lymphocyte Count; P/L: platelets -to-lymphocyte ratio; CRP: c reactive protein; ABG: ABG: arterial blood gases, HPF: High power field * Significant.

Table 3 shows a statistically significantly lower mean of hemoglobin, MCH, sodium, and a lower median of MCV, in addition to a higher mean of RDW, PMI, monocyte count, AST, ALT, potassium, CRP, and stool leucocytes among patients. Additionally, cases showed an acidic ABG with a p-value < 0.001.

Table (4): Comparisons of degrees of vesikari score as regards different laboratory tests among cases.

Variables	vesikari score				P-value
	Mild/ Moderate (n=90)		Severe (n=10)		
	Mean	±SD	Mean	±SD	
HB g\dl	10.1	±1.3	10.4	±2.4	0.18
RDW fl	16.8	±3.2	16.7	±3.1	0.97
PLT 10^3 / µL	390.2	±132.9	414.4	±131.1	0.72
MPV fl	8.9	±1.2	8.6	±1.1	0.29
PMI	3473.8	±1268.8	3495.1	±947.3	0.83
PDW %	10.6	±1.3	10.2	±1.2	0.42
ALT U|L	25.9	±9.4	21.7	±9.1	**0.01***
Na^+ mmol\l	135.5	±3.3	134.3	±3.1	0.26
K^+ mmol\l	4.3	±0.45	3.9	±0.35	**0.004***
	Median	**Range**	**Median**	**Range**	
TLC	10	3.4-28	9.8	7-20	0.58
L/M	5.4	0.19-133.7	62.02	0.19-133.7	0.47
N/L	0.78	0.24-6.6	0.76	0.29-6.4	0.55
M count	940	3.9-8200	1010	7.4-7790	0.62
N count	3500	24.5-16590	4100	1470-15800	0.33
L count	4536.8	62.7-14000	4749.5	984-11200	0.58
MPV/PLT	0.022	0.012-0.063	0.021	0.01-0.034	0.59
P/L	83.9	16.1-7461.7	101.7	45.8-286.6	0.33
CRP mg\l	18	0-60	49.8	3.8-78	**0.009***
stool Leucocyte (/HPF)	19	10-50	27.5	15-45	**0.005***

SD: standard deviations; HB: hemoglobin level; RDW: red cell distribution width; PLT: platelet count; MPV: mean platelet volume; PMI: platelet mass index; PDW: platelet distribution width; ALT: alanine aminotransferase; TLC: Total leucocytic count; L/M: Lymphocyte monocyte ratio; N/L: neutrophil-to-lymphocyte ratio; M count: monocyte count; N count: neutrophil count; L count: Lymphocyte Count; P/L: platelets -to-lymphocyte ratio; CRP: c reactive protein, HPF: High power field, * significant

Cases with a severe degree of the Vesikari score showed a statistically significantly lower level of ALT and potassium, and a higher level of CRP and stool leucocyte count(Table 4).

Table (5): Logistic regression analysis to establish the laboratory predictors of severe degree of the Vesikari score among cases.

	B	S.E.	Wald	Sig.	Exp(B)
CRP	0.041	0.020	4.387	**0.036***	1.042
ALT	-0.016	0.064	.064	0.800	0.984
K^+	-1.810	1.038	3.039	0.081	0.164
leucocyte in stool	0.054	0.042	1.620	0.203	1.056
Stool culture	-0.830	1.531	.294	0.588	0.436
ABG	1.158	1.214	.910	0.340	3.184
Constant	2.897	4.486	.417	0.518	18.128

CRP: C-reactive protein; ALT: alanine aminotransferase; ABG: Arterial blood gases, B: Beta coefficient, S.E.: standard error, Sig.: significance, Exp(B): exponential beta * Significant.

Regarding the laboratory predictors of a severe degree of the Vesikari score among cases, we found that there was a statistically significant prediction effect of CRP level with a p-value of 0.036 using the multivariate logistic regression model analysis (Table 5).

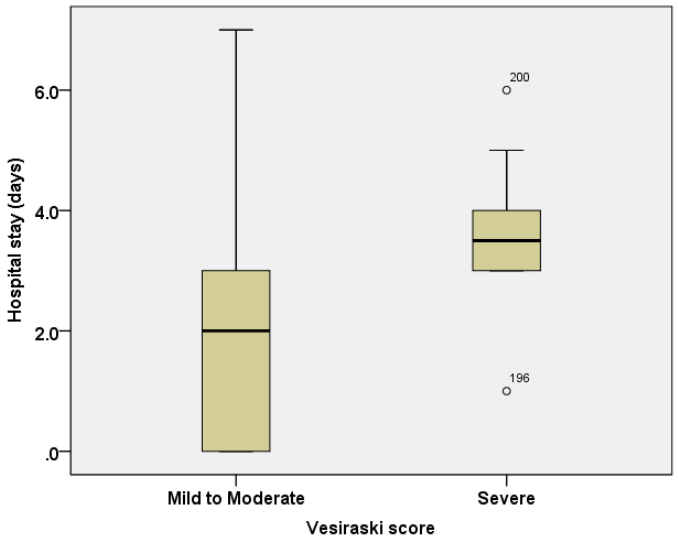


Figure (1): Correlation of period of hospital stay (days) and vesikari score degrees among cases.

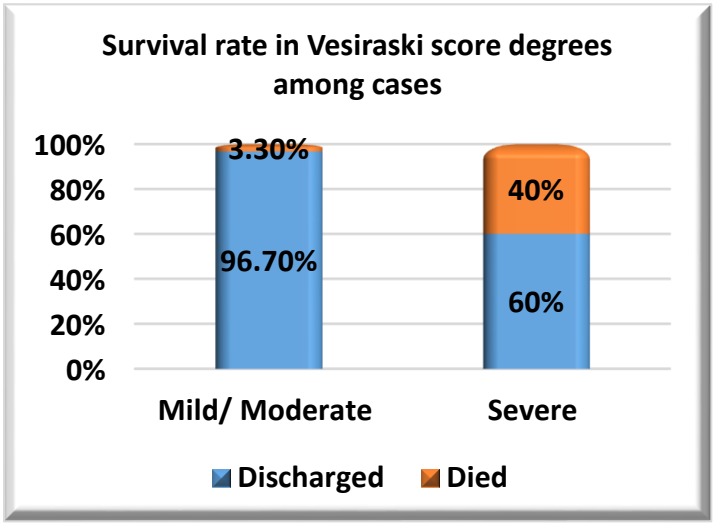


Figure (2): Comparison of survival rate in Vesikari score degrees among cases.

The mortality rate of cases with a severe degree of the Vesikari score was 40%, which is statistically significant in comparison to cases with mild and moderate degrees of the Vesikari score. They also exhibited a longer period of hospital stay, which is statistically significant (Figures 1, 2**).**

Table (6): Sensitivity and specificity of different laboratory investigations in the prediction of the Vesiraski score degree among cases.

Variable	Sensitivity	Specificity	AUC	cutoff	P-value (95%CI)
CRP	80%	63.3%	75.1%	23.5	**0.01*** (0.554-0.947)
ALT	80%	70%	74.5%	21.5	**0.01*** (0.555-0.935)
K^+	90%	55.6%	77.1%	4.15	**0.005*** (0.632-0.909)
leucocyte in stool	80%	66.7%	76.8%	22.5	**0.006*** (0.629-0.907)

AUC: area under the curve; CRP: C-reactive protein; ALT: alanine aminotransferase, CI: confidence interval; * Significant.

The ROC curve was employed to assess the specificity and sensitivity of different laboratory investigations in predicting a severe degree of the Vesikari score among cases. It revealed that CRP, ALT, potassium level, and stool leucocytes had statistically significant sensitivity and specificity in

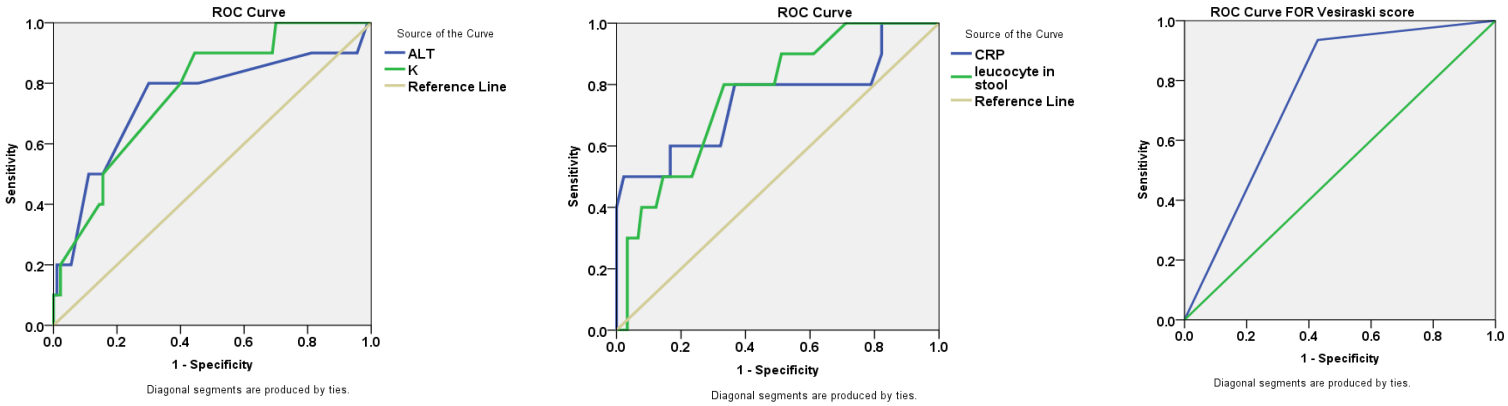
forecasting the Vesikari score, with sensitivities of 90% and 80%, and specificities ranging between 55.6% for potassium and 70% for ALT (Table 6 and Figure 3).

Table (7): Sensitivity and specificity of Vesiraski score in prediction of surviving outcome among cases.

Variable	Sensitivity	Specificity	PPV	NPV	AUC	P-value (95%CI)
Vesiraski score	93.5%	57.1%	96.7%	40%	75.3%	**0.026*** (0.524-0.983)

AUC: area under the curve; CRP: C-reactive protein; ALT: alanine aminotransferase, CI: confidence interval; * Significant.

The ROC curve for the Vesikari score in predicting survival outcome among cases reveals a significant predictive effect on the survival rate, with a sensitivity of 93.5% and a specificity of 57.1%, and an area under the curve of 75.3% (Table 7 and Figure 3).



A **B** **C**

Figure (3): ROC curve for:

A) ALT, and Potassium level in the prediction of the Vesikari score degree among cases.

B) CRP, and leucocyte count in stool in the prediction of the Vesiraski score degree among cases.

C) *The Vesikari score in prediction of survival outcome among cases.*

Discussion

Throughout the world, intestinal disorders are a significant public health concern for children in underdeveloped nations (5). Rotavirus has been recognised as the leading cause of severe dehydrating diarrhoea in children worldwide, particularly in developing countries (6).

Since the introduction of the Vesikari score for rotavirus vaccine trials, severity scoring systems have been widely employed in research to evaluate gastroenteritis severity. The classification of gastroenteritis as mild, moderate, or severe is beneficial for predicting patients' daycare and the count of lost workdays for their parents (7).

The current study is a case-control study that encompassed 100 children with AGE to assess the value of different hematological and other routine laboratory investigations in predicting the severity and outcome of pediatric AGE.

In the current study, the incidence of AGE was more common in males; however, it was not significant, in accordance with Ahmed et al. (8), who documented that some research indicated a higher incidence in boys, but the difference was not statistically significant in any of the investigations.

Since the rotavirus vaccine is not a part of our nation's regular immunization schedule, breastfeeding is the most effective way to prevent diarrhea. Compared to infants who are not breastfed, breastfed babies typically have less severe diarrhea and a significantly lower risk of dehydration. Breastfeeding offers significant benefits that protect the intestine, boost the child's immune response, and guarantee the persistence of a healthy intestinal flora (9). This is in line with our findings that AGE occurred in a lower percentage in breastfed babies.

Severe cases had longer hospital stays than mild and moderate cases. A study from Egypt confirmed our findings (10). The mean of hospital stays was 2.4 days which was lower than a study from Lebanon (11).

The mortality rate in our study was 7% which was lower than in another work (12) which was 21%. This may be attributed to a lack of routine rotavirus immunisation in our region

According to the VSS score, severe cases showed higher serum CRP, serum creatinine, and acidic ABG levels. Sasaran et al. (7) noted the same results, which are consistent with our findings.

The serum potassium was lower in severe cases in our study. This contradicts (7) which found a higher potassium level in severe cases. This might be ascribed to the small percentage of severe cases in our study. Our findings demonstrated increased ALT levels in severe cases, which is consistent with earlier research (13). This may be attributed to dehydration and some degree of inflammation.

The diagnostic utility of several hematological markers in AGE patients was examined in this study. Hemogram parameters can be a useful tool for early disease detection, prompt supportive therapy initiation, determining the degree of inflammation, and prognostic assessment due to their speed and accessibility (14).

Numerous studies that found a relationship among platelet activation and the pathophysiology of inflammatory processes have described the unique role of platelets in inflammation (15). In contrast to our findings, many trials showed a significant reduction in MPV levels, despite the fact that the majority of them involved children. According to recent research by Mete et al. (16), children with rotavirus gastroenteritis had lower MPV levels than children in good health. However, Çelik et al. (17) revealed that patients with gastroenteritis who had amebiasis had greater MPV levels. The variability in results could be attributed to factors such as systemic inflammatory intensity, small sample size, and inability to identify causative organisms. To our knowledge, this is the first study that investigated the relation between PMI and AGE. Our results concluded that PMI is higher in cases than in controls.

In our study, gastroenteritis cases had decreased hemoglobin levels compared to the healthy controls. Also, Bardakci et al. (4) agreed with us.

NLR, PLR, and LMR were also investigated in our work, with no statistical significance. However, Bardakci et al.(4)contradicted our findings. They mentioned that NLR and PLR were greater in gastroenteritis cases.

RDW was significantly greater in cases compared to control children, but it couldn't predict the severity. On the other hand, Korkmaz et al. (1) discovered that higher RDW was related to severe cases.

Conclusions

Haematological parameter changes were observed in children with AGE, including increased RDW and PMI. CRP was a significant predictor of the severity of the Vesikari score and the longer period of

hospital stay. There was a high mortality rate in cases with a severe Vesikari score. The sensitivity of the Vesikari score in predicting survival outcomes among cases was 93.5%, and the specificity was 57.1% using the ROC curve.

Recommendations

We recommend using the Vesikari score as a prognostic score for the severity and mortality in children with AGE. Follow up CBC with a great emphasis on different parameters, such as HB, MCH, PDW, RDW, and PMI, during the management of children with AGE.

Limitations

One major limitation of our research is that our cases did not conduct any investigations for the diagnosis of causative organisms, such as stool PCR for rotavirus analysis. A relatively small number of cases were enrolled in this study; large-scale multicenter clinical trials are required to validate this evidence. In addition, biomarkers were only assessed upon admission. Serial measures would have provided a greater correlation with clinical outcomes. Finally, other inflammatory markers such as interleukin-6 and procalcitonin were better investigated, but we didn't use them due to limited resources.

Authors contribution

Huda Ahmed El-Kady: Writing – discussion, review & editing, conclusion, recommendation, limitations, gathering data, Investigation, Data curation, and corresponding author.
Azza El-Ashiry: Writing – methodology, gathering data, Formal analysis, Conceptualization.
Amany M. Ahmed: Writing – laboratory analysis, Investigation, and interpretation of investigations.
Asmaa Younis Elsary: Writing – methodology, statistical analysis.
Heba Abdel Gwad Borayek: Gathering data, Formal analysis, Methodology, Writing – introduction, review & editing.
The final paper was carefully reviewed and approved by all the authors.

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