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A New Approach to Blood Parameters in Dogs with Hemorrhagic Enteritis

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ABSTRACT

***Background*:** Some blood parameters have diagnostic and prognostic importance for the infections in human medicine. However, there is insufficient research regarding the importance of blood parameters and their correlations in veterinary medicine. Increased blood cell distribution width (RDW) and platelet activity can link with the important inflammatory markers. The main objective of the present study was the evaluation of the relationship among some important blood parameters namely RDW, platelet count (PLT), platelet distribution width (PDW), mean platelet volume (MPV), plateletcrit (PCT), their potential usage in the diagnosis and determination of the clinical severity in dogs with hemorrhagic enteritis.
***Materials, Methods & Results*:** In this study, the case records of 29 dogs with hemorrhagic enteritis were evaluated and the records of 10 healthy dogs were used as controls. The animals of the study group were presented at the Ondokuz Mayis University, Veterinary Internal Medicine Clinic. The complete blood count (CBC), which includes the total WBC, RBC, hematocrit (HCT), hemoglobin concentration (Hgb), MCV, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), RDW, PLT, MPV, PCT, and PDW, was determined. Significant positive correlations between RDW and RBC, HCT, MCHC, PLT and PDW, and a negative correlation with MCV, were determined. PDW was positively correlated with the lymphocyte count, MCHC and RDW, and negatively correlated with PCT. PLT was negatively correlated with MCV and MPV and positively correlated with RBC and RDW. In addition, MPV was positively correlated with MCV and MCH, and negatively correlated with PLT. Furthermore, there were significant differences between the granulocyte, WBC, HCT, RDW and PDW values ($P < 0.001$) and monocyte count, Hgb and MCV ($P < 0.05$), of the study and control groups.
***Discussion*:** Acute hemorrhagic enteritis has various causes in dogs such as idiopathic hemorrhagic gastroenteritis and a number of viral, bacterial and parasitic agents. Hematological and biochemical parameters are not specific to enteric diseases, but these paremeters can provide clinically helpful information for differential diagnosis, response to treatment, and prognosis. In this frame, the evaluation of MCV and RDW in combination, and the determination of the mean red cell size and the extent of heterogeneity of the red cell population, can be especially useful to the diagnosis of different red blood cell disorders. In the present study, differences in RDW and MCV values were statistically significant between the study and control groups ($P < 0.05$). Increased RDW and decreased MCV can be good indicators of hemorragic diseases and in the present study, in addition to these findings, decreased Hgb and Hct confirmed anemia in dogs with hemorrhagic enteritis. The other key findings of this study were statistically significant relationships between RDW, PLT and PDW, which could be important indicators of inflammation in dogs with hemorrhagic enteritis. These parameters should be evaluated carefully in clinical cases of hemorrhagic enteritis. However, due to nature of retrospective studies, there were some limitations (the lack of another control group of dogs suffering from other hemorrhagic diseases) lack of serial measurements of the blood parameters and further studies should be carried out on dogs with hemorrhagic enteritis for a more detailed evaluation and confirmation of the findings of this study.

Keywords: Blood parameters, hemorrhagic enteritis, mean platelet volume (MPV), platelets, platelet distribution width (PDW), red blood cell distribution width (RDW).

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INTRODUCTION

Hematological and biochemical parameters are not specific enough to reveal the cause of enteric diseases, but they can provide clinically helpful information for differential diagnosis, response to treatment, and prognosis [2,3,5]. To evaluate these parameters, the levels of red blood cells (RBCs), white blood cells (WBCs) and platelets (PLT) are measured electronically [13].

Red blood cell distribution width (RDW) is a very useful parameter for the evaluation of the anisocytosis, the degree of heterogeneity of erythrocyte volume, and is used in laboratory haematology for the diagnosis of different anemias [15]. Additionally, it has been reported that RDW can be used as a marker of inflammation and there was a relationship between increased RDW and bloodstream infection [6].

Platelets appear to be important in a variety of pathological conditions in dogs [8,12]. Plateletcrit (PCT), mean platelet volume (MPV) and platelet distribution width (PDW) are important parameters in the examination of platelet activation [20]. MPV and PDW are the mean platelet size and the variation in platelet size, respectively. The PCT, which is derived from the platelet count and the MPV, indicates the percentage of platelets in a decilitre of blood, in a similar manner to hematocrit determination for erythrocytes [17].

Against that background, the aim of this study was the evaluation of the relationship among some important blood parameters, namely RDW, PLT, PDW, MPV PCT, and their potential usage in the diagnosis and determination of the clinical severity in dogs with hemorrhagic enteritis.

MATERIALS AND METHODS

Collection of blood samples

The blood test results of 29 dogs with hemorrhagic enteritis (2-12 months old), which were presented at the Ondokuz Mayis University, Veterinary Internal Medicine Clinic, were used as the study group. The blood test results of 10 clinically healthy dogs were used as the control group. Blood samples were collected into tubes containing EDTA.

Hematological analysis

The samples were analyzed with an automated blood analyzer (Abacus Junior Vet - Mindray Bc-5000)[1]. The complete blood count (CBC), which includes the total WBC, lymphocytes, monocytes, granulocytes, RBC, hematocrit (HCT), hemoglobin concentration (Hgb), MCV, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), RDW, PLT, MPV, PCT, and PDW, was determined.

Data Analysis

Pearson's correlation test was used for the determination of the degree of correlation among the investigated blood parameters. In addition, after the determination of normality of the data, for statistical comparison of the groups, the Independent Samples *t*-Test was employed for parametric values and the Mann-Whitney U test was used for non-parametric values. Differences were considered significant when P values were less than 0.05.

RESULTS

In this study, significant positive correlations between RDW and RBC, HCT, MCHC, PLT and PDW, and a negative correlation with MCV, were determined. PDW was positively correlated with the lymphocyte count, MCHC and RDW, and negatively correlated with PCT. PLT was negatively correlated with MCV and MPV and positively correlated with RBC and RDW. In addition, MPV was positively correlated with MCV and MCH, and negatively correlated with PLT (Table 1).

Furthermore, there were significant differences between the granulocyte, WBC, HCT, RDW and PDW values ($P < 0.001$) and monocyte count, Hgb and MCV ($P < 0.05$), of the study and control groups (Table 2). However, there was no significant difference between the RBC, MCH and MCHC values of the groups ($P > 0.05$).

DISCUSSION

RDW is mainly used for the detection and classification of anemias. In addition, the evaluation of MCV and RDW in combination, and the determination of the mean red cell size and the extent of heterogeneity of the red cell population, can be especially useful to the diagnosis of different red blood cell disorders. When MCV is insufficient for a diagnosis, RDW can be an additional finding. In addition, this information has a potential use in the screening and monitoring of marrow function in iron deficiency [11].

Table 1. Correlations among the blood parameters of dogs with hemorrhagic enteritis and healthy dogs.

Parameters	Correlation analysis	WBC	LYM	MONO	GRA	RBC	HGB	HCT	MCV	MCH	MCHC	RDWc	PLT	PCT	MPV	PDW
WBC	Pearson Correlation	1	**.419***	**.430***	**.921****	-.078	-.132	-.076	-.064	.052	.072	-.065	-.254	-.242	.067	.203
	Sig. (2-tailed)		.024	.020	.000	.688	.493	.696	.742	.790	.710	.736	.192	.214	.734	.301
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
LYM	Pearson Correlation	**.419***	1	.091	.036	.163	.173	.197	.093	.212	.275	.207	.007	-.202	.130	**.494****
	Sig. (2-tailed)	.024		.639	.855	.399	.369	.305	.632	.270	.149	.282	.971	.304	.509	.008
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
MONO	Pearson Correlation	**.430***	.091	1	**.379***	-.020	.047	-.003	-.084	.021	.119	-.078	-.012	-.024	-.006	-.245
	Sig. (2-tailed)	.020	.639		.043	.917	.809	.988	.663	.916	.537	.688	.952	.902	.976	.208
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
GRA	Pearson Correlation	**.921****	.036	**.379***	1	-.149	-.221	-.161	-.108	-.034	-.035	-.145	-.294	-.199	.020	.042
	Sig. (2-tailed)	.000	.855	.043		.441	.248	.404	.578	.860	.855	.452	.129	.311	.918	.834
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
RBC	Pearson Correlation	-.078	.163	-.020	-.149	1	**.643****	**.943****	-.147	-.246	.111	**.508****	**.454***	.001	-.327	.303
	Sig. (2-tailed)	.688	.399	.917	.441		.000	.000	.447	.199	.568	.005	.015	.997	.089	.117
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
HGB	Pearson Correlation	-.132	.173	.047	-.221	**.643****	1	**.749****	.343	**.471****	**.579****	.239	.218	.015	-.097	.259
	Sig. (2-tailed)	.493	.369	.809	.248	.000		.000	.068	.010	.001	.212	.266	.941	.622	.183
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
HCT	Pearson Correlation	-.076	.197	-.003	-.161	**.943****	**.749****	1	.150	-.062	.265	**.454***	.301	-.023	-.173	.290
	Sig. (2-tailed)	.696	.305	.988	.404	.000	.000		.436	.750	.165	.013	.120	.908	.379	.134
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
MCV	Pearson Correlation	-.064	.093	-.084	-.108	-.147	.343	.150	1	**.561****	.239	**-.439***	**-.477***	.073	**.421***	-.176
	Sig. (2-tailed)	.742	.632	.663	.578	.447	.068	.436		.002	.211	.017	.010	.713	.026	.370
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
MCH	Pearson Correlation	.052	.212	.021	-.034	-.246	**.471****	-.062	**.561****	1	**.787****	-.134	-.288	-.081	**.380***	.169
	Sig. (2-tailed)	.790	.270	.916	.860	.199	.010	.750	.002		.000	.490	.137	.683	.046	.390
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
MCHC	Pearson Correlation	.072	.275	.119	-.035	.111	**.579****	.265	.239	**.787****	1	**.411***	-.032	-.249	.257	**.393***
	Sig. (2-tailed)	.710	.149	.537	.855	.568	.001	.165	.211	.000		.027	.871	.202	.186	.039
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
RDWc	Pearson Correlation	-.065	.207	-.078	-.145	**.508****	.239	**.454***	**-.439***	-.134	**.411***	1	**.392***	-.224	-.011	**.580****
	Sig. (2-tailed)	.736	.282	.688	.452	.005	.212	.013	.017	.490	.027		.039	.251	.957	.001
	N	29	29	29	29	29	29	29	29	29	29	29	28	28	28	28
PLT	Pearson Correlation	-.254	.007	-.012	-.294	**.454***	.218	.301	**-.477***	-.288	-.032	**.392***	1	.141	**-.589****	-.024
	Sig. (2-tailed)	.192	.971	.952	.129	.015	.266	.120	.010	.137	.871	.039		.474	.001	.905
	N	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
PCT	Pearson Correlation	-.242	-.202	-.024	-.199	.001	.015	-.023	.073	-.081	-.249	-.224	.141	1	.073	**-.414***
	Sig. (2-tailed)	.214	.304	.902	.311	.997	.941	.908	.713	.683	.202	.251	.474		.712	.028
	N	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
MPV	Pearson Correlation	.067	.130	-.006	.020	-.327	-.097	-.173	**.421***	**.380***	.257	-.011	**-.589****	.073	1	.080
	Sig. (2-tailed)	.734	.509	.976	.918	.089	.622	.379	.026	.046	.186	.957	.001	.712		.687
	N	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
PDW	Pearson Correlation	.203	**.494****	-.245	.042	.303	.259	.290	-.176	.169	**.393***	**.580****	-.024	**-.414***	.080	1
	Sig. (2-tailed)	.301	.008	.208	.834	.117	.183	.134	.370	.390	.039	.001	.905	.028	.687	
	N	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28

Bold marked values are statistically different from the control group ($P < 0.05$; **$P < 0.001$).

Table 2. Blood parameters of the control group and the study group of dogs with hemorrhagic enteritis (Mean ± S.E.M.).

Parameter	Control (n = 10)	Study group (n = 29)
WBC (10^9/L)	12.00 ± 0.73	5.89 ± 0.78**
Lymphocytes (10^9/L)	1.98 ± 0.22	1.98 ± 0.30
Monocytes (10^9/L)	0.65 ± 0.12	0.28 ± .0.49*
Granulocytes (10^9/L)	9.36 ± 0.65	3.61 ± 0.69**
RBC (10^{12}/L)	6.61 ± 0.18	5.88 ± 0.30
HGB (g/dL)	15.91 ± 0.52	13.21 ± 0.81*
HCT (%)	45.45 ± 1.41	36.97 ± 2.09*
MCV (fL)	68.76 ± 0.88	63.76 ± 0.97*
MCH (pg)	24.08 ± 0.36	23.33 ± 1.12
MCHC (g/L)	34.73 ± 0.31	35.40 ± 1.84
RDWc (%)	14.40 ± 0.48	17.69 ± 0.85**
PLT (10^9/L)	352.20 ± 28.20	449.11 ± 55.32
PCT (mL/L)	0.91 ± 0.40	0.56 ± 0.12
MPV (fL)	9.47 ± 0.30	9.68 ± 0.34
PDW (%)	15.48 ± 0.09	33.43 ± 1.93**

Significantly different from the control group ($P < 0.05$; **$P < 0.001$).

In the present study, differences in RDW and MCV values were statistically significant between the study and control groups ($P < 0.05$). Increased RDW and decreased MCV can be good indicators of hemorragic diseases [10,14] and in the present study, in addition to these findings, decreased Hgb and Hct confirmed anemia in dogs with hemorrhagic enteritis. In addition, a previous study reported that RDW can be used to evaluate the prognosis of septic shock and severe sepsis in human patients [7]. Unterer *et al*. [19] reported that there is an increased probability of bacterial translocation due to damage to the intestinal epithelial barrier and increased risk of sepsis in the case of acute intestinal diseases. In the present study, the mean RDW value of the study group was significantly higher than in the control group ($P < 0.01$). This finding may show that increased RDW level can also be important in veterinary medicine and indicate the severity of sepsis and therefore be prognostic for hemorrhagic enteritis in dogs.

Furthermore, increased RDW is linked with the important inflammatory markers, interleukin-6 and tumor necrosis factor. The cytokines may have a role in the suppression of the maturation and reduction of the half-life of RBCs [6,10,14]. The RDW status represents a surrogate marker for illness severity and the early stage of acute illness and thereby correlates with the clinical prognosis [22]. RDW also has prognostic value in patients with acute myocardial infarction, cardiac arrest, congestive heart failure, critical illness, pneumonia and pulmonary embolism. The mechanism changing RDW range is not clearcut in these diseases, but it has been associated with the inflammatory process [6]. In the present study, increased RDW could also be reflecting severe clinical inflammation in dogs with hemorrhagic enteritis.

Platelets are intimately involved in homeostasis, inflammation, immunity, tissue regeneration and other physiological and pathological processes [18]. Some researchers have reported that,as for RDW, platelets are very important in the pathogenesis of local and systemic inflammation related disorders. Platelet activation has been reported in particular diseases, such as acute systemic inflammatory response syndrome (SIRS), disseminated intravascular coagulation (DIC), gastrointestinal disorders, inflammatory bowel disease and septicemia, in animals and human beings [16,18].

The three platelet parameters, namely PCT, MPV and PDW, are important indicators of platelet activation [20]. Activated platelets have some chemotactic substances such as the platelet-derived growth factor and lipopolysaccharides. These substances facilitate the binding of leukocytes to the endothelium and their extra-vasation, and they may either stimulate or inhibit the inflammatory responses of leukocytes. The platelets themselves also contain a group of pro-inflammatory compounds and are therefore accepted to be mediator and effectors cells in inflammation [4,8,21].

In the present study, although the mean platelet count of the study group was higher than that of the control group, the difference was not statistically significant. Several studies have presented data which infer a correlation between higher MPV values and active inflammatory disease [9]. Researchers have re-

ported a nonlinear, inverse relationship between MPV and platelet count in dogs and humans. However, in dogs, there is contradictory information as to whether there is a statistically significant relationship between MPV and PLT [1,23]. In this study, a negative correlation between MPV and PLT was determined in dogs with hemorrhagic enteritis.

Increased numbers of larger platelets increase platelet heterogeneity (PDW). The PDW is also elevated as a bone marrow response to thrombocytopenia. In human medicine, divergences from the expected relationship between MPV and PLT have been used to differentiate the causes of thrombocytopenia in terms of their importance for determination of the current situation and prognosis. PDW may be a more sensitive indicator of increased proportions of macroplatelets than MPV because the latter may be decreased by the presence of smaller platelets and cellular debris [1].

In the present study, mean MPV values were almost the same in the control group as in the study group, whereas the mean PDW values of the study group were two times higher than the control group ($P < 0.001$). Furthermore, PDW was positively correlated with lymphocyte numbers. Therefore, abnormal RDW and PDW counts may be indicative of a severe response to inflammation in dogs with hemorrhagic enteritis and be useful new parameters for the diagnosis of hemorrhagic enteritis.

CONCLUSIONS

In conclusion, in the present study there was a significant relationship between RDW, PLT and PDW, which could be an important indicator of inflammation in dogs with hemorrhagic enteritis. Therefore, these parameters should be evaluated carefully in clinical cases of hemorrhagic enteritis. However, it should be noted that the data was obtained from a retrospective study, which implies limitations such as the lack of another control group of dogs suffering from other hemorrhagic diseases and lack of serial measurements of the blood parameters. For a more detailed evaluation and confirmation of the findings of this study, further studies should be performed on dogs with hemorrhagic enteritis.

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