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RESEARCH ARTICLE

Diagnostic and prognostic value of lipopolysaccharide binding protein and soluble urokinase plasminogen activator receptor in dogs with parvoviral enteritis

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Parvoviral enteritisli köpeklerde lipopolisakkarit bağlayıcı protein ve soluble ürokinaz plazminojen aktivatör reseptörünün tanısal ve prognostik değeri

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Öz

Amaç: Bu çalışmada, parvoviral enteritisli köpeklerde lipopolisakkarit bağlayıcı protein (LBP) ve soluble ürokinaz plazminojen aktivatör reseptörünün (suPAR) tanısal ve prognostik değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: Bu çalışmanın hayvan materyalini 1-6 ay yaşlar arasında farklı ırk ve cinsiyette kanlı ishal semptomu gösteren hızlı test kiti yardımıyla parvoviral enteritis teşhisi konulan 20 köpek hasta grubunu oluşturdu. Kontrol amacıyla kliniğe getirilen ve yapılan fiziksel muayeneler sonucunda sağlıklı olduğu belirlenen 10 köpek kontrol grubunu oluşturdu. Çalışmadaki köpeklerin tamamından bir defa *Vena cephalica antebrachi*'den kan örnekleri alındı. Alınan örnekten tam kan hücresi sayımı yapıldı. Serum örneklerinden serum biyokimyasal analizleri yapıldı.

Bulgular: Serum örnekleri ise biyokimyasal ölçümler yapılana kadar -20°C'de muhafaza edildi. Hematoloji bulgularında hasta grupta total lökosit sayısı, eritrosit sayısı, hemoglobin sayısı ve hematokrit yüzdesi kontrol grubuna kıyasla istatistiksel olarak anlamlı düşük bulundu ($p<0,05$). Hasta grupta kreatinin ($p=0,040$), üre ($p=0,036$), total bilirubin ($p=0,011$), seruloplazmin ($p=0,008$), haptoglobin ($p<0,001$) ve LBP ($p=0,011$) konsantrasyonları kontrol grubuna göre istatistiksel olarak anlamlı yüksek bulurken, albümin ($p=0,005$) ve suPAR ($p=0,012$) konsantrasyonları düşük bulunmuştur.

Öneri: Sonuç olarak parvoviral enteritisli köpeklerde seruloplazmin, haptoglobin, LBP ve suPAR diagnostik ve prognostik olarak önemli bulunmuştur.

Anahtar kelimeler: Köpek, LBP, parvoviral enteritis, suPAR

Abstract

Aim: The aim of this study was to evaluate the diagnostic and prognostic values of lipopolysaccharide binding protein (LBP) and soluble urokinase plasminogen activator receptor (suPAR) in dogs with parvoviral enteritis (CPV).

Materials and Methods: Twenty dogs, 1-6 months old, from different breeds and genders were enrolled in the study. The presence of parvoviral enteritis confirmed by rapid test kit and ongoing bloody diarrhea. Ten healthy age matched dogs were enrolled in the study as control group. Blood samples were taken once from all of the dogs from *Vena cephalica antebrachi*. A complete blood cell count was measured from taken sample. Serum biochemical analyses were performed from the serum samples

Results: Total leukocyte count, erythrocyte count, hemoglobin count and hematocrit percentage were significantly lower in the dogs with CPV compared to the control group ($p<0.05$). While creatinine ($p=0.040$), urea ($p=0.036$), total bilirubin ($p=0.011$), ceruloplasmin ($p=0.008$), haptoglobin ($p<0.001$) and LBP ($p=0.011$) concentrations were significantly higher in the dogs with CPV compared to the control group, albumin ($p=0.005$) and suPAR ($p=0.012$) concentrations were found to be low.

Conclusion: Ceruloplasmin, haptoglobin, LBP and suPAR were found to be diagnostically and prognostically important in dogs with parvoviral enteritis.

Keywords: Dog, LBP, parvoviral enteritis, suPAR

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Introduction

Parvovirus was isolated from a healthy dog feces in the United States in 1967. Then it was grown in Walter Reed cell culture (Bloom and Kerr 2006). Two types of parvovirus have been identified that cause disease in dogs (Willard 2009). One of these has been detected in respiratory and digestive system diseases in dogs and has been named Canine minute virus (CPV-1). Canine parvovirus type-1 causes pneumoenteritis and myocarditis in dogs aged 7-21 days (Willard 2009). Later, in 1978, a different species was isolated and named Canine parvovirus type-2 (CPV-2). Parvoviral enteritis (PVE) is a worldwide viral disease that usually leads to severe infection with a high morbidity and mortality rate with an acute course in dogs younger than 1 year of age (especially those younger than 6 months of age) (Er and Ok 2015, Decaro et al 2007, Karayigit and Karatas 2018). Diseased dogs scatter the agent to the environment with urine, saliva, nasal discharge and especially feces. The most important transmission route is the fecal-oral route. Those who recover continue to spread the agent into the environment for months. Direct contact with all excrets and secretions of diseased animals, fecal-oral route and respiratory tract play a role in transmission (Bloom and Kerr 2006, Er and Ok 2015). Lipopolysaccharide binding protein (LBP) is an acute phase reactivator. It is a glycosylated protein and has a weight of 58 kDa. In traumatic situations, stress and sepsis, its concentration increases 30 times. In cases of infection, it oscillates within 15-30 minutes and reaches a high concentration within 24-48 hours (Altin 2011). LBP exhibits both inflammatory and non-inflammatory properties. This is because lipoplisaccharides increase toxic activity by a factor of 100-1000 under the influence of LBP (Fierer et al 2002). In addition, LBP produces an immune response to LPS. LBP binds to the lipid A part of LPS's structure and cytokine is released as a result of its interaction with toll-like receptor 4 (Gold 2011).

Soluble urokinase plasminogen activator receptor (suPAR) has a pathogenic function as well as being an inflammatory biomarker. High concentrations of suPAR cause damage to the kidneys. In particular, it plays a role in the pathogenesis of glomerulosclerosis. Once suPAR enters the glomeruli, it binds to β3 integrin, which leads to its activation, podocyte dysfunction and therefore proteinuria (Wei et al 2011, Bilgili and Cinel 2013).

The aim of this study was to evaluate the diagnostic and prognostic values of LBP and suPAR concentrations in dogs with parvoviral enteritis.

Material and Methods

Animal material

The animal material of this study consisted of 20 diseased dogs of different breeds and genders that were between the ages of 1-6 months, showed symptoms of bloody diarrhea, diagnosed with parvoviral enteritis with the help of a rapid test kit, and 10 dogs that were brought to the clinic for control purposes and determined to be healthy as a result of laboratory and physical examinations. In addition, those who die during treatment and those who recovered in the patient group were grouped for prognostic evaluation. Patient dogs were divided into two groups as recovering and dead.

Study protocol

Dogs, showed clinical symptoms of bloody diarrhea in the study and diagnosed with parvoviral enteritis as a result of laboratory findings and rapid test kit (Canine Parvovirus Antigen-CPV Ag Test, Asan Easy Test, China), were included in the study. Blood samples were taken once from dogs diagnosed with parvoviral enteritis and from healthy control group dogs. Dogs with PVE hospitalized for 7 days. Biochemical analyzes were performed in the laboratories of Kafkas University Faculty of Veterinary Medicine, Department of Internal Medicine and Biochemistry.

Clinical examination

Clinical examinations such as respiratory rate, rectal temperature, heart rate, and hydration status were performed for all dogs and recorded. The degrees of dehydration were also determined and fluid therapy was applied.

Taking blood samples and storing samples

Blood samples were taken once in dogs with PVE and healthy dogs from Vena cephalica antebrachiusing a holder and compatible sterile needle tip (Vacuette®, Greiner Bio-One GmbH, Austria). Blood samples taken with blood tubes with vacuum EDTA (BD Vacutainer®, BD, UK) for hematological measurements were measured within 10 minutes. Blood samples taken into vacuum gel serum tubes (BD Vakutainer®, BD, UK) were kept at room temperature for about 1 hour and then centrifuged for 10 minutes at 3000 rpm (Hettich Rotina 380R®, Hettich, Germany) and serum samples were obtained. Serum samples to be used for suPAR and LBP measurements were stored at -20 °C until analyses made.

Hemogram and biochemical analyses

Alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), glucose, creatinine, urea, total bilirubin, total protein, albumin, were measured with a fully automatic biochemistry device (Mindray BS120®, Mindray Medical Technology, Istanbul, Turkey). Using complete blood count device (DH36 Auto Hematology Analyzer®, Shenzhen Dymind Biotechnology, China) total leukocyte count (WBC), lymphocyte count (Lym), monocyte count (Mon), granulocyte count (Gra), red blood cell count (RBC), mean red cell volume (MCV), percent haematocrit (HCT), mean red cell haemoglobin (MCH), mean red cell haemoglobin (MCHC), hemoglobin concentration (HGB), platelet count (THR) were determined.

SuPAR, LBP, haptoglobin and ceruloplasmin analyses

Dog suPAR, dog LBP (Dog suPAR and LBP ELISA Kit®, ELK Biotechnology, China) were measured colorimetrically with ELISA kit according to the method reported by haptoglobin Batchelor et al. (1989) and ceruloplasmin by Colombo and Ricterich (1964). ELISA tests were applied as recommended by the manufacturer and the optical densities were determined in the ELISA reader (Epoch®, Biotek, USA) at a wavelength of 450 nm.

Treatment protocol

Dogs in the patient group were treated with fluid and eletrolyte, antiemetic, antidiarrheal, antibiotic, anti-bleeding and vitamins. Fluid-electrolyte treatment was applied by determining the degree of dehydration of diseased dogs. 0.9% NaCl (PVC®, 1000 ml, Eczacibasi Baxter, Istanbul, Turkey), lactate ringer (Polifleks®, Polifarma, Tekirdag, Turkey) and 5% dextrose (Polifleks®, Polifarma, Tekirdag, Turkey) treatment was applied at a daily dose of at least 40 mL/kg. Sulfadoxin-trimethoprim (Animar®, Ceva, Australia) was administered twice daily at a dose of 30 mg/kg once intramuscularly at 48 intervals. As antidiarrheatic, neomycin sulfate and bismuth subcarbonate-containing powder (Cesamolin®, Topkim, Turkey) were administered orally at a dose of 10-20 mg/kg for 3 days. Vitamin C (Maxivit-C®, Bavet, Turkey) was administered by intravenous injection at a dose of 200 mg/kg for 7 days, and vitamin B complex (Berovit B12®, Ceva, Australia) was administered in a practical dose of 3 mL/dog for 7 days. Metoclopramide (Metpamid®, Sifar, Turkey) was administered by subcutaneous injection twice daily at a dose of 0.5 mg/kg as an anti-vomiting drug, and vitamin K (Fitadinon-K®, Provet-Alivira, Turkey) was administered by subcutaneous injection once a day at a practical dose of 1 mL/10 kg body weight as an anti-bleeding drug once a day for 3 days.

Statistical analysis

Statistical analysis of the results was performed using SPSS® (SPSS 26.0, Chicago, IL, USA) program. The normality test distribution of the groups (patient and control) was evaluated by Shapiro-Wilk test. As the data showed a normal distribution, the statistical differences between the patient and the control group were evaluated by Independent Sample T-Test. One-way ANOVA test was used for multiple comparison of dead, recovering and control groups, and Tukey HSD test was used for post hoc comparison. Pearson correlation coefficient were calculated to define the correlation between the variables. The results obtained were given as ± standard error of mean (SEM). In the evaluation of the results, the value of $p \leq 0.05$ was considered statistically significant.

Results

The clinical examination findings in our study are given in Table 1. There was no significant difference between the patient and the control group in rectal temperature, respiratory rate and heart rate ($p>0.05$, Table 1). All of the dogs in the patient group in the study had signs of depression,

Table 1. Mean and standard error values of clinical findings in the patient and control groups

Parameters	Groups		p Value
	Patient (n=20)	Control (n=10)	
Rectal temperature (°C)	38.28±0.40	38.83±0.12	0.203
Breaths/min	40.80±4.09	45.60±3.44	0.453
Heart beats/min	136.65±10.29	127.90±5.50	0.460

N: Number of animals in groups. $p<0.05$: Indicates statistical significance between patient and control groups

Table 2. Mean and standard error values of patient and control group hematological parameters

Parameters	Groups		p Value
	Patient (n=20)	Control (n=10)	
WBC	3.11±0.82	7.36±0.73	<0.001
Lym (%)	26.62±6.10	15.34±2.59	0.101
Mon (%)	9.07±0.80	4.51±0.37	<0.001
Gra (%)	64.31±5.88	79.88±2.35	0.022
Lym (x10^3/µL)	1.30±0.32	1.74±0.45	0.447
Mon (x10^3/µL)	0.47±0.17	0.30±0.04	0.053
Gra (x10^3/µL)	2.37±0.79	4.67±0.34	<0.001
RBC (x10^6/µL)	5.02±0.39	9.39±0.23	<0.001
MCV (fL)	61.16±1.03	69.14±0.59	<0.001
HCT (%)	31.53±1.60	64.85±1.49	<0.001
MCH (pg)	22.35±1.05	16.14±0.32	<0.001
MCHC (g/dL)	36.11±1.04	23.37±0.32	<0.001
HGB (g/dL)	10.75±0.61	15.19±0.37	<0.001
THR (x10^3/µL)	233.60±36.43	150.40±13.95	0.043

N: Number of animals in groups. p<0.05: Indicates statistical significance between patient and control groups. WBC: Total leukocyte count, Lym: Lymphocyte, Mon: Monocyte count, Gra: Granulocyte, RBC: Red blood cell count, MCV: Mean red cell volume, HCT: Percent haematocrit, MCH: Mean red cell haemoglobin, MCHC: Mean red cell haemoglobin, HGB: Hemoglobin concentration, THR: Platelet count.

hemorrhagic diarrhea, loss of appetite, varying degrees of dehydration, and apathy towards the environment. It was observed that in dogs recovered during an average one-week treatment period, appetite increased, hemorrhagic diarrhea did not exist, depression disappeared, dehydration and interest in the environment increased.

Hematologic data in the study are given in Table 2. WBC was statistically significantly lower in the patient group compared to control (p<0.001). Similarly, granulocyte percentage, granulocyte count, RBC, MCV, HCT and HBG were statistically significantly lower in the patient group compared to control (p<0.05). The percentage of MCH, MCHC, THR and monocytes in the patient group was statistically significantly higher compared to control (p<0.05). RBC, HGB and HCT parameters, which were evaluated as anemia criteria, were found to be statistically significantly lower in the patient group compared to the control group (p<0.001, Table 2).

In the study, creatinine (p=0.040, Table 3), urea (P=0.036, Table 3), total bilirubin (p=0.011, Table 3), seruluplasmin (p=0.008, Table 3), haptoglobin (p<0.001, Table 3) and LBP (p=0.011, Table 3) concentrations were found to be statistically significantly higher compared to control, while albumin (p=0.005, Table 3) and suPAR (p =0.012, Table 3) concentrations were found to be low in the patient group.

In the patient group, the dogs that were treated within a week and were found to be healthy as a result of the clinical and laboratory examinations were determined as the "recovered group", and the dogs that deceased on different days of the treatment within a week were determined as the "deceased group". The disappearance of clinical findings (bloody diarrhea, vomiting, depression), the normalization of eating and drinking and the improvement of the general condition were taken into consideration as the recovery criteria. In the study, 10 (50%) of the dogs in the patient group recovered, while the other 10 deceased on different days during the one-week treatment period. Comparison of WBC, albumin, ceruloplasmin, haptoglobin, suPAR and LBP concentrations between deceased, recovered and control groups for prognostic evaluation is given in Table 4. WBC (p=0.011, Table 4), albumin (p<0.001, Table 4) and suPAR concentrations (p<0.001, Figure 1) were statistically lower in the deceased group compared to the other groups.

Table 3. Mean and standard error values of patient and control group serum biochemical parameters

Parameters	Groups		p Value
	Patient (n=20)	Control (n=10)	
Albumin (g/dL)	1.96±0.01	2.59±0.19	0.005
Ceruloplasmin (mg/dL)	6.61±0.50	4.83±0.34	0.008
Haptoglobin (g/L)	2.50±0.13	1.44±0.12	<0.001
suPAR (pg/mL)	910.05±40.49	1094±78±56.77	0.012
LBP (ng/mL)	6.31±0.38	4.44±0.58	0.011
ALT (IU/L)	29.65±4.82	25.15±2.63	0.787
AST (IU/L)	42.97±4.60	32.97±2.95	0.113
ALP (IU/L)	140.37±8.26	107.29±5.92	0.086
Glucose (mg/dL)	91.07±9.48	104.10±3.81	0.212
Creatinine (mg/dL)	1.68±0.17	0.76±0.07	0.040
Urea (mg/dL)	71.15±6.70	55.29±2.40	0.036
Total Bilirubin (mg/dL)	0.99±0.34	0.03±0.01	0.011
Total protein (g/dL)	7.14±1.29	5.38±0.36	0.595

N: Number of animals in groups. p<0.05: Indicates statistical significance between patient and control groups. suPAR: Soluble urokinase plasminogen activator receptor, LBP: Lipopolysaccharide binding protein, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, ALP: Alkaline phosphatase

Table 4. Comparison of WBC, albumin, ceruloplasmin, haptoglobin, suPAR and LBP concentrations in dead, recovering and control groups

Parameters	Groups			p Value
	Dead (n=10)	Recovering (n=10)	Control (n=10)	
WBC (x10^3/µL)	2.65±0.51^a	6.68±0.79^b	7.36±0.73^b	0.011
Albumin (g/dL)	1.63±0.11^a	2.29±0.11^b	2.59±0.19^b	p<0.001
Ceruloplasmin (mg/dL)	7.77±0.59^b	4.45±0.35^a	4.83±0.34^a	p<0.001
Haptoglobin (g/L)	2.83±0.17^c	2.18±0.15^b	1.44±0.12^a	p<0.001

p<0.05 is statistically significant between groups. N: Number of animals in groups. $^{a-c}$: Different letters on the same line represent the statistical difference between groups. WBC: Total leukocyte count

Table 5. Pearson correlation of WBC, albumin, haptoglobin, ceruloplasmin, suPAR and LBP concentrations

Parameters	WBC (x10³/µL)	Albumin	Haptoglobin	Ceruloplasmin	suPAR
Albumin (g/dL)	0.479**				
Haptoglobin (g/L)	0.395*	-0.566**			
Ceruloplasmin (mg/dL)	-0.291	-0.398*	0.677**		
suPAR (pg/mL)	0.191	0.337	-0.507**	-0.528**	
LBP (ng/mL)	-0.399*	-0.459*	0.550**	0.482**	-0.593**

*The correlation is significant at the 0.05 level. **. The correlation is significant at the 0.01 level.
suPAR: Soluble urokinase plasminogen activator receptor, LBP: Lipopolysaccharide binding protein, WBC: Total leukocyte count

Ceruloplasmin ($p<0.001$, Table 4), haptoglobin ($p<0.001$, Table 4) and LBP concentrations ($p<0.001$, Figure 2) were statistically significantly higher in the deceased group compared to the other groups.

In the comparison of suPAR of the dogs in the deceased group, the recovered group and the control group in the study, the lowest one was determined in the deceased group (Figure 1).

In the comparison of the LBP of the dogs in the deceased group, the recovered group, and the control group in the study, the highest was determined in the deceased group (Figure 2).

The correlation between albumin, WBC, haptoglobin, ceruloplasmin, suPAR and LBP is given in Table 5. A

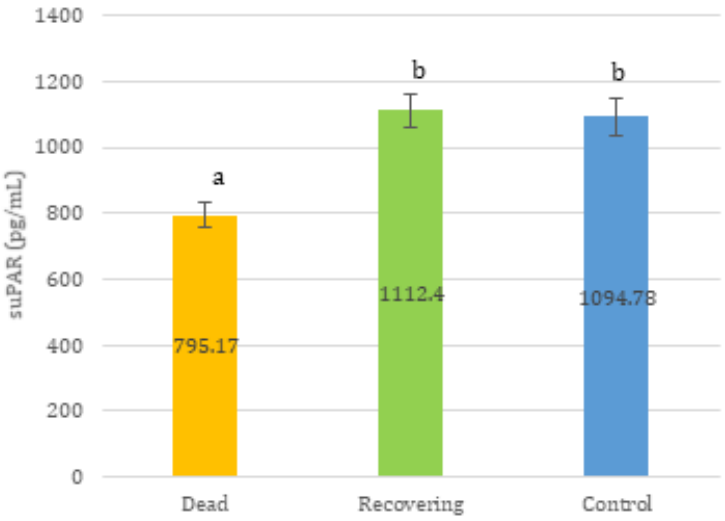


Figure 1. Serum suPAR concentrations of dead, recovering and control group dogs ($p<0.001$).

a,b: Express the statistical difference between the groups. suPAR: Soluble urokinase plasminogen activator receptor

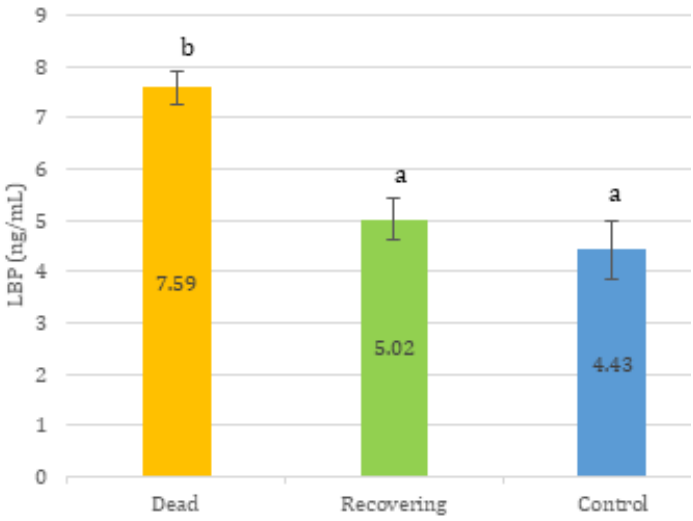


Figure 2. Serum LBP concentrations of dead, recovering and control group dogs ($p<0.001$).

a,b: Express the statistical difference between the groups. LBP: Lipopolysaccharide binding protein

statistically significant negative correlation was determined between suPAR and LBP (Table 5). In addition, suPAR showed negative correlation with haptoglobin and ceruloplasmin. LBP had a negative correlation with WBC and albumin, and a statistically significant positive correlation with haptoglobin and ceruloplasmin (Table 5).

Discussion

Parvoviral enteritis leads to severe infection with a high morbidity and mortality rate, especially in puppies younger than 6 months of age (Decaro et al 2007, Karayigit and Karatas 2018). In our study, all of the dogs in the patient group were 6 months of age or younger. 50% of the dogs in the patient group recovered.

At the onset of the enteritis form of the disease, loss of appetite, mental stagnation, and fever were observed. 1-2 days after these findings, persistent projectile vomiting and diarrhea that starts as gray-yellow color turns into hemorrhagic form in a short time (Decaro and Buonavoglia 2012). All of the dogs in the patient group in the presented study had signs of loss of appetite, mental stagnation and hemorrhagic diarrhea. As some of the diseased dogs have hyperthermia and some have hypothermia due to severe fluid loss, we think that there is no statistically significant difference.

In parvoviral enteritis, lymphopenia, neutropenia, and panleukopenia occur in 85% of diseased animals on the 0-3rd day of the disease. Patients with severe leukopenia have also been reported to have poor prognosis (Er and Ok 2015, Haligur et al 2009). The reason for this is the state of sepsis that occurs with increased susceptibility to secondary infections (Goddard et al 2008). In our study, there was severe leukopenia and a decrease in granulocyte count in the patient group. In addition, the fact that the dogs in the deceased group had a very severe leukopenia picture compared to the control, which recovered, confirms this information.

Anemia is common in dogs with parvoviral enteritis. The reason for this is blood loss in the intestines, suppression of erythrocyte production (Goddard et al 2008) and changes in lipid peroxidase and antioxidant enzyme capacity (Panda et al 2009). In our study, it was determined that there was a significant decrease in RBC, MCV, HCT and HGB used in the evaluation of anemia in the patient group compared to the control group. We think that the reason for this is losses with bloody diarrhea and the factor blocking blood production.
As a result of dehydration due to fluid loss in the disease, perfusion in the tissues decreases. Prerenal azotemia develops due to decreased perfusion in the tissues (Prittie 2004). An increase in serum urea and creatinine concentrations occurs due to dehydration (Goddard and Leisewitz 2010, Akyuz et al 2022). In addition, high urea and creatinine concentrations may be related to an inflamed kidney (Akyuz et al 2021). In our study, severe dehydration occurred due to bloody diarrhea and a picture of prerenal azotemia emerged. As a result of dehydration, an increase in urea and creatinine concentrations was determined in the patient group compared to the control group. We also think that the concentrations of urea and creatinine affected by the kidneys as a result of azotemia may have increased accordingly. Urea and creatinine concentrations were statistically significantly higher in the patient group compared to the control group.

Total bilirubin concentration increases in hepatobiliary diseases in dogs (Negis and Altintas 2018). In our study, we think that the reason for the increase in total bilirubin in the patient group compared to the control group is the effect of the liver and gallbladder due to infection and decreased tissue perfusion.

A decrease in albumin concentration occurs in dogs with parvoviral enteritis due to losses and bleeding in the digestive tract (Er and Ok 2015). In addition, the concentration of albumin, which is a negative acute phase protein, decreases in cases of infection and inflammation (Akyüz and Gokce 2021). In the presented study, the reason for the low albumin concentration in the dogs in the patient group compared to the control may have been the result of bleeding-related losses, infection and inflammation.

Acute phase proteins are proteins synthesized by the liver in response to stimuli that cause acute phase response such as inflammation, tissue damage, infection and neoplastic growth (Petersen et al 2004, Akyuz and Aydin 2022). Haptoglobin and ceruloplasmin are positive acute phase proteins that increase serum concentrations during inflammation (Petersen et al 2004, Erkilic et al 2019). Ceruloplasmin is used less frequently for diagnostic purposes compared to other acute phase proteins. It protects cells against oxidative damage and has cytoprotective activity (Erkilic et al 2019). It is also used in determining the presence of infection and inflammation (Bozukluhan et al 2021). In many researches, an increase in the concentration of ceruloplasmin caused by disease and infection has been reported (Erkilic et al 2019, Akyuz et al 2022). In our study, the concentration of ceruloplasmin was significantly higher in the patient group compared to the control group. We think that the possible reason for this increase is the acute phase response following the activation of the defense systems of the infection and inflammation formed in the patient group. Haptoglobin increases in concentration in cases of acute infection, inflammation, trauma (Erkilic et al 2019, Bozukluhan et al 2021). In our study, haptoglobin concentration was found to be statistically significantly higher in the patient group compared to the control group. We think that the possible

cause of this is the result of inflammation and tissue damage caused by parvoviral enteritis. In addition, the highest level of ceruloplasmin and haptoglobin concentrations were determined in the deceased group when comparing the deceased, recovered, and the control group. We believe that this result, increased haptoglobin and ceruloplasmin concentrations will be important in determining disease severity and prognostic evaluation.

Lipopolysaccharide binding protein is an acute phase protein synthesized by the liver after the immune response of the organism to endotoxins and leads to the initiation of the inflammatory response (Jerala 2007, Sonmezer and Tulek 2015). The most important task of LBP, which has a polipeptide structure, is lipopolysaccharide binding. It has a high specificity especially in patients with high body temperature and neutropenia in the blood table (Jerala 2007). In addition to hepatocytes, lipopolysaccharide binding protein synthesis occurs by muscle cells. Lipopolysaccharide binding protein concentration increases approximately 6-8 hours after infection occurs (Bulbul and Odabasi 2020). In traumatic situations, stress and sepsis, its concentration increases 30 times. In cases of infection, it oscillates within 15-30 minutes and reaches a high concentration within 24-48 hours (Altin 2011). In our study, the concentration of LBP in the patient group was found to be higher than the control group. It is likely that sepsis has been formed in diseased dogs as a result of parvoviral enteritis, as a result of which the concentration of LBP has increased. Sepsis-induced inflammatory response syndrome may be initiated and may cause an increase in the concentration of LBP in response to the acute phase. We also believe that the stress factor in diseased dogs accompanies this increase.

suPAR is released from monocytes, neutrophils, macrophages and T cells and plays a role in many immunological tasks such as migration, adhesion, differentiation and proliferation. The amount of leukocytes increases in inflammatory conditions (Bilgili and Cinel 2013). In combination with inflammatory stimulation, proteases lead to the formation of suPAR from the surface of cells into the bloodstream (Huttunen et al 2011). suPAR allows inflammatory cells to come together with its chemotactic property (Backes et al 2012). Therefore, the increase in suPAR means that the immune system and the inflammatory response are activated. It provides information both in terms of the severity of the inflammation and the prognose of the disease (Wittenhagen et al 2004, Ostergaard et al 2004, Lynqbaek et al 2012). In our study, the concentration of suPAR in the patient group was found to be statistically significantly lower than the control group. The main reason why suPAR concentration is low is that leukocytes are released in inflammatory conditions. In our study, the presence of leukopenia in the seriously patient group supports this information. We think that parvoviral enteritis may have decreased release as a result of suppressing the immune system and causing leukopenia. In addition, the fact that the WBC of the deceased group was the lowest in the comparison of the deceased, recovered and the control group strengthens this prediction.

Conclusion

In the comparison of WBC, albumin, haptoglobin, ceruloplasmin, suPAR and LBP concentrations in dogs with parvoviral enteritis among die dogs, recovered dogs and healthy dogs, WBC, albumin, suPAR concentrations were found to be statistically lower in the deceased group, while ceruloplasmin, haptoglobin and LBP concentrations were found to be higher in this group. In line with these results, it was concluded that suPAR and LBP concentrations may be important in the diagnosis of dogs with parvoviral enteritis and in the evaluation of the prognosis of diseased animals.

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Conflict of Interest

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During this study, any pharmaceutical company which has a direct connection with the research subject, a company that provides and / or manufactures medical instruments, equipment and materials or any commercial company may have a negative impact on the decision to be made during the evaluation process of the study or no moral support.

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Ethical Approval

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