ERCİYES ÜNİVERSİTESİ VETERİNER FAKÜLTESİ DERGİSİ
Journal of Faculty of Veterinary Medicine, Erciyes University
Research Article/ Araştırma Makalesi
22(2), 119-125, 2025
DOI: 10.32707/ercivet.1633661

Evaluation of Serum Neopterin and Procalcitonin Levels in Dogs with Ascariasis

Yusuf Umut BATI[1,a], Oğuz MERHAN[2,b], Enes AKYÜZ[1,c], Mert SEZER[1,d], Ekin Emre ERKILIÇ[1,e], Ali Haydar KIRMIZIGÜL[1,f]

[1]Kafkas University, Faculty of Veterinary Medicine, Department of Internal Medicine, Kars-TÜRKİYE
[2]Kafkas University, Faculty of Veterinary Medicine, Department of Biochemistry, Kars-TÜRKİYE
ORCID No: [a]0000-0001-7528-4376; [b]0000-0002-3399-0667; [c]0000-0002-3288-2058; [d]0000-0003-1691-7764; [e]0000-0003-2461-5598; [f]0000-0002-9283-1391

Corresponding author: Yusuf Umut BATI, E-mail: umutbati.ub@gmail.com
How to cite: Batı YU, Merhan O, Akyüz E, Sezer M, Erkılıç EE, Kırmızıgül AH. Evaluation of serum neopterin and procalcitonin levels in dogs with ascariasis. Erciyes Univ Vet Fak Derg 2025; 22(2):119-125

Abstract: Ascariasis is a commonly encountered parasitic infection in dogs that can lead to gastrointestinal damage and systemic inflammatory responses. However, studies evaluating the role of inflammatory biomarkers in the diagnosis of ascariasis remain limited. The aim of this study was to evaluate the association between ascariasis and the levels of inflammatory biomarkers, specifically serum neopterin and procalcitonin, in dogs. The study included 15 puppies aged between 1 and 6 months, diagnosed with ascariasis, and 10 clinically healthy control dogs. All animals were of different breeds and included both males and females. A single blood sample was collected from both infected and healthy animals. The samples were centrifuged at 3000 rpm for 10 minutes to separate the serum. The analysis revealed that serum neopterin (5.06±0.50 nmol/L) and procalcitonin (68.47±2.86 pg/mL) levels in the infected dogs were significantly higher (P<0.05) than those observed in healthy controls (neopterin: 3.67±0.26 nmol/L; procalcitonin: 57.42±3.91 pg/mL). The study concludes that gastrointestinal damage caused by ascariasis is associated with increased serum levels of neopterin and procalcitonin. These biomarkers may have clinical value in supporting the differential diagnosis of parasitic infections associated with inflammatory responses in dogs, and they may contribute to the early detection and monitoring of disease severity. Further studies with larger sample sizes and a broader panel of inflammatory markers are warranted to validate these findings and to better elucidate the role of neopterin and procalcitonin in the immunopathogenesis of canine ascariasis.
Keywords: Ascarid**,** dog, neopterin, procalcitonin

Askariazisli Köpeklerde Serum Neopterin ve Prokalsitonin Düzeylerinin Değerlendirilmesi

Öz: Askariazis, köpeklerde yaygın olarak görülen paraziter bir enfeksiyondur ve gastrointestinal hasara ile sistemik inflamatuar yanıtlara yol açabilir. Ancak, askariazis tanısında inflamatuar biyobelirteçlerin rolünü değerlendiren çalışmalar sınırlıdır. Bu çalışmanın amacı, köpeklerde askariazis ile inflamatuar biyobelirteç düzeyleri özellikle serum neopterin ve prokalsitonin arasındaki ilişkiyi değerlendirmektir. Çalışmaya, askariazis tanısı konulan 1 ila 6 aylık yaş aralığında 15 yavru köpek ile klinik olarak sağlıklı 10 kontrol köpeği dahil edilmiştir. Tüm hayvanlar farklı ırklardan olup hem erkek hem de dişi hayvanlar çalışmaya dahil edilmiştir. Hem enfekte hem de sağlıklı hayvanlardan tek seferlik kan örnekleri alınmıştır. Serum örnekleri elde etmek amacıyla kan örnekleri 3000 devirde 10 dakika santrifüj edilmiştir. Gerçekleştirilen analizler sonucunda, hastalıklı köpeklerdeki neopterin (5.06±0.50 nmol/L) ve prokalsitonin (68.47±2.86 pg/mL) seviyelerinin, sağlıklı köpeklerde belirlenen neopterin (3.67±0.26 nmol/L) ve prokalsitonin (57.42±3.91 pg/mL) seviyelerine kıyasla istatistiksel olarak anlamlı düzeyde yüksek olduğu (P<0.05) tespit edilmiştir. Çalışma, askariazisin neden olduğu gastrointestinal hasarın artmış serum neopterin ve prokalsitonin düzeyleri ile ilişkili olduğunu ortaya koymaktadır. Bu biyobelirteçler, özellikle köpeklerde inflamatuar yanıtla ilişkili paraziter enfeksiyonların ayırıcı tanısında klinik olarak destekleyici tanı değeri taşıyabilir ve hastalığın erken tespiti ile şiddetinin izlenmesine katkı sağlayabilir. Bu bulguların doğrulanması ve neopterin ile prokalsitoninin köpeklerde askariazisin immünopatogenezindeki rolünün daha iyi aydınlatılması için daha geniş örneklem büyüklüklerine ve daha kapsamlı bir inflamatuar belirteç paneline sahip çalışmalara ihityaç vardır.
Anahtar kelimeler: Askarid, köpek, neopterin, prokalsitonin

Introduction

Ascariasis is one of the most prevalent zoonotic parasitic diseases worldwide (Macpherson, 2013). The causative agents of this disease, which is commonly observed in dogs, are *Toxocara canis* and *Toxascaris leonina*. These gastrointestinal nematodes are highly resistant to disinfectants and can survive for months or even years both inside the host and in the external environment under suitable conditions (McTier et al., 2000; Tınar et al; 2006; Macpherson, 2013; Sezer et al., 2024). The transmission routes of the disease vary depending on the species. While *T. leonina* is transmitted solely through oral ingestion (Parsons, 1987; Rostami et al., 2020), *T. canis* can infect hosts through oral, galactogenic, and transplacental routes (Robertson and Thompson, 2002; Romasanta et al.,

Geliş Tarihi/Submission Date : 05.02.2025
Kabul Tarihi/Accepted Date : 17.05.2025

2004; Rostami et al., 2020). Infected puppies play a crucial role in disease transmission by shedding millions of eggs into the environment through their feces (Schnieder et al., 2011; ESCCAP, 2024). These parasites induce various hematological, biochemical, and pathological alterations in the host (Cansız, 2015). Given their persistence in the environment and the high egg-shedding capacity of infected puppies, understanding the epidemiology and transmission dynamics of *T. canis* and *T. leonina* is essential for effective control and prevention strategies.

Ascariasis is more commonly observed in dogs aged 0-6 months (Overgaauw and Knapen, 2013). Studies have shown that the disease does not exhibit breed predisposition or gender differences (Gingrich et al., 2010). The clinical signs can vary depending on the age of the infected animal, the intensity, location, and developmental stage of the parasite. However, the disease is primarily characterized by gastrointestinal symptoms such as enteritis, vomiting, growth retardation, abdominal distension (bloating), constipation, and mechanical obstruction in the intestines (Epe, 2009; Atasoy et al., 2015; Corda et al., 2019).

Neopterin (Np), a pteridine derivative, was first identified in bee larvae in 1963 and subsequently isolated from human urine by Sakurai and Goto in 1967. Synthesized predominantly by monocytes, macrophages, and T lymphocytes upon stimulation by interferon-gamma (IFN-γ), Np serves as a sensitive marker of cellular immune activation. Although other cell types-such as renal epithelial cells, fibroblasts, and vascular smooth muscle cells-can also produce Np in response to stimuli involving guanosine triphosphate (GTP), its release during immunological processes primarily reflects IFN-γ-mediated activation of mononuclear phagocytes, particularly during infectious diseases, oxidative stress, and systemic immune responses (Berdowska and Zwirska-Korczala, 2001; Miao et al., 2018; Ünüvar and Aslanhan, 2019; Akyüz, 2020; Akyüz et al., 2022). The secretion of Np typically precedes the peak proliferation of T lymphocytes and the emergence of specific antibody responses, making it a valuable early indicator of Type 1 T helper (Th1)-type immune activity. Elevated serum Np levels have been associated with various pathological conditions, including infections, malignancies, autoimmune disorders, and organ transplant rejection (Eisenhut, 2013). In particular, parasitic diseases such as toxocariasis have been shown to trigger significant increases in circulating Np, likely reflecting the activation of IFN-γ-esponsive macrophages during tissue invasion by migrating larvae (Kozłowska-Murawska and Obuchowicz, 2008; Batı et al., 2023). Supporting this interpretation, Başbuğ et al. (2020) reported markedly elevated Np concentrations in animals with systemic inflammatory response syndrome (SIRS), reinforcing its potential as a biomarker of early and robust immune system activation.

Procalcitonin (Pct) is a small peptide, weighing 13 kDa and consisting of 116 amino acids, produced by the parafollicular cells of the thyroid gland (Matur et al., 2021). However, it can also be synthesized by extrathyroidal organs such as the pancreas, liver, spleen, adrenal glands, lungs, kidneys, brain, spinal cord, testes, stomach, small intestines, colon, abdominal adipose tissue, and white blood cells (Müller et al., 2000). The release of procalcitonin is regulated by proinflammatory cytokines and may vary depending on the severity of inflammation (Gürbüz and Ulutaş, 2017). Yılmaz et al. (2008) reported an increase in serum Pct levels in dogs following endotoxin administration. Similarly Dözen (2018) reported elevated plasma Pct levels in dogs with acute diarrhea compared to the control group.

Materials and Methods

This study was conducted with the approval of the Kafkas University Animal Experiments Local Ethics Committee (decision dated 25.10.2022, number KAÜ -HADYEK/2022-173) to ensure compliance with ethical standards. Additionally, blood samples were obtained following the recommended "standard sample collection procedure," ensuring that animals were neither stressed nor harmed in any way. All procedures involving animals complied with institutional guidelines and national regulations on animal welfare.

Animal Material

The material of this study consisted of dogs aged 1-6 months, of different breeds and sexes, brought to the Internal Medicine Department of the Faculty of Veterinary Medicine at Kafkas University. The study groups included 15 dogs diagnosed with ascariasis (Group I), which were examined through physical examination, and 10 healthy dogs (Group II) without any signs of illness.

Clinical Examination

After determining that the relevant pathogens were negative using the rapid test kit (CPV/CCV/Giardia Ag Rapid Test Kit, Anigen, South Korea), fecal samples were collected from the dogs suspected of ascariasis for examination purposes. The collected samples were placed on a slide, diluted with 1-2 drops of physiological saline, and homogenized. A coverslip was then applied, and microscopic examination was performed (Yılmaz et al., 2017). For animals with a definitive diagnosis, pyrantel pamoate was administered at a dose of 10 mg/kg for treatment.

Blood Sample Collection

Blood samples were collected in a single draw from the *V. cephalica antebrachii* using an appropriate holder and a sterile holder needle (Vacuette®, Greiner Bio-One GmbH, Austria) into serum tubes and EDTA blood tubes (BD Vacutainer®, BD, UK). To obtain serum, the blood samples were centrifuged at 3000 rpm for 10 minutes (Hettich Rotina 380R®,

Hettich, Germany). The serum samples to be used for ELISA measurements were stored at -20°C until the analysis was performed.

Complete Blood Count Analyzes

For CBC, blood samples were collected in EDTA tubes, and the following values were recorded using a VG-MS4e® analyzer (Melet Schloesing, France): total leukocyte count (WBC x10³/µL), erythrocyte count (RBC x10⁶/µL), hematocrit percentage (HCT %) and hemoglobin concentration (HGB g/dL).

Neopterin and Procalcitonin Analyzes

Serum Pct and Np concentrations were determined using dog-specific commercial ELISA kits (Canine Neopterin ELISA Kit®, Canine Procalcitonin ELISA Kit®, BT Lab, Shanghai Korain Biotech Co, China). The ELISA tests were performed according to the manufacturer's instructions, and optical densities were measured at a wavelength of 450 nm using an ELISA microplate reader (Epoch®, Biotek, USA). Neopterin and procalcitonin values were calculated through regression analysis.

Statistical Analysis

The sample size was determined based on an effect size of 1.67 reported in a previous study by Atasoy et al. (2015), with a statistical power of 95% and a significance level of 5%. An a priori power analysis was conducted using G*Power® software (Version 3.1.9.4, Franz Faul, Universität Kiel, Germany) for a one-tailed independent samples t-test. The analysis indicated that a minimum total sample size of 18 subjects (9 per group) would be sufficient to detect a statistically significant difference between the groups. The normality of the data was assessed using the Shapiro -Wilk test. Since the distributions of procalcitonin, opterin and pulse values did not follow a normal distribution, group comparisons for these parameters were conducted using the Mann-Whitney U test. All statistical analyses were performed using SPSS software (Version 20.0, IBM Corp., Armonk, NY, USA). A significance level of $P < 0.05$ was considered statistically significant. All parameter values are presented as mean ± standard error of the mean (SEM).

Results

In the clinical examinations of the dogs included in the study, diarrhea, vomiting, abdominal distension and tension, anorexia, coat condition deterioration, halitosis were observed. Dehydration was assessed based on sunken eyes and reduced skin elasticity, while anemia was suspected in animals exhibiting pale or whitish mucous membranes. Clinical examinations were performed on the dogs in the patient group before treatment, and their body temperature, respiratory rate per minute, and heart rate per minute were statistically evaluated (Table 1).

Table 1. Mean and standard error values of the vital signs of dogs in the ascariasis and control groups.

Vital Parameters	Patient Group (n=15)	Control Group (n=10)	P Value
Pulse Rate (per minute)	113.46±4.84	108.60±3.15	P>0.05
Respiratory Rate (per minute)	30.40±1.79	29.60±1.07	P>0.05
Body Temperature (°C)	38.46±0.18	38.16±0.07	P>0.05

Table 1. Mean and standard error values of the vital signs of dogs in the ascariasis and control groups.

The vital signs of dogs with ascariasis were compared with the control group, and it was determined that the obtained results were not statistically significant (P>0.05).

Hematological assessments revealed no statistically significant difference in white blood cell (WBC) counts between the patient and control groups (P>0.05). In contrast, red blood cell (RBC) count, hematocrit (HCT), and hemoglobin (HGB) levels were significantly lower in dogs with ascariasis compared to healthy controls (P<0.001) (Table 2).

Table 2. Mean and standard error values of hematologic parameters in dogs with ascariasis and the control group

Vital Parameters	Patient Group (n=15)	Control Group (n=10)	P Value
WBC ($x10^3$/µL)	4.21±1.12	6.42 ± 0.55	P>0.05
RBC ($x10^6$/µL)	4.91±0.51	9.59 ± 0.16	P<0.001
HCT (%)	31.19±2.07	63.85 ± 1.44	P<0.001
HGB (g/dL)	10.71±0.80	15.19 ± 0.37	P<0.001

Statistical difference between patient and control groups (P<0.05)

temperature, and respiratory rate values were normal within the groups, comparisons were performed using the independent samples t-test. In contrast, as ne-

Serum Np and Pct levels were examined in dogs with ascariasis and in the control group. The analyses revealed that the Np and Pct levels in the affected group were significantly higher compared to the control group (P<0.05). The results are presented in Table 3.

Table 3. Mean and standard error values of neopterin and procalcitonin in dogs with ascariasis and the control group

Biomarkers	Patient Group (n=15)	Control Group (n=10)	P Value
Neopterin (nmol/L)	5.06±0.50	3.67±0.26	P<0.05
Procalcitonin (ng/L)	68.47±2.86	57.42±3.91	P<0.05

Statistical difference between patient and control groups (P<0.05)

Discussion and Conclusion

Studies on ascariasis in dogs have reported that the disease does not show breed predisposition and is most commonly observed in dogs aged 0-6 months (Gingrich et al., 2010; Overgaauw and Knapen, 2013). In accordance with the literature, our study group consisted of dogs aged 0–6 months, representing different breeds and both sexes.

In dogs with ascariasis, gastrointestinal symptoms such as vomiting, growth retardation, abdominal distension, constipation, and, in severe cases, intestinal obstruction may be observed (Epe, 2009; Atasoy et al., 2015). Clinical examinations of the dogs included in our study revealed diarrhea, vomiting, growth retardation, abdominal distension and tension, anemia, anorexia, deterioration of coat quality, halitosis, and dehydration. These clinical findings are consistent with previous reports describing systemic effects and gastrointestinal manifestations of ascariasis in dogs (Altuğ et al., 2007; Cansız, 2015; Corda et al., 2019). Specifically, halitosis and coat condition deterioration have also been noted in naturally infected puppies (Corda et al., 2019), and signs such as dehydration, anorexia, and anemia have been previously reported in association with parasitic gastrointestinal infections (Altuğ et al., 2007; Cansız, 2015).

Cansız (2015) reported that body temperature, pulse, and respiratory rates might not show statistically significant differences in cases of ascariasis. This variability was attributed to individual differences among infected animals, as these parameters could increase in some animals, decrease in others, or remain within normal limits, resulting in an overall average that falls within the reference range. Similarly, in the current study, vital parameters such as body temperature, pulse rate, and respiratory rate did not differ significantly between infected dogs and healthy controls, confirming that ascariasis may present without clear alterations in these clinical parameters.

Iron deficiency is a well-documented complication of intestinal parasitic infections in young animals, frequently resulting in decreased serum iron, transferrin saturation, HGB, and HCT levels, and ultimately leading to the development of microcytic-hypochromic anemia (McCown and Specht, 2011). In *Toxocara canis* infections, internal hemorrhages caused by larval migration through the liver and intestinal mucosa further exacerbate this condition by significantly reducing RBC counts (Schnieder et al., 2011). Cansız (2015) also reported a marked decline in RBC levels in cases of severe infestation. Similarly, Altuğ et al. (2007) observed statistically significant decreases in HCT and HGB levels in dogs with ascariasis and suggested that these findings might be attributed to iron deficiency secondary to malabsorption. In the present study, consistent with previous findings, statistically significant reductions in RBC, HCT, and HGB levels were identified in puppies with ascariasis (P<0.001). These hematological changes are likely associated with mucosal damage in the gastrointestinal tract, chronic blood loss, and malabsorption.

The use of more reliable biomarkers for evaluating the prognosis and diagnosis of diseases has been increasingly adopted in both human and veterinary medicine. Biomarkers are fundamental molecules that fluctuate under physiological and pathological conditions, playing a crucial role in disease assessment (De Loor et al., 2013; Köse and Maden, 2013). The objective of this study was to investigate serum neopterin and procalcitonin levels in dogs with ascariasis and to evaluate the diagnostic significance of these biomarkers in the disease.

In the present study, serum Np levels were found to be significantly elevated in dogs naturally infected with *Toxocara canis* compared to healthy controls. This finding supports the hypothesis that *T. canis* infection elicits a strong cellular immune response, likely driven by immunopathological processes associated with the larval migratory phase. As larvae migrate through hepatic and gastrointestinal tissues, they induce mechanical damage and trigger local inflammation, hemorrhage, and cytokine release, particularly interferon-gamma (IFN-γ), which is a key inducer of neopterin synthesis. The elevated Np levels observed in our study are therefore consistent with IFN-γ-mediated activation of mononuclear phagocytes in response to larval tissue invasion.

Previous studies have demonstrated that *T. canis* infection is characterized by marked eosinophilic and monocytic infiltration, especially during the tissue-migratory phase (Salem et al., 2015). Given that Np secretion typically precedes peak T lymphocyte proliferation and antibody production, it serves as an early marker of Th1-type immune activation during parasit-

ic infections. Our findings align with earlier reports of elevated Np levels in other parasitic diseases (Kozłowska-Murawska and Obuchowicz, 2008; Batı et al., 2023), supporting the notion that Np can function as a valuable biomarker of early and active immune responses during helminthic infections.

Additionally, the significantly higher Np concentrations found in infected dogs mirror findings in animals with systemic inflammatory response syndrome (Başbuğ et al., 2020), reinforcing the link between tissue damage, immune activation, and Np elevation. Taken together, these results suggest that serum Np may serve not only as a marker of general immune activation but also as a specific indicator of immunopathological changes occurring during larval migration in canine ascariasis.

Procalcitonin is an acute-phase reactant that increases particularly in response to bacterial sepsis and systemic infections. This increase has been attributed to the host immune system's response to endotoxins and proinflammatory cytokines, including interleukin-6 (IL-6), interleukin-1β (IL-1β), and tumor necrosis factor-alpha (TNF-α), which stimulate PCT synthesis in various extrathyroidal tissues such as the lungs, liver, and leukocytes (Panico and Nylen, 2013; Duru, 2014; Hacımustafaoğlu, 2017). These studies highlight that PCT levels correlate with the severity of infection and inflammatory burden, and may exceed other conventional markers such as C-reactive protein in both sensitivity and prognostic value. Consequently, it has been reported that Pct levels rise significantly in severe infection cases (Balcı et al., 2003; Köse et al., 2013; Dözen, 2018).

Ascarids are significant parasitic pathogens that cause enteritis in dogs (Willard, 2013). These parasites typically reside in the small intestine and induce a variety of pathophysiological effects. The inflammatory response, mediated by lymphocytes, plasma cells, and phagocytic cells within the intestinal layers, leads to lymphocytic infiltration accompanied by degenerative changes in the mucosal glands and the smooth muscle layer of the intestinal wall. This inflammatory process results in villus atrophy, hyperplasia, and shedding of intestinal epithelial cells (Majeed Alnassiri, 2023). The destructive effects within the gastrointestinal tract facilitate the translocation of pathogenic microorganisms and their toxins from the gut flora into the systemic circulation, thereby predisposing the host to sepsis (Singer et al., 2016). Sepsis is one of the primary triggers for procalcitonin (Pct) release. During this process, Pct production occurs not only from monocytes but also from parenchymal tissues such as the lungs, liver, and intestines (Goggs et al., 2018). In the present study, consistent with the aforementioned literature, it is considered that intestinal damage caused by ascarid infestation promotes secondary bacterial invasion, leading to sepsis, which in turn results in increased serum Pct concentrations.

Our study has several limitations. First, the limited sample size reduces the statistical power and generalizability of the findings. Second, key proinflammatory cytokines such as IL-6, IL-1β, and TNF-α—which are essential for evaluating systemic inflammation and immune response-were not measured. The absence of these markers limits the interpretation of elevated Pct and Np levels and prevents definitive conclusions about the presence of inflammation or activation of the immune system in dogs with ascariasis. Although Np is known to be secreted by activated macrophages during Th1-type immune responses, the lack of complementary cytokine data hampers a clear understanding of the immune profile in these animals. These limitations will be addressed in future studies to achieve more accurate and meaningful results.

In conclusion, this study demonstrated that serum neopterin and procalcitonin levels are elevated in dogs with ascariasis, suggesting that these biomarkers may have potential diagnostic utility for the disease. The findings support the role of immune response and inflammatory processes in the pathogenesis of ascariasis, as previously reported in studies demonstrating hematological, immunological, and inflammatory alterations in parasitic infections such as toxocariasis (Altuğ et al., 2007; Başbuğ et al., 2020; Sezer et al., 2024). These results highlight the need for further research to comprehensively evaluate the diagnostic and prognostic value of these biomarkers in parasitic diseases of veterinary importance.

References

Akyüz E, Merhan O, Aydın U, Sezer M, Kuru M, Karakurt E, Yıldız U, Bozukluhan K, Batı YU, Yıldız A, Gökce G. Neopterin, procalcitonin, total sialic acid, paraoxonase-1 and selected haematological indices in calves with aspiration pneumonia. Acta Vet Brno 2022; 91(2): 115-24.

Akyüz E. Investigations on Neopterin, Procalcitonin, Clinical Biochemistry and Hematology in Neonatal Sepsis Suspicious Calves. **Doktora tezi,** Kafkas Üniv Sağ Bil Enst, Kars 2020; s. 1-2.

Altuğ N, Yüksek N, Göz Y, Ağaoğlu TZ. Doğal askaridiozisli yavru köpeklerde hematolojik bulgular, lenfosit alt tipleri ve serum immunglobulin konsantrasyonları. YYÜ Vet Fak Derg 2007; 18(1): 13-8.

Atasoy N, Mustafa D, Bekir O. Changes that take place in some biochemical parameters (ALT, LDH, total protein, albumin, cholesterol, triglyceride, glucose) in dogs with ascariasis. YYÜ Vet Fak Derg 2015; 16(1-2): 53-7.

Balcı C, Sungurtekin H, Gürses E, Sungurtekin U, Kaptanoglu B. Usefulness of procalcitonin for diagnosis of sepsis in the intensive care unit. Crit Care

2003; 7(1): 85-90.

Basbug O, Aydogdu U, Agaoglu ZT. Neopterin and soluble urokinase type plasminogen activator receptor as biomarkers in dogs with systemic inflammatory response syndrome. J Hellenic Vet Med Soc 2020; 71(1): 1945-52.

Batı YU, Merhan O, Aydın N, Akyüz E, Sezer M, Emre Erkılıç E, Vatansever Z, Kırmızıgül AH. *Sarcoptes canis*'le doğal enfeste köpeklerde serum neopterin ve prokalsitonin seviyeleri. Vet Sci Pract 2023; 18(1): 31-4.

Berdowska A, Zwirska-Korczala K. Neopterin measurement in clinical diagnosis. J Clin Pharm Ther 2001; 26(5): 319-29.

Cansız F. Dışkılarında Askarit Yumurtası Görülen ve Görülmeyen Yavru Köpeklerin Kan Serumlarında Fe ve Vitamin B12 Düzeylerinin Karşılaştırılması. Yüksek Lisans Tezi, Ankara Üniv Sağ Bil Enst, Ankara 2015; s.1-2.

Corda A, Tamponi C, Meloni R, Varcasia A, Parpaglia M, Gomez-Ochoa P, Scala A. Ultrasonography for early diagnosis of *Toxocara canis* infection in puppies. Parasitol Res 2019; 118(3): 873-80.

De Loor J, Daminet S, Smets P, Maddens B, Meyer E. Urinary biomarkers for acute kidney injury in dogs. J Vet Intern Med 2013; 27(5): 998-1010.

Dözen A. Akut İshalli Köpeklerde Plazma Prokalsitonin Konsantrasyonunun Değerlendirilmesi. **Yüksek Lisans Tezi,** ADÜ Sağ Bil Enst, Aydın 2018; s. 1-2.

Duru S. Pnömoni ve biyobelirteçler. Günc. Göğüs Hast. Ser 2014; 2(1): 78-85.

Eisenhut M. Neopterin in diagnosis and monitoring of infectious diseases. J Biomarkers 2013; (2013): 196432.

Epe C. Intestinal nematodes: biology and control. Vet Clin North Am Small Anim Pract 2009; 39(6): 1091-107.

ESCCAP. European Scientific Counsel Companion Animal Parasites. Guidelines. https://www.esccap.org/guidelines/. Erişim tarihi: 15.01.2024.

Gingrich EN, Scorza AV, Clifford EL, Olea-Popelka FJ, Lappin MR. Intestinal parasites of dogs on the Galapagos Islands. Vet Parasitol 2010; 169(3-4): 404-7.

Goggs R, Milloway M, Troia R, Giunti M. Plasma procalcitonin concentrations are increased in dogs with sepsis. Vet Rec Open 2018; 5(1): e000255.

Gürbüz H, Ulutaş P. Procalcitonin is not a marker of sterile inflammation in dogs after ovariohysterectomy. Acta Vet 2017; 67(1): 131-6.

Hacımustafaoğlu M. Akut faz belirteci olarak prokalsitonin. J Pediatr Inf 2017; 11(4): 196-7.

Kozlowska-Murawska J, Obuchowicz AK. Clinical usefulness of neopterin. Wiad Lek 2008; 61(10-12): 269-72.

Köse B, Özcan N, Kaymak Ç, Başar H, Kotanoğlu M, Özcan A, Baltacı B. Septik ve non-septik hasta takibinde kullanılan skorlama sistemleri, prokalsitonin düzeyleri ve kan gazı parametrelerinin değerlendirilmesi. Turkiye Klinikleri J Anest Reanim 2013; 11(3): 137-42.

Köse Sİ, Maden M. Biyobelirteçler ve klinik kullanımları. Dicle Üniv Vet Fak Derg 2013; 2(1): 1-8.

Macpherson CN. Dog zoonoses and human health: a global perspective. CAB Mini Rev 2013; 8(2): 1-2.

Majeed Alnassiri SH. Histological assessment for the effect of Toxocara spp. on the intestine of stray dogs and cats (comparative study). J Res Appl Sci Biotechnol 2023; 2(6): 10-13. https://doi.org/10.55544/jrasb.2.6.2

Matur E, Dokuzeylül B, Mukaddes Ö, Handan Ç, Murat A, Erman O, Songül E, Ülker Ç. Can procalcitonin be used as a clinical biomarker during bacterial, viral and parasitic infections in dogs? Jpn J Vet Res 2021; 69(1): 5-17.

McCown JL, Specht AJ. Iron homeostasis and disorders in dogs and cats: a review. J Am Anim Hosp Assoc 2011; 47: 151-60.

McTier TL, Siedek EM, Clemence RB, Wren JA, Bowman DD, Hellmann K, Holbert MS, Murphy MG, Young DR, Cruthers LR, Smith DG, Shanks DJ, Rowan TG, Jernigan AD. Efficacy of selamectin against experimentally induced and naturally acquired ascarid (*Toxocara canis* and *Toxascaris leonina*) infections in dogs. Vet Parasitol 2000; 91(3-4): 333-45.

Miao S, Shen P, Zhang Q, Wang H, Shen J, Wang G, Lv D. Neopterin and mini-mental state examination scores, two independent risk factors for postoperative delirium in elderly patients with open abdominal surgery. J Can Res Ther 2018; 14(6): 1234-38.

Müller B, Becker KL, Schächinger H, Rickenbacher PR, Huber PR, Zimmerli W, Ritz R. Calcitonin precursors are reliable markers of sepsis in a medical intensive care unit. Crit Care Med 2000; 28(4): 977-83.

Overgaauw PAM, Van Knapen F. Veterinary and public health aspects of *Toxocara canis*. Vet Parasitol 2013; 193(4): 398-403.

Panico C, Nylen E. Procalcitonin beyond the acute phase: novel biomediator properties? BMC Med 2013; 11(1): 189.

Parsons JC. Ascarid infections of cats and dogs. Vet Clin North Am Small Anim Pract 1987; 17(16): 1307-39.

Robertson ID, Thompson RC. Enteric parasitic zoonoses of domesticated dogs and cats. Microbes Infect 2002; 4(8): 867-73.

Romasanta A, Paz-Silva A, Sanchez-Andrade R, Suarez JL, Panadero R, Arias M, Pedreira J, Diaz P, Diez-Banos P, Morrondo P. Antibody-mediated response in dogs experimentally infected with *Toxocara canis*: effect of procodazole. Helminthologia 2004; 41(1): 3-7.

Rostami A, Riahi SM, Fallah Omrani V, Wang T, Hofmann A, Mirzapour A, Foroutan M, Fakhri Y, Macpherson C, Gasser RB. Global prevalence estimates of *Toxascaris leonina* infection in dogs and cats. Pathogens 2020; 9(6): 503.

Salem NY, Farag HS, El-Nabi MR. Hematobiochemical and mineral status in dogs with intermittent diarrhea and unthriftiness. Res J Vet Pract 2015; 3(4): 83-8.

Sezer M, Akyüz E, Bati Y, Merhan O, Ölmez N, Kirmizigül A. Evaluation of serum soluble urokinase plasminogen activator receptor, lipopolysaccharide binding protein, ceruloplasmin and haptoglobin levels in dogs with symptoms of diarrhea infected with *Toxocara canis*. FU Vet J Health Sci 2024; 38 (1): 47-52.

Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M. The third international consensus definitions for sepsis and septic shock (sepsis-3). JAMA 2016; 315(8): 801-10.

Tınar R, Umur Ş, Köroğlu E, Güçlü F, Ayaz E, Şenlik B, Muz MN. Helmintoloji. Tınar R. (ed.). In: Helmintoloji. First Edition. Ankara: Nobel Yayın Dağıtım 2006; pp. 375-80.

Ünüvar S, Aslanhan H. Clinical significance of increased serum neopterin in chronic kidney failure as a biomarker of cell-mediated immunity. J Med Biochem 2019; 38(1): 1-5.

Willard MD. Diarrhea. Nelson RW, Couto CG. eds. In: Small Animal Internal Medicine. St. Louis: Elsevier, 2014; pp. 376-80.

Yılmaz AB, Orunç Kılınç Ö, Göz Y, Denizhan V. Van ilinde dışkı muayenesine göre sokak köpeklerinde görülen mide-bağırsak parazitleri. Muş Alparslan Üniv Fen Bil Derg 2017; 5(2): 425-9.

Yılmaz Z, Ilcol YO, Ulus IH. Endotoxin increases plasma leptin and ghrelin levels in dogs. Crit Care Med 2008; 36(3): 828-33.