Clinical Toxoplasmosis in Cats: A Cohort Study

Sinem ULGEN[1,a], Alev AKDOGAN KAYMAZ[1,b], Alper BAYRAKAL[1.c,*], Mustafa ASLAN[2,d], Lora KOENHEMSI[1,e], Utku BAKIREL[1,f]

[1]Istanbul University-Cerrahpasa, Faculty of Veterinary Medicine, Department of Internal Medicine, Istanbul, Turkey
[2]Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine, Department of Microbiology and Clinical Microbiology, Istanbul, Turkey
[a]ORCID: 0000-0002-2198-6396, [b]ORCID: 0000-0003-4457-6856, [c]ORCID: 0000-0003-4002-435X,
[d]ORCID: 0000-0002-4530-3190, [e]ORCID: 0000-0002-4979-170X, [f]ORCID: 0000-0001-7536-6435

Geliş Tarihi: 21.01.2019 **Kabul Tarihi: 16.12.2019**

Abstract: *Toxoplasma gondii,* which can cause a variety of symptoms, is a protozoan widely distributed around the world. Due to a suppressed immune response, reactivation of this disease can cause mortality. We designed a cohort study for the alterations in clinical course, laboratory findings, and presence of FeLV and FIV. We created two groups (Groups I and II). Group I contained 11 cats diagnosed with clinical toxoplasmosis. Group II included 15 healthy seronegative cats. We based our diagnosis of toxoplasmosis on the presence of the following clinical signs: a fourfold increase in immunoglobulin G for *Toxoplasma gondii,* presence of clinical signs, differential diagnosis of other causes and positive response to treatment with clindamycin hydrochloride. We found significant differences in erythrocyte, leukocyte, hemoglobin, and hematocrit levels between the groups (respectively $P = 0.05$, $P < 0.001$, $P < 0.05$, $P < 0.01$). The mean leukocyte counts of Group I was 37985 µL. After treatment, we determined significant differences in leukocyte ($P < 0.05$) and trombocyte ($P < 0.05$). Although all cats in Group I were found negative for FeLV and FIV, six cats had other disorders. As a result, we concluded that severe clinical signs might occur in the absence of FIV and FeLV more frequently than previously thought. Further research must be performed on the diagnostic utility of resistant and severe leukocytosis in clinical toxoplasmosis.
Keywords: *Cat, Toxoplasmosis, Toxoplasma gondii.*

Kedilerde Klinik Toksoplazmoz: Bir Kohort Araştırması

Özet: *Toxoplasma gondii* tüm dünyada yaygın olarak bulunan çok çeşitli klinik tablolara neden olabilen bir protozoondur. Özellikle immün yanıtı baskılanmış olanlarda re-aktivasyonlara bağlı olarak mortaliteye neden olan bir paraziter hastalıktır. Çalışmamızda aktif toksoplazmoz tanısı almış kedilerde, immün sistemi baskılayan Feline leukemia virus (FeLV) ve Feline immundeficiency virus (FIV) varlığı araştırılmış ve bu olguların tedavi öncesi ve sonrasındaki klinik ve laboratuvar bulgularının değişimini saptamaya yönelik bir kohort çalışma yapılması amaçlanmıştır. Bu amaçla iki grup (grup I ve II) oluşturuldu. Grup I klinik toksoplazmoz tanısı almış 11 kediden oluştu. Sağlıklı seronegatif kediler (n=15) ise kontrol grubuna (grup II) dahil edildi. Toksoplazmozun tanısı; klinik bulguların varlığına, serolojik olarak *Toxoplasma gondii* IgG titrasyonundaki en az 4 kat artışa ve ayrıca seropozitif olduğu belirlenen kedilere uygulanan anti paraziter klindamisin hidroklorid kemoproflaksisine olumlu yanıt alınmasına dayandırılarak yapıldı. Hastaların hemogram sonuçları değerlendirildiğinde; olguların eritrosit, lökosit, hemoglobin ve hematokrit seviyelerinde gruplar arası belirgin farklılık saptandı (sırasıyla $P=0.05$, $P<0.001$, $P<0.05$, $P<0.01$). Grup I'e ait ortalama lökosit sayısı 37985 µL olarak bulundu. Klindamisin tedavisinin 14. gününde, grup I' e ait kedilerden kan alınarak total kan sayımı ve serum biyokimyasal analizler yapıldı. Tedavi sonrası, lökosit ($P<0.05$) ve trombosit ($P<0.05$) değerlerinde istatistiksel olarak anlamlı farklılık saptandı. Grup I'deki tüm kediler FeLV ve FIV yönünden FIV Ab/FeLV Ag Antigen test ile negatif olarak saptandı. Sonuç olarak; toksoplazmozise ait şiddetli klinik bulguların varlığı FIV, FeLV yokluğunda sanıldığından daha sık ortaya çıktığı ve dirençli ve şiddetli lökositozun kedilerin aktif toksoplazmozu için diagnostik açıdan faydasını araştıracak başka çalışmalara ihtiyaç olduğu kanısına varıldı.
Anahtar Kelimeler: *Kedi, Toksoplazmoz, Toxoplasma gondii.*

Introduction

Toxoplasmosis is caused by the obligate intracellular protozoan parasite *Toxoplasma gondii,* which is the most common type of parasite in animals worldwide (Dubey, 1994; Lappin, 2005; Lappin, 2009). The agent completes the sexual stage in the feline host, and the oocysts are shed by the cat's feces (Berdoy et al., 2000; Lappin, 2009). Final and intermediate hosts become infected by oral ingestion of sporozoites, tachyzoites, and bradyzoites of *T. gondii*. Each stage of the development of *T. gondii* occurs in the cat; bradyzoite and tachyzoite phases can only be seen in intermediate hosts (Dubey and Lappin, 2006). Bradyzoites can remain in tissues of humans, dogs, and cats for life unless medical treatment is applied (Lappin, 2009). *Toxoplasma gondii* infection takes an active state in cases of immunosuppressive therapy with corticosteroids or cyclosporine, and immunosuppressive diseases as caused by the feline immunodeficiency virus (FIV) (Dubey and Frenkel, 1974).

Diagnosis of toxoplasmosis in cats is very difficult. General clinical signs initially include depression and fever; afterwards, hypothermia, anorexia, peritoneal effusion, icterus, and dyspnea. But, clinical findings may not always be detectable (Lappin, 2005). The presence of specific antibodies of *T. gondii*-specific antibodies, antigens, immune complex and *T. gondii* DNA can give a positive result in both previously exposed cats (clinically normal) and cats with clinical (active) toxoplasmosis. However, in cats with clinical toxoplasmosis, for serological diagnosis, elevated levels of *T. gondii*-specific antibodies (IgG, IgM) are useful (Lappin, 2009). The antemortem diagnosis of clinical toxoplasmosis can be done by a method offered by Lappin (Lappin, 2005; Lappin, 2009). It should be based on a combination of (Dubey, 1994) the presence of clinical signs of disease, (Lappin, 2005) the positivity of antibodies in serum, which demonstrates exposure to *T. gondii*, (Lappin, 2009) the demonstration of IgM titer > 1 : 64 or a fourfold increase in IgG titer, which suggest recent or active infection, (1) a differential diagnosis for common causes of clinical syndrome, and (Dubey and Lappin, 2006) a positive response to appropriate treatment within a few days (Lappin, 2005; Lappin, 2009). Depending on this method, we aimed to research the clinical course and laboratory findings of cats with clinical toxoplasmosis and the presence of other diseases or conditions leading to immunosuppression.

Materials and Methods

Animal collection: Two groups of cats were used for the study, including diseased and healthy cats. Group I included 11 cats ranging in age from 1-17 years old and diagnosed with clinical toxoplasmosis. Group I consisted of four male and seven female cats of different breeds [Turkish Angora (n=3), Siamese (n=1), mixed breed (n=7)]. Healthy seronegative cats (n=15) over the age of 1 year were included in the control group (Group II). The procedure followed were in accordance with ethical standards. Diagnosis of clinical toxoplasmosis was based on a combination of (Dubey, 1994) the presence of some of the clinical signs (anorexia, depression, hyperthermia or hypothermia, diarrhea, peritoneal effusion, icterus, muscular hyperesthesia, seizure, paresis); and (Lappin, 2005) an approximate fourfold increase in IgG (> 4.0 immune status ratio) for *T. gondii* titer. The animals providing these parameters, but having no positive response to clindamycin treatment in 5 days and associated with other diseases by differential diagnosis, were excluded from the study. Group II consist of the cats that had no clinical symptoms and mainly came for vaccination.

General examination and treatment procedure: After detailed anamnesis, general examinations were performed. The whole history, clinical signs, and, if present, primary disorders were recorded. Clindamycin hydrochloride (12.5 mg/kg *bid*) treatment was applied intramuscularly. Clinical signs were monitored for 15 days and recovery of clinical signs within 5 days was stated as one of the inclusion criteria.

Blood sample collection: Blood samples were taken prior to any treatment via venipuncture from vena jugularis or vena cephalica antebrachii by aseptic technique. The blood samples were collected into different tubes: EDTA tubes for hematological examination, standard biochemistry tubes for biochemistry, snap testing, and serology. To prepare the serum prior to analysis, blood samples were centrifuged at 3000 g. All examinations were carried out within 1 hour after collection.

Total blood count testing: Blood testing was performed on all cats. Total blood counts were analyzed using the Mindray BC-2800 Vet (Shenzen, China) hematology analyzer. Total blood count levels of red blood cells (RBC), white blood cells (WBC), hematocrit (PCV), hemoglobin (Hb), mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) were analyzed. This test was performed on all cats (n=26) prior to treatment and on the 14th day of treatment of the animals (n=7) of which the owners had given the permission for blood testing.

Blood Biochemistry profile: Biochemical profiles were analyzed using the Tokyo Boeki Prestige 24i (Tokyo, Japan) chemistry analyzer. Blood urea nitrogen (BUN), ALT, AST, creatinine, and glucose levels were measured. Serum biochemistry analysis was also performed on the animals (n=6) of which the owners had let the analysis after the 14th day of treatment.

Snap testing: For detection of feline immunodeficiency, virus antibodies, and feline leukemia virus antigen in the animals, either serum or whole blood (heparinized or EDTA) samples were used for the FIV Ab/FeLV Ag Anigen test (Korea); these tests were performed following the manufacturer's instruction.

***Toxoplasma gondii*-specific IgG titration by enzyme-linked immunoassay (ELISA):** The enzyme-linked immunosorbent assay (ELISA) (EVL Feline Toxoplasma Antibody, The Netherlands) for detection of *T. gondii*-specific immunoglobulin G titration was performed as per the manufacturer's instruction manual. To standardize the ELISA test, positive, negative, and cutoff serum samples were

used. In order to confirm appropriate test conditions, the positive control should give an extinction higher than 1.000 optical density (OD) units; the negative control should give an OD of ≤ 0.400 units. An OD of 0.500 was designated by the manufacturer as the cutoff for a positive reaction. For each specimen, an immune status ratio (ISR) was calculated by dividing the specimen optical density to cutoff optical density. The specimen was considered as positive if the result was at least 1.10 ISR. The results over 4.0 ISR were included in the study.

Other testing: ELISA testing for detection of the feline coronavirus antibody and blood smear testing for the diagnosis of *Mycoplasma haemofelis* were also applied in suspected cases.

Statistical analysis: The results of total blood counts and serum biochemistry analysis between groups were evaluated by an independent samples t-test. The results of the total blood count and serum biochemistry analysis pre- and after-treatment of seven cats were compared statistically by a paired-samples t-test. Differences were considered significant when the p-value was ≤ 0.05.

Results

Clinical signs and history of animals: Depending on general examinations and anamnesis, obtained data are given in Table 1.

Table 1. Distribution of clinical signs of cats in Group I before treatment.

Clinical signs of Group I	Number of cats
Gastrointestinal signs	5
Respiratory signs	5
Hyperthermia	5
Anorexia	4
Neurologic signs	3
Anisocoria	3
Behavioural signs	3
Icterus	2
Hypothermia	2
Muscular signs	1

Generally, diarrhea was not present in animals. Respiratoric signs included auscultated interstitial and wheezy lung sounds. Various neurological findings were present. We recorded lameness, muscle tenderness and hyperesthesia (n=1), seizure (n=1), peripheral neuropathy (n=1), mild incoordination, and head tilt (n=1) in Group I. Three animals showed symptoms of behavioral disorders. Acute onset aggression (n=2) and excessive vocalization (n=1) were diagnosed. All symptoms began to improve after the fifth day. The seven cats of Group I had been referred to our university clinic for unresponsiveness to treatment with long term antibiotheraphy.

Laboratory results: There was highly significant leukocytosis in total blood count analysis of Group I (Table 2). The mean result of WBC was 37985 µL. Leukocytosis ranged between 27000 - 62040 µL and was seen predominantly in the 10 cats of Group I (n=11). There were also elevations in serum ALT levels in two cats (ranging between 92 IU/L - 150 IU/L). The mean results of Groups I and II are given in Table 2.

We measured the mean levels of IgG titers for *T. gondii* as 5.518 ISR (ranged between 4.2 - 8.4 ISR). Results of snap testing for FIV/FeLV were negative in all animals. We performed ELISA testing for feline coronavirus antibody on five cats (with neuropathy and icterus) although there was no effusive sign. None of them were positive. The presence of *Mycoplasma haemofelis* was investigated in five cats with hyperthermia and anemia, but no organism was identified in a stained blood smear under light microscopy.

Secondary disorders: Secondary disorders had been recently present in eight cats. Ovarian hysterectomy operation (n=3), feline lower urinary tract disease (n=2), stage 2 of chronic kidney disease (n=1), hyperthyroidism (n=1), and boarding stress (n=1) identified by anamnesis at least three weeks previous to the first examination.

Statistical analysis of pre- and after-treatment: We found significant differences in RBC, WBC, Hb, and PCV values between groups (respectively, $P = 0.05$, $P < 0.001$, $P < 0.05$, $P < 0.1$) (Table 2). After treatment, we determined a significant decline in the WBC value ($P < 0.05$) and an increase in the PLT value ($P < 0.05$) (Table 3).

Discussion and Conclusions

As clinical toxoplasmosis is rarely seen and very difficult to diagnose, many cases may be overlooked in practice. Practical methods are needed in veterinary practice. Lappin's method of antemortem diagnosis (Lappin, 2005) of clinical toxoplasmosis offers easy and useful criteria for veterinarians. However, clinical toxoplasmosis may be present in cases with lower titration of immunoglobulins.

The limit of this study is the inability to distinguish whether the infection is due to first exposure or reactivation. According to data from human immunodeficiency virus (HIV) studies, *T. gondii* can be reactivated after a long time (Davidson et al., 1993). Primary exposure to *T. gondii* is known to cause disseminated disease with pneumonia, myocarditis, and myositis, as well as express neurologic signs (Muray, 1991). However, it is not clear whether primary exposure will lead to severe infections (Davidson et al., 1993). Davidson

Table 2. Mean values of total blood count and serum biochemistry analysis of Group I and II before treatment (NS: not significant).

Parameters	Group	N	Mean	Std. Deviation	P value
RBC	Group I	11	6.8727	1.96341	P=0.05
($x10^6$ µL)	Group II	15	8.3840	1.76010	
WBC	Group I	11	37.9855	13.32231	P<0.001
($x10^3$ µL)	Group II	15	12.2000	4.49253	
Hb	Group I	11	9.418	2.1283	P<0.05
(g/dl)	Group II	15	11.873	2.4970	
PCV	Group I	11	28.1791	7.04236	P<0.01
(%)	Group II	15	37.1333	8.42502	
PLT	Group I	11	376.09	235.138	NS
($x10^3$ µL)	Group II	15	258.33	192.569	
BUN	Group I	11	81.36	136.483	NS
(mg/dl)	Group II	15	42.47	13.005	
Crea	Group I	11	2.173	3.8619	NS
(mg/dl)	Group II	15	1.060	0.3312	
AST	Group I	11	30.30	18.142	NS
(IU/L)	Group II	15	67.67	75.370	
ALT	Group I	11	40.55	44.225	NS
(IU/L)	Group II	15	62.53	55.411	

Table 3. Laboratory results of pre- and after-treatment of Group I statistically (NS: not significant).

Parameters	Time	N	Mean	Std. Deviation	P value
RBC	initial	7	7.7029	1.90856	NS
($x10^6$ µL)	after	7	9.0071	1.68148	
WBC	initial	7	37.0143	10.61970	P<0.05
($x10^3$ µL)	after	7	19.34	8.531	
Hb	initial	7	10.514	1.8578	NS
(g/dl)	after	7	12.114	1.4871	
PCV	initial	7	31.7143	6.07493	NS
(%)	after	7	36.86	3.805	
PLT	initial	7	360.57	270.194	P<0.05
($x10^3$ µL)	after	7	490.29	174.600	
BUN	initial	6	52.83	20.595	NS
(mg/dl)	after	6	47.50	31.021	
Crea	initial	6	0.950	0.5394	NS
(mg/dl)	after	6	1.133	0.3777	
AST	initial	6	29.67	21.201	NS
(IU/L)	after	6	29.83	32.585	
ALT	initial	6	46.50	53.590	NS
(IU/L)	after	6	68.00	89.525	

et al. (1993) demonstrated that severe tachypnea, dyspnea, and tachycardia were apparent in primary infections of *T. gondii* in FIV-infected cats. Although there is not enough research on this topic, seropositivity of *T. gondii* infection is estimated by Tutuncu et al. (2003) to be higher in cats in Turkey. However, symptomatic toxoplasmosis is relatively uncommon (Parker et al., 1981). Parker et al. (1981) have conducted research on experimental models of acute feline toxoplasmosis and shown that the density of organisms like the liver, lungs, and spleen was 10-fold to 10,000-fold higher than that of the heart and brain, causing severe and fatal pneumonitis in cats. We also found severe and apparent respiratoric signs (n=4) in our study. However, we detected icterus in two cats, of which one of them had a higher value of ALT (150 IU/L). According to the study results of Davidson et al. (1993), eight cats with *T. gondii* and FIV infection showed hyperthermia and severe respiratory distress. Central nervous system signs showed in only one cat. A mild clinical disease characterized by anorexia, lethargy, and chorioretinitis occurred in only *T. gondii*-infected cats (Davidson et al., 1993). It is known that effective immune response to *T. gondii* occurs in most cases unless the immune system is compromised by FIV infection (Davidson et al., 1993; Dubey and Frenkel, 1974; Lappin, 2005; Lappin, 2009; O'neil et al.,1991). We found severe forms of clinical toxoplasmosis in cats without FIV and FeLV infections unlike these studies. We defined neurological signs in three cats in Group I. Also, biweekly seizures (recovered by clindamycin therapy) were present in one cat. Apparent respiratoric distress, anorexia and gastrointestinal findings were common in Group I. We found all cats in our study to be negative for FIV and FeLV infections. However, we detected secondary disorders in eight of 11 cats in Group I. The presence of recent secondary diseases and conditions might lead to immunosuppression as well. A 16-year-old cat had mild neurological signs, and a 17-year-old cat had neuropathy in one hind limb and respiratory distress. Geriatry is also an important factor for the progressive weakening of immune functions (Fortney, 2004). Besides, *T. gondii* infection can be immunosuppressive. Infection with FIV apparently does not destroy the animal's immunity, it may delay the antibody class shift from IgM to IgG (Lappin et al., 1989). In our study, the presence of higher titers of IgG was one of the inclusion criteria, but no FIV positivity was found in the cats in Group I. However, Lappin et al. (1989) reported that they did not find higher titers of IgG in clinical toxoplasmosis cats without FIV.

Javadi et al. (2010) searched for hematological changes of cats with *T. gondii*-specific antibodies and higher IgM titers and found significance in PCV, RBC, and monocyte values which should be considered for toxoplasmosis (Javadi et al., 2010). Oppositely, in our study, we detected significant declines in values of RBC and PCV in Group I (respectively, $P = 0.05$, $P < 0.01$). Although we found no significance in PLT values between groups, PLT levels increased after treatment in Group I ($P < 0.05$). However, Javadi et al. (2010) defined increased PCV as an incompatible finding and attributed it to possible dehydration. Similarly, Lappin et al. (1989) diagnosed clinical toxoplasmosis in 15 cats and reported neutrophilic leukocytosis in four of 15 cats. Severe and resistant leukocytosis was apparent in our study with a mean value of WBC as 37985 µL. Seven cats in Group I had a history of poor response to treatment with various broad spectral antibiotherapy. Several studies searched for diagnostic and clinical aspects of toxoplasmosis (Dubey and Carpenter, 1993; Javadi et al., 2010; Lappin et al., 1989; O'Neil et al., 1991); one report conducted comparisons of complete blood count results with lower and higher values of antibodies to *T.gondii* (Javadi et al., 2010). Veterinarians need practical diagnostic signs to identify *T. gondii* infection in cats to prevent public health risks and the possibility of overlooking clinically diseased cats (Javadi et al., 2010).

While Dubey and Carpenter (1993) did not report kidney disease as a cause of death, they determined *T. gondii* stages in 11 of 61 kidneys of cats. According to our data, chronic renal failure had been recently identified in two cats (2/11) of Group I. Hsu et al. (2011) found no association in the aetiological role of *T. gondii* and progression of chronic renal failure (Hsu et al., 2011). Also, in our study, behavioral alterations, including acute onset aggression (n = 2) were recorded in three cats. Experimental studies conducted on rodents suggest that *T. gondii* infection can cause behavioral alteration in its hosts. The mechanism of action is unknown, but it may also be associated with schizophrenia in human infections (Webster, 2007). In our study, all cats responded quite well to treatment with clindamycin hydrochloride on the 14th day. In another study by Lappin et al. (1989), 13 of 15 cats responded well to treatment. One of the cats responded poorly to treatment and was also infected with FIV.

O'Neil et al. (1991) detected higher seroprevalence to *T. gondii* in FIV-infected cats. However, Zimmerman (1961) found no association between them. So, it is not fully understood why some animals develop clinical toxoplasmosis whereas others do not. Correlatively, the prevalence and results of primary infection and reactivations are not well defined (Davidson and

English, 1998). As a result of this study, further studies should be conducted on the diagnostic relevance of severe and resistant leukocytosis in clinical feline toxoplasmosis as veterinarians need easy and practical laboratory results to evaluate the active *T. gondii* infection in cats. Researchers have noted that clinical feline toxoplasmosis may also frequently develop in the absence of FIV and that FeLV, as the mechanism leading to immunosuppression, may occur in the presence of other secondary disorders and conditions.

References

Berdoy M, Webster JP, Macdonald DW, 2000: Fatal attraction in rats infected with *Toxoplasma gondii. Proc Biol Sci,* 267, 1591-1594.

Davidson MG, English RV, 1998: Feline ocular toxoplasmosis. *Vet Ophtamol*, 1, 71-80.

Davidson MG, Rottman JB, English RV, Lappin MR, Tompkins MB, 1993: Feline Immunodeficiency Virus Predisposes Cats to Acute Generalized Toxoplasmosis. *Am J Pathol*, 143, 1486-1497.

Dubey JP, Carpenter JL, 1993: Histologically confirmed clinical toxoplasmosis in cats: 100 cases (1952-1990). *J Am Vet Med Assoc*, 203, 1556-1566.

Dubey JP, Frenkel JK, 1974: Immunity to feline toxoplasmosis: modification by administration of corticosteroids. *Vet Pathol*, 11, 350-379.

Dubey JP, Lappin MR, 2006: Toxoplasmosis and Neosporosis. In "Infectious Disease of The Dog and Cat" Ed; Greene CE, St Louis, USA: Saunders, p.754.

Dubey JP, 1994: Toxoplasmosis. *JAVMA,* 205, 1593-1598.

Fortney WD, 2004: Geriatrics and Aging. In "Geriatrics and Gerontology of the Dog and Cat" Ed; Hoskins JD, Saunders, Missouri, USA, pp.1-4.

Hsu V, Grant DC, Zajac AM, Witonsky SG, Lindsay DS, 2011: Prevalence of IgG antibodies to *Encephalitozoon cuniculi* and *Toxoplasma gondii* in cats with and without chronic kidney disease from Virginia. *Vet Parasitol*,176, 23-26.

Javadi S, Asri Rezaci S, Tajik H, Hadian M, Shokouhi F, 2010: Haemotological changes of cats with Toxoplasma gondii-specific antibodies. *Comp Clin Pathol*,19, 307-310.

Lappin MR, Greene CE, Winston S, Toll SL, Epstein ME, 1989: Clinical toxoplasmosis: serologic diagnosis and therapeutic management of 15 cases. *J Vet Med,* 3, 139-143.

Lappin MR, 2009: Protozoal and miscellaneous infections. In "Textbook of Veterinary Internal Medicine 6th ed." Ed; Ettinger SJ, Feldman EC, Saunders, St Louis, USA, pp. 639-642.

Lappin MR, 2009: Toxoplasmosis. In "Kirk's Current Veterinary Therapy 14th ed" Ed; Bonagura JD, Saunders, St Louis, USA, pp.1254-1259.

Muray HW, 1991: Toxoplasmosis. In "Harrison's Principles of Internal Medicine" Ed; Wilson JD, Braunwald E, Isselbacker KJ, Mc Graw-Hill, New York, USA, p.795.

O'Neil SA, Lappin MR, Reif JS, 1991: Clinical and epidemiological aspects of feline immunoeficiency virus and *Toxoplasma gondii* coinfections in cats. *JAAHA,* 27, 211-220.

Parker GA, Lanoloss JM, Dubey JP, Hoover A, 1981: Pathogenesis of acute toxoplasmosis in spesific-pathogen-free cats. *Vet Pathol*, 18, 786-803.

Tutuncu M, Akkan HA, Karaca M, Ağaoğlu Z, Berktaş M, 2003: Prevalence of toxoplasmosis in Van cats in Turkey. *Indıan Vet J,* 80, 730-732.

Webster JP, 2007: The Effect of *Toxoplasma gondii* on animal behavior: playing cat and mouse. *Schizophrenia Bulletin*, 33(3), 752–756.

Zimmerman LE, 1961: Ocular pathology of toxoplasmosis. *Surv Ophthalmol*, 6, 832-867.

***Corresponding autor:** Alper BAYRAKAL
Istanbul University-Cerrahpasa, Faculty of Veterinary Medicine, Department of Internal Medicine, Istanbul, Turkey
e-mail: alper.bayrakalistanbul.edu.tr