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Original article

Feline ocular toxoplasmosis: seroprevalence, diagnosis and treatment outcome of 60 clinical cases

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Abstract

Toxoplasmosis is one of the most important protozoa zoonotic diseases worldwide. The present study describes the clinical, seroprevalence findings with ocular toxoplasmosis and the outcome of medicinal treatment of these cats. This study was carried out on 105 cats with various ocular signs, no historical evidence of ocular trauma or drug/vaccine exposure for at least 3 months prior to admission, and without clinical or laboratory evidence of other systemic diseases. Complete case history, physical and ophthalmic examinations were carried out. The seroprevalence of *Toxoplasma gondii* antibodies was determined using the Toxoplasma Ab Rapid Test and Enzyme Linked Immunosorbent Assay. Out of 105 examined cats with ocular lesions, 60 cats representing 57.14% were seropositive to *T. gondii*. Out of these 60 cats, 15 cats (25%) had bilateral ocular abnormalities, 25 cats (41.67%) had right-sided ocular disease, and 20 cats (33.33%) had left-sided ocular disease. There were 38 cats (63.33%) with anterior uveitis, 12 cats (20%) with posterior segment involvement, 5 cats (8.33%) with anterior uveitis and anterior chamber abnormalities, 3 cats (5%) with corneal abnormalities and 2 cats (3.34%) with anterior uveitis with concurrent corneal involvement. There was a significant difference in the index values of IgM and IgG between seropositive and seronegative cats with *T. gondii* antibodies ($p<0.05$). There was no significant difference between the different ages, genders and breeds of cats with seroprevalence of *T. gondii* antibodies as well as between the age and total number of cats with seropositive and seronegative *T. gondii*. Out of 60 treated cats, 28 cats (46.7%), 25 cats (41.7%) and 7 cats (11.6%) showed complete, partial and poor response to treatment, respectively. In conclusion, cats showing ocular signs without obvious etiology should be examined serologically for toxoplasmosis and the seropositive cats should be treated with both specific topical and systemic treatments.

Key words: cats, chorioretinitis, keratitis, seroprevalence, *Toxoplasma gondii*, uveitis

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Introduction

Toxoplasmosis is one of the most common zoonotic diseases caused by intracellular *Toxoplasma gondii* protozoa (Tenter et al. 2000). *Toxoplasma gondii (T. gondii)* is an obligate, protozoan parasite that belongs to the phylum Apicomplexa, subclass coccidia, which undergoes a complicated life cycle including both sexual and asexual reproduction (Holland et al. 1996). Cats have played a crucial role in dissemination of the disease due to sexual reproduction; they excrete numerous infective oocysts that become more resistant to environmental conditions (Dubey 2010, Jones and Dubey 2010).

Felines shed oocysts after ingesting any of the 3 infectious stages of *T. gondii*: tachyzoites in gatherings, bradyzoites in tissue cysts, and sporozoites in oocysts. The prepatent period (days to shedding of oocysts) is dissimilar after ingesting bradyzoites versus tachyzoites or oocysts (Dubey and Frenkel 1976). The prepatent period subsequent to after ingesting bradyzoites is 3-10 days (Dubey and Frenkel 1976, Dubey 2001) and 18 days or more after ingesting oocysts or tachyzoites (Dubey and Frenkel 1976, Freyre et al. 1989, Dubey 1996). The life cycle of *T. gondii* after ingesting bradyzoites or tissue cysts was depicted in detail by Dubey and Frenkel (1972). Notwithstanding the extraintestinal cycle showed in all intermediate hosts of *T. gondii*, 5 asexual types (types A–E) were seen before the development of the sexual cycle in the intestine of cats (Dubey and Frenkel 1972). The oocyst--induced cycle has likewise been studied beforehand (Freyre et al. 1989, Dubey 1996).

Feline toxoplasmosis constitutes a worldwide problem with high seroprevalence rates ranging from 60 % to 90% (Lindsay et al. 1997, Dubey 1998). There are several forms of *T. gondii* such as oocyst, tachyzoite, and cyst. Sexual reproduction of the parasite results in oocysts that shed in feline feces. Tachyzoites are the obligate intracellular form of the parasite, having the ability to invade most of the host tissues and cause severe inflammatory response, tissue damage and clinical manifestations. Tachyzoites are transformed into bradyzoites under the pressure of the immune response and form cysts (Dobrowolski and Sibley 1996, Dubey 2010).

Ocular toxoplasmosis is the most common cause of chorioretinitis in humans in the United States, particularly in patients with acquired immune deficiency syndrome as an important opportunistic parasite (Smith 1990).

The first reports of feline ocular toxoplasmosis were recorded between 1960 and 1970 in cats with a necrotizing retinochoroiditis and concurrent systemic abnormalities (Holland et al. 1996, Holland and Lewis 2002). Since then, feline toxoplasmosis has been associated with several ocular lesions such as; multifocal to diffuse retinochoroiditis, chorioretinitis, optic neuritis, and anterior uveitis (Lindsay et al. 1997, De Moura et al. 2006, Dubey 2010).

Unlike human toxoplasmosis, the recent clinical and experimental studies of feline toxoplasmosis have concluded that the primary lesion of feline ocular toxoplasmosis is choroiditis with secondary retinitis that is characterized by chorioretinitis (Lindsay et al. 1997, De Moura et al. 2006, Dubey 2010).

Accurate diagnosis of feline ocular toxoplasmosis is difficult, particularly in the absence of characteristic clinical findings and histopathological examination of the organism (Dubey et al. 1995). Moreover, the clinical appearance of most ocular lesions is similar with most etiologies and no pathognomonic lesions for feline ocular toxoplasmosis have been illustrated; therefore, the diagnosis of feline ocular toxoplasmosis usually depends on the serological tests.

Enzyme Linked Immunosorbent Assay (ELISA) has been applied for detection of *T. gondii* immunoglobulin M (IgM) and immunoglobulin G (IgG) in the serum of cats. In the experimental studies, the seropositive IgM titers develop within two to three weeks post-inoculation while the IgG antibody titers develop within 2-4 weeks post-inoculation and usually remain seropositive for months to years post-inoculation (Lappin et al. 1989a). In naturally infected animals, several cats also have detectable IgM and IgG antibody titers (Lappin et al. 1989b). Some cats with clinical toxoplasmosis show seropositivity for *T. gondii* IgM without IgG after infection (Lappin et al. 1989c).

Historically in humans, combinations of drugs reducing folic acid production, which is necessary for *T. gondii* proliferation, have been used as the primary treatment of human ocular toxoplasmosis. However, the most common therapeutic combination is pyrimethamine (a dihydrofolate reductase inhibitor), a sulfonamide such as sulfadiazine and corticosteroids (Soheilian et al. 2005).

Several antimicrobial agents are also used for treatment of human ocular toxoplasmosis, such as tetracyclines, clindamycin, clarithromycin, and atovaquone (Kishore et al. 2001).

In contrast, cats do not tolerate the pyrimethamine/ /sulfonamide combinations (Dubey and Yeary 1977). However, clindamycin hydrochloride is considered to be the main antimicrobial treatment for feline toxoplasmosis (Lappin et al. 1989c). The recommended dosage of clindamycin for toxoplasmosis in cats is 12.5 mg/kg orally twice daily for 14-21 days (Dubey and Yeary 1977, Lappin et al. 1989c). This study reports

the common ocular manifestations associated with feline toxoplasmosis and the outcome of their treatment.

Materials and Methods

Animals

This study was carried out on 105 cats with general ocular signs including; corneal involvement (35/105, 33.3%), vision impairment or loss of vision (25/105, 23.8%), ocular discharges (20/105, 19.1%), red eye (15/105, 14.3%) and blepharospasm (10/105, 9.5%). The cats were of various ages, sexes, breeds and body weights. All cats were admitted to the ophthalmology service at the Faculty of Veterinary Medicine, Cairo University, Egypt during the period from December 2018 to January 2020. All cats fulfilled the following two inclusion criteria: (1) no historical evidence of ocular trauma or systemic drug/vaccine exposure for at least 3 months prior to admission, and (2) presenting with no clinical manifestations of other systemic diseases. The full case history of each cat was collected from the clients.

This study was carried out in strict accordance with the recommendations in the Guide for the Care and Use of Laboratory Animals. Approval to conduct this study was obtained from the Institutional Review Board of the Institutional Animal Care and Use Committee (Vet CU-IACUC) of the Faculty of Veterinary Medicine, Cairo University, Egypt.

Clinical and ophthalmic examinations

A complete physical examination including body temperature, heart and respiratory rates as well as examination of the mucous membranes was carried out.

Ophthalmic evaluation of the cats was performed by a qualified ophthalmologist (KMA) via visual examination and direct and indirect ophthalmoscopy (Riester e-scope, Germany) for detection of current ocular abnormalities (Ali et al. 2021). Commercially available fluorescein strips (Bio-Glo® Fluorescein sodium Strips 1 mg; HUB pharmaceuticals, LLC., USA) were used when deemed necessary. Measurement of intraocular pressure (IOP) was done using a Tonopen tonometer (Tonopen XL®, Reichert Technologies, NY, USA).

Collection of blood samples

Blood samples from the 105 cats were collected from the jugular vein using a sterile syringe after cleaning, shaving, and disinfection of the vein area. The collected blood samples were kept in clean test tubes without anticoagulant for serum collection. These samples were transported to the parasitology laboratory at the Faculty of Veterinary Medicine, Cairo University, Egypt. Serum was separated by centrifugation at 3000 rpm for 10 minutes and stored at -20°C until tested.

Detection of *T. gondii* antibodies in feline serum

Toxoplasma Ab Rapid Test

The feline serum samples were examined using flow chromatographic immunoassay (Toxoplasma Ab Rapid Test, MEDIAN Diagnostics, Inc. Korea) for screening of anti-*Toxoplasma gondii* according to the manufacturer's instructions. After collection of serum, 10 µL of serum was added to the sample hole of kits, then 100 µL of sample dilution buffer was thenadded and finally the test result was interpreted after 10 min in comparison with the control positive.

Enzyme-Linked Immunosorbent Assay (ELISA)

The antibody-Toxoplasma IgM and IgG in feline serum were detected using cat toxoplasma IgM and IgG ELISA kits (Toxoplasma IgM, IgG, MyBioSource, Inc. USA) according to the manufacturer's instructions. The ELISA analytical biochemical technique of these kits was based on the immunological interaction between Toxoplasma IgM, IgG antibody and Toxoplasma IgM, IgG antigen. A colorimetric detection system was applied using Horseradish Peroxidase (HRP) to detect the Toxoplasma IgM, IgG antibody in the serum samples.

Treatment of cats seropositive to *T. gondii*

Systemic treatment was given to the cats with a seropositive result to *T. gondii* in the form of clindamycin hydrochloride (Dalacin® C 150mg capsule; Pfizer, Egypt) at a dose of 12.5 mg/kg orally twice daily for 21 days (Lappin et al. 1989c). The topical treatment included an ophthalmic combination of tobramycin and dexamethasone (Tobradex ophthalmic solution®, Alcon Comp, Egypt) and tropicamide1% eye drops (Mydriacyl®, Alcon Comp, Egypt) 3-4 times/day.

At the end of the treatment period, the outcome of treatment was assessed by clinical evaluation and serological testing using a rapid test of *T. gondii* by detection of anti-*Toxoplasma gondii* in serum samples. The response to treatment was graded as: complete: disappearance of the visible ocular lesions and seronegative rapid test, partial: persistence of ocular signs and seronegative rapid test or poor: persistence of ocular signs and seropositive rapid test.

Table 1. Ocular abnormalities of feline toxoplasmosis in 60 clinically infected cats.

Ocular abnormalities	Manifestations	No.	%
Anterior uveitis	Iritis with iris neovascularization	25	41.7
	Iris atrophy	6	10
	Dispersion of uveal pigment	4	6.6%
	Posterior synechia	3	5
Posterior segment involvement	Chorioretinitis, subretinal bleeding and retinal detachment	8	13.3
	Chorioretinitis and secondary glaucoma	4	6.7
Anterior uveitis and anterior chamber involvement	Hyphema	2	3.3
	Organized anterior chamber membrane	3	5
Anterior uveitis and corneal involvement	Ulcerative keratitis with granulation tissue	1	1.7
	Endothelial keratic precipitates	1	1.7
Corneal abnormalities	Superficial keratitis with corneal vascularization	2	3.3
	Keratitis with granulation tissue and central sequestrum	1	1.7
Total		60	100

Statistical analysis

The statistical analysis was performed using a Kruskal-Wallis H test for determination of the significant differences between seroprevalence of *T. gondii* antibodies in cats, index value of IgM, IgG and age. An independent *t*-test was used to compare the age of the cats and total number of cats with seropositive and seronegative *T. gondii* antibodies. A Chi-Square test was used to compare the breed and gender of cats with seroprevalence of *T. gondii* antibodies. One-way ANOVA was used to compare the number of cats with various grades of treatment outcome. The above statistical tests were analyzed using the "R" Developer Core Team, 2019. A p-value <0.05 was considered significant.

Results

Clinical and ophthalmic findings

The breeds of the 105 cats included Domestic Shorthair (n=67, 63.8%), *Persian* (n=21, 20%), *Siamese* (n=9, 8.6%), and *Himalayan* cats (n=8, 7.6%). The cats were 53 females (50.5%) and 52 males (49.5%) as shown in Table 1. All cats were sexually intact except 5 which were spayed females.

Out of 105 examined cats with ocular lesions, 60 cats, representing 57.14%, were seropositive to *T. gondii*. Out of these 60 cats, 15 cats (25%) had bilateral ocular abnormalities, 25 cats (41.67%) had right-sided ocular disease, and 20 cats (33.33%) had left-sided ocular disease.

The ocular signs were noticed between 5 and 30 days before admission. A history of short-term ophthalmic application of tobramycin and dexamethasone (Tobradex®; ophthalmic solution, Alcon, Egypt) before presentation was reported in 15 cats. The cats had vital parameters within normal ranges, slight loss of appetite, and lethargy.

Out of 60 cats with a seropositive result to *T. gondii*, 38 cats (63.33%) had anterior uveitis, 12 cats (20%) had posterior segment involvement, 5 cats (8.33%) had anterior uveitis with anterior chamber abnormalities, 3 cats (5%) had corneal abnormalities, and 2 cats (3.34%) had anterior uveitis with concurrent corneal involvement. The ocular manifestations reported in this study are summarized in Table 1.

Out of 38 cats with anterior uveitis, there were 25 cats with iritis and iris neovascularization (rubeosis iridis) (Fig. 1a), 6 cats with iris atrophy (Fig. 1b), 4 cats with dispersion of uveal pigment (Fig. 1c) and 3 with posterior synechia (Fig. 1d).

Out of 12 cats with posterior segment involvement, there were 8 cats with chorioretinitis, subretinal bleeding and retinal detachment (Fig. 2a) and 4 cats with chorioretinitis and secondary glaucoma (Fig. 2b).

Anterior uveitis with secondary anterior chamber involvement included chronic uveitis with an anterior chamber membrane in 3 cats (Figs. 3a, b, c) and anterior uveitis with hyphema in 2 cats (Fig. 3d).

Corneal abnormalities included superficial keratitis with corneal vascularization (Fig. 4a), keratitis with granulation tissue and central sequestrum (Fig. 4b), ulcerative keratitis with granulation tissue and concurrent anterior uveitis (Figs. 4c, d) and endothelial keratic precipitates with concurrent anterior uveitis (Fig. 4e).

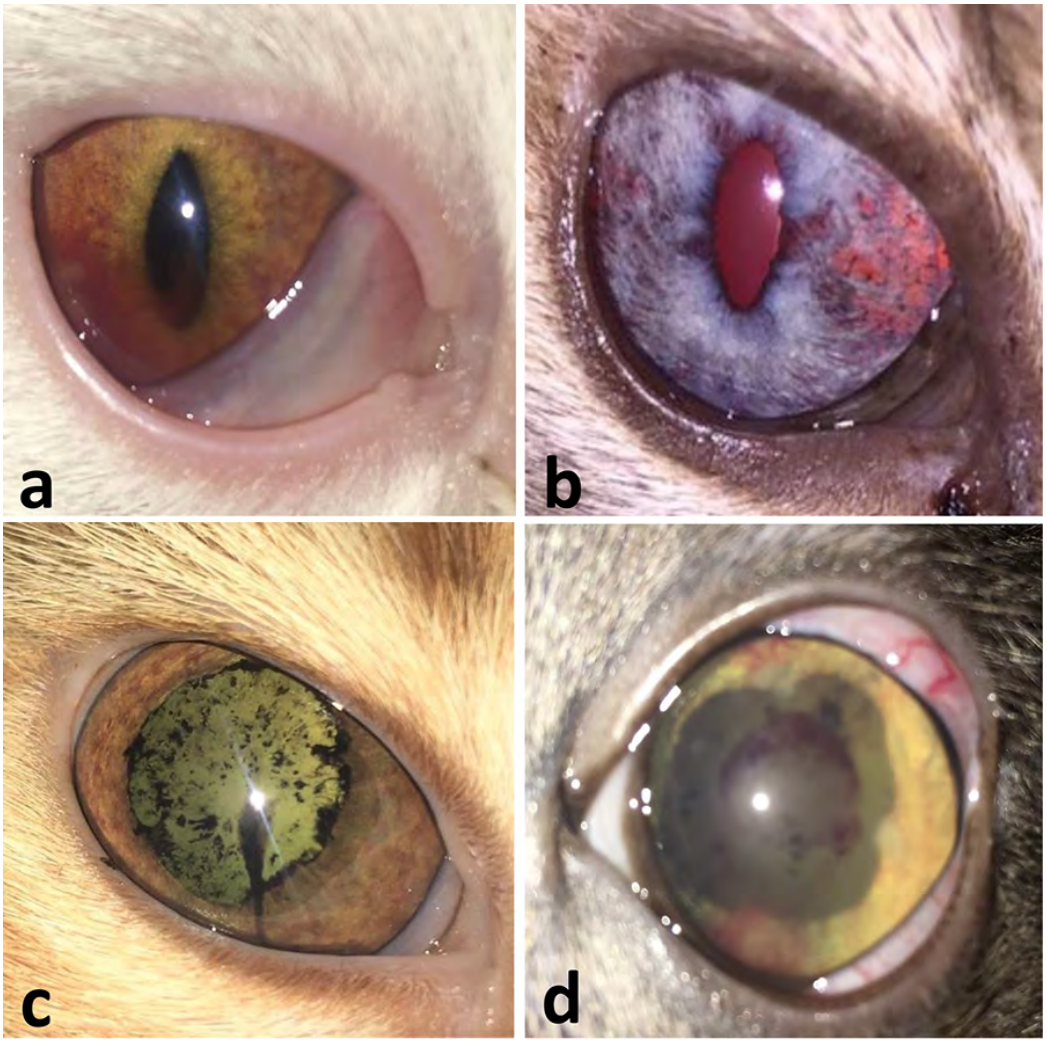

Fig. 1. Ocular manifestations of anterior uveitis in cats infected with *T. gondii*. (a) Iritis and rubeosis irids. (b) Iris atrophy. (c) Dispersion of uveal pigment. (d) Posterior synechia with iris vascularization .

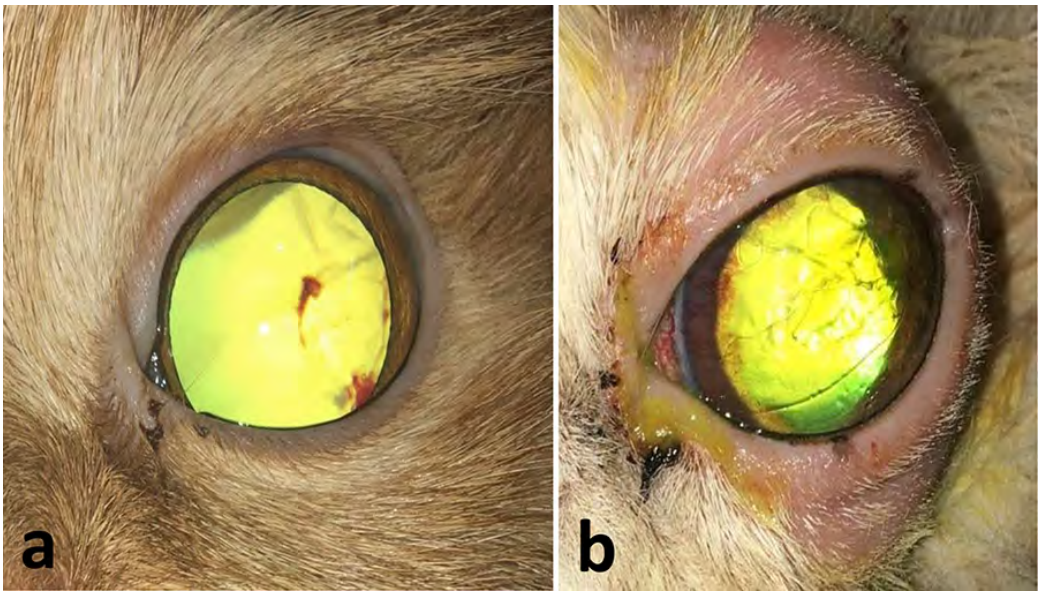

Fig. 2. Posterior segment abnormalities in cats infected with *T. gondii*. (a) Chorioretinitis, subretinal bleeding and retinal detachment. (b) Chorioretinitis and secondary glaucoma .

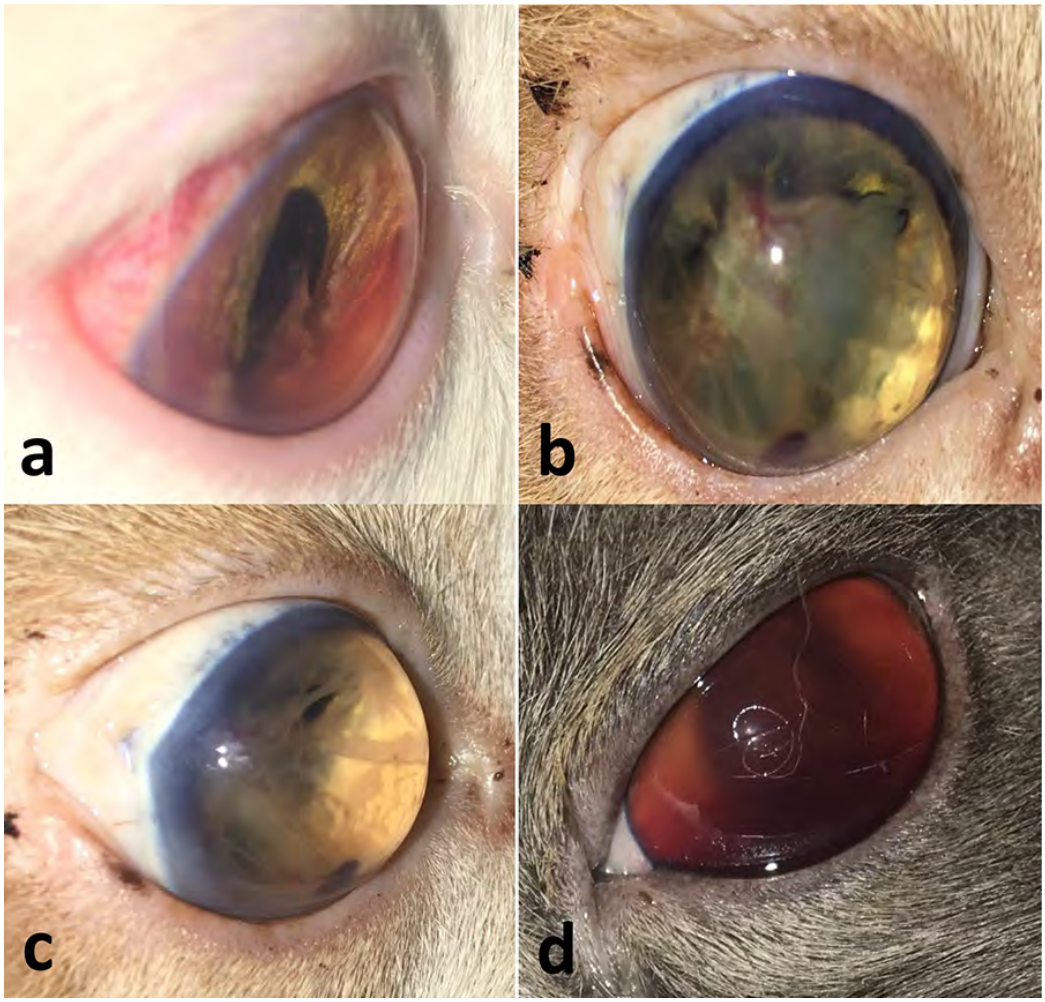

Fig. 3. Anterior chamber manifestations in cats infected with *T. gondii*. (a,b,c) Chronic iritis with iris neovascularization and anterior chamber fibrous membrane crossing the pupil. (d) Hyphema .

Serological findings

Out of 105 cats, there were 60 with seropositive of *T. gondii* antibodies (IgM, combined IgG & IgM and IgG) representing 57.14% of the cats examined using *Toxoplasma* Ab Rapid Test and ELISA (Table 2). A Kruskal-Wallis H test showed a significant difference in index value of IgM between seropositive and seronegative cats with *T. gondii* antibodies according to the chronicity of infection, $\chi 2$ (3) = 79.584, p = 0.001, with a mean rank IgM output of 84.11 for cats with seropositive IgM, 94.85 for cats with seropositive of both IgM and IgG, 53.79 for cats with seropositive IgG and 27.0 for cats with seronegative IgM and IgG. Moreover, there was a significant difference in index value of IgG between seropositive and seronegative cats with *T. gondii* antibodies according to the chronicity of infection, $\chi 2$ (3) = 90.32, p = 0.001, with a mean rank IgG output of 52.29 for cats with seropositive IgM, 93.62 for cats with seropositive of both IgM and IgG, 75.98 for cats with seropositive IgG and 23.07 for cats with seronegative IgM and IgG. However, there was a non-significant difference between the different ages of cats with seroprevalence of *T. gondii* antibodies, $\chi 2$ (3) = 0.807, p = 0.848, with a mean rank age of 53.50 for cats with seropositive IgM, 58.85 for cats with seropositive of both IgM and IgG, 51.81 for cats with seropositive IgG and 51.40 for cats with seronegative IgM and IgG.

In contrast, the outputs of the Independent *t*-test revealed no significant difference between the age of cats and total number of cats with seropositive and seronegative *T. gondii* antibodies in which t (96.78) = 0.534, p-value = 0.594.

A Chi-Square test was performed to examine the relation between different breeds of cat with seroprevalence of cats with antibodies of *T. gondii*. The relation between these variables was non-significant, X^2 (3, n=105) = 3.39, p-value = 0.33. The Chi-Square test was also performed to examine the relation between the gender of cats and seroprevalence of cats with antibodies of *T. gondii*. The relation between these variables

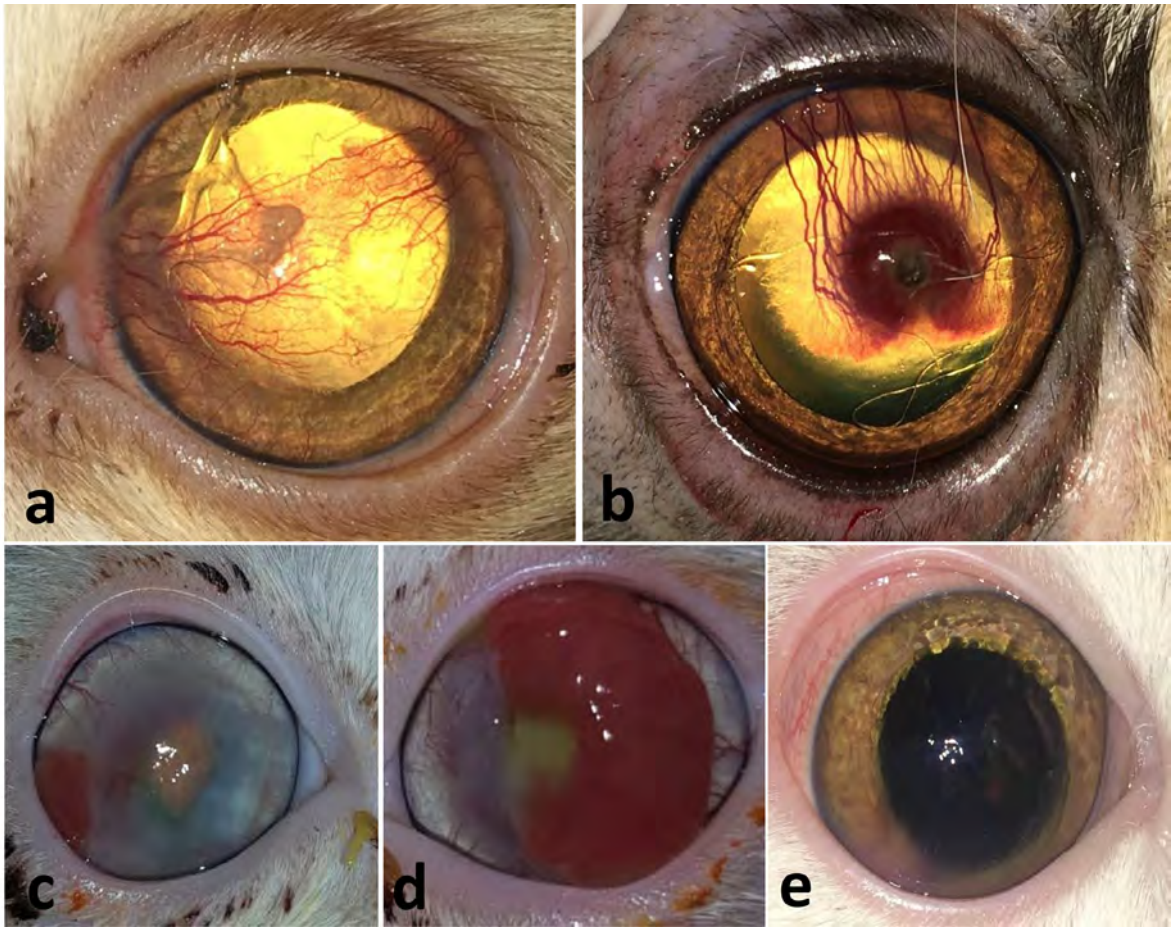

Fig. 4. Corneal abnormalities in cats infected with *T. gondii*. (a) Keratitis with corneal vascularization; (b) Keratitis with granulation tissue and central sequestrum; (c, d) Ulcerative keratitis with granulation tissue and concurrent uveitis; (e) Keratic precipitates .

Table 2. Seroprevalence of antibodies (IgM and IgG) to *Toxoplasma gondii* in different ages, genders and breeds of the total examined cats (N=105).

Antibodies	No. of cats (%)	Age (Month)			Breed				Gender		IgM*		IgG*	
		Mean±SE	Range	Mean rank	*DSH*	*Persian*	*Siamese*	*Himalyan*	Male	Female	Mean±SE	Mean rank	Mean±SE	Mean rank
IgM	14 (13.33)	32.21 ±6.05	(6-72)	53.50	7	5	1	1	7	7	3.736^{b}±0.176	84.11	0.816^{b}±0.046	52.29
IgG & IgM	17 (16.19)	37.94±6.02	(8-84)	58.85	10	5	2	0	8	9	5.052^{c}±0.249	94.85	6.422^{d}±0.232	93.62
IgG	29 (27.62)	30.97±3.78	(8-72)	51.81	19	5	2	3	14	15	0.685^{a}±0.029	53.79	4.892^{c}±0.11	75.98
Total seropositive antibodies (%)	60 (57.14)	33.23±2.84	(6-84)	---	36 (34.28)	15 (14.28)	5 (4.76)	4 (3.81)	29 (27.62)	31 (29.52)	--------	---	----------	------
Total seronegative antibodies (%)	45 (42.29)	30.96±3.17	(6-84)	51.40	31 (29.52)	6 (5.71)	4 (3.81)	4 (3.81)	23 (21.90)	22 (20.95)	0.323^{a}±0.042	27.00	0.229^{a}±0.021	23.07

* An index value of IgM and IgG (Absorbance/Cut-Off value) < 0.9 is seronegative and >1.1 is seropositive.
SE = Standard error $^{a, b, c, d}$ Different superscripts within the same column of mean index value of IgM, IgG indicate significant differences at $p<0.05$.
DSH: Domestic Shorthair Cat

was non-significant, X^2 (1, n=105), p-value = 0.778, 0.378. The percentage of seropositive female and male cats with *T. gondii* antibodies were 29.52% and 27.62% respectively (Fig. 5).

Outcomes of the treatment

Response rate of feline ocular toxoplasmosis to both systemic and topical treatments in 60 cats with a seropositive result to *T. gondii* is shown in Table 3.

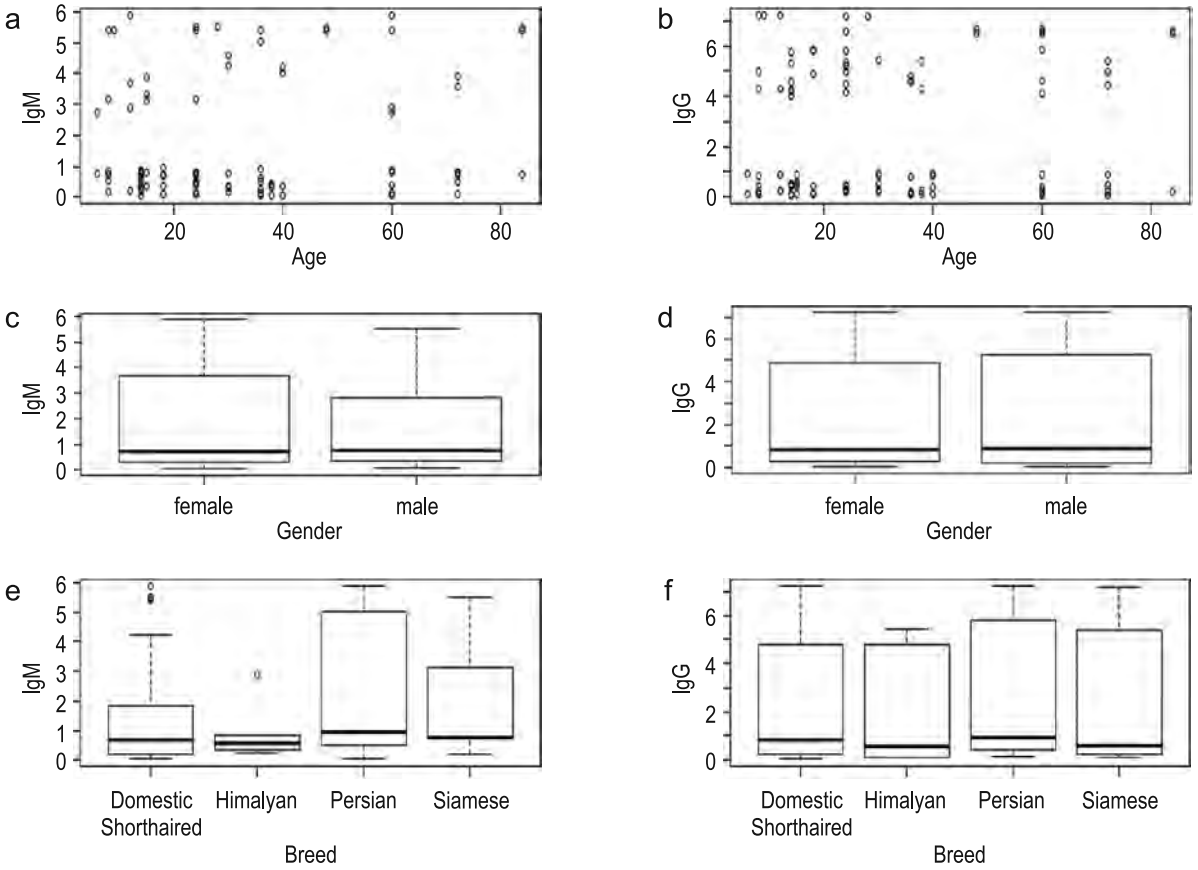

Fig. 5. Seroprevalence of *Toxoplasma gondii* antibodies (IgM and IgG) in different ages (a&b), genders (c&d) and breeds (e&f) of the cats examined by ELISA .

Out of 60 treated cats, 28 cats (46.7%), 25 cats (41.7%) and 7 cats (11.6%) showed complete, partial and poor response to treatment, respectively as shown in Table 3 and Fig. 6. The cats with a poor response to treatment lost vision in the affected eye/s. The number of cats demonstrating complete resolution of ocular manifestations after treatment was significantly higher than those showed partial or poor responses ($p<0.05$).

Discussion

Toxoplasmosis is a very important zoonotic disease of global distribution. Due to the wide range of clinical manifestations, diagnosis of feline toxoplasmosis can be complicated. Feline animals are the definitive hosts for *T. gondii* and all non-feline animals and humans constitute the intermediate host. Most pathologies associated with toxoplasmosis are caused by tachyzoites that undergo active multiplication in the tissues (Calero--Bernal and Gennari 2019).

In the present study, the seroprevalence of *T. gondii* in 105 cats with ocular signs was 57.14%, where the seropositive IgG (27.62%) was higher than seropositive IgM (13.33%), and combined IgM and IgG (16.19%). The recorded high seroprevalence of toxoplasmosis here could be attributed to the specific cat population included in this study, only cats with ocular signs. Also, the variation between IgG, IgM and combined IgM and IgG levels depends upon the chronicity of *Toxoplasma* infection. The cats seropositive for *T. gondii* IgG have an old infection while the cats seropositive for *T. gondii* IgM have active and recent infection and the cats seropositive for both IgM and IgG *T. gondii* have chronic and recent active infections. On the other hand, the seronegative cats for *T. gondii* IgM and IgG have not yet been exposed to the *T. gondii* parasite and remain susceptible to the infection in the future (Dubey et al. 1995, Iewida and Cabanacan-Salibay 2010). This result is similar to a previous study that examined 177 cats from Cairo, Egypt by Indirect Fluorescent Antibody Test (IFAT) and found that 58.8% of the cats were *T. gondii* seropositive (Aboul-Magd et al.1988). Moreover, 18.4% of 114 cats from Gharbia Province, Egypt were *T. gondii* seropositive by indirect hemagglutination test (IHAT), and 57.7% of 97 cats by latex agglutination (Abu-Zakham et al. 1989). In contrast, Al-Kappany et al. (2011) reported the highest prevalence of *T. gondii* in cats (95%) from Giza, Egypt. These variations in the seroprevalence of feline

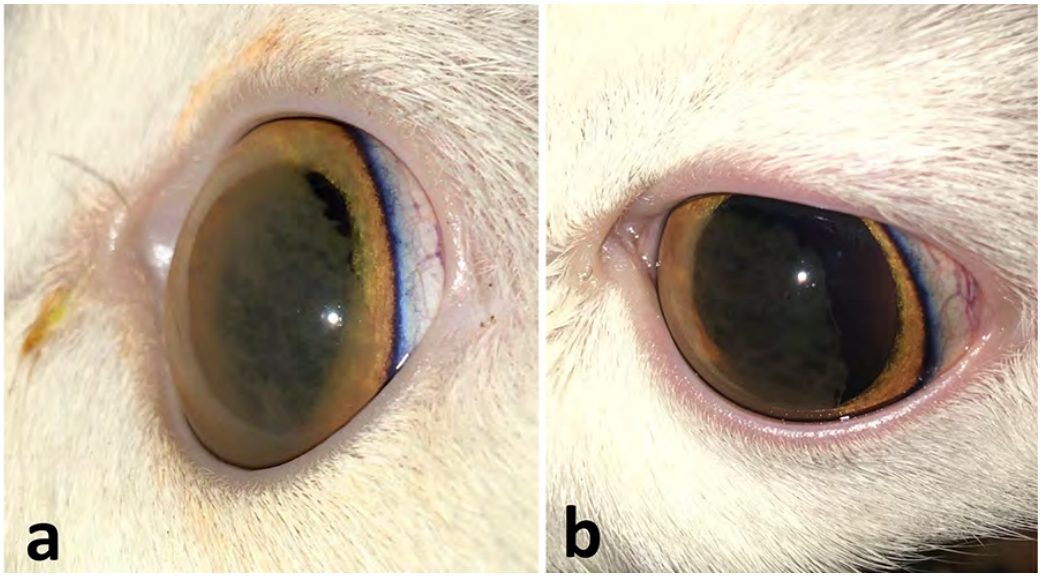

Fig. 6. (a) A 2-year-old Persian spayed cat showing unilateral uveitis with keratic precipitates; (b) The same cat showing partial recovery after 7 days of treatment .

T. gondii in Egypt is probably related to the lifestyle of these cats, the breeds, variation in environmental, and geographical factors as well as the type of serological tests used in detection of *T. gondii* antibodies. Globally, the seroprevalence and/or parasite prevalence in dogs and cats ranges from 6 to 88% (Dubey 2010). The seroprevalence of *T. gondii* in cats from Iran ranges from 32.1% to 46.67% (Akhtardanesh et al. 2010, Raeghi et al. 2011) and in cats from Iraq it is 58.3% for IgG and 39.9% for IgM (Naser et al. 2016).

The results of this study showed no significant differences ($p<0.05$) between the age, gender and breed of cats with ocular toxoplasmosis. Therefore, all ages and breeds as well as both sexes of cats are at risk of ocular toxoplasmosis. However, no significantly higher seroprevalence of *T. gondii* was recorded in older cats (Akhtardanesh et al. 2010, Al-Kappany et al. 2011). This difference could be explained by the differences in the lifestyle of theses cats. Additionally, the infection was higher in stray cats than in household cats because the stray cats usually catch rodents, and reptiles and scavenge raw food scraps and there is improper management of the stray cats compared to the household cats (Iewida and Cabanacan-Salibay 2010, Naser et al. 2016). Both the serological test (ELISA) and PCR are sensitive and specific and are used to confirm a diagnosis of Toxoplasmosis. However, the presence of a parasitaemia is seldom detected, and therefore PCR of blood has a low negative predictive value (Liu et al. 2015).

Cats with clinical toxoplasmosis may develop hepatitis, pneumonia, encephalitis, myelitis, myocarditis, cutaneous lesions or splenomegaly, with symptoms of ascites, vomiting, diarrhea, lethargy, dyspnea, cutaneous nodules or ulcers and neurological signs (Calero-Bernal and Gennari 2019). None of these findings was seen in the present study and it is not understood why. Further studies are recommended to answer this question. Similar findings were recorded in cats with ocular toxoplasmosis without poly-systemic clinical signs of disease (Nutter et al. 2004).

The results of the present study show a wide range of ocular manifestations that may be associated with feline ocular toxoplasmosis. These manifestations include; keratitis, keratitis with granulation tissue, iritis with iris rubeosis, iris atrophy, iris fibrovascular membrane, posterior synechia, panuveitis, hyphema, chorioretinitis and retinal detachment. Anterior or posterior uveitis, iritis, iridocyclitis, chorioretinitis, aqueous flare, keratic precipitate, lens luxation, glaucoma, optic neuritis and retinal detachment were recorded previously in cats with ocular toxoplasmosis (Dubey and Carpenter 1993, Dubey et al. 1995, De Moura et al. 2006). Therefore, a complete ocular examination should be carried out in cats showing a seropositive result to *T. gondii*.

Interestingly, in this study the incidence of unilateral feline ocular toxoplasmosis was higher than that of the bilateral ones. Although cats play a crucial role in the life cycle of *T. gondii*, the protozoan rarely results in clinical findings in them. Development of clinical signs of toxoplasmosis in cats depends mainly upon the infected cat's immune response.

Due to the lack of a gold standard method for diagnosis of *T. gondii*, at least two different tests should be performed (Dubey and Carpenter 1993). Therefore, the diagnosis of feline toxoplasmosis was based on the Rapid Diagnostic Test and ELISA in the present study. There are several serological tests used for diagnosis of feline toxoplasmosis such as IHAT, IFAT, the latex

agglutination test (LAT), ELISA and the modified agglutination test (MAT) (Zhu et al. 2012). ELISA is the most widely used method for *T. gondii* detection worldwide and there is no significant difference between ELISA and MAT for diagnosis of toxoplasmosis in cats (Hill et al. 2006, Zhu et al. 2012). The main advantages of ELISA over other diagnostic techniques are the easily applied, semi-automated method, and objective reading without the need for experts (Zhu et al. 2012). In addition, fecal examination for detection of oocysts is not a reliable diagnostic technique due to the similarity of the oocysts and some other parasites and absence of oocyst shedding in most cats with clinical toxoplasmosis.

Unfortunately, there is a clear association between exposure to *T. gondii* and feline uveitis. Additionally, no significant association between ocular manifestations of *T. gondii* infection and the clinical phase of the disease has been detected in this study because the results showed that ocular manifestations may occur either in the acute or the chronic phase of the disease.

In the present study, either complete (70%), partial (20%) or poor (10%) recovery was recorded after treatment with topical ophthalmic drops of antibiotic/anti--inflammatory drops that counteract the inflammation as well as a specific systemic treatment for toxoplasmosis. Clindamycin is the most common antibiotic used for treatment of toxoplasmosis due to its anti-protozoan action. The variation in the treatment outcomes may be due to the chronicity of the case, the degree of ocular damage and the immune status of infected cats. Moreover, it may also be due to ocular disease being caused by another problem in some cats, especially if exhaustive diagnostics were not performed to rule out other diseases.

The treatment of ocular toxoplasmosis should be begun just after diagnosis and continued for a few days after the disappearance of clinical signs.

Finally, there are good preventive measures for feline toxoplasmosis including; feeding the cats commercially prepared or cooked food, preventing them from eating raw meat or intermediate hosts such as rats and preventing their access to food-producing livestock and food storage areas.

In conclusion, cats showing ocular signs without obvious etiology should be examined serologically for toxoplasmosis and seropositive cats should be treated with both specific topical and systemic treatments.

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