GSC Biological and Pharmaceutical Sciences
eISSN: 2581-3250 CODEN (USA): GBPSC2
Cross Ref DOI: 10.30574/gscbps
Journal homepage: https://gsconlinepress.com/journals/gscbps/

(REVIEW ARTICLE)

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A review study for Toxocariasis

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GSC Biological and Pharmaceutical Sciences, 2021, 16(03), 191–199

Publication history: Received on 16 August 2021; revised on 23 September 2021; accepted on 25 September 2021

Article DOI: https://doi.org/10.30574/gscbps.2021.16.3.0280

Abstract

Many researchers reported rates of infected dogs with *T. canis* and cats with *Toxocara cati* all over the world. The degree of tissue damage in the host and the concomitant elicitation of signs and symptoms are varied in different invaded tissues. The liver, lungs and central nervous system, including the eyes, are considered the most sensitive organs. In addition, the number of migrating juveniles and the age of the host. Inflammation manifests as eosinophilic granulomas. The immediate hypersensitivity responses to dying and dead larvae in the viscera, including the lungs, liver and brain, produce symptoms characteristic of VLM.

The current review discusses the *Toxocara* sp. infection from the historical background, taxonomy, lifecycle, pathogeneses, clinical signs, epidemiology, diagnosis, control and treatment. And provides an overview of existing literature and data on the *Toxocaraiasis* with their references.

Keywords: *Toxocara canis*; *Toxocara cati*; Disease; Dogs; Cats

1. Introduction

1.1. Historical background of *Toxocara canis*

In the past century, Nutall and Strickland [1] examined dogs in Cambridge- England, they identified *T. canis.*

Human infection with *Toxocariasis* was first described by Wilder [2]. The latter he identified a nematode larva of unknown species within a retinal granuloma of a child. Subsequently, similar cases were reported considered the connection between Toxocariasis and dogs was established. In 1952, [3] reported similar cases in a series of children suffered high circulating eosinophilia and severe, long-term, multisystem disease. From this group of patients, they described most of the clinical features of VLM and in histopathological sections of tissues obtained at biopsy, correctly classified the causative agents as the larva of either *T. canis* or *T. cati*. Since that time, the juveniles of these two parasite species have been detected in a variety of lesions of the eye and throughout the body [4, 5] in patients in different part of the world.

1.2. Taxonomy

The Taxonomy of *Toxocara* sp. was according to [6]:
Kingdom: Animalia
Phylum: Nematoda
Class: Secernentea
Order: Ascaridida
Family: Toxocaridae

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Genus: *Toxocara* (Stiles, 1905)
= *Belascaris* (Leiper, 1907)
= *Neoascaris* (Travassos, 1927)
= *Toxocara* (Ranther, 1930)

1.3. Life cycle of *Toxocara* sp.

When a *Toxocara canis* egg hatches inside a dogs stomach, the larva invades the bowel wall and arrives in a pulmonary capillary; its considerably more prone to remain in the circulation than to break into the alveolus, especially if its host in mature dog. If the larva fails to enter the alveolus, it will be returned to the heart by pulmonary veins and carried away by the systemic circulation, perhaps to lodge in the kidney or some other somatic tissue, where it will encyst as an arrested infective larva [7]. The most important arrested larvae of *T. canis* are those to be found in the tissues of the female dog. Transmission of infection from bitch to pups occurs almost exclusively by way of transplacental transmission. During the last trimester of pregnancy, arrested larvae are reactivated and migrate from the tissues of the bitch to the pups in utero [8]. After parturition, small numbers of reactivated larvae also may be shed in the milk.

1.4. Pathogenesis

The degree of tissue damage in the host and the concomitant elicitation of signs and symptoms are varied in different invaded tissues. The liver [9], lungs [10] and central nervous system (CNS) [11], including the eyes [12], are considered the most sensitive organs. In addition, the number of migrating juveniles and the age of the host are two additional factors important as to whether a given individual's condition will become elevated above the clinical horizon. Pathological consequences are largely dependent upon the death of the juveniles. Their death heralds the onset of marked delayed-type and immediate-type hypersensitivity responses. Inflammation manifests as eosinophilic granulomas. The immediate hypersensitivity responses to dying and dead larvae in the viscera, including the lungs, liver and brain, produce symptoms characteristic of VLM. In the eye, migrating third stage larvae can damage the retina, inducing granulomatous reactions leading to impaired sight.

In severe cases, the granuloma was responsible for the loss of sight. These pathological manifestations have, in the past, occasionally been misdiagnosed as retinoblastoma [13, 14]. Today, with reliable immunodiagnostic reagents and methods, OLM is almost never mistaken for other clinical entities. Epidemiologic evidence suggests that ocular disease tends to occur in the absence of systemic involvement and vice versa, which has led to the proposal that the two manifestations of this infection be reclassified as OLM.

Portion of dog small intestine with adult *T. canis* [15]. It is possible that there are strains of *T. canis* with specific tropisms. Alternatively, VLM may reflect the consequences of a host inflammatory response to repeated waves of migrating larvae through the viscera, whereas OLM occurs in individuals who have not been previously sensitized [16].

2. Clinical signs and symptoms

2.1. Clinical Signs of *Toxocara canis* in dogs

Young puppies usually have the most severe signs of toxocariasis. The typical symptoms include poor growth, loss of condition and sometimes an enlarged abdomen (potbelly). Worms may be passed in the feces or vomited. Other possible symptoms are diarrhea, constipation, vomiting, flatulence, coughing or nasal discharge. Chronic enteritis can result in thickening of the intestinal wall or intussusception. In severe cases, puppies may die from obstruction of the gall bladder, bile duct or pancreatic duct or even rupture of the intestine and subsequent peritonitis. Intestinal infections with small numbers of parasites tend to be asymptomatic [7].

The pass invasion of the larvae through the lungs can cause inflammation and producing respiratory distress of varying severity. Pneumonia can be seen soon after birth if the puppy was infected *in utero*. Affected puppies may die within 2 or 3 days after birth. Severe infections can also cause ascites, fatty degeneration of the liver, secondary bacterial pneumonia or chronic stunting. Myocarditis is a rare complication. Symptomatic infections are rare in adult dogs. High levels of liver enzymes may be detected during larval migration and ocular signs, may be observed such as orbital cellulitis and multifocal retinal disease. In sheep dogs, retinal disease is characterized by well-delineated areas of hyper reflectivity in the tapetal fundus, often accompanied by retinal hyperpigmentation and mild vitreal clouding. In severely affected animals, widespread hyperreflectivity and attenuation of the retinal blood vessels have been reported. Most dogs with retinal lesions do not seem to be visually impaired [17].

2.2. Clinical Signs of *Toxocara canis* infection in human

A variety of disease states are described but some symptoms are not well understood and require further elucidation.

2.2.1. Visceral Larva Migrans

The VLM is mainly a disease of young children (5 years old) [18]. The disease manifested with fever; enlargement and necrosis of the liver [19]; enlargement of the spleen; lower respiratory symptoms (particularly bronchospasm, resembling asthma); eosinophilia sometimes raised up to 70% [20] and hypergammaglobulinemia of immunoglobulin M (IgM), IgG, and IgE classes. In the last of these instances, symptoms are more pronounced with increased levels of IgE/anti-IgE immune complexes [19]. Myocarditis [21], nephritis [22] and involvement of the CNS have been described. The involvement of CNS can lead to seizures, neuropsychiatric symptoms, or encephalopa encephalopathy. There is an increasing appreciation that more subtle clinical manifestations might also arise as a result of long-term exposure to the migrating juveniles. So-called covert toxocariasis ranges in spectrum from asymptomatic infection to larvae migrating in specific target organs [23, 24, 25]. In the lungs, larval migrations may result in asthma [26, 27]. It was suggested that *T. canis* as an environmental risk factor for asthma among some inner-city populations [28]. Similarly, in the brain, *T. canis* has been implicated as one of the causes of so-called idiopathic seizure disorders [29]. One study implicated *Toxocara* as a contributing factor in skin disorders of at least two varieties (prurigo and urticaria) [30]. While another presented indirect evidence linking *Toxocara* infection with a form of eosinophilic arthritis [31]. In experimental infections in mice, learning behavior and memory are affected and both appeared to be dose and time dependent [32]. It is therefore reasonable to speculate that similar phenomena are likely to be at work in long-term infections in humans, as well.

2.2.2. Ocular Larva Migrans

Usually OLM occurs in 5 to 10 years old children and typically presents as unilateral vision impairment that is sometimes accompanied by strabismus [33]. The most serious consequence of the infection is invasion of the retina, leading to granuloma formation, which occurs typically peripherally or in the posterior pole. These granulomas drag the retina and create a distortion, heteropia, or detachment of the macula [34]. The degree of visual acuity impairment depends on the specific area involved and the blindness is common. The OLM can also cause qadiffuse endophthalmitis or papillitis which can be followed by secondary glaucoma can follow. In at least one rare instance following long-term infection with *Toxocara*, a choroidal neovascular membrane formed after presenting earlier as chorioretinitis [35].

2.2.3. Cutaneous and covert toxocariasis

Two syndromes were described such as, covert toxocariasis and common toxocariasis, which were less typical and not as severe. During the last two decades, cutaneous manifestations such as chronic urticaria, chronic pruritus and miscellaneous eczema, in patients with *Toxocara* antibodies, have been studied by different investigators. In some cases, these cutaneous manifestations were the only signs indicating the presence of the disease and they were cured after antihelmintic treatment when there was good patient compliance. Beatrice [36] focused on these particular skin manifestations regarding their clinical description, diagnosis and treatment.

2.2.4. Nervous toxocariasis

Clinical involvement of the nervous system in visceral larva migrans due to Toxocara is rare, although in experimental animals the larvae frequently migrate to the brain. Sandra [37] reviewed the literature in the past five decades to date found only 29 cases of brain involvement in toxocariasis. In 20 cases, various clinical and laboratory manifestations of eosinophilic meningitis, encephalitis, myelitis or radiculopathy were reported. They reported two children with neurological manifestations, in which there was cerebrospinal fluid pleocytosis with marked eosinophilia and a positive serology for Toxocara both in serum and CSF. Serology for *Schistosoma mansoni, Cysticercus cellulosae* and *Toxoplasma* were negative in CSF, that where sterile in both cases [38].

3. Epidemiology

3.1. Prevalence of *Toxocara canis* in Iraq

The *T. canis* was first recorded in Iraq by Leiper [39]. Other study in Mosul Woodruff [40] recorded 25.5% polluted soil with *T. canis*; were as 25.7% rate of infected dogs recorded by Al-Kalidy [41]. Then, Al-Saqer [42] considered domestic dogs as a reservoir hosts to *T. canis* infection. Subsequently, Sultan [43] showed that infection rate with *T. canis* was up 46% in dogs in Al- Najif province. Then after, in Basrha, Al-Emara [44] found a rate of 35.2% in dogs infected with *T. canis*, and contaminated soil 25% and contaminated gardens grasses 10%. Earth worm was recorded as transmitter to

the *Toxocara* sp. in Baghdad by Hadi & Al- Amery [45]. In Sulaimani province, Bajalan [46] recorded 36% of dogs infected with *T. canis*. Then, in Baghdad province, Hadi [47] found *T. canis* caused highest rate (53.3%) that polluted the Lettuce. In addition of polluted fresh vegetables up to 18.3% [48]. Finally, Hadi & Faraj [49] found high rate 67.5% of *T. canis* in fecal samples of stray dogs in Baghdad province. Hadi and Kawan [50] revealed the total infection rate of *Toxocara canis* 52% in the domestic and stray

4. Diagnosis

4.1. Diagnosis of *Toxocara canis* in dogs

Patent infections in dogs can be diagnosed by fecal flotation technique [51]. In fact, enzyme-linked immunosorbent assay (ELISA) has been used to detect the non-patent infections in dogs [52]**.** In addition to that, an immunological test (IHAT) was used to diagnose the infection with *T. canis* worms in dogs as definitive host and in mice experimentally infected with second stage larvae of *T. canis* as paratenic host, in Basrah province [53].

Scanning electron microscopy images were scientific photography featuring science were best than the direct photo for adult of *Toxocara* warms [54].

4.2. Immuno-serological techniques for diagnosing human toxocariasis

The excretory- secretory antigens of *T. canis* larvae (TES) are widely used in serodiagnostic tests that are used for both the diagnosis and seroepidemiological studies [55]. These antigens are obtained from *in vitro* maintenance of infective larvae and are a mixture of highly immunogenic glycoproteins [56]. Since the first description of TES antigens production [57], few modifications in the method have been made. Recently, modified protocols for TES antigens production has been reported, increasing the parasite yield up to five fold, improving the larval purity and reducing the execution time of the protocol [58]. The use of validated serodiagnostic tests has provided a good understanding on the prevalence of human exposure to *Toxocara*. Toxocariasis is one of the few human parasitic diseases whose serodiagnosis uses a standardized antigen [59]. Currently, the best serodiagnostic options are using the ELISA-IgG as a screening test and confirm any positive serum with an immunoblot test.

4.3. Enzyme linked Immunosorbent Assay (ELISA)

Human toxocariasis is most often a benign, asymptomatic and self-limiting disease, as long as re-infection does not occur. Until moment, the ELISA assay is the most widely accepted serodiagnostic test for the detection of anti-*Toxocara* IgG antibodies. Although the ELISA may detect infections by both *T. canis* and *T. cati* [60]. A positive result in a serological test does not necessarily indicate a causative relationship between *Toxocara* infection and current disease [61]. Probably, a mixture of recombinant antigens will improve the efficacy of the immunoassays [62]. Hadi, [63] revealed to ELISA human IgG tests for *T. canis* were done on 92 serum samples taken from 22 healthy and 70 hospitalized patients with eye conditions randomly in Baghdad city. Of the 22 healthy persons, 4 were positive and of 70 patients, 15 were positive accounting for a prevalence of 18.18% and 21.42%, respectively.

4.4. Molecular diagnosis

Investigations into the molecular biology of *Toxocara* have mainly focused on the secreted proteins of the migrating juvenile stages. These proteins have proven useful in immunodiagnosis of VLM, and OLM. Speculation favors these same proteins in aiding the worm regarding its capacity to evade potentially protective immune responses. This idea derives from the fact that the juvenile stage wanders about the tissues for months to years without apparent interference from the host. Presumably, the worms eventually die of old age.

The fact that many of the excretory-secretory proteins from the juvenile stages constitute a family of at least six highly antigenic mucins [64] associated with the cuticular surface reinforces this concept [65]. Secreted mucins temporarily coat the surface of the worm [66] and are shed into the host periodically [67]. It is thought that this shedding behavior represents an attempt on the part of the parasite to confuse the host's immune system, leaving behind it a trail of slime, not unlike that of a snail [68]. Cathepsin-z-like protease genes have been cloned and their cDNAs have been sequenced, identifying a cysteine protease coding region expressed both in the adult and infective larva[69].

Molecular vaccines could prove useful in aiding in the control of infection in domestic dogs and cats. The search so far has identified the myosins of *Toxocara* as potential candidates [70].

Polymerase chain reaction (PCR)-based methods for *Toxocara* identification in clinical and environmental samples have been described [71], but are not widely available. These methods should provide useful tools for the diagnosis and molecular epidemiological investigations of toxocariasis [72]. Hadi and Kawan, [50] reported the development of sensitive and specific PCR assay allowing rapid and reliable identification of *T. canis* by the fragment size amplified was 380 bp in ITS-2 gene.

5. Prevention and control

5.1. Treatment

5.1.1. In dogs

Owing to the transplacental transmission, unless heroic measure have been taken to prevent infection, pups may be assume to be infected. Medication should start routinely as early as the second week of life and repeated every two weeks until the pup is three month old. Young puppies are also regularly treated with piperazine compounds, which is considered safe and highly effective against ascarids in the lumen of the alimentary tract and therefore ideally suited to removing *Txocara canis* as they arrive and develop in the intestinal lumens of perinatally infected pups. Puppies over 6 weeks in age can be treated with fenbendazole or ivermectine with pyrantel pamoate. At 8 weeks the formulation of ivermectin with pyrantel pamoate and praziquantel is labeled for use in puppies [7].

5.1.2. In human

Anthelmintic drugs can be used to treat severe visceral larva migrans. Treatment may lead to severe hypersensitivity reactions caused by dying larvae, and anti-inflammatory medications such as corticosteroids are often given concurrently. Treatment of ocular disease may include surgery, laser photocoagulation, and/or drugs to decrease further damage to the eye [38].

6. Control measurements

6.1. Avoiding infection with eggs

Prevention of human infections depends on the treatment and prevention of *Toxocara* infections in animals, the removal of feces before the eggs can become embryonated, good hygiene and public education. To reduce human exposure, puppies and kittens should be dewormed [38].

Adult animals may also need to be treated for patent infections. Canine feces should be removed from areas where children play before the eggs become embryonated [46]. The feces should be burned, buried, or bagged and disposed of in the trash. There is no practical way to remove eggs from the soil once contamination has occurred. Contamination can be decreased in public areas by restrictions on uncontrolled dogs and cats, collection of feces by dog owners, and prevention of animal access to areas such as children's playgrounds. Puppies from 3 weeks to 3 months old excrete large numbers of *T. canis* eggs and appear to be the greatest hazard to humans, [7].

6.1.1. Cleaning measures

Good hygiene can help prevent infections or severe disease. Hands and raw foods should be washed before eating. Children should be taught not to eat soil, and to wash their hands after playing with pets or outdoor activities. Children should not be allowed to play in areas where animal feces are found. Families may also consider postponing the acquisition of a new pet until children are past the toddler stage [38].

7. Conclusion

Human Toxocariasis was caused by ingestion the eggs of *Toxocara canis* or *T. cati* accidently. The Visceral Larva Migrans VLM is a disease manifested with fever; enlargement and necrosis of the liver; enlargement of the spleen; lower respiratory symptoms (particularly bronchospasm, resembling asthma). Second: The Ocular Larva Migrans OLM occurs in 5 to 10 years old children and typically presents as unilateral vision impairment that is sometimes accompanied by strabismus. The Cutaneous toxocariasis such as chronic urticaria, chronic pruritus and miscellaneous eczema, in patients with *Toxocara* antibodies, have been studied by different investigators. The Nervous toxocariasis such as various clinical and laboratory manifestations of eosinophilic meningitis, encephalitis, myelitis or radiculopathy were

reported. A variety of disease states are described but some symptoms are not well understood and require further elucidation.

Compliance with ethical standards

Acknowledgments

Many thanks to Prof. Dr. Kawan M. (University of Baghdad, Veterinary Medicine collage, Parasitology Department) for providing many thesis and references. We would appreciate for Prof. Dr. Yaccob A. (retired professor) for reviewing the article.

Disclosure of conflict of interest

The authors declare that they have no known competing Financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Nutall and Strickland, Cited by: "Kanthack and Nutall Library (2005). University of Cambridge, Department of Pathology. 1980.

[2] Wilder HC. Nematode endopthalmitis. Transactions of the American Academy of Ophthalmology and Otolaryngology 55: 99–109. Cited by: Smith H. and Noordin R. (2006). Diagnostic Limitations and Future Trends in the Serodiagnosis of Human Toxocariasis. Book: Toxcara the Enigmatic parasite. Edited by: C. V. Holland and H. V. Smith. CABI Publishing. 1950; 89-112.

[3] Beaver PC, Snyde CH, Carrera GM. Chronic eosinophilia due to visceral larva migrans. Pediatrics 9:7–19. Cited by: Maizels ,R. M. (2013). Toxocara canis: Molecular basis of immune recognition and evasion. Vet. Parasit. 1952; 193: 365– 374.

[4] Tost F, Hellman A, Ockert G. Toxocara canis infection. Environmental, parasitologic and epidemiologic studies. Ophthalmology. 1998; 95: 486–489.

[5] Magnaval JF, Glickman LT, Dorchies P, Morassin B. Highlights of human toxocariasis. Korean J. Parasitol. 2001; 39: 1–11.

[6] GBIF, Global Biodiversity International Facility. (2021). Toxocara Stiles, 1905.

[7] Bowman DD. Georgis' parasitology for veterinarians. Ninth edition. Library of congress cataloging. 2009; 202.

[8] William HR, Guita R. Immunodiagnosis of Human Toxocariasis. Serological Diagnosis of Certain Human, Animal and Plant Diseases, Dr. Moslih Al-Moslih (Ed.). 2012; 97-112.

[9] Hartleb M, Januszewski K. Severe hepatic involvement in visceral larva migrans. Eur. J. Gastroenterol. Hepatol. 2001; 13: 1245–1249.

[10] Kuziemski K, Jassem E, Mierzejewska E. Lung manifestation of visceral larva migration syndrome due to Toxocara canis infection. Pneumonol.. Alergol. Pol. 1999; 67: 554–557.

[11] Magnaval JF, Galindo VL, Glickman T, Clanet M. Human Toxocara infection of the central nervous system and neurological disorders :a case-control study. Parasitology. 1997; 115: 537–543.

[12] Sabrosa NA, Souza EC. Nematode infections of the eye: toxocariasis and diffuse unilateral subacute neuroretinitis. Curr. Opin. Ophthalmol. 2001; 12: 450–454.

[13] Lopez VR, Suarez M, Figueroa D, Gimeno L. Ocular toxocariasis or retinoblastoma. Enferm. Infec. Microbiol. Clin. 1995; 13: 242–245.

[14] Wolach B, Sinnreich Z, Uziel Y. Toxocariasis: a diagnostic dilemma. Isr. J. Med. Sci. 1995; 31: 689–692.

[15] Glickman LT, Schantz PM. Epidemiology and pathogenesis of zoonotic toxocariasis. Epidemiology Reviews. 1982; 10: 143–148.

[16] Kazacos KR .Visceral and ocular larva migrans. Semin. Vet. Med. Surg. (Small Anim.). 1991; 6: 227–235.

[17] Oliveira ST, Amarante AF, Ferrari TB, Nunes LC. Prevalence of intestinal parasites in dogs from Sao Paulo State, Brazil. Vet. Parasitol. 2002; 103: 19-27.

[18] Worley GI, Green A, Frothingham TE. Toxocara canis infection: clinical and epidemiological associations with seropositivity in kindergarten children. J. Infect. Dis. 1984; 149: 591–597.

[19] Rayes AA, Teixeira DJ, Serufo CV, Nobre C, Antunes M, Lambertucci JR. Human toxocariasis and pyogenic liver abscess: a possible association. Am. J. Gastroenterol. 2001; 96: 563–566.

[20] Arango CA. Visceral larva migrans and the hypereosinophilia syndrome. Sc. Med J. 1998; 91: 882–883.

[21] Prunier F, Delpine S, Victor J. Lofflerís fibroblastic endocarditis. A report of a case complicating toxocariasis. Arch. Maladies Cour. Vaisseau. 2001; 94: 226–230.

[22] Shetty AK, Aviles DH. Nephrotic syndrome associated with Toxocara canis infection. Ann. Pediatr. 1999; 19: 297–300.

[23] Nathwani D, Laing R B, Currie PF. Covert toxocariasis as a cause of recurrent abdominal pain in childhood. Br. J. Clin. Pract. 1992; 46: 271-280.

[24] Tariq SM, Matthews S, Stevens M. Epidemiology of allergic disorders in early childhood. Pediatr.. Pulmonol.. Suppl. 1997; 16: 69-73.

[25] Sharghi N, Schantz P, Hotez PJ. Toxocariasis: an occult cause of childhood asthma, seizures, and neuropsychological deficit. Semin.. Pediatr. Infect. Dis. 2001; 32: 111–116.

[26] Buijs J, Borsboom G, van Gemund JJ, Hazebroek A, van Dongen PAM, van Knapen F, Neijens HJ. Toxocara seroprevalence in 5-year-old elementary schoolchildren: relation with allergic asthma. Ame. J. Epid. 1994; 140: 839–847.

[27] Taylor MR, Keane CT, O'Connor P. The expanded spectrum of toxocaral disease. Lancet I. 1988 ; 692–694.

[28] Oteifa NM, Moustafa MA, Elgozamy BM. Toxocariasis as a possible cause of allergic diseases in children. J. Egypt Soc. Parasitol. 1998; 28: 365–372.

[29] Critchley EM, Vakil SD, DN. Hutchinson. Toxoplasma, Toxocara, and epilepsy. Epilepsia. 1982; 23: 315–323.

[30] Humbert P, Niezborala M, Salembier R. Skin manifestations. 2000. associated with toxocariasis: a case-control study. Dermatology. 2000; 210: 230–234.

[31] Rayes AA, Lambertucci JR. Human toxocariasis as a possible cause of eosinophilic arthritis. Rheumatology. 2001; 40:109–110.

[32] Cox DM, Holland CV. Relationship between three intensity levels of Toxocara canis larvae in the brain and effects on exploration, anxiety, learning and memory in the murine host. J. Helminthol. 2001; 75: 33–41.

[33] Dinning WJ, Gillespie SH, Cooling RI, Maizels RM. Toxocariasis: a practical approach to management of ocular disease. Eye. 1988; 2: 580–582.

[34] Small KW, McCuen BW, De Juan E, Machemer R. Surgical management of retinal retraction caused by toxocariasis. Am. J. Ophthalmol. 1989; 108: 10–14.

[35] Monshizadeh R, Ashrafzadeh MT ,Rumelt S. Choroidal neovascular membrane: a late complication of inactive toxocara choroiretinitis. Retina. 2000; 20: 219–220.

[36] Beatrice G, Renaud P, François A, Laurence M, Philippe H. Cutaneous manifestations of human toxocariasis. J. Am. Acad. Dermatol. 2008; 59(6): 1031–1042.

[37] Sandra FM, Murilo GR, Joao LP, Camila PG, Larissa HF, Fausto EL. Toxocariasis of the central nervous system: with report of two cases. Revista. Sociedade Brasileira Med. Trop. 2004; 37(2): 169-174.

[38] Dickson D. Toxocariasis: clinical aspects, epidemiology, medical ecology, and molecular aspects. Clin. Micro. Rev. 2003; 16(2): 265–272.

[39] Leiper JW. Report to the government of Iraq on animal parasites and their control FAO report . Cited by: Hasso, S. A. (2007). A Review of confirmed pathogen of dogs and cats in Iraq. Bas. J. Vet. Res. 1957; 6(2): 156- 161.

[40] Woodruff AW, Watson J, Shikova I, AL-Azzi NSH, Al-haithi T, Al-Adhami SBH. Toxocara ova in soil in the Mousl district, Iraq and their revelance to public health measures in the middle east. Ann. Trop. Med. Parasitol. 1980; 75(5): 555-557.

[41] Al-Kalidy NW, Daoud MS, Shubber AH, Al-Alousi TI. A survey for internal and external parasites in dogs in Mosul (Iraq). Iraq. J. Vet. Sc 1988; 1(2): 9-17.

[42] Al –Saqur EM. Internal helminthes of domestic dogs in Baghdad city. Second scientific Conference for medical researches and technology. Baghdad. 1990; 10(11) : 85-90.

[43] Sultan BE. Epidemiology study of Toxocara canis in Najef area. PHD. Thesis. Coll. Vet. Med. Uni. Baghdad. 1997.

[44] Al-Emara GY. Epidemiology study of Nematode in digestive Tract of Dogs in Basrha area. MSc. Thesis. Coll. Vet. Med. Uni. Baghdad. 1999.

[45] Hadi AM, Al-Amery AMA. Isolation and identification of some parasites that transmitted by Earthworms. Al-Anbar J. Vet. Sci. 2010; 3(2): 68-72.

[46] Bajalan MM. Prevalence of intestinal helminths in stray dogs of Kalar city / Sulaimani province. Iraqi J. Vet. Med. 2010; 34(1): 151-157.

[47] Hadi AM. Isolation and identification of parasites from Lactuca Sativa. J. Al-Nahrain Uni. 2011; 14 (1): 134-141.

[48] Hadi AM. Isolation and identification of intestinal parasites from vegetables from different markets of Iraq. Bull. Iraq Nat. Hist. Mus. 2012; 11(4): 17-25.

[49] Hadi AM, Faraj AA. Isolation and identification of intestinal parasites &protozoa from dogs in Baghdad. Iraqi J. of Vet. Med. 2016; 40(1): 1-4.

[50] Hadi, Afkar M, Kawan MH. Diagnosis of Toxocara canis in Dogs in Baghdad by PCR Technique. International Journal of Recent Scientific Research. 2016; 7(6): 12169-12173.

[51] Inoue H, Tsuji M. Studies on visceral larva migrans: Detection of anti - Toxocara canis IgG antibodies by ELISA in human and rat sera. Jpn. J. Parasitol. 1989; 38: 68-76.

[52] Overgaauw PAM. A spects of Toxocara epidemiology, Toxocarosis in dogs and cats. Crit. Rev. Microbiol. 1997; 23: 233-251.

[53] Awad AH, Suzan AA, Al-Azizz S. Immunological study of Toxocara canis In dogs and mice at Basrah city. QMJ. 2007; 3(3): 62-67.

[54] Hadi AM. Morphology study of Toxocara canis (Werner, 1788) worms by scanning microscope. International Journal of Biosciences. 2019; 14(3): 293-298.

[55] Roldn WH, Espinoza YA, Huapaya PE, Jiménez S. Diagnóstico de la toxocarosis humana. Revista Peruana de Medicina Experimental y Salud Publica, 27(4): 613-620. Cited by: William, H. R. and Guita, R. (2012). Immunodiagnosis of Human Toxocariasis. Serological Diagnosis of Certain Human, Animal and Plant Diseases, Dr. Moslih Al-Moslih (Ed.). 2010; 97-112.

[56] Maizels RM, Bundy DA, Selkirk ME, Smith DF, Anderson RM. Repeated patent infection of adult dogs with Toxocara canis. J. Healminthology. 1993; 365: 797-805.

[57] De Savigny DH. *In vitro* maintenance of Toxocara canis larvae and a simple method for production of Toxocara ES antigen for use in serodiagnostic tests for visceral larva migrans. J. Parasitol,. 6(4):781-2. Cited by: William, H. R. and Guita, R. (2012). Immunodiagnosis of Human Toxocariasis. Serological Diagnosis of Certain Human, Animal and Plant Diseases, Dr. Moslih Al-Moslih (Ed.). 1975; 97-112.

[58] Pouns- Macotela M, Auron RC, Gustavo EP, Mario NM. A simplified method for hatching and isolating Toxocara canis larvae to facilitate excretory- secretory antigen collection in vitro. Vet. Parasite. 2011; 175(3-4) : 382-385.

[59] Smith H, Noordin R. Diagnostic Limitations and Future Trends in the Serodiagnosis of Human Toxocariasis. Book: Toxcara the Enigmatic parasite. Edited by C. V. Holland and H.V. Smith. CABI Publishing. 2006; 89-112.

[60] Hotez PJ, Wilkins PP. Toxocariasis: America's most common neglected infection of poverty and a helminthiasis of global importance. PLoS Neglected Trop. Dis. 2009; 3: 1-4.

[61] Pawlowski Z. Toxocariasis in humans: clinical expression and treatment dilemma. J. Helminthology. 2001; 75(4): 299-305.

[62] Mohamad S, Azmi NC, Noordin R. Development and evaluation of a sensitive and specific assay for diagnosis of human toxocariasis by use of three recombinant antigens (TES-26, TES-30USM, and TES-120). J. Clin. Microbiol. 2009; 47: 1712–1717.

[63] Hadi Afkar M. An ELISA Serodiagnostic survey of Toxacara canis in normal and hospitalized eye patients from Baghdad, Iraq. Online Journal of Veterinary Research. 2017; 21(2): 45-50.

[64] Doedens A, Loukas A, Maizels RM. A cDNA encoding Tc- MUC-5, a mucin from Toxocara canis larvae identified by expression screening. Acta. Trop. 2001; 79: 211–217.

[65] Loukas A, Hintz M, Linder D. A family of genes active during the resting stage of the parasite were cloned and their cDNA sequences determined. Secreted mucins from the parasitic nematode Toxocara canis bears diverse mucin domains but shares similar flanking six-cysteine repeat motifs. J. Biol. Chem. 2000; 275: 39600–39607.

[66] Page AP, Rudin WE, Fluri M, Blaxter L, Maizels RM. Toxocara canis: a labile antigenic coat overlying the epicuticle of infective larvae. Exp. Parasitol. 1992; 75: 72–86.

[67] Badley JE, Grieve RB, Bowman DD. Immune-mediated adherence of eosinophils to Toxocara canis infective larvae: the role of excretory-secretory antigens. Parasite Immunol. 1987; 9: 133–143.

[68] Maizels RM, Holland MJ. Parasite immunology: pathways for expelling intestinal helminths. Curr. Biol. 1988; 8: 711–714.

[69] Falcone FH, Tetteh KK, Hunt P. The new subfamily of cathepsin-z-like protease genes includes Tc-cpz-1, a cysteine protease gene expressed in Toxocara canis adults and infective stage larvae. Exp. Parasitol. 2000; 94: 210–217.

[70] Obwaller A, Duchene M, Bruhn H. Recombinant dissection of myosin heavy chain of Toxocara canis shows strong clustering of antigenic regions. Parasitol. Res. 2001; 87: 383–389.

[71] Zhu XQ, Jacobs DE, Chilton NB, Sani RA, Cheng NA, Gasser RB. Molecular characterization of a Toxocara variant from cats in Kuala Lumpur, Malaysia. Parasitology. 1998; 117: 155–164.

[72] Li M, Lin R, Chen H, Sani R, Song H. PCR tools for the verification of the specific identity of ascaridoid nematodes from dogs and cats. Molecular and cellular probes. 2007; 21: 349–354.