ZOONOTIC DISEASES: CAT-SCRATCH DISEASE AND TOXOPLASMOsis
(2 CE hours)

Learning objectives:
- List the risk factors for Bartonella infections.
- Explain how and where humans and animals can become infected.
- Explain how to diagnose, treat and prevent cat-scratch disease.
- List recommendations you can provide to pet owners about treatment and prevention.
- List the contraindications when prescribing medications for cat-scratch disease.
- List the risk factors for Toxoplasma gondii infections.
- Explain how and where humans and animals can become infected.
- Explain how to diagnose, treat and prevent toxoplasmosis.
- Describe the life cycle of these parasites.
- List recommendations you can provide to pet owners about treatment and prevention.
- List the contraindications when prescribing medications for Toxoplasma gondii.

Introduction
Zoonoses are infectious diseases that are transmitted from animal to man. More than 60 percent of emerging human pathogens are zoonotic. Causative groups of agents include parasites, fungi, bacteria and viruses. Often of minor importance and producing only minor symptoms, they can lead to severe disease, especially in the very young and those in weakened condition.

This course looks at two common diseases found mainly in cats that can be transmitted to man: cat-scratch disease, caused by the Bartonella henselae bacterium, and toxoplasmosis, caused by the Toxoplasma gondii parasite. While symptoms for both illnesses in many cases are not serious, in others they can indeed be dangerous or even fatal for humans. Veterinarians need to understand both of these diseases and help educate animal owners about them and the precautions they need to take.

Part I: Bartonellosis: Cat-scratch disease
The diseases caused by the various members of the group Bartonella vary from insignificant in man to deadly: Bartonella bacilliformis (Carrion’s disease), Bartonella quintana (trench fever), Bartonella elizabethae (endocarditis), Bartonella grahamii (retinitis), Bartonella vinsoni (endocarditis), Bartonella wassonii (myocarditis), Bartonella clarridgeiae (bacteremia), Bartonella rochalimae (Carrion’s disease-like syndrome) and Bartonella henselae (cat-scratch disease).

There are more than 20 known species of Bartonella. Bartonella henselae is distributed worldwide. The cat-scratch disease it produces is the most widely recognized form of bartonellosis. The main host of this strain of Bartonella is the cat, and it is passed from cat to cat via the feces of the cat flea (ctenophalid species).

Causative agent
Bartonella henselae is a curved, pleomorphic, rod-shaped gram-negative, facultative intracellular bacterium infecting the cat. It is of little consequence in the cat, with little symptomatology. Other species of Bartonella-infecting domestic cats are Bartonella clarridgeiae, Bartonella koehleriae and Bartonella bovis.

In man, it produces a self-limiting disease varying from painful regional lymphadenopathy after being scratched or bitten by a cat to bacillary angiomatosis and peliosis hepatis, hepatitis, neuroretinitis, endocarditis, relapsing fever with bacteremia and central nervous system complications.

Transmission
Direct transmission from cat to cat is not known. It requires an arthropod vector, with the carrier being the cat flea (Ctenophalid species), although ticks have been considered possible vectors as well. The cat flea sucks blood from the infected cat and deposits the digested blood in its feces onto the fur coat of its host while taking up its blood meal. Bacteremia for Bartonella henselae is intermittent, and only blood from the bacteremic phase will be infective.

Flea feces appear as black specks, often comma shaped, on the cat fur. Eggs produced by the flea are white. They may fall off the cat along with the flea feces, and the hatching larvae may consume the feces and thus become infected. When the cat scratches the flea bite area, it picks up the infectious flea deposits in its claws and nail beds. It can pass on the disease and continue its spread by scratching other cats.

The presence of Bartonella henselae DNA in the saliva of the cat has been confirmed by polymerase chain reaction and demonstrated the possible infectiousness of the cat bite. In fact, there have been suggestions that the organism may cause plasma cell stomatitis, a progressive oral disease of the cat. The transmission of Bartonella henselae from cat to human happens by cat scratch or bite, although there has been the occasional suggestion that the flea might pass it on as well. There is one report suggesting transplacental transfer from mother to child.

Bartonella quintana, causing trench fever, is transmitted by body lice. While found in the unsanitary and crowded conditions of the trenches of World War I, today it causes disease in the homeless, the drug addicted and those immunosuppressed by disease or chemotherapy. In the HIV/AIDS population in particular, one frequently finds bacillary angiitis and bacillary peliosis hepatitis.

There is some evidence of bartonellosis in dogs, usually associated with granulomatous disease and endocarditis in larger-breed dogs. Bartonella is also found in the blood of numerous animal species, including gray squirrels, flying squirrels, groundhog, wood rat, cattle, deer, elk and sheep, each having their own species, without showing an active disease.

Being able, as suggested in one report, to pass the placental barrier in man, the impact of bartonellosis is not well understood and deserves further study. Many arthropods have been shown to carry Bartonella in addition to cat fleas, including sand flies, human body lice, rodent fleas, biting flies and ticks. Whether they are actively involved in passing the organism to mammalian hosts is not confirmed.

Pathogenesis: While Bartonella henselae may be the most common species in the cat, Bartonella clarridgeiae and Bartonella koehleriae are sometimes compromised as well and co-infections are possible. As many as six different strains of Bartonella have co-habited in the same cat.

Chronic recurrent bacteremia in the cat is frequent (25-41 percent) and often long lasting, even years. Bacteremic phases will be interspersed with a-bacteremic ones, and the isolation of bacteria from the blood will depend on the presence of bacteria at the time of sample. Bacteremic cats do not necessarily show antibody, and antibody does not necessarily interfere with bacteria in the blood stream, possibly protected within erythrocytes and other host cells.

Bartonella bacteria will attach to red blood cells and endothelial cells of capillary walls, enter these cells and produce inflammatory tissue damage throughout the body. In particular, they will affect the mucosa of the respiratory system, including the oral cavity, the eye, the skin and lymph nodes, liver and spleen. The incidence of seropositivity in cats is greater than the rates for bacteremia.

Even though Bartonella henselae does not appear to be of serious concern for human health, it is the one most widely known.

In the typical cat-scratch disease of man, the initial signs of the disease are single or multiple small bumps, developing to erythematous papules within about 3-12 days after the infection near the cat scratch or cat bite site, usually at hands, arms or face. These papules may progress, become pustules and ulcerate. The individual may show symptoms of fever, headache and anorexia. Within about three weeks the regional, usually epitrochlear, cervical, and axillary lymph nodes become inflamed, increase in size and become painful to the touch. In about one quarter of the cases, they may abscess and burst. In the immunocompetent individual, healing will take a few weeks, and within a few more weeks lead to full recovery.

About one of 10 infected patients may exhibit atypical symptoms, such as encephalitis, which occurs in 2-4 percent of all cases. Encephalitis is reflected by headache, confusion, altered mental status, restlessness, combativeness, disorientation, coma and evidence of meningitis and transient nuchal rigidity. This encephalitis usually follows the natural course of the disease, but it can also occur without precursory evidence. Fortunately, it seems to be self-limiting, not requiring special treatment and rarely leaving lasting impairment.
Other atypical events, often following lymphadenopathy and generalized influenza-like symptoms, are:

- Neuroretinitis, characterized by unilateral vision loss, papilledema, swelling of the optic disk and macular exudates.
- Parinaud’s oculoglandular syndrome (granulomatous conjunctivitis and regional, same side lymphadenopathy) appearing in 6 percent of patients.
- Osteomyelitis (0.3 percent).
- Prolonged fever, joint pain, respiratory symptoms and abdominal pain due to hepatitis (hepatic granuloma 0.3 percent).
- Splenitis.

If complicated by simultaneously occurring immunosuppressive disease or immunosuppressive treatment of organ recipients or radiation and cancer chemotherapy, the severity of the disease will be greatly exacerbated. It will lead to systemic generalization, involvement of visceral organs and central nervous system complications, convulsions and coma.

**Pathology**

Infected cats are usually asymptomatic, although there may be the occasional evidence of stomatitis. Rarely there are signs of uveitis and endocarditis. Even in the absence of overt signs of the disease, there is a high incidence of bacteremia and antibody to the infecting agent. Bartonella is responsible for gingivitis, stomatitis, oral ulcers, upper respiratory disease, rhinitis, sinusitis, conjunctivitis, uveitis (inflammation of the uvea, the pigmented middle layer of the eye consisting of the iris and ciliary body together with the choroid), chorioretinitis (inflammation of the retina and choroid of the eye), cornal ulcers, keratitis, inflammatory bowel disease, diarrhea and vomiting, heart disease, lymphoid hyperplasia, dermatitis and undefined fevers.

In man, the classical picture near the site of a bite or scratch shows local lesions, such as erythema, minor swelling, bumps in the skin developing to red papules and local lymphadenopathy (lymph nodes swollen, tender to the touch and painful). Under the microscope, the local lesions comprise focal accumulation of immune cells, histiocytes, multinucleated giant cells, lymphocytes and eosinophils surrounding centralized necrotized areas and microabscesses with neutrophils. The lymph node swelling, result of a reactive follicular hyperplasia, may exhibit centralized necrosis and suppurative granuloma. There may be influenzalike symptoms: fever, headache and chills, which are overcome relatively quickly by the immunocompetent person.

Atypically, one in 10 times, the disease may take other forms, especially when the patient is immunocompromised: bacillary angiomatosis and parenchymal bacillary peliosis can be found relatively frequently, while it is hardly ever seen in the immunocompetent individual. Bacillary angiomatosis usually exists of lobular proliferation of capillaries with large endothelial cells, neutrophilic debris and clumps of bacteria. There may be an enlarged spleen, typically an exaggerated cutaneous and subcutaneous proliferation of blood vessels and growthlike masses in visceral organs, peliosis hepatitis, fever, bacteremia, granulomatous conjunctiva, optical neuritis, neuropathy, retinitis, keratitis, meningoencephalitis, osteomyelitis, arthritis, arthralgia, myositis, inflammatory bowel disease, lymphadenopathy, pulmonary infiltrates and heart valve infection.

The cutaneous lesions may take the form of globular red papules or purple nodules looking like Kaposi lesions, suggesting the possibility of Kaposi cancer and requiring biopsy to confirm diagnosis. They may also appear subcutaneously, ulcerate and form an abscess. Lesions can be distributed throughout the body, the central nervous system, visceral organs, bone and bone marrow and the intestinal tract with symptoms varying according to the underlying condition such as peliosis hepatitis, endocarditis and vegetative cardiac lesions.

**Morbidity and mortality**

Cat-scratch disease is self-limiting, even though it may manifest occasionally a more profound and more painful symptomatology, and usually will resolve itself within about two to five months and leave no serious aftereffects. However, when the infected individual is immunosuppressed, either through genetic predisposition, disease or medical manipulation (cancer treatment, organ transplantation), the situation may become much more serious, if not life-threatening.

**Diagnosis**

In cats, *Bartonella henselae* is usually asymptomatic. Fever of unknown origin and suspected heart disease suggest bartonellosis. You may find evidence of meningitis or encephalitis as expressed by abnormal behavior, aggression, seizures, and myelopathy and neuropathy.

In man, historically, to diagnose cat-scratch disease, there had to be at least three of four possible findings confirmed:

1. Cat bite or scratch.
2. Positive delayed hypersensitivity response (Arthus phenomenon) to Bartonella antigen in the scarified skin.
3. Regional lymph nodes exhibiting centralized necrotizing granulomas surrounded by multinucleated giant cells and lymphocytic infiltration.
4. Inexplicable lymphadenopathy.

Today the skin test is no longer a regular diagnostic tool, with the opportunity of iatrogenic complications too great. There usually is a report of cat scratch or bite, erythema near the site of the lesion and developing welts suggestive of the disease.

Yet some 20 percent to 30 percent report no such incident or signs. There may be a single enlarged lymph node, fever and headache, or the development of scattered granulomas that may develop necrotic centers, eventually coalescing and abscess forming.

Seizures and altered consciousness, irritability, coma and stiff neck suggest the development of cat-scratch disease encephalopathy. Cerebrospinal fluid may show general elevated protein levels and mild pleocytosis. An EEG (electroencephalogram) will not bring much more.

There are no general laboratory tests with a quick answer. Minor rises in leukocyte count and increased erythrocyte sedimentation rates are unlikely to be useful. Histopathology in the swollen lymph nodes includes lymphocytic infiltrates, granuloma and stellate abscess formation. Warthin-Starry silver staining and the Brown-Hoppe gram-stains may find small gram-negative bacteria in regional lymph nodes or focalized inflammation processes from patients with cat-scratch disease.

Blood cultures have been used to isolate the bacteria from bacteremic cats. However, the culture process may take as long as 40 days, occasionally rendered useless by the presence of antibiotic in the sample being cultured. The polymerase chain reaction (PCR) has amplified and identified bacterial DNA in skin lesions, in lymph node biopsies, bacillary angiomatosis and in the oral cavity of cats.

PCR amplification of Bartonella DNA is the test of choice, and it can distinguish between different strains of Bartonella. The presence of Bartonella can be determined utilizing the enzyme immune assay (EIA) or enzyme-linked immunosorbent assay (ELISA) and indirect fluorescent antibody (IFA). Aside from identifying the bacterium itself or its DNA, the presence of antibody to *Bartonella henselae* antigen is additional proof of its presence, as long as you are aware that 11 percent of cats with bacteremia do not have detectable antibody.

In the past, delayed hypersensitive skin testing had been found useful in man: known antigen is placed on a fresh skin scratch, and if positive, there will be a measurable reaction within 48 hours (Arthus phenomenon similar to TB testing). However, since this requires the introduction of the killed pathogen into the skin of the patient, the off-chance of iatrogenic infection makes this an undesirable procedure.

In cats, which are poor delayed hypersensitivity responders, this test has not been used. Antibody assays employing ELISA (EIA) and IFA for Bartonella have been employed with mixed results because of relatively low sensitivity for IgG (about 50 percent). It was more promising when measuring IgM, which showed a sensitivity of 90 percent and better. However, there was cross reactivity for non-Bartonella antigens: Epstein-Barr virus, cytomegalovirus, *Toxoplasma* gondii and streptococcus pyogenes. The Western Blot is another antibody test that has been performed successfully, within the above parameters.

**Diagnostic procedures**: Biopsy samples of a swollen lymph node may show clusters of small gram-negative bacilli identifiable by the Warthin-Starry silver stain, a silver nitrate-based staining method used in histology, and the Brown-Hoppe gram-staining procedure.

Bacteremia has been confirmed by isolating the bacteria in enrichment blood culture using...
Baronella alpha Proteobacteria growth medium (BAPGM). Since bacteremia is not continuous, several samples must be taken over time to bridge the occasional intermittent phase when the organism is not circulating. PCR amplification of bacteria circulating in the blood stream, though a somewhat faster test than the blood culture procedure, also requires multiple sampling for the same reason.

Better diagnostic efficiency relied on enrichment culture followed by PCR testing of the product identifying nucleic acid sequences. Tests to demonstrate the presence of Baronella antigen on biopsy samples, centrifugal or filter concentrates, include the ELISA test, by which samples are flooded with specific antibody that had been labeled with an enzyme, such as horseradish peroxidase, and rinsed to remove the unattached antibody from the test sample. The retained antibody, if any, is then allowed to react with the enzyme substrate to visualize the presence of antigen. This same test can be modified by flooding the antigen test sample with a specific antibody, removing the unattached antibody by washing it off the sample surface and then identifying the retained antibody by specific enzyme-linked anti-gammaglobulin antibody. In essence, it sandwiches the primary antibody that identifies the antigen between antigen and secondary indicator antibody.

The following antibody assay systems have been used:

- **The ELISA test**: Bartonella antigen attached to a surface is exposed to the antibody test sample. Antibody present in the test sample will adhere to the antigen. After rinsing away all unattached material, a secondary antibody, labeled with an enzyme, such as horse radish peroxidase, and specific for the primary or test antibody is added and allowed to react. Enzyme substrate is then added and if there is secondary, enzyme-labeled antibody retained in the sample, it will react and become visualized.

- **The IFA test** in which antigen or antibody can be identified by its reaction with specific antibody, conjugated with fluorescein isothyanate and detected by means of a fluorescence microscope. For example, antigen adhering to cells or tissue sections can be flushed with specific antibody that had been labeled with the fluorochrome, rinsed free from all unattached antibody and then examined under the fluorescence microscope to verify the presence of antibody remaining attached to the antigen. Alternatively, anti-gamma globulin antibody specific for the specific antibody donor animal can be employed to check the retention of the specific antibody.

- **In the Western Blot test**, the sample proteins are isolated according to size by gel electrophoresis, transferred to nitrocellulose paper or similar, and then reacted with enzyme-labeled specific antibody. If this antibody is retained by the antigen, its presence can be detected by its reaction with the enzyme substrate and colorize the location of the antigen.

**Differential diagnosis**

In the more advanced stage of the disease, lymphoma, neuroblastoma, carcinoma, mycobacterial and fungal infection must be excluded.

**Geographic distribution**

About one of five seemingly healthy cats in the United States is infected and likely to spread the disease. Spread of the disease is more likely in hot and humid regions because that is when and where fleas proliferate. Close to half the cat population is infected in the southern states, compared to less than a quarter in the more northern states. The incidence of cat-scratch disease reported annually ranges between 6,000 and 22,000 overall.

**The public health problem**

Bartonella organisms are found in the blood of many animal species without producing a noticeable disease. Bartonella henselae-infected cats may be bacteremic, and indeed be infective for years and continue to be an ongoing source of the disease. Considering that rates of seropositivity vary from 3 to more than 60 percent in the general population of different countries, only few infected individuals exhibited the actual symptoms of the disease (e.g. in the U.S., 3 percent would represent about 9,000,000 individuals, and only 22,000 are reported to have the disease).

Nearly 90 percent of those infected report a history of contact with cats, and 75 percent of them report scratches, bites or even licking by cats. Reports of cat-scratch disease rise toward fall and early winter months: Kitten births are prevalent in mid-summer, and the cat population as well as flea infestation rise accordingly. In fall, cats are brought inside the house and, of course, children are the ones more likely infected. About 80 percent of the cases reported are in young adults (less than 21 years old), and more males are infected than females by a 3:2 ratio.

Of the 22,000 cases of cat-scratch disease occurring in the U.S. each year, about 10 percent require hospital care with an average stay of four days. The incidence of cat-scratch disease is calculated to be about 9.3 per 10,000 ambulatory patients per year in the U.S. The question that is still lingering for scientists is what role does Bartonella play in the large number of undiagnosed fevers in HIV-infected individuals?

**Treatment**

The treatment of cats should be essentially symptomatic because the disease usually will resolve itself spontaneously within two to four months (unless, of course, it becomes necessary to protect immunocompromised individuals living in the household). A three-week course of treatment with azithromycin seems to be effective in only about four of five infected cats, and no drug combination has been shown to reliably eliminate the contagion.

It is therefore essential that all household cats be monitored regularly, and that strict flea and tick control be applied. The simultaneous presence of feline immunodeficiency virus would require more stringent measures.

In man, there is no treatment known to specifically attack the disease or its causative agent. A cat scratch or bite wound should be washed out immediately with lots of soap and hot water. One is left with the generic treatment of the general symptoms: local inflammation with anti-inflammatory medication, use of analgesics and antipyretics, warm compresses applied to the swollen and painful local lymph nodes. If necessary to relieve pain, percutaneous needle aspiration on fluctuant lymph nodes and a five-day course of azithromycin may be applicable.

In the more severe cases, when the disease has become systemic and in the immune-compromised patient, chemotherapy must be considered.

Azithromycin, azithromycin, cephalexin, ciprofloxacin, clarithromycin, doxycycline, enrofloxacin, erythromycin, gentamicin and rifampin (rifadin, rimactane), trimethoprim-sulfamethoxazole, ß-lactams and levofloxacin have been used as well. However, the evidence of substantive effectiveness is still being questioned.

Antibiotics are reported to be quite effective against Bartonella in vitro, while the in vivo responsiveness is questionable. It has been suggested that Bartonella may be hiding within cells protecting it from antibiotics to a varying extent. On the other hand, that there may be a different functional host response to the infection. The effectiveness of antibiotics appears to be better in the immunocompromised patient as compared to the immunocompetent host.

Thus the question arises: Does the cat-scratch disease symptomatology represent more the body’s immune response to the infection rather than the bacterial damage per se? Accordingly, the disease progression without evidence of immune responsiveness (absence of granuloma) might be more responsive to the effects of antibiotic. Penicillin, amoxicillin and nafcillin should not be used because Bartonella henselae appears to be resistant to these drugs. In immunocompromised individuals, bacteria may enter the lymphatic system and the blood stream and require extended hospital care.

**Prognosis and complications**

Progress of the disease is usually uneventful and mild, and recovery in both adult and child is likely without treatment. Complications in the immunocompetent person are rare. They may appear as encephalitis, meningitis, inflammation of the spinal cord, osteomyelitis, granulomata in the various visceral organs, disseminated infection, seizures and coma.

However, in the immunosuppressed patient they are much more frequent and considerably more severe. Treatment with antibiotics, such as azithromycin, is often necessary and usually will lead to full recovery. Unanticipated complications are the coexistence and resurgence of other chronic diseases.

**Preventive measures**

Avoid cats. Do not tease or provoke them. Do not pick up stray cats, and make sure shelter cats or cats from a multi-cat household are carefully screened.
before they enter your home; preferably, they should be at least a year old and appear healthy.

There is no benefit from blood culture or serology testing before acquiring a cat, and there is no need for preventive chemotherapy when scratched or bitten by a cat. Because antimicrobial therapy has only questionable effect on bacteremia in the cat, it makes little sense to do it. Wash out a scratch or bite wound with ample hot water and soap.

Keep house cats inside the house as much as possible. Regular and carefully monitored flea and tick control should be enforced to minimize the cat-to-cat transfer of Bartonella and prevent bartonellosis in man.

On the other hand, cat-scratch disease has also occurred without a bite or scratch, and may have been picked up by handling the cat. Keeping away from cats or thorough hand washing after handling a cat is recommended, especially for the immunocompromised person.

Blood donor cats, of course, must be screened and monitored regularly and held in a flea- and tick-free environment. There is no vaccination available, and because as many as six different strains of Bartonella have been found to live in one cat, cross protection between members of the Bartonella family appears not an option.

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Educating and counseling pet owners
Pet owner education regarding intestinal parasites and their effects on the health of both their pets and family members should be included in a well-pet exam. Pet owner education should focus on prevention and include the following:

- Description of parasites that infect pets, early signs of illness, and when pets are at greatest risk for infection (in utero and when nursing).
- Understanding the need for regular flea and tick control and monitoring.
- How they cause disease in humans, especially in children whose play habits and attraction to pets put them at increased risk.
- How prophylactic treatment of pregnant and nursing pets and their offspring can protect their pets from becoming infected, thus preventing them from shedding eggs into and contaminating the environment.
- The need for regular diagnostic examinations of kittens or prophylactic treatment of older pets.

Part II: Toxoplasma gondii

Toxoplasma gondii, one of the world’s most common parasites, grows intracellularly in domestic cats and in wild felines, its primary and only definitive host, and will spread to intermediate hosts such as warm-blooded vertebrates, including birds and man. Even sea otters have been found to be infected with Toxoplasma gondii. Worldwide, 2-4 billion people are thought to be toxoplasma infected.

The parasite

Toxoplasma gondii is a coccidian protozoa, suborder coccina, which uses the cat and other felines as its natural host. It replicates asexually and sexually in the cells of the cat’s intestinal epithelium producing oocysts that are passed with the feces and become infective within a day or two. (Oocysts are thick-walled structures in which sporozoan zygotes develop and that serves to transfer them to new hosts.)

There are three forms of Toxoplasma gondii:

- **Oocysts**, about 10 μm -12 μm in diameter.
- **Tachyzoites**, 2 μm x 6 μm, a stage in the development of the tissue phase of certain coccidial infections, rapidly and actively growing, multiplying and circulating in the blood stream.
- **Bradyzoites**, 7 μm x 1.5 μm, a slowly multiplying form enclosed and protected within tissue cysts, unaffected by chemotherapy, responsible for maintaining immunity and protecting the host from active re-infection over the long term.

Bradyzoites are the source of infection for omnivores and carnivores.

Life cycle, zoonotic transmission and human disease

The only known definitive hosts for Toxoplasma gondii are members of family Felidae (domestic cats and their relatives). Unsporulated oocysts are shed in the cat’s feces 1. Although oocysts are usually only shed for 1-2 weeks, large numbers may be shed. Oocysts take 1-5 days to sporulate in the environment and become infective. Intermediate hosts in nature (including birds and rodents) become infected after ingesting soil, water or plant material contaminated with oocysts 2. Oocysts transform into tachyzoites shortly after ingestion. These tachyzoites localize in neural and muscle tissue and develop into tissue cyst bradyzoites 3. Cats become infected after consuming intermediate hosts harboring tissue cysts 4. Cats may also become infected directly by ingestion of sporulated oocysts. Animals bred for human consumption and wild game may also become infected with tissue cysts after ingestion of sporulated oocysts in the environment 5. Humans can become infected by any of several routes:

- Eating undercooked meat of animals harboring tissue cysts 6.
- Consuming food or water contaminated with cat feces or by contaminated environmental samples (such as fecal-contaminated soil or changing the litter box of a pet cat) 7.
- Blood transfusion or organ transplantation 8.
- Transplacentally from mother to fetus 9.

In the human host, the parasites form tissue cysts, most commonly in skeletal muscle, myocardium, brain and eyes; these cysts may remain throughout the life of the host. Diagnosis is usually achieved by serology, although tissue cysts may be observed in stained biopsy specimens 10. Diagnosis of congenital infections can be achieved by detecting T. gondii DNA in amniotic fluid using molecular methods such as PCR 11.

Transmission

Felids can acquire the disease:

1. Through the ingestion of oocysts from contaminated cat feces and water.
2. By catching and consuming infected rodents and birds.
3. By vertical transmission through the placenta.
4. From tachyzoites sometimes found in feces, vomitus, urine, ulcer exudates and saliva.
5. By transplantation of tissue cyst containing organs, an operation more likely to happen in man.

Toxoplasma gondii is transmitted usually from the feces of cats and wild felines containing the Toxoplasma oocysts. Only felines produce oocysts, which are products of the parasite’s sexual reproductive cycle. Although infected cats shed oocysts only for about three weeks, they may have millions of oocysts in one stool.
After the oocysts sporulate, they are available to infect any warm-blooded host, including man, birds and rodents.

Sporulated oocysts are very resistant to environmental influences: they have been shown to survive in soil for 18 months, in 4°-degree C seawater for two years, and in room temperature water for at least one year and six months. Contaminated sources of water, soil, fresh, unwashed and uncooked fruits and vegetables can carry oocysts. Oocysts have been transferred by cockroaches and flies from contaminated cat feaces to food and kitchen utensils and cutting boards.

Other known phoretic hosts are mussels and the eastern oyster, which pick up sporulated oocysts from seawater and keeps them alive and infective for more than 85 days. Earthworms have been shown to carry them as well. Yard work and playing in soil and sand boxes frequented by non-domesticated cats carries the risk of *Toxoplasma gondii* transmission.

The consumption of undercooked meat with tissue cysts containing bradyzoites is another source of the disease. This is probably the main source of infection for domesticated and wild cats hunting for infected rodents. Farm animals feeding on sporozoite contaminated grain or hay may produce tissue cysts and the opportunity for transmission with raw or under-cooked meats. Infective tachyzoites have been found in the tissues and milk of acutely infected animals and in the eggs of infected poultry. However, tachyzoites, not having a protective shell, are easily destroyed by heat or chemicals.

**Pathogenesis**

Domestic and non-domestic cats, which are essentially carnivorous, acquire *Toxoplasma gondii* by catching and consuming infected rodents and birds. There are two pathways by which *Toxoplasma gondii* replicates itself: The intra-intestinal or entero-epithelial one, which is sexual and only happens in its definitive natural host, the felid, and the extra-intestinal pathway that is asexual and takes place in both the natural as well as all the intermediate hosts.

The **intra-intestinal** pathway begins by ingesting tissue cysts and digesting the cyst wall, which encapsulates the bradyzoites in the gastric juices of stomach and the intestine. After the bradyzoites are released, they start migrating and invade the epithelial wall of the small intestine, passing through five different stages or types of schizonts: Type A schizont about Type E schizont. They may stay at one level through several replicative cycles before going on to the next one. Inside their host cells they multiply by endodygeny and endopolygeny by which the nucleus may divide several times before the cytoplasm does, completely destroying the occupied cell. The end product of this asexual phase of reproduction are Type E Merogonies, 50-80 of which may appear tightly packed together, detaching from their mother schizont.

They will lead to the **sexual** phase of reproduction: Microgamonts and macrogamonts, which produce micro- and macrogametes respectively, represent the male (microgamocyte) and female (macrogamocyte) part of the sexual process. After the male has fertilized the female gamocyte, a wall is formed around the fertilized macrogamont producing the oocyst, which is then, in its sporulated form, shed from the intestinal epithelium and excreted. Depending on oxygen tension, moisture and temperature in the environment, the oocysts, containing two sporocytes each, will sporulate, i.e., each sporocyte produces four sporozoites, and becomes infective within about one to five days. This entire process may last from three to 15 days.

The **extra-intestinal**, asexual pathway of replication takes place in cats as well as non-feline warm-blooded vertebrates, either following direct or indirect contact with oocyst-contaminated fecal matter, water or after ingesting raw or undercooked meat.

After sporulated oocysts are consumed, they enter the intestinal tract, disencapsulate, invade intestinal cells and start to replicate and produce tachyzoites. Tachyzoites will migrate throughout all parts of the body, the central nervous system, muscle tissue and the visceral organs, replicating continuously, destroying every cell they occupy, and producing a considerable amount of focalized necrosis and tissue damage. This phase essentially represents the acute phase of the disease.

After about three weeks, with host immunity developing, they will enter a cell to sequester and produce a tissue cyst, a meront. This meront, encapsulated by a well-defined host cell membrane and producing bradyzoites, can be found almost everywhere in the body: in the brain, skeletal muscle, the heart and visceral organs. Bradyzoites will multiply repeatedly by endodygeny, i.e. asexual replication.

Tissue cysts containing bradyzoites may remain protected from outside influences, including the chemotherapeutics employed to treat the disease. They remain infective for years, if not for the life of the host, before they end up in raw hamburger or as prey for carnivorous hunting animals or birds of prey. Their presence also serves to immunize and protect their host from re-infection in the long term.

In **man**, the most frequent source of infection from tissue cysts are undercooked meats from sheep, goat, pig, and kangaroo and less so from beef or poultry.

The infection with bradyzoites, bypassing the initial unseathing of sporozoites and the tachyzoite development phase, allows immediate entry into the epithelial cells of the small intestine and the rapid development of numerous tachyzoites within less than eight hours. After three to six days of continued growth and replication, tachyzoites enter the bloodstream and are disseminated throughout the body, producing tissue damage and, sometimes, open disease.

After two to three weeks, they will become encapsulated inside their host cell or produce another meront and restart the cycle as bradyzoites. As the body goes through this process, it will produce an immune response that will limit the acute stage of the disease, shorten parasite progression, establish a chronic infection and provide enhanced resistance to future Toxoplasma infections. Immunosuppressed individuals, following immunosuppressive therapy to support organ transplantation, hypogammaglobulinemia, or any kind of immunosuppressive disease (HIV/AIDS), however, may still succumb to a new infection or allow the resurgence of an old one.

During the parasitic phase in the pregnant woman, in utero transmission can occur. The risk of in utero infection rises from the first three months of pregnancy to the last three months. Congenital transmission of *Toxoplasma gondii* can result in considerable morbidity and mortality for the newborn. The earlier the infection occurs during the course of pregnancy, the greater the congenital damage. The worldwide incidence of vertically transmitted *Toxoplasma gondii* in live birth is close to 1 percent. While women with antibody appear to be safe, there have been occasional reports of congenital transmission, possibly due to inadequate levels of antibody or the inability to form a satisfactory immune response.

Chromically infected women have been known to transmit Toxoplasma to the fetus. There is evidence that an old Toxoplasma infection in a woman with Toxoplasma antibody can still permit the infection of a newborn with all signs of toxoplasmosis: Toxoplasma scars on the retina, calcified granuloma in the brain, Toxoplasma antibody. Reactivation of a previous, latent infections, such as the release of bradyzoites from their tissue capsule is a possible cause for this event. A high percentage of infected newborns will show catastrophic damage to the eye and the central nervous system. In newborns with little or no evidence of infection at the time of birth, damage to the central nervous system may show up much later. Newborn sheep, goats and cats with Toxoplasma caused damages of similar nature and provide evidence of their susceptibility to transplacental transmission of the parasite.

**Pathology**

While clinical symptoms are most severe in newborn kittens, obviously in utero infected, they may arrive stillborn or die soon thereafter. They may show signs of hepatitis, pneumonia and inflammation of the central nervous system. Their abdomen may be enlarged due to hepatomegaly and ascites. Otherwise, *Toxoplasma gondii* infections may be asymptomatic, except for some fever and swollen lymph nodes, quickly overcome in a month or two.

Others show cutaneous lesions, produced by tachyzoites: reddening of the skin and skin rash, prurigo, urticaria and maculopapular lesions. There are a few individuals showing severe symptoms: encephalitis, hepatitis, myositis, pneumonia, blurred vision. There have been suggestions of a possible connection with changes in behavior, depression, anxiety and schizophrenia. The infecting organism, either the
In more severe cases fever, lymphadenopathy, may be no sign of the disease and there may be of disease, fever or swollen lymph nodes. There suggest congenital toxoplasmosis. As a rule, continuous sleeping or crying of the newborn stillbirth, weak debilitated newborns, In the cat or an organ transplant is a possibility. Inadvertent transplantation via blood transfusion reported as well for dogs, cats, sheep and goats. Transmissions of Toxoplasma gondii have been signs of the disease and will develop mental Many newborns, however, do not show any newborns show signs of the disease. Evidence toxoplasmosis. Only a small number of About one third of children surviving the congenital toxoplasmosis. Thirty percent of pregnant women infected by Toxoplasma will pass it on, producing severe damage to the fetus and newborn. Congenital toxoplasmosis may cause jaundice, intellectual impairment, retinocochroidal lesions and recurrent retinal disease, seizures, motor difficulties, microcephalus, hydrocephalus, severe eye infections and hearing loss. About one third of children surviving the congenital infection may show ocular toxoplasmosis. Only a small number of newborns show signs of the disease. Evidence of neurological symptoms at the time of birth suggests the early development of complications. Many newborns, however, do not show any signs of the disease and will develop mental retardation, loss of vision and hearing loss later in life, when they reach their teens. In utero transmissions of Toxoplasma gondii have been reported as well for dogs, cats, sheep and goats. Inadvertent transplantation via blood transfusion or an organ transplant is a possibility. Diagnosis In the cat stillbirth, weak debilitated newborns, jaundiced appearance, enlarged abdomen, continuous sleeping or crying of the newborn suggest congenital toxoplasmosis. As a rule, toxoplasma infected cats show little evidence of disease, fever or swollen lymph nodes. There may be no sign of the disease and there may be sudden death in cats. In more severe cases fever, lymphadenopathy, lethargy and loss of appetite, suggestions of myositis, encephalitis, hepatitis, uveitis, iritis, retinitis, chorioretinitis and other damage to the eye may direct your diagnosis. There may be vomiting, diarrhea, occasional lameness and signs of neurological disease. When concomitant with other diseases, especially diseases that suppress the immune system, toxoplasmosis can be severely exacerbated and lead to quick death. Dogs are less frequently infected and seem to be much more resistant to the disease unless they are immunocompromised or weakened by some other disease. Look for signs reflecting affection of muscles and the central nervous system: cranial nerve deficit, seizures, ataxia, stiffness of gait and lameness, paresis.

Blood work, including blood chemistry and white blood cell counts, help round out the disease picture: increases in white blood cells are suggestive of systemic infection, general tissue damage and localized necrosis in the various visceral organs, the central nervous system, skeletal muscle and red blood cells. Raised levels of serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), serum alkaline phosphatase (ALP), serum creatine kinase and serum bilirubin are usually result of necrotic damage to liver and musculature. Pancreatitis will result in increased levels of serum amyrase and lipase activities as well as proteinuria and bilirubinuria. With lung involvement, thoracic radiography may show evidence of alveolar coalescence and increased opacity in the lungs. Radiography of the abdomen can point to pancreatitis and increased density of intestines and their lymph nodes. Confirmation of toxoplasmosis, however, can only occur by:

- Direct isolation of the organism.
- Demonstration of the toxoplasma DNA.
- Presence of oxoplasma antigen.
- The host’s antibody response to that antigen.

Direct isolation of the organism itself is not a very promising undertaking: cats are shedding oocysts only for about three weeks, and they do not appear to be very sick during that period, unless they are affected by immunosuppressive treatment or some immunosuppressive disease, such as feline immunodeficiency virus. On occasions, tachyzoites can be found in cerebrospinal and amniotic fluid and in peritoneal, pleural and thoracic effluents (ascites). The presence of toxoplasma DNA can be determined by PCR (polymerase chain reaction). Various serological tests are available to detect and measure toxoplasma antibody and antigen: hemagglutination (both direct and indirect), latex agglutination, modified agglutination, enzyme-linked immune sorbent assay and indirect fluorescent antibody test. The presence of antibody in cats is not a reliable diagnostic indicator for the disease: IgG especially only confirms a history of past toxoplasmosis. IgG usually remains detectable for years after infection, reflecting the immune status of the animal and protection from re-infection. On the other hand, the finding of IgM suggests an early response to active infection, especially when it is accompanied with a concomitant fourfold rise of IgG over a period of two to four weeks. The presence of toxoplasma antigen is more definitive. Using the enzyme-linked immune sorbent assay (ELISA), toxoplasma antigen can be detected in the amniotic fluid, cerebrospinal fluid and in the aqueous humor of cats with uveitis. Vertical transmission is known and the results are often severe: stillborn or death before weaning.

The disease is more common in sheep and goats, usually affecting the reproductive process leading to abortion and weak newborns. In man, the majority of infected individuals show no symptoms at all, and their robust immune system will keep the disease at bay and protect them from re-infection. Only one or two of 10 infected individuals show some influenzalike evidence of disease: headache, fever, body aches, swollen lymph nodes, sore throat, fatigue, blurred vision.

In more severe cases, symptoms include myalgia, arthralgia, generalized lymphadenopathy, headache, hepatosplenomegaly, pneumonia, confusion, poor coordination, seizures, neurological disorders (chorioretinitis, Guillain-Barre syndrome). Immunosuppressed individuals and HIV/AIDS infected individuals often develop the more severe symptoms, including encephalitis, leading to death in 10-30 percent.

The infection with Toxoplasma gondii can be recognized by changes in cell count in cerebrospinal fluid and protein level and confirmed by the finding of rising toxoplasma antibody levels. Blood cell profiles and blood chemistry are suggestive for tissue inflammation and damage, but are not very conclusive. Occasionally you can find the organism in cerebrospinal fluid, in biopsies, in lymph nodes and in the lesions of cutaneous toxoplasmosis (skin lesions, pustulas, echymoses), in amniotic fluid, and in the aqueous humor of the eyes from cats with ocular toxoplasmosis. In the absence of measurable expressions of the disease, the presence of specific antibody and/or toxoplasma antigen and DNA will aid diagnosis. Confirmation of in utero infections requires the demonstration of tachyzoites microscopically in the amniotic fluid and/or the presence of toxoplasma antigen by means of PCR. If positive, these results should be followed by appropriate ultrasonographic procedures to check for congenital damage to the fetus. Immunofluorescent antibody assays (IFA), enzyme immune assays (ELA) also called enzyme-linked immune sorbent assays (ELISA) can be used to measure the presence of antigen as well as IgG and IgM. Differential assays of IgG and IgM allow you to distinguish between an acute infection and an old or chronic one. The presence of IgM, a primary immune response gammaglobulin and a rise in titters of IgG over two to three weeks suggest a new infection, while absence of IgM and level titters of IgG indicate a chronic infection.
Similarly, differential agglutination of tachyzoites fixed by aceton versus those fixed by formalin made it possible to distinguish agglutinating antibody from recent, acute infection which was binding aceton fixed tachyzoites from antibody coming from more distant, chronic infections.

Since the presence of toxoplasma antigen is prerequisite for the development of antibody, its measurement is another diagnostic means. Damaged tissue cells containing the antigen will show up by their reaction with specific immunoglobulins, while the presence of toxoplasma DNA can be determined utilizing the highly specific polymerase chain reaction. In more severe encephalitic cases, it may be necessary for magnetic resonance imaging (MRI) and a brain biopsy to confirm the diagnosis of toxoplasmosis.

**Diagnostic procedures**

Fecal matter can be checked for oocysts. Unless this is done within the first three weeks of infection, there is little chance of finding any. Affected tissue of the central nervous system and lymph nodes as well as visceral effusions, amnionic and cerebrospinal fluid, pleural lavage, vitreous and aqueous humor of the affected eye and urine can be examined microscopically for tachyzoites, usually after concentration by centrifugation or filtration. Simple cell staining (Wright-Giemsa) with immunoperoxidase or immunofluorescence have been used effectively. The PCR test has become a standard procedure to identify toxoplasma DNA in those same effluents.

With the immunofluorescent assay (IFA), it is possible to identify antigen by its reaction with specific antibody that has been conjugated with an immunofluorescent dye, such as fluorescent isothiocyanate. This test can be modified by using anti-gammaglobuline antibody that has been similarly labeled and locating specific antibody tied to its antigen.

Enzyme immune assays (EIA) or enzyme-linked immune-sorbent assay (ELISA) involves toxoplasma-specific antibody attached to a surface exposed to and incubated with the test antigen sample. If antigen is present, it will attach to the antibody and remain behind after rinsing away excess sample. More toxoplasma-specific antibody, this time labeled with an enzyme such as horseradish peroxidase, is added to the test to attach to the antigen held back by the initial layer of antibody, essentially forming a sandwich. After rinsing off excess material the indicator substrate is added to visualize the enzyme retained.

Vice versa: Toxoplasma antigen can be labeled with the horseradish peroxidase and used to detect antibody. The latex agglutination test consists of toxoplasma antigen coated polystyrene particles that will be agglutinated by antibody.

Another way to titrate antibody levels is the hemagglutination test, carried out with tanned red blood cells sensitized with toxoplasma antigen.

Finally, the Sabin-Feldman dye test, not much used in the field because it requires live tachyzoites as indicator for the presence of tachyzoite killing antibody, is very sensitive and highly specific. Live tachyzoites take up alkaline methylene blue. Antibody in the presence of complement will kill tachyzoites and keep them from taking up the dye.

**Geographic distribution**

Worldwide incidence in humans varies greatly, essentially based on route of transmission and cultural demographics, such as personal hygiene, eating habits and the prevalence of potential carriers. This variation is thought to range from 30 percent to 65 percent or more, and some say as many as 4 billion people may be affected worldwide. While there are about 15,000 cases reported every year in the United States, there may be as many as 225,000 actual cases.

The mild, often asymptomatic infection leads to considerable underreporting of the extent of toxoplasmosis. Therefore, the presence of toxoplasma antibody is a more meaningful indicator of past or present toxoplasma experiences. Immunocompromised individuals and individuals under immunosuppressive therapy are more likely to exhibit symptoms of the disease.

About one third of domesticated and wild felines, including zoo animals, carry *Toxoplasma gondii*. For a short time (two to three weeks or so), they produce hundreds of thousands of oocysts per gram of feces, and millions during their lives. Oocysts are highly resistant to environmental stress of temperature, disinfectants and drying and continue to remain a major cause of toxoplasmosis around the world.

**The public health problem**

Home gardeners, children playing in sand boxes frequented by domestic and feral cats, poor sanitation in underdeveloped areas and countries, careless hygiene, cockroaches, flies and earthworms carrying oocysts contribute to the vast distribution of the toxoplasmosis causing parasite. Moreover, sporulated oocysts are not easily affected by disinfection, freezing and drying.

Adult dogs or cats may be asymptomatic or mildly affected, fever, depression, loss of appetite, while the very young may be more severely affected and die in utero or early in life. Infected cats will shed oocysts and assure the spreading to other mammals.

Tachyzoites can also be found in cat feces, urine, ulcer exudates and vomit.

Human toxoplasmosis can be congenital, with newborns showing encephalitis, chorioretinitis and blindness, rash, liver enlargement and jaundice. It can be acquired as well: Individuals eating undercooked meats may pick up bradyzoites from the tissue cysts present in infected animals.

Symptoms can be mild: malaise, headache, fever, sore throat, influenza like, occasionally lymphadenopathy similar to mononucleosis, chorioretinitis that may lead to blindness, occasionally seizures, and rarely, skin lesions. In the pregnant woman, however, toxoplasmosis will severely damage if not kill the fetus in about 30 percent of infected mothers. The incidence of congenital infection among United States women is about 0.1 percent to 0.01 percent; in Europe it has been found to be more than two times as high. In individuals with AIDS or otherwise severely depressed immune system, toxoplasmosis may be a leading cause of death.

**Table 1. Drugs for the treatment of Toxoplasma gondii infections in dogs and cats:**

<table>
<thead>
<tr>
<th>Formulary</th>
<th>Route / Frequency</th>
<th>Dosage</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrimethamine/sulfadiazine</td>
<td>Per os / daily</td>
<td>50 mg PYR 4 g SUL</td>
<td>Man</td>
</tr>
<tr>
<td>Spiramycin</td>
<td>p.o. / twice a day</td>
<td>25 mg/kg</td>
<td>Man, Cat</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>p.o. / twice a day</td>
<td>25 mg/kg</td>
<td>Cat</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>p.o. / twice a day</td>
<td>5-10 mg/kg</td>
<td>Dog</td>
</tr>
<tr>
<td>Monensin</td>
<td>p.o. in dry cat food</td>
<td>0.02% solution</td>
<td>Cat</td>
</tr>
<tr>
<td>Toltrazuril</td>
<td>p.o. in drinking water</td>
<td>2.5 mg/l</td>
<td>Chicken, Turkeys</td>
</tr>
<tr>
<td>Toltrazuril</td>
<td>p.o.</td>
<td>200 ml 5%</td>
<td>Horse</td>
</tr>
<tr>
<td>Toltrazuril</td>
<td>p.o. / Twice a day</td>
<td>5-10 mg/kg</td>
<td>Cat, Dog</td>
</tr>
<tr>
<td>Sulfadiazine</td>
<td>p.o. / 4 times/day</td>
<td>60-120 mg/kg</td>
<td>Man</td>
</tr>
<tr>
<td>Pyrimethamine</td>
<td>p.o. / daily</td>
<td>1 mg/kg</td>
<td>Man, Cat</td>
</tr>
<tr>
<td>Minocycline</td>
<td>p.o. / twice a day</td>
<td>100 mg</td>
<td>Man</td>
</tr>
<tr>
<td>Atovaquone</td>
<td>p.o. / 2-4x a day</td>
<td>750 mg</td>
<td>Man</td>
</tr>
<tr>
<td>Trimethoprim- sulfamethoxazole</td>
<td>p.o. / 2x a day</td>
<td>80-160 mg/kg TRI 400-800 mg/kg SUL</td>
<td>Man</td>
</tr>
<tr>
<td>Azithromycin</td>
<td>p.o. / 1x a day</td>
<td>1000 mg/kg</td>
<td>Man</td>
</tr>
</tbody>
</table>

**Considerations when using above drugs:** All the medications here listed have similar side effects: loss of appetite, gastric upset, nausea, diarrhea, stomach pains, vomiting, dizziness, drowsiness and headache. Some produce increased sensitivity to sun light. Since pyrimethamine may prevent the body from absorbing folic acid (Vitamin B-9), additional folic acid, perhaps in the form of baker’s yeast, should be considered. Spiramycin should be used for the toxoplasma-infected pregnant woman to protect the baby. Clindamycin is especially effective in the central nervous system because it can cross the blood-to-brain barrier of the toxoplasma-infected host animal.
immunocompromised individuals, it can lead to encephalitis and death.

Treatment of toxoplasmosis

Since the disease is relatively mild and readily dealt with by the host’s immune system, only immunocompromised individuals and individuals with more severe and persistent symptoms should receive treatment. The drugs here mentioned will suppress *Toxoplasma gondii* but they will not completely eliminate it. In particular, once bradyzoites are encapsulated within their tissue cyst, they are protected from the effect of the drug. The same holds true for oocysts prior to sporulation.

It takes about one to two days for clinical symptoms to begin to subside after treatment, although it may take weeks for some of CNS symptoms to be resolved. Cats having concomitant complicating diseases, such as feline immune deficiency virus, will take longer to recover.

Preventive measures

Do not adopt stray cats. Outdoor cats start hunting soon after they are weaned and will become infected soon thereafter. For disinfecting purposes and to kill tachyzoites and bradyzoites on litter boxes and kitchen utensils, the water should be more than 70 degrees C.

Careful personal hygiene mandates hand washing after handling uncooked meats, washing of cutting boards and utensils, hand washing after the handling of cats and the daily removal of cat litter. Remember that oocysts remain non-infective for the first day or so after being shed. Keep cats from eating uncooked meats, bones, viscera and offal and stay with or dry canned foods. Earthworms, cockroaches and flies have been known to transport oocysts.

Wash fresh fruit and vegetables before eating, do not drink unpasteurized milk and make sure meats are well cooked before consumption. This is of particular importance when eating lamb, pork, venison. It has been said that the freezing and irradiation of meat will kill tachyzoits. However, unless done under controlled conditions it should not be considered safe.

Although the risk is not considered to be high when dealing with litter boxes of the domestic cat, pregnant women should avoid changing cat litter boxes or at least wear gloves and make sure to keep their hands free from feces-contaminated cat litter and wash them carefully after changing the box. Rather change them more frequently, at least daily, than allowing oocysts to become sporulated and become infective.

Obviously, immune-suppressed individuals, people undergoing chemotherapy or who are taking steroids or other immune suppressing drugs should avoid handling cat litter boxes and use careful personal hygiene. Actively oocyst-shedding cats should be removed and treated. Keep cats away from gardens and children’s sand boxes.

Veterinarians can help prevent human disease:

Most cases of human intestinal parasite infestations can be prevented by practicing good personal hygiene, eliminating intestinal parasites from pets through early and frequent treatment and making potentially contaminated environments, such as unprotected sand boxes, off limits to children.

In this context, preventive measures for toxoplasmosis are similar to those for ascarsids and hookworms and will be reiterated together.

It is obvious that pet owners should clean up pet feces on a regular basis to remove potentially infective eggs and oocysts before they become disseminated in the environment. Hookworm eggs can develop into infective stage larvae in the soil in as little as five days, and ascarid eggs within two weeks, depending on temperature and humidity. To illustrate the extent of environmental contamination that can occur as the result of one infected puppy, a single female ascarid can produce more than 100,000 eggs per day, resulting in millions of potentially infective ascarsid eggs per day spread throughout the area the puppy is allowed to roam. Once the eggs become infective, they can remain infective in the environment for years.

By comparison, toxoplasma oocysts are only shed early in the infection process and only for two to three weeks, shedding however, as many as 100,000 oocysts per gram of feces, which are relatively hardy, surviving infective for months if not years. Most pet owners do not know that their pets may carry parasites capable of infecting people. Therefore, practicing veterinarians can provide an important public service by recommending regular fecal examinations, providing frequent treatments, counseling clients on potential public health hazards and advising them on any precautionary measures that may be undertaken. Veterinarians are in an ideal position to provide pet owners with this service because of their access to the pet-owning public, their knowledge and training and their role in the human-animal bond.

Educating and counseling pet owners

Pet owner education regarding intestinal parasites and their effects on the health of both their pets and family members should be included in a well-pet exam. Pet owner education should focus on prevention and include the following:

- Description of intestinal parasites that infect pets, early signs of illness, and when pets are at greatest risk for infection (in utero and when nursing).
- How they cause disease in humans, especially in children whose play habits and attraction to pets put them at increased risk.
- How prophylactic treatment of pregnant and nursing pets and their offspring can protect their pets from becoming infected, thus preventing them from shedding eggs into and contaminating the environment.
- The need for regular diagnostic fecal examinations of pups or kittens or prophylactic treatment of older pets.
- The need for prompt collection and disposal of pet feces, especially in areas where children play, to remove eggs from the environment before they can become a problem.
- The need to keep children away from areas that may be contaminated with pet feces.

References and suggested reading

**Bartonellosis: Cat-scratch disease**


69. Persson J., Engvall E., Perlman P. (1971). Enzyme-linked immunosor- 


