REVIEW ARTICLE

Cat-Associated Zoonoses

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Cats co-occupy one third of all residences in the United States. As common household pets, they serve as sources of joy and companionship for their owners. However, feline ownership also comes with its own inherent risks, as cats can transmit an array of diseases to their owners, ranging from trivial to fatal ailments. By understanding the pathogenesis of cat-associated diseases, owners and their pets can live together with little risk of disease transmission. This article reviews cat-related diseases, with an emphasis on their prevention and management.

Arch Intern Med. 2002;162:1945-1952

In the United States, it is estimated that there are at least 57 million pet cats living in one third of all households.[1] Cats are a source of companionship and enjoyment to many people, but they can also transmit a wide array of diseases to humans, ranging from trivial dermatophyte infections to life-threatening conditions, such as bubonic plague. No single population is safe, as cats can cause disease from the first trimester onward. Cat-related diseases are also not uncommon. For example, more than 400 000 cat bites occur in the United States each year, and these, as well as other exposures, can lead to disease.[2] Herein, we review the features of cat-associated diseases, with an emphasis on prevention and management, to lower the risk of feline ownership.

CAT BITE CELLULITIS

In the United States each year, it is estimated that there are a few million animal bites, resulting in 1% of all emergency department visits. Cats inflict approximately 400 000 of these bites, representing 3% to 15% of all animal bites.[2] Almost 90% of cat bites appear to be from provoked animals, while more than 50% of dog bites result from unprovoked attacks.[3] Between 28% and 80% of cat bites are complicated by infection.[4]

The normal flora of a cat's oropharynx determines the microbes responsible for an infected cat wound. *Pasteurella multocida* is carried by more than 90% of healthy cats and is implicated in 75% of all infected cat bites.[4,5] Sixty percent of infected cat bites contain a mixture of aerobes and anaerobes, with a median number of 5 bacteria isolated per wound. The frequency of bacterial isolation from 57 consecutive infected cat bites[4] is shown below:

Aerobes, %	Anaerobes, %
Pasteurella multocida, 75	*Fusobacterium*, 33
Streptococcus, 35	*Porphyromonas*, 30
Staphylococcus, 35*	*Bacteroides*, 28
Moraxella, 35	*Prevotella*, 19
Corynebacterium, 28	*Propionibacterium*, 18

**Staphylococcus aureus*, 4%.

The majority of cat bites occur on the upper extremties or face, with fewer than 25% occurring on the lower extremities. After a bite, the median time until the development of infection is only 12 hours, which is less than the time from dog bite to infection.[4] A study from an emergency department found that 56% of cat bite wounds were described as punctures, 25% abrasions, and 17% lacerations.[6] The long, sharp teeth of a cat make a puncture wound

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particularly dangerous, as 85% of infected cat bites are the result of punctures.[4] Other risk factors associated with cat bites becoming infected include older age of the bitten individual, longer time interval between bite and medical care, and being bitten by a pet cat.[6] Approximately 40% of cat bite infections present with a nonpurulent wound, 40% with a purulent wound, and 20% with an abscess, with lymphangitis complicating 30% of infections.[4]

The management of all cat bites involves early irrigation, debridement, and assessment of tetanus status and rabies risk. Primary closure of a cat bite is not recommended initially, as many bites are deeper than they appear. Lacerations should be closed after a waiting period of at least 4 days.[7] Tetanus toxoid and immunoglobulin injections should be administered according to the guidelines of the Centers for Disease Control and Prevention, with punctures being treated as contaminated wounds. The risk of rabies transmission from cats is low, with only 3.5% of all cases of nonhuman rabies occurring in cats in 1998.[8] If immunization status is unknown and the attack is unprovoked, the cat should be quarantined for 10 days to watch for signs of bizarre behavior. If the animal dies or exhibits strange behavior, its brain should be analyzed for evidence of rabies. If a cat without known immunization history escapes after an unprovoked attack, rabies vaccine and immunoglobulin injections should be administered.

Because of the likelihood that cat bites will become infected, all persons with a cat bite should be treated with prophylactic antibiotic therapy, although, to our knowledge, no definitive study supports this practice.[9] The treatment of infected cat bites requires an understanding of susceptibility patterns of the most common bacteria isolated. Treatment should begin empirically and wound cultures should be obtained. *Pasteurella multocida* is most susceptible to penicillin, ampicillin, second- or third-generation cephalosporins, doxycycline, trimethoprim-sulfamethoxazole, quinolones, azithromycin, or clarithromycin. It is poorly responsive in vivo to first-generation cephalosporins, antistaphylococcal penicillins, erythromycin, and clindamycin.[10] Anaerobes, which are involved in more than two thirds of infections, commonly produce β-lactamase. Thus, initial antibiotic treatment of an infected cat bite should be different from treatment of typical cellulitis. Effective antibiotics include amoxicillin-clavulanate, ampicillin-sulbactam, azithromycin, or a quinolone along with clindamycin. The recommended length of treatment is 10 to 14 days.

Complications from infected cat bites occur rarely, but can be devastating. Risk factors for hospitalization include immunosuppression, age (both very young and elderly), and, most importantly, initial use of inappropriate antibiotics.[10] Severe complications include meningitis, septic arthritis, osteomyelitis, and endocarditis.

CAT-SCRATCH DISEASE

Cat-scratch disease (CSD) is a relatively common, benign, self-limited cause of localized lymphadenitis caused by the gram-negative rod *Bartonella henselae*. There are approximately 22 000 cases, leading to 2000 hospitalizations, each year in the United States.[11] Of these cases, typical CSD is the most common clinical manifestation, although atypical CSD occurs in 10% to 14% of patients.[12]

Cats were first identified as the reservoir for *B henselae* in 1994, when *Rochalimaea henselae* was isolated from the blood of 41% of asymptomatic cats in the San Francisco Bay area, in California.[1] Since then, other studies have supported the association of cats with *B henselae* bacteremia.[13,14] Cats transmit *B henselae* directly via a bite or a scratch or indirectly via the cat flea *Ctenocephalides felis*, which can bite both cats and humans. Kittens younger than 12 months represent a higher risk for disease transmission.[15]

Typical CSD can present in all age groups, with a peak incidence in children 2 to 14 years of age; more than 80% of cases occur in persons younger than 21 years.[11] The highest incidence occurs in the fall and winter, when outdoor cats spend more time indoors. Typically, 3 to 10 days after inoculation, a 0.5- to 1.0-cm red-brown papule develops, followed 2 weeks later by tender, regional lymphadenopathy, which usually occurs in the epitrochlear, axillary, pectoral, or cervical lymph nodes. Solitary lymphadenitis occurs in 85% of cases.[11] Fewer than 25% of typical CSD cases present with systemic symptoms, including low-grade fever and malaise. Typical CSD is self-limited and resolves within 3 months, although cases lasting up to 2 years have been reported.[11]

The diagnosis of CSD is generally made clinically, with the history of cat exposure being of paramount importance. With a typical history and appearance, no further evaluation is necessary. However, if a patient is unable to provide the pertinent history, obtaining a lymph node biopsy specimen is necessary to eliminate mycobacterial infection as a cause of the lymphadenitis. On histologic examination of the specimen, *B henselae* can be identified with a Warthin-Starry silver stain as a small gram-negative rod in association with microabcesses or granulomas. Skin tests with purified extracts from the lymph node of a patient with CSD can aid in diagnosis but are rarely used. Culture of *B henselae* is difficult because of its slow growth and is therefore infrequently performed. Polymerase chain reaction and indirect immunofluorescence assays for antibodies to *B henselae* are predominantly used for clinical studies and are not routinely available.

Typical CSD is self-limited, and it is unclear if antibiotic therapy can alter the natural course. To our knowledge, there has only been 1 randomized, controlled, double-blind study to assess the effects of antibiotic therapy on the course of CSD. Five days of azithromycin therapy was found to significantly decrease ultrasound-measured lymph node volume but did not affect any clinical outcome.[16] Other antibiotics that are effective in vitro include erythromycin, doxycycline, rifampin, sparfloxacin, and aminoglycosides.[17] Antibiotics are therefore not routinely prescribed for typical CSD, but are used for more severe, atypical manifestations.

Lymph node aspiration can be performed for enlarged and uncomfortable lymph nodes, but its benefit is unproved.

Prevention of CSD involves the treatment of flea-infested cats and avoidance of bites and scratches if possible. Antibiotic treatment of cats that are infected with *B henselae* has been proposed, but has not been adopted owing to the asymptomatic nature of the feline infection and the high prevalence of bacteremia in cats.

Atypical CSD occurs in 10% to 14% of patients infected with *B henselae*. The most common atypical manifestation is Parinaud oculoglandular syndrome, which was first described in 1889 by Parinaud.[11] Parinaud oculoglandular syndrome, which is caused by direct inoculation of *B henselae* into the conjunctiva, occurs in approximately 6% of patients with CSD.[18] Patients present with a unilateral nonsuppurative conjunctivitis associated with regional lymphadenitis (usually preauricular or submandibular).

Neurological complications occur in up to 2% of cases; encephalitis is the most common. Encephalitis due to CSD is rarely fatal, with two thirds of patients showing complete recovery within 4 weeks and almost universal recovery at 1 year.[19] Antibiotic therapy, though recommended, does not appear to alter the natural course.[19] Other neurological manifestations of CSD include neuroretinitis, Bell palsy, aseptic meningitis, peripheral neuropathy, and transverse myelitis.

Bartonella henselae has been shown to be the third most common cause of fever of unknown origin in children, accounting for approximately 5% of cases.[20] Endocarditis has been reported to occur on both abnormal and normal valves.[21] Pneumonia, pleural effusions, mediastinal masses, and multifocal osteomyelitis have also been reported.[12,22] Antibiotic therapy does not appear to alter the course of osteomyelitis, and spontaneous, complete recovery is the rule.[22] *Bartonella henselae* has also been associated with erythema nodosum.[23]

Although bacillary angiomatosis (BA) and peliosis hepatis are not usually considered in the spectrum of CSD, they represent atypical appearances of *B henselae* infection. A case-control study of 48 patients with either BA or peliosis hepatis showed a significant association with owning a cat and with a history of a recent cat bite, lick, or scratch.[24] Thus, these 2 manifestations can be considered atypical appearances of CSD.

Bacillary angiomatosis, which can also be caused by *Bartonella quintana*, typically presents in immunosuppressed patients, especially those who have acquired immunodeficiency syndrome and a CD4 cell count below 100/μL or who have undergone transplantation. Transmission of *B henselae* in BA occurs by the same means as in CSD. The typical clinical appearance is single or multiple red, raised, friable vascular nodules occurring throughout the skin and mucous membranes. Lesions can grow, spontaneously regress, and disseminate throughout the body to the brain, liver, spleen, bone, lungs, pleura, and peritoneum. On appearance alone, the lesions of BA can be difficult to distinguish from those of the more common Kaposi sarcoma. Thus, definitive diagnosis is required for proper management. The diagnosis can be made by histopathologic examination of the lesion, which reveals gram-negative rods on Warthin-Starry silver stain within a network of proliferating blood vessels. Culture, polymerase chain reaction, and indirect immunofluorescence assay can differentiate between *B henselae* and *B quintana* but are not required for diagnosis.[25] Treatment of BA involves prolonged courses of a macrolide or tetracycline for at least 3 weeks, and usually for a few months.

Peliosis hepatis is an uncommon manifestation of disseminated *B henselae* infection that can occur with or without BA. Through 1996, only 42 definitive cases were reported in the literature.[26] Although peliosis hepatis is considered an acquired immunodeficiency syndrome–defining opportunistic infection, approximately half of all reported cases have occurred in patients with intact immune systems. Affected patients often present with a prolonged course of fever, abdominal discomfort, weight loss, and hepatosplenomegaly. Liver failure rarely occurs, and laboratory values reveal elevated erythrocyte sedimentation rates and elevated alkaline phosphatase levels, with minimal increases in alanine or aspartate aminotransferase levels. Ultrasound examinations or computed tomographic scans reveal multiple hypodense lesions in the liver, with or without splenic involvement. Diagnosis is made by biopsy, serology, culture, or polymerase chain reaction. To our knowledge, no controlled trials have addressed the treatment of peliosis hepatis, and prolonged courses of multiple agents (usually >1 month), including erythromycin, tetracycline, rifampin, gentamicin, and trimethoprim-sulfamethoxazole, have been used. Children are usually treated with rifampin, with the addition of gentamicin or trimethoprim-sulfamethoxazole to the regimen if there is inadequate response within 3 to 4 days.[27]

TOXOPLASMOSIS

Toxoplasma gondii is an obligate intracellular protozoan that can infect all mammals, who serve as an intermediate host. Human infection with *T gondii* causes a wide array of clinical manifestations, depending on the age and immune status of the affected individual. Cats are the only complete hosts in which the protozoan can undergo both sexual and asexual reproduction. Knowledge of the protozoan's life cycle and pathogenesis is necessary to understand the cat's role in disease transmission and the preventive methods that can diminish the clinical consequences.

Toxoplasmosis is common and is found throughout the world. The prevalence of *T gondii* infection varies from country to country and between cultures. Cultures that encourage the consumption of raw meat have a high prevalence of infection. Yearly seroconversion rates in the United States range from 1% to 2% per year, depending on the location and cultural background.[28] Ten percent to 40% of patients who are infected with the human immunodeficiency virus in the United States harbor tissue cysts, representing latent infection. Finally, there are approximately 3000 cases of congenital toxoplasmosis in the United States each year.[28]

Toxoplasma gondii exists primarily in 3 forms during its life cycle. Oocysts are the product of sexual reproduction and are produced in the small intestine of a cat that has consumed tissue cysts containing *T gondii*. Oocysts are only produced for 2 weeks in the life of a cat when it first acquires infection, which is usually as a kitten. Oocysts contain infectious sporozoites. Tachyzoites represent the rapidly asexually dividing *T gondii* within host cells (usually macrophages) before or without an adequate immune response. Bradyzoites are slowly dividing *T gondii* contained by an immune response in tissue cysts.

Humans acquire toxoplasmosis predominantly by 1 of 3 mechanisms. The most common mode of acquisition is the ingestion of tissue cysts in undercooked meat.[29] Bradyzoites can be found in 8% of beef, 20% of pork, and 20% of lamb.[30] Direct ingestion of oocysts is less common and unlikely to occur from direct contact with a cat. Transplacental transmission of tachyzoites from a mother with primary infection causes fetal infection. Rare cases are attributed to transmission of tachyzoites in blood transfusions.[28]

Once tissue cysts or oocysts are ingested and enzymatically degraded, the infectious bradyzoites or sporozoites are released into the intestine. They then penetrate the intestinal wall and infect macrophages. Within the macrophages, the tachyzoites rapidly divide, causing lysis of the host cell and spread of infection. Before an immune response occurs, the tachyzoites disseminate hematogenously to lymph nodes, muscle, brain, retina, myocardium, placenta, lungs, and liver.[29] After 7 to 10 days, an immune response develops and causes containment of *T gondii* in tissue cysts, where the protozoa can remain dormant for the life of the intermediate host.

Disease transmission from cats rarely occurs from direct contact for a number of reasons. First, as stated earlier, cats only release oocysts for approximately 2 weeks of their life, when they first acquire infection from ingesting tissue cysts. This occurs primarily in kittens that hunt outdoors. Second, once released, oocysts require 1 to 5 days to become infective.[28] Thus, regular cleaning of a cat's litter should diminish contact with infective oocysts significantly. On the other hand, oocysts can survive in soil for years and are resistant to acid, alkali, and detergents.[28]

The role of cats in transmission of toxoplasmosis is thus unclear. A case-control study of 252 cases of primary toxoplasmosis in pregnant women failed to reveal a significant association with any cat exposure, including having an adult cat or kitten at home, cleaning the litter, or owning a cat that actively hunts. Significant risks were found with consuming undercooked meat and with soil contact without gloves.[31] Soil contact allows oocysts, which are deposited by infected outdoor cats, to ultimately be transmitted by fecal-oral contact. A prospective study in human immunodeficiency virus–infected adults also failed to reveal any association with cat ownership or exposure.[32]

In immunocompetent individuals, more than 90% of infections are asymptomatic. In symptomatic infections, the most common presentation is a mononucleosis-like syndrome with cervical lymphadenopathy, headache, malaise, low-grade fever, and fatigue. Rarely, infection is complicated by chorioretinitis, meningoencephalitis, myocarditis, or hepatitis.[28]

Immunosuppressed individuals, especially those with CD4 cell counts lower than 100/μL, are prone to reactivation of latent infections. Latent infections account for up to 95% of symptomatic infections in immunocompromised individuals.[33] Reactivation can occur anywhere tissue cysts are contained but most commonly occurs in the central nervous system and presents as encephalitis. Other sites of reactivation include the lungs, heart, retina, and liver.[29]

Congenital toxoplasmosis results from transplacental passage of tachyzoites from a mother with primary infection. The range of symptoms in the newborn is vast, from asymptomatic infections to miscarriage, with such neurological complications as microcephaly, hydrocephalus, seizures, and mental retardation. Asymptomatic newborns can also present with chorioretinitis up to 20 years later.[30]

The diagnosis of toxoplasmosis is most commonly achieved via serologic testing. Indirect immunofluorescence assays are widely available to detect both IgG and IgM antibodies. IgM antibodies are detectable within a few days of infection, and their levels remain elevated for 2 to 3 months, whereas the levels of IgG antibodies increase 1 to 2 weeks after infection and can remain elevated indefinitely.[29] Diagnosis of primary infection requires increased titers of both antibodies. Since toxoplasmic encephalitis commonly results from reactivation of bradyzoites that are no longer contained by an immune response, elevation of IgM antibody levels is uncommon. The diagnosis of toxoplasmic encephalitis is based on clinical symptoms, evidence of prior *Toxoplasma* infection (elevated IgG levels), and imaging (ie, computed tomography or magnetic resonance imaging). Definitive diagnosis, which is not required to initiate treatment, requires either a brain biopsy specimen or evidence of *T gondii* DNA in cerebrospinal fluid via polymerase chain reaction amplification.[34]

Immunocompetent individuals without severe complications require no specific treatment. Chorioretinitis is treated with pyrimethamine, sulfadiazine, leukovorin, and corticosteroids or pyrimethamine, clindamycin, leukovorin, and corticosteroids for 3 to 4 weeks.[35] Suspected cases of toxoplasmic encephalitis are treated with either of the above regimens for at least 4 to 6 weeks. Alternative regimens include azithromycin or atovaquone. Clinical and radiological response typically occurs within a few days, with 85% and 90% of patients showing improvement in 1 and 2 weeks, respectively. If a patient experiences worsening symptoms or no improvement within 2 weeks, reimaging and/or brain biopsy is required.[34] Fetal infection is treated through the mother for the duration of pregnancy, with the most common regimen consisting of pyrimethamine, sulfadiazine, leukovorin, and spiramycin. Pyrimethamine in early pregnancy is teratogenic and should be avoided in the first trimester.[30]

Secondary prophylaxis with pyrimethamine, sulfadiazine, and leukovorin (or alternative regimens) is required in all human immunodefi-

ciency virus–infected patients who have been successfully treated for toxoplasmic encephalitis. This practice lowers recurrence rates from 80% to 10% to 33%.[34] Primary prophylaxis is recommended in patients with acquired immunodeficiency syndrome and CD4 cell counts below 100/μL. Primary prophylaxis with trimethoprim-sulfamethoxazole or dapsone plus pyrimethamine has been shown to lower the 1-year incidence of toxoplasmic encephalitis from 18.8% to 6.2%.[36]

Prevention of toxoplasmosis involves limiting contact with known routes of transmission. Since the most common mode of transmission is ingestion of tissue cysts in undercooked meat, meat should be heated to 66°C and hands should be washed thoroughly after it is handled. Also, gloves should be worn during contact with soil that is possibly contaminated with cat feces. Litter pans should be emptied daily, since oocysts require 1 to 5 days to become infective. If this is done, direct contact with cat feces during the cleaning of a litter box is an unlikely mode of transmission. However, whether pregnant women or immunosuppressed individuals should avoid changing litter is debatable. If they already have IgG antibodies to *T gondii*, there is no reason to avoid changing the litter. However, if they do not show evidence of prior exposure, they are susceptible to primary infection. In this situation, the risk of primary infection in the cat should be assessed. Indoor cats who eat prepackaged food are unlikely to ingest tissue cysts and thus represent a low risk for transmission.[28] On the other hand, if a cat hunts outdoors, there is a strong likelihood of primary infection at some point in the cat's life. In this situation, a pregnant women or an immunosuppressed individual should probably avoid changing the litter, even though there is no direct evidence to support this practice.

CUTANEOUS LARVA MIGRANS

Cutaneous larva migrans (CLM), also known as *creeping eruption*, is a pruritic skin eruption caused by either the dog or cat hookworm. Cats are responsible for infections caused by *Ancylostoma braziliense*, while dogs can carry either *A braziliense* or *Ancylostoma caninum*. This common infection is the most frequent dermatosis diagnosed among travelers returning from tropical countries.[37] These hookworms have a worldwide distribution, with most cases occurring in tropical climates where dogs and cats have access to moist, sandy, coastal soil. In the United States, the hookworms are endemic in the southeastern and central regions.[38]

Dogs or cats that carry the hookworms deposit the larvae in their feces into the sand or soil, where the larvae can survive for several days.[39] On contact with unprotected skin, the larvae penetrate the epidermis but are contained by the basement membrane.[38] Humans are an incidental host, and the hookworms cannot complete their life cycle. Instead, the larvae remain confined within the lower epidermis and begin to migrate aimlessly. As they migrate, they release hydrolytic enzymes, a process that leads to an intense allergic and inflammatory reaction.[39]

A few minutes after infection, small wheals can be noted at the site of entry, followed in a few hours by erythematous, pruritic papules. In 5 to 14 days, the characteristic serpiginous, reddened, intensely pruritic skin eruption is visible along the path of larval migration, as shown in the **Figure**. The larve migrate a few centimeters each day, releasing hydrolytic enzymes along their path. Since the inflammatory reaction is delayed, the skin eruption tends to be located several centimeters behind the actual location of the larvae.[40] Cutaneous larva migrans is usually self-limited, with most cases lasting a few weeks or months. However, cases lasting up to 22 months have been reported.[41] Complications of infection are most commonly a result of bacterial infection caused by scratching.[39] Eosinophilia of more than 7% of the total leukocyte count was reported in 20% of cases in one series.[42] Visceral migration of *A caninum* has been reported, leading to eosinophilic inflammation of the gut.[43]

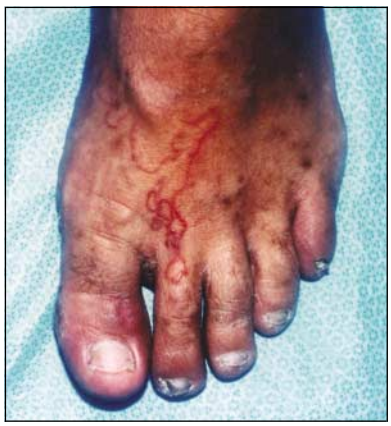
The diagnosis of CLM is based on clinical appearance and history consistent with probable exposure. Biopsy specimens of the skin lesion usually do not contain the larvae, because the larvae are located a few centimeters past their tract.

Treatment of CLM is not required but is usually recommended to manage intense pruritis and to lower the risk of bacterial superinfection. Topical thiabendazole applied 2 to 3 times a day for 5 days has a cure rate of 98%.[40] This treatment is devoid of systemic adverse effects, which limit the use of oral thiabendazole. Single 12-mg doses of ivermectin are effective for multiple lesions.[40] Cryotherapy is ineffective because the larvae are not located within the tract.

Since the most common mode of acquisition of CLM is direct contact with larvae on coastal soil, banning dogs or cats from beaches should lower the risk of infection. In a survey of 140 travelers returning from Barbados, 90% reported seeing cats on the beach. Also, never or rarely wearing footwear was associated with a significant increased risk of CLM.[44] Therefore, during a trip to tropical areas, the risk of acquiring this infection can probably be lowered by wearing footwear on the beach. Finally, deworming of cats and dogs should lower the risk of transmission.[45]

VISCERAL LARVA MIGRANS

Aberrant migration of the dog or cat roundworm through the viscera of incidental human hosts causes visceral larva migrans, a far more serious infection than CLM. Most human infections are caused by the dog roundworm, *Toxocara canis*, not by



Cutaneous larva migrans.

the cat roundworm, *Toxocara cati*, possibly because cats are more fastidious than dogs in covering up their feces, thereby limiting exposure.[46]

Visceral larva migrans primarily develops in children, with most cases occurring before the age of 5 years, coinciding with the peak incidence of pica in children. Ocular larva migrans, owing to its prolonged migration, typically occurs in older children, between the ages of 5 and 10 years.[47]

A dog or cat with *Toxocara* worms in its intestine releases eggs with its feces into sand or soil. The eggs then require a minimum of 2 weeks under ideal moisture and temperature conditions to develop into infective eggs.[46] Thus, as is the case with toxoplasmosis, direct contact with an infected animal is an unlikely source of infection. Through fecal-oral transmission after contact with contaminated sand or soil, infective eggs are ingested. Ingestion of undercooked liver and other meats from infected animals can also lead to human infection.[45] In the human stomach, the eggs hatch and release infective larvae. The larvae then migrate through the wall of the small intestine and into the bloodstream. As in CLM, humans are accidental hosts and *Toxocara* is unable to complete its life cycle. Instead, larvae wander aimlessly and can invade any organ, including the liver, muscle, lungs, retina, central nervous system, and skin. Clinical symptoms due to larval migration result primarily from allergic and inflammatory responses.[46] Migration into the retina may result in ocular larva migrans.

Symptoms of visceral larva migrans are nonspecific and a consequence of the inflammatory response to *Toxocara*. Asymptomatic infections commonly occur, with up to one third of adults showing serologic evidence of prior exposure.[48] Typical symptoms include fever, malaise, myalgias, cough, and vague abdominal discomfort, with hepatomegaly on examination. Allergic symptoms, including urticaria and wheezing, are common. Systemic eosinophilia and hypergammaglobulinemia are common laboratory findings. Uncomplicated cases are self-limited, lasting a few months. Severe complications, including hypereosinophilia,[49] liver abscess,[50] eosinophilic meningoencephalitis,[46] myocarditis,[51] pericardial tamponade,[52] and eosinophilic pleural effusion, occur less often.[53] Ocular larva migrans typically presents with unilateral diminished visual acuity with or without strabismus.[47]

Owing to the nonspecific nature of symptoms, a high clinical index of suspicion is essential in the diagnosis of visceral larva migrans. Any child with unexplained fever, vague abdominal discomfort, and eosinophilia should be investigated for infection with *Toxocara*. Diagnosis is typically made by enzyme-linked immunosorbent assay to detect *Toxocara* antibodies. This assay has a reported sensitivity of 78% and a specificity of 92%.[47] Ocular larva migrans is diagnosed on funduscopic examination, as the sensitivity of enzyme-linked immunosorbent assay is low given the diminished immune response.

Treatment is warranted in severe cases or in cases with any involvement of the central nervous system, heart, or retina. No studies comparing treatments are available, to our knowledge, but most antihelminthics, including albendazole, mebendazole, diethylcarbamazine, and ivermectin, have been used successfully.[46] Treatment is generally continued for a few weeks. Corticosteroids can be added to the treatment regimen to diminish hypersensitivity reactions to dying larvae. Ocular larva migrans can be treated with laser photocoagulation and either local or systemic steroids.[46]

Prevention of visceral larva migrans involves avoidance of the 2 known means of acquisition. Washing hands after handling soil or sand in areas where dogs or cats live will likely decrease the risk of fecal-oral transmission. Covering public sandboxes with vinyl sheets at night and on rainy days was also shown to significantly reduce *Toxocara* contamination.[54] Finally, thoroughly cooking liver will lower the risk of ingesting infective larva.

OTHER CAT-ASSOCIATED DISEASES

Cats are known to harbor numerous intestinal microbes that can cause human enteritis. A survey of enteric zoonotic organisms has shown that 1% of cats carry *Salmonella typhimurium*, with or without diarrhea.[55] Multidrug-resistant *S typhimurium* has been reported to occur in domestic cats and can continue to be shed for prolonged periods after recovery from the acute illness.[56,57] Thus, because there is potential for human infection to be acquired from cats, adherence to hand washing and keeping cats away from food preparation would be expected to diminish transmission.

Yersinia enterocolitica and *Yersinia pseudotuberculosis* are both acquired through fecal-oral transmission from infected food or water sources. Though not quantified, infection from domestic cats is possible given their role as a natural reservoir.[17] Cases of pseudotuberculosis have been linked to indirect contact with infected stray cats.[58] *Giardia* is carried by 2% to 3% of cats; most cases are seen in cats with diarrhea.[55] No definitive relationship has been established between feline and human cases, although strong evidence from genetic analysis points to a likely zoonotic association.[59]

The strongest evidence for enteric transmission from cats to humans exists with *Campylobacter enteritis*. One percent of cats surveyed were found to carry *Campylobacter jejuni*, with or without diarrhea.[55] A case-control study of 218 patients with *C enteritis* revealed an increased risk associated with contact with any animal with diarrhea 1 week before illness. Most cases were from dogs, but no single animal was associated with an increased risk by itself.[60] Another case-control study involving 45 patients showed an increased risk after contact with a cat or kitten 1 week before illness.[61]

Cryptosporidium parvum is carried by almost 5% of cats, with or without symptoms.[55] Given the high prevalence in cats, one would expect direct transmission from cats to occur. However, no increased risk with feline contact was shown in a case-control study of 48 patients with acquired immunodeficiency syndrome.[62] Thus, the role of cats in human cases of cryptosporidiosis is unclear. In all suspected cases of cat-

associated diarrhea, simple preventive methods such as veterinary care and hand washing should lower the risk of human infection.

There are several other diseases that can be attributed to contact with cats in rare cases. Human infection with *Francisella tularensis* most commonly occurs from contact with infected rabbits or transmission via a tick vector. However, direct transmission from cats has been reported in approximately 50 cases since 1928.[63] Cats likely acquire the bacteria from eating infected rabbits or rodents. Although most infected cats are asymptomatic, they can transmit the infection to humans via a bite or scratch. The most common form of tularemia acquired from cats is ulceroglandular, occurring in the upper extremity in more than 80% of cases. Also, pneumonia has been reported to complicate more than 25% of cases. Though rare, this diagnosis should be considered in patients suspected to have cat bite cellulitis or CSD who do not respond to initial treatment or who appear toxic. Diagnosis involves detection of an immune response with indirect immunofluorescence assay or culture. Effective treatments include streptomycin or aminoglycosides.

Of the 297 cases of human plague reported in the United States between 1977 and 1998, 7.7% were attributed to cat transmission.[64] Cats likely acquire infection from flea bites or from eating infected rodents. The mode of transmission from cats to humans is unclear, with only 8 of 23 cases documenting a cat bite or scratch. In contrast to cats infected with tularemia, cats infected with *Yersinia pestis* are severely ill. The most common form of plague transmitted is bubonic plague. Cat-associated human plague differs from other forms of plague because of a predominance of axillary buboes and higher rate of primary pneumonic plague. Diagnosis is made with culture of either buboes or blood, and treatment involves streptomycin, gentamicin, tetracycline, or chloramphenicol.

Q fever due to *Coxiella burnetii* has been reported to occur from exposure to parturient cats.[65] The true incidence of cat transmission is difficult to determine because the disease is likely to be underdiagnosed. A review of 80 patients hospitalized with confirmed Q fever revealed cat contact in approximately 6% of cases.[66] Suspected cases can be diagnosed by detection of antibodies to the phase II antigen with either indirect immunofluorescence assay or enzyme-linked immunosorbent assay. Treatment consists of either doxycycline or a quinolone.

Cases of psittacosis due to feline *Chlamydia psittaci* have been reported, accounting for either conjunctivitis or pneumonia.[67] Specific serologic tests can identify a unique form of feline *C psittaci* that can be differentiated from the more common avian *C psittaci*.

Various dermatologic infections can be transmitted from cats to humans. Dermatophytes, including *Microsporum canis*, can be transmitted from the coat of symptomatic or asymptomatic cats and can cause tinea infections.[17] Cats with sporotrichosis skin lesions can transmit the fungus to humans via direct contact.[68] Cat fleas (*C felis*) or cat mites (*Cheyletiella blakei*) can cause either infestation or localized dermatitis.[17] Also, cat fleas can act as a vector for the transmission of *B henselae* or *Yersinia pestis*.

Transmission of tuberculosis from cats has been postulated but never proved. Also, cats are inherently resistant to *Mycobacterium tuberculosis* and thus are unlikely to represent a reservoir for infection.[69] One case report of the simultaneous occurrence of spongiform encephalopathy in a cat and its owner has been reported, but, to our knowledge, no conclusive evidence for direct transmission exists.[70]

CONCLUSIONS

There are many diseases that can be linked to transmission from cats. Many diseases are more likely to be encountered by outdoor cats that can acquire infections from hunting. Indoor cats are less likely to be sources of human infections. Simple preventive measures, such as washing hands before eating, using gloves when gardening, changing the litter daily, and thoroughly cooking all meat, can reduce the risk of acquiring disease from a cat. Also, routine veterinary care, including appropriate vaccinations, deworming, and care for sick animals, should reduce the risk of disease transmission. Cats should not be thought of as vectors for disease transmission, but as sources of joy and companionship for their owners.

Accepted for publication February 6, 2002.

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REFERENCES

1. Koehler JE, Glaser CA, Tappero JW. *Rochalimaea henselae* infection: a new zoonosis with the domestic cat as reservoir. *JAMA.* 1994; 271:531-535.
2. Presutti RJ. Bite wounds: early treatment and prophylaxis against infectious complications. *Postgrad Med.* 1997;101:243-254.
3. Patrick GR, O'Rourke KM. Dog and cat bites: epidemiologic analyses suggest different prevention strategies. *Public Health Rep.* 1998;113:252-257.
4. Talan DA, Citron DM, Abrahamian FM, Moran GJ, Goldstein EJ. Bacteriologic analysis of infected dog and cat bites: Emergency Medicine Animal Bite Infection Study Group. *N Engl J Med.* 1999;340:85-92.
5. Raj N, Nayar R, White R, Teh L-S. Once bitten, twice shy. *Ann Rheum Dis.* 2000;59:684-687.
6. Dire DJ. Cat bite wounds: risk factors for infection. *Ann Emerg Med.* 1991;20:973-979.
7. Layton CT. *Pasteurella multocida* meningitis and septic arthritis secondary to a cat bite. *J Emerg Med.* 1999;17:445-448.
8. Krebs JW, Smith JS, Rupprecht CE, Childs JE. Rabies surveillance in the United States during 1998. *J Am Vet Med Assoc.* 1999;215:1786-1798.
9. Israeli E, Attali M, Kracoff OH, Polevshikov M, Malnick SDH. Smitten by a kitten. *South Med J.* 1999; 92:909-911.
10. Holm M, Tärnvik A. Hospitalization due to *Pasteurella* multocida–*infected animal bite wounds: correlation with inadequate primary antibiotic medication.* Scand J Infect Dis. *2000;32:181-183.*
11. Maguina C, Gotuzzo E. Emerging and re-emerging diseases in Latin America: bartonellosis, new and old. *Infect Dis Clin North Am.* 2000;14:1-22.
12. Margileth AM, Baehren DF. Chest-wall abscess due to cat-scratch disease (CSD) in an adult with antibodies to *Bartonella clarridgeiae*: case report and review of the thoracopulmonary manifestations of CSD. *Clin Infect Dis.* 1998;27:353-357.
13. Chomel BB, Abbott RC, Kasten RW, et al. *Bartonella hensalae* prevalence in domestic cats in California: risk factors and asoociation between bacteremia and antibody titers. *J Clin Microbiol.* 1995; 33:2445-2450.
14. Bergmans AM, deJong CM, van Amerongen G, Schot CS, Schouls LM. Prevalence of *Bartonella* species in domestic cats in the Netherlands. *J Clin Microbiol.* 1997;35:2256-2261.
15. Zangwill KM, Hamilton DH, Perkins BA, et al. Cat scratch disease in Connecticut: epidemiology, risk factors, and evaluation of a new diagnostic test. *N Engl J Med.* 1993;329:8-13.

16. Bass JW, Freitas BC, Freitas AD, et al. Prospective randomized double blind placebo-controlled evaluation of azithromycin for treatment of cat-scratch disease. *Pediatr Infect Dis J*. 1998;17:447-452.
17. Tan JS. Human zoonotic infections transmitted by dogs and cats. *Arch Intern Med*. 1997;157:1933-1943.
18. Grando D, Sullivan LJ, Flexman JP, Watson MW, Andrew JH. *Bartonella hensalae* associated with Parinaud's oculoglandular syndrome. *Clin Infect Dis*. 1999;28:1156-1158.
19. Carithers HA, Margileth AM. Cat-scratch disease: acute encephalopathy and other neurologic manifestations. *AJDC*. 1991;145:98-101.
20. Jacobs RF, Schutze GE. *Bartonella hensalae* as a cause of prolonged fever and fever of unknown origin. *Clin Infect Dis*. 1998;26:80-84.
21. Raoult D, Fournier PE, Drancourt M, et al. Diagnosis of 22 new cases of *Bartonella* endocarditis. *Ann Intern Med*. 1996;125:646-652.
22. Hulzebos CV, Koetse HA, Kimpen LL, Wolfs TF. Vertebral osteomyelitis associated with cat-scratch disease. *Clin Infect Dis*. 1999;28:1310-1312.
23. Margileth AM. Dermatologic manifestations and update of cat scratch disease. *Pediatr Dermatol*. 1988;5:1-9.
24. Tappero JW, Mohle-Boetani J, Koehler JE, et al. The epidemiology of bacillary angiomatosis and bacillary peliosis. *JAMA*. 1993;269:770-775.
25. Gasquet S, Maurin M, Brouqui P, et al. Bacillary angiomatosis in immunocompromised patients. *AIDS*. 1998;12:1793-1803.
26. Liston TE, Koehler JE. Granulomatous hepatitis and necrotizing splenitis due to *Bartonella hensalae* in a patient with cancer: case report and review of hepatosplenic manifestations of *Bartonella* infection. *Clin Infect Dis*. 1996;22:951-957.
27. Arisoy ES, Correa AG, Wagner ML, Kaplan SL. Hepatosplenic cat-scratch disease in children: selected clinical features and treatment. *Clin Infect Dis*. 1999;28:778-784.
28. Markell EK, John DT, Krotoski WA. Toxoplasma gondii. In: *Markell and Voge's Medical Parisitology*. 8th ed. Philadelphia, Pa: WB Saunders Co; 1999:161-171.
29. Despommier DD, Gwadz RW, Hotez PJ. *Toxoplasma gondii*. In: *Parasitic Diseases*. 3rd ed. New York, NY: Springer-Verlag NY Inc; 1995:162-169.
30. Beazley DM, Egerman RS. Toxoplasmosis. *Semin Perinatol*. 1998;22:332-338.
31. Cook AJ, Gilbert RE, Buffolano W, et al. Sources of *Toxoplasma* infection in pregnant women: European multicentre case-control study. *BMJ*. 2000;321:142-147.
32. Wallace MR, Rossetti RJ, Olson PE. Cats and toxoplasmosis risk in HIV-infected adults. *JAMA*. 1993;269:76-77.
33. Kasper LH. *Toxoplasma* infection and toxoplasmosis. In: Isselbacher KJ, Braunwald E, Wilson JD, Martin JB, Fauci AS, Kasper DL, eds. *Harrison's Principles of Internal Medicine*. 13th ed. New York, NY: McGraw-Hill Co; 1994:903-908.
34. Cohen BA. Neurologic manifestations of toxoplasmosis in AIDS. *Semin Neurol*. 1999;19:201-211.
35. Nussenblatt RB, Belfort R. Ocular toxoplasmosis: an old disease revisited. *JAMA*. 1994;271:304-307.
36. Oksenhendler E, Charreau I, Tournerie C, Azihary M, Carbon C, Aboulker JP. *Toxoplasma gondii* infection in advanced HIV infection. *AIDS*. 1994;8:483-487.
37. Caumes E, Carrière J, Guermonprez G, Bricaire F, Danis M, Gentilini M. Dermatoses associated with travel to tropical countries: a prospective study of the diagnosis and management of 269 patients presenting to a tropical disease unit. *Clin Infect Dis*. 1995;20:542-548.
38. Esser AC, Kantor I, Sapadin AN. Souvenir from the Hamptons: a case of cutaneous larva migrans of six months' duration. *Mt Sinai J Med*. 1999;66:334-335.
39. Despommier DD, Gwadz RW, Hotez PJ. Aberrant nematode infections. In: *Parasitic Diseases*. 3rd ed. New York, NY: Springer-Verlag NY Inc; 1995:61-64.
40. Caumes E. Treatment of cutaneous larva migrans. *Clin Infect Dis*. 2000;30:811-814.
41. Richey TK, Gentry RH, Fitzpatrick JE, Morgan AM. Persistent cutaneous larva migrans due to *Ancylostoma* species. *South Med J*. 1996;89:609-611.
42. Jelineck T, Maiwald H, Northdurft HD, Loscher T. Cutaneous larva migrans in travelers: synopsis of histories, symptoms, and treatment of 98 patients. *Clin Infect Dis*. 1994;19:1062-1066.
43. Croese J, Loukas A, Opdebeeck J, Fairley S, Prociv P. Human enteric infection with canine hookworms. *Ann Intern Med*. 1994;120:369-374.
44. Tremblay A, MacLean JD, Gyorkos T, MacPherson DW. Outbreak of cutaneous larva migrans in a group of travelers. *Trop Med Int Health*. 2000;5:330-334.
45. Juckett G. Pets and parasites. *Am Fam Physician*. 1997;56:1763-1774.
46. Overgaauw PA. Aspects of *Toxocara* epidemiology: human toxocarosis. *Crit Rev Microbiol*. 1997;23:215-231.
47. Despommier DD, Gwadz RW, Hotez PJ. Visceral larva migrans. In: *Parasitic Diseases*. 3rd ed. New York, NY: Springer-Verlag NY Inc; 1995:64-66.
48. Elliot DL, Tolle SW, Goldberg L, Miller JB. Pet-associated illness. *N Engl J Med*. 1985;313:985-995.
49. Arango CA. Visceral larva migrans and the hypereosinophila syndrome. *South Med J*. 1998;91:882-883.
50. Rayes A, Teixeira D, Nobre V, et al. Visceral larva migrans syndrome complicated by liver abscess. *Scand J Infect Dis*. 1999;31:324-325.
51. Dao AH, Virmani R. Visceral larva migrans involving the myocardium: report of two cases and review of literature. *Pediatr Pathol*. 1986;6:449-456.
52. Herry I, Philippe B, Hennequin C, Danel C, Lejeunne C, Meyer G. Acute life-threatening toxocaral tamponade. *Chest*. 1997;112:1692-1693.
53. Jeanfaivre T, Cimon B, Tolstuchow N, de Gentile L, Chabasse D, Tuchais E. Pleural effusion and toxocariasis. *Thorax*. 1996;51:106-107.
54. Uga S, Nobumasa K. Measures to control *Toxocara* egg contamination in sandpits of public parks. *Am J Trop Med Hyg*. 1995;52:21-24.
55. Hill SL, Cheney JM, Taton-Allen GF, Reif JS, Bruns C, Lappin MR. Prevalence of enteric zoonotic organisms in cats. *J Am Vet Med Assoc*. 2000;216:687-692.
56. Wall PG, Threlfall EJ, Ward LR, Rowe B. Multiresistant *Salmonella typhimurium* DT104 in cats: a public health risk. *Lancet*. 1996;348:471.
57. Wall PG, Davis S, Threlfall EJ, Ward LR, Ewbank AJ. Chronic carriage of multidrug resistant *Salmonella typhimurium* in a cat. *J Small Anim Pract*. 1995;36:279-281.
58. Fukushima H, Gomyoda M, Ishikura S, et al. Cat-contaminated environmental substances lead to *Yersinia pseudotuberculosis* infection in children. *J Clin Microbiol*. 1989;27:2706-2709.
59. Thompson RC, Meloni BP, Lymbery AJ. Humans and cats have genetically-identical forms of *Giardia*: evidence of a zoonotic relationship. *Med J Aust*. 1988;148:207-209.
60. Saeed AM, Harris NV, DiGiacomo RF. The role of exposure to animals in the etiology of *Campylobacter jejuni/coli* enteritis. *Am J Epidemiol*. 1993;137:108-114.
61. Deming MS, Tauxe RV, Blake PA, et al. *Campylobacter* enteritis at a university: transmission from eating chicken and from cats. *Am J Epidemiol*. 1987;126:526-534.
62. Glaser CA, Safrin S, Reingold A, Newman TB. Association between *Cryptosporidium* infection and animal exposure in HIV-infected individuals. *J Acquir Immune Defic Syndr*. 1998;17:79-82.
63. Capellan J, Fong IW. Tularemia from a cat bite: case report and review of feline-associated tularemia. *Clin Infect Dis*. 1993;16:472-475.
64. Gage KL, Dennis DT, Orloski KA, et al. Cases of cat-associated human plague in the Western US, 1977-1998. *Clin Infect Dis*. 2000;30:893-900.
65. Pinsky RL, Rishbein DB, Greene CR, Gensheimer KF. An outbreak of cat-associated Q fever in the United States. *J Infect Dis*. 1991;164:202-204.
66. Caron F, Meurice JC, Ingrand P. Acute Q fever pneumonia: a review of 80 hospitalized patients. *Chest*. 1998;114:808-813.
67. Cotton MM, Partridge MR. Infection with feline *Chlamydia psittaci*. *Thorax*. 1998;53:75-76.
68. Reed KD, Moore FM, Geiger GE, Stemper ME. Zoonotic transmission of sporotrichosis: case report and review. *Clin Infect Dis*. 1993;16:384-387.
69. Wynne JJ, Jenkins PA. Is tuberculosis in domestic cats hazardous to human beings? *Lancet*. 1995;346:442-443.
70. Zanusso G, Nardelli E, Rosati A, et al. Simultaneous occurrence of spongiform encephalopathy in a man and his cat in Italy. *Lancet*. 1998;352:1116-1117.