**Chapter 42**

**Zoonoses in Cancer Patients**

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**Abstract** Prevention of zoonoses in cancer patients is the theme of this chapter and it is hoped that it will encourage and help doctors caring for such patients to educate them to avoid the infections. Avoidance need not include separation from a pet or occupation or recreation, but the use of caution conditioned by knowledge of the sources of infection and the ways we contact them should lead to effective prevention.

**Keywords** Zoonoses • Immunocompromised cancer patients • Prevention • Epidemiology • Hygiene • Veterinarians

Zoonoses are defined as infectious diseases, which are transmitted from nonhuman animals to man. According to one study [1] there are 1,415 organisms that infect man and of these 868 (61%) can cause zoonoses. A number of these have a predilection for infecting and for being especially severe in the immunocompromised host [2–4]. Because of this, prevention is extremely important for patients with neoplastic disease and immune defects associated with the neoplasm or its therapy. Immune defects can be categorized as indicated in Table 1.1 [5] and they are discussed extensively in other chapters. This chapter will stress the prevention of zoonoses in patients with neoplastic disease including those who appear to have intact immune responses for that may change with progression of disease or future chemotherapy or irradiation. It must be stressed that pets are extremely important to most humans and often especially to those who are ill. They provide companionship or they can be the objects of biological interest and study. Nonhuman animals provide occupations for large numbers of humans. Contact with various species can result in infections, however, and these can be especially severe in patients with immune defects. There are far too many examples to be included in this chapter, thus the most common will be discussed along with some of the rarer examples, which may be emerging infections and therefore of particular interest. The aim of this chapter is to encourage doctors to educate their patients so that they are aware of these dangers and how best to avoid them.

Unusual contact such as kissing, nuzzeling, and even touching [6–8], in an uncontrolled setting, pets and other animals should be discouraged. And, of course, simple hygiene such as hand washing should be stressed. In addition, patient and at times medical doctor contacts with veterinarians is important so that non human animals will receive preventive care as well as care for apparent illnesses.

In addition, in some difficult situations such as a question of whether to initiate rabies vaccine, departments of public health, city or state or the Centers for Disease Control can be very helpful.

**Epidemiology**

On June 1, 1778, Edward Jenner introduced his paper on vaccination with cowpox to protect against smallpox with the following words [9]. “The deviation of man from the state in which he was placed by nature seems to have proven to him a prolific source of diseases. From the love of splendor, from the indulgences of luxury and from his fondness for amusement, he has familiarized himself with a great number of animals, which may not originally have been intended for his associates. The wolf disarmed of ferocity is now pillowed in the lady’s lap. The cat, the little tiger of our island, whose natural home is the forest, is equally domesticated and caressed.” I assume Dr. Jenner would be amazed, if not appalled at the number and variety of pets owned by people on his island and worldwide – and how pets, wild animals that have contact with pets and people travel, meet and exchange microorganisms. In evaluating the epidemiology of zoonoses there are four major factors to take into account; Geography, the Home, Occupation and together, Habits and Hobbies. Transmission of infections from humans to nonhuman pets has been observed with associated illness. It should be considered especially when either host could be
a carrier with reinfection occurring (“ping-pong infections”). Two other methods of exposure, bioterrorism and xenotransplantation, will not be discussed in this chapter.

Geography

World travel of both people and pets has allowed and continues to present opportunities for spread of zoonoses. Not only people or pets can carry microorganisms but vectors such as mosquitoes can travel by plane and introduce new organisms to a new environment. An example of this is West Nile Virus that came from the Middle East to New York City and then moved across the continent to the west coast of the United States. It has been postulated that the trip across the Atlantic was via mosquitoes on a plane and that the transcontinental trip was by infected crows or humans or other birds. In addition, wild birds migrating over thousands of miles may bring organisms from and to domesticated or wild avian species and thus to humans.

A history of travel of a human should be routinely obtained and should include exposures to pets belonging to the patients and also belonging to friends or neighbors. A pet travel history can be equally important in revealing zoonotic exposures. Vacation plans should be discussed and patients educated about avoiding endemic areas for zoonoses such as the southwestern USA (plague) or babesiosis on islands off the northeastern coast.

Home

Our homes may be shared with mice, rats, and bats among others, each carrying microorganisms that can infect humans and may be lethal particularly in immunocompromised individuals. Some may choose these animals for “pets” including bats by putting out nesting “bat boxes,” others may find them as unwelcome “guests.” They are difficult to exclude or evict from a home, but it is wise to do so and professional exterminators may be necessary in some instances. Raccoons may make themselves “at home” especially when food may be available in uncovered garbage. Raccoons may bite when they feel cornered or threatened. They may carry rabies. Young raccoons may carry a roundworm parasite, Baylis ascaris procyonis that human toddlers may ingest from raccoon feces that can result in brain abscesses.

Occupations

Veterinarians in practice are constantly exposed to pets and farm animals and in some cases to zoo animals. They should be vaccinated against rabies. In the southwestern USA veterinarians have contracted the plague from treating infected cats which are especially prone to be infected or carry fleas from wild rodents. In addition to veterinarians, butchers, abattoir workers, farmers, ranchers, biologists, zoo workers and animal breeders are all liable to be exposed to zoonoses in their daily work. Animal husbandry can expose farmers to three Brucella species and Q fever from birth products of cows, goats, and pigs. Microbiologists have been infected with a number of organisms especially Brucella spp. and Mycobacterium tuberculosis.

Habits and Hobbies

Some people are more regularly exposed to the microflora of pets by sleeping with them or kissing them while the pet licks the humans’ mouths. Changing cat litter exposes people to toxoplasmosis. In addition sandboxes can be used by neighbors’ or feral cats and serve as a source for Toxoplasma gondii to infect children. Changing papers from bird cages (as well as handling and kissing birds) may expose owners to ornithosis, salmonellosis, or cryptococcosis, the latter two being well recognized opportunistic pathogens. Hunting and dressing prey can include exposure to tularemia, or brucellosis and even horse back riding can include exposure to mice and rats living with the horses in the stables and shedding their organisms. In addition, Rhodococcus equi, is an opportunistic pathogen which has been associated with horse contact.

Since dogs, cats, and birds are the most common pets and live closest to their human owners, they will receive the most attention.

Dogs (Table 42.1)

Dog bites frequently result in infections just as human bites do and the mouth flora bacteria causing infection are similar with the exception of Pasteurella multocida and Capnocytophaga canimorsus, which are more commonly found in dog bites. Both the organisms are sensitive to beta lactams and augmentin. The most important feature of bites, however, is that anaerobes may flourish in the presence of dead tissue so that drainage is all important. Prevention is dependent on education of children and adults about caution with strange dogs and with their own pet dogs, which may bite because of fear often combined with surprise such as stumbling on the pet. Other infections from dogs may be from organisms carried in their gastrointestinal tracts and hygienic measures must be stressed in all potential hosts, but especially those who are immunocompromised. Particular care should be taken with dogs with loose stools. Dog saliva or sputum may carry Bordetella bronchiseptica, an opportunistic
pathogen, which can produce a whooping cough-like illness in the immunocompromised patient. Dog saliva can also be colonized with *Yersinia pestis*. *Leptospira* spp. can be passed onto humans from dog urine producing leptospirosis. An increase in incidence of this infection has been reported in humans in suburban areas. Dog fleas and ticks should be controlled as indicated in Table 42.1 as part of routine veterinary care and if found should be removed immediately using tweezers or gloves and dropped in alcohol, a toilet or a campfire.

Among the fungi, *Blastomyces dermatitidis* has been associated with dog contact, but it maybe the soil with which both human and dog have contact, which is the vector. Dermatophytes may cause severe skin infections in patients with T-cell defects and when seen in a dog should be cared for promptly.

| Organisms                              | Exposures                        | Prevention | Diagnosis                  | Treatment                             |
|----------------------------------------|----------------------------------|------------|----------------------------|---------------------------------------|
| *Bacteria*                             |                                  |            |                            |                                       |
| Mixed mouth flora including *Streptococcus pyogenes* MSSA or MRSA | Bites                            | Avoid      | Smear and culture          | Augmentin, usually empiric, drain when necessary |
| *Pasteurella multocida*                | Bites                            | Avoid      | Smear and culture          | Augmentin, usually empiric, drain when necessary |
| *Capnocytophaga canimorsus*            | Bites                            | Avoid      | Smear and culture          | Augmentin, usually empiric, drain when necessary |
| *Brucella canis*                       | Urine and birth products         | Avoid      | Smear and blood culture    | Tetracycline                           |
| *Bordetella bronchoseptica*            | Saliva or sputum                 | Avoid      | Serology, culture and smear| Tetracycline                           |
| *Salmonella spp. (except *Salmonella typhosa*)* | Feces                            | Avoid      | Culture stool and blood    | Quinolone, susceptibility prn          |
| *Campylobacter spp.*                   | Feces                            | Avoid      | Culture stool and blood    | Quinolone or macrolide susceptibility prn |
| *Yersinia pestis*                      | Fleas, sputum                    | Carefully remove | Culture blood and lymph node, sputum | Gentamicin ± quinolone empiric prn |
| *Francisella tularensis*               | Ticks, skincuts                   | Carefully remove | Culture blood and skin lesion | Quinolone or aminoglycoside             |
| *Leptospira* spp.                      | Urine                            | Avoid      | Serology, PCR              | Penicillin, tetracycline               |
| *Borrelia burgdorferi*                 | Ticks                            | Avoid, remove immediately (within 24 h) | Blood smear, culture PCR | Tetracycline                           |
| *Anaplasma phagocytophilum*            | Ticks                            | Avoid, remove immediately | Blood smear, culture PCR | Tetracycline                           |
| *Ehrlichia* spp.                       | Ticks                            | Avoid, remove immediately | Blood smear, culture PCR | Tetracycline                           |
| *Rickettsia rickettsii*                | Ticks                            | Avoid, remove immediately | Serology, PCR, skin biopsy | Tetracycline                           |
| *Fungi*                                |                                  |            |                            |                                       |
| *Blastomyces dermatitidis*             | Sylvan soil on pets              | Keep clean | Smear and culture          | Amphotericin B                         |
| *Microsporon* spp.                     | Hair or lesions                  | Keep clean and treat | Smear and culture          | Topical azole                          |
| *Trychophyton* spp.                    | Hair or lesions                  | Keep clean and treat | Smear and culture          | Topical azole                          |
| *Parasites*                            |                                  |            |                            |                                       |
| *Giardia lamblia*                      | Feces                            | Avoid      | Stool exam                 | Metronidazole                          |
| *Babesia* species*                     | Ticks                            | Remove, tick powder | Blood smear serology       | Clindamycin + quinine, atovaquone + azithromycin |
| *Toxocara canis*                       | Feces                            | Avoid      | Smear                      | Mebendazole or thiabendazole           |
| *Dipylidium caninum*                   | Feces, fleas                     | Avoid      | Smear                      | Niclosamide                            |
| *Dirofilaria immitis*                  | Mosquitoes                       | Avoid      | Smear                      | Extirpation                            |
| *Echinococcus granulosus*              | Feces                            | Avoid      | Smear or biopsy            | Albendazole or extirpation             |
| *Ankylostoma caninum*                  | Feces                            | Avoid      | Smear or biopsy            | Albendazole                            |
| *Cryptosporidium* spp.*                | Feces                            | Avoid      | Smear                      | Paramomycin, nitazoxanide, azithromycin |
| *Viruses*                              |                                  |            |                            |                                       |
| *Rabies* virus                         | Bites, saliva                     | Avoid, vaccine | PM on dog                 | Presumptive vaccine therapy            |
| LCM virus*                             | Urine                            | Avoid      | Serology, PCR              | Supportive                             |
| Influenza virus*                       | Respiratory secretions           | Avoid, vaccine | Sputum smear serology, PCR | Oseltamivir, zanamivir                |
| Mumps virus*                           | Respiratory secretions           | Avoid, vaccine | Saliva                    | Supportive                             |

*Opportunistic pathogen*
Parasites are usually passed from dogs to humans via feces. *Dipylidium caninum*, the dog tapeworm, however, is transmitted by infected fleas, usually ingested by children. *Dirofilaria immitis*, the dog heartworm is transmitted via mosquitoes and can be prevented by prophylaxis of the dog as directed by a veterinarian.

Viruses can be transmitted by various routes, usually respiratory or by saliva. The frequency of spread of influenza viruses to humans is unclear, but should be prevented by immunization of humans. An immunosuppressed patient may not show a normal antibody response, but some protection may result. In the event of a novel influenza virus such as H1N1, when a vaccine is not available, respiratory precautions should be used. Rabies should be considered in any dog bite. If rabies cannot be ruled out in the dog, prophylactic vaccine should be administered to the patient. The regimen should include five inoculations in an immunocompromised host rather than the four now recommended for the normal host [10].

**Cats (Table 42.2)**

Most infections we get from cats (with the possible exception of bites) are from free roaming cats, which acquire the zoonotic infection from other animals in the wild. Cats carry many of the same organisms as dogs and bites result in the same types of infections. The bites are usually associated with stepping on the cat, startling it in some other fashion or holding it against its will. Cleansing and draining are important just as for dog bites.

Cat scratch disease due to *Bartonella henselae* has been associated with cat scratches of minimal size as well as larger and sometimes none are apparent at all. Kittens are often the carriers, especially those which roam outside. Feral cats are much more likely to be infected than house cats [11].

Q fever due to *Coxiella burnetii* usually follows exposure to farm animals, but cats – especially farm cats can carry it and pass it to humans through exposure to birth products.

The Plague due to *Y. pestis* can be transmitted to humans by cat fleas or if the cat is sick with pneumonia the organism can be carried in the saliva or sputum. The cats contract the infection or fleas from rodents. The organism is endemic to the USA southwest, but can also be found worldwide. Tularemia due to *Francisella tularensis* can be contracted from direct contact with rabbits or from ticks from cats as well as dogs and is endemic to the southern USA.

The ubiquitous gastrointestinal pathogens *Campylobacter* spp. and *Salmonella* spp. can be transmitted through cat feces.

Among the fungi, *Cryptococcus neoformans* or *Cryptococcus gattii* may be carried by cats especially in nasopharyngeal granulomas. How often they may be passed to humans is uncertain, but nuzzling cats when immunosuppressed should be avoided.

| Table 42.2 Cats associated zoonoses in cancer patients |
|--------------------------------------------------------|
| **Organisms** | **Exposures** | **Prevention** | **Diagnosis** | **Treatment** |
| Bacteria | | | | |
| Mixed mouth flora | Bites | Avoid | Smear and culture | Drain prn augmentin |
| including *S. pyogenes* and MSSA | | | | |
| *Pasteurella multocida* | Bites | Avoid | Smear and culture | Drain prn augmentin |
| *Capnocytophaga* spp. | Bites | Avoid | Smear and culture | Drain prn augmentin |
| *Bartonella henselae* | Bites scratches | Avoid | Smear and culture serology | Drain prn azithromycin or beta lactam |
| *Coxiella burnetii* | Exposure to birth products | Avoid | Blood, lymph node biopsy culture | Tetracycline |
| *Yersinia pestis* | Saliva/spitum fleas | Avoid, flea powder | Smear and culture serology | Gentamicin ± quinolone, empiric prn |
| *Francisella tularensis* | Ticks, sores, cuts | Remove, tick powder | Smear and culture | Quinolone or aminoglycoside |
| *Campylobacter* spp. | Feces | Avoid | Culture feces ± blood | Quinolone or macrolide |
| *Salmonella* spp. | Feces | Avoid | Culture feces ± blood | Beta lactam or quinolone |
| Fungi | | | | |
| *Cryptococcus neoformans* | Nasal secretions | See DVM avoid | Smear and culture antigen detection | Amphotericin B + 5FC fluconazole |
| Dermatophytes | Skin lesions | See DVM avoid | Smear, culture | Topical azoles |
| Parasites | | | | |
| *Toxoplasma gondii* | Feces | Avoid | Serology biopsy | Sulfapyrimethamine |
| *Ancylostoma caninum* | Feces | Avoid | Stool exam | Albendazole |
| *Echinococcus multilocularis* | Feces | Avoid | Stool exam | Albendazole |
| Viruses | | | | |
| Rabies virus | Bites, saliva | Avoid, vaccine | Biopsy of contact | Vaccine |
| Cowpox virus | Skin lesions | Avoid | Smear, culture | Supportive |

*Opportunistic pathogen*
Just as with dogs, cat dermatophytes should be controlled in consultation with a veterinarian.

*T. gondii* is the most significant opportunistic parasite carried by cats, which takes advantage of T-cell defects. It is widespread in nature, found in mice and other rodents which transmit it to cats, which can then pass it to humans through their feces. In the normal host most infections are asymptomatic or mild, but severe disease including brain abscesses may be seen in highly susceptible patients. Since many of the disseminated infections are due to unpredictable reactivation of latent infections it is impractical to use antimicrobial prophylaxis for all patients with antibody indicating previous infection. Very low T cells (<200 cells/μL) should be a consideration for prophylaxis. It is prudent to advise all patients at risk to avoid cat feces and specifically not to empty “kitty litter” boxes. Somebody else in the household should.

*Ancylostoma caninum* and *Echinococcus multilocularis* can be contracted from cat feces as well as from dogs

Among the viruses, cats can transmit rabies and should be vaccinated and kept up to date just as with dogs.

Cowpox virus can be transmitted to humans from exposure to infected cats [12]. Infections can be severe and persistent in humans and especially in those in the habit of nuzzling the cat’s nose where the virus may be carried with or without evident lesions. In humans, the lesions can be destructive locally or in the immunocompromised, disseminate. It is possible that an apparent increase in these infections in Europe is associated with loss of immunity among the general population due to cessation of smallpox vaccinations with vaccinia virus (cowpox) vaccine.

**Birds (Table 42.3)**

It is not easy to avoid bird feces, especially if the birds are kept as pets. Some one has to clean the cages and it should not be an immunocompromised host. The best known organism is *Chlamydia psittaci*, the cause of parrot fever or psittacosis, which should be called ornithosis because any bird can be a carrier not just psitticines or parrot-like birds. Most birds purchased in pet shops have been quarantined before sale and thus should be cleared of the danger of carrying *C. psittaci*, but regularly birds are sold without this precaution, especially by unauthorized dealers.

Birds may also carry *Campylobacter* and *Salmonella* species.

Very rarely members of the parrot family have carried *M. tuberculosis* and infected humans [13]. Such birds are usually symptomatic exhibiting weight loss, ruffled feathers, hoarseness and lymphadenopathy.

*Histoplasma capsulatum* find the feces of birds a rich source of nourishment and colonize their gastrointestinal tracts as well as the feces. The fungus grows in abundance particularly in the feces of chickens and “blackbirds” including swallows and starlings. Chicken farms and coops, chimneys, blackbird roosts in belfries, or cospes should be avoided by the immunocompromised host.

*C. neoformans* is classically known to flourish in pigeon feces, but also has been isolated from a patient with cryptococcal meningitis and his parakeet with genetically identical fungi [14].

**Table 42.3**  Birds associated zoonoses in cancer patients

| Organisms                      | Exposures                      | Prevention          | Diagnosis                          | Treatment                         |
|--------------------------------|--------------------------------|---------------------|------------------------------------|-----------------------------------|
| **Bacteria**                   |                                |                     |                                    |                                   |
| *Chlamydia psittaci*           | All birds                      | Avoid feces         | Sputum smear, culture              | Tetracycline, erythromycin        |
| *Salmonella* spp.              | All birds                      | Avoid feces         | Stool culture                      | Beta lactam, fluoroquinolone      |
| *Campylobacter* spp.           | All birds                      | Avoid feces         | Stool culture                      | Azithromycin, fluoroquinolone     |
| *Mycobacterium tuberculosis*   | Parrot family                  | Avoid respiratory secretions | Smear, culture, PCR               | Quadruple therapy                 |
| **Fungi**                      |                                |                     |                                    |                                   |
| *Histoplasma capsulatum*       | Blackbirds, chickens           | Avoid feces         | Smear, culture, sputum urine antigen | Azoles or amphotericin B          |
| *Cryptococcus neoformans*      | Pigeons, psitticines           | Avoid feces         | Antigen in CSF or serum smear, culture | Azoles or amphotericin B±5FC     |
| **Parasites**                  |                                |                     |                                    |                                   |
| *Cryptosporidium* spp.         | Wild or caged birds            | Avoid feces         | Stool smear                        | Nitazoxanide                      |
| *Giardia lamblia*              | Wild or caged birds            | Avoid feces         | Stool smear                        | Metranidazole                     |
| **Viruses**                    |                                |                     |                                    |                                   |
| *Influenza viruses*            | Ducks, chickens, migrating birds | Vaccine, avoid feces | Sputum smear, culture, PCR         | Smear, culture, PCR               |
| *Alphaviruses*                 | Migrating birds                | Avoid mosquitoes    | Culture, serology                  | Supportive care                   |
| *Flaviviruses*                 | Migrating birds                | Avoid mosquitoes    | Culture, serology                  | Supportive care                   |
| *West Nile virus*              | Migrating birds                | Avoid mosquitoes    | Culture, serology                  | Supportive care                   |

*Opportunistic pathogen*
Among the parasites, Cryptosporidia species have been isolated from wild or caged birds and implicated in infecting humans. A rare occurrence has been the finding of *Giardia lamblia* causing diarrheal disease in a patient and his love birds.

Farm birds such as chickens, turkeys, ducks, geese and others, and wild migrating birds of all sorts have proven to be a rich source of viral infection for humans. Many of these infections such as influenza are spread through the feces and others are the result of mosquitoes carrying the virus from birds to humans. These include alphaviruses and flaviviruses causing encephalitis. An excellent example is the West Nile virus, which so readily crossed the North American continent with migrating birds and mosquitoes infecting horses as well as humans.

**Less Common Pets or Contacts (Table 42.4)**

**Mammals**

Rodents: The usual pathogens passed from rodents to humans are mouth flora from bites usually including *P. multocida*, and fecal spread of *Campylobacter* spp. and *Salmonella* spp. Mice in the southwestern USA carry Hanta virus, which regularly causes a fatal pneumonia. Mice and hamsters may carry lymphocytic choriomeningitis virus and mice may also harbor mites that carry *Rickettsia akari*, which cause rickettsialpox.

Prairie dogs (some people keep as pets) along with other wild rodents may carry plague or tularemia (especially rabbits), and ferrets may carry influenza. Raccoons, in addition to rabies, may carry a parasite, *B. ascaris* whose eggs maybe ingested from stools especially by infants playing in dirt, resulting in encephalitis. Pet rats may carry *Streptobacillus moniliformis* [15, 16] resulting in endocarditis in owners.

Bats are the most common carriers of rabies in the USA. They are to be avoided. Fruit bats have been implicated in Australia and Indonesia in transmitting encephalitis viruses that infect horses and humans in the former and pigs and humans in the latter. Bats are also carriers of the SARS corona virus in addition to civet cats and raccoon dogs in Asia.

Beasts of burden: Horses can transmit rabies. They also serve as an intermediate host for encephalitides (Eastern, Western and Venezuelan Equine, and West Nile virus) via mosquitoes to humans. Horse associated *R. equi* can cause severe disease, which manifests by skin and pulmonary lesions in patients with T-cell defects.

Farm animals: Brucellosis can be acquired from cows, pigs, and goats. They are popular in petting zoos and should be handled with special precautions by the zoo keepers and visitors. It is best not to pet them. This includes sheep which may infect humans with orf virus, which cause large pustular skin lesions. Cows may excrete *Escherichia coli* 0157:H4, which can cause lethal disease in humans. Bovine tuberculous due to *Mycobacterium bovis* can cause invasive infection in the immunosuppressed patient. Water buffalo urine can be a rich source of *Leptospira* spp. for human infections.

Nonhuman primates: Even in the immunocompetent, human *Herpes simiae* infection is close to 100% lethal due to encephalitis. Rhesus, cynomolgus or vervet monkeys should not be kept as pets. They can be asymptomatic carriers of this potentially fatal herpes virus. Animal handlers should be trained to work with monkeys, which should be free from infection before contact. Even so, trained animal handlers have died due to this infection.

The highly lethal Marburg and Ebola viruses can also be transmitted from monkey to man.

Monkey pox virus can cause local lesions in man and even disseminate causing a smallpox like disease. A recent outbreak in the USA was caused by a Gambian rat, which developed monkey pox lesions after arriving in a pet store where the infection was transmitted to American prairie dogs, which were sold as pets and resulted in multiple cases in humans. Physicians and public health officials included small pox in the differential diagnosis causing quite a stir in several communities [17].

Chimpanzees have been kept as pets and can infect humans with *M. tuberculosis* or carry human malaria. They have become infected with measles, hepatitis A virus, or influenza virus along with *Streptococcus pneumoniae* and *Staphylococcus aureus*. Intestinal pathogens such as giardia and Strongyloides can be excreted by chimpanzees.

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**Table 42.4** Less common pets or contacts

| Mammals                        |
|-------------------------------|
| Rodents: mice, rats, hamsters, gerbils, guinea pigs, rabbits, ferrets, and raccoons |
| Beasts of burden: horses, mules, donkeys, oxen, camels, and water buffalo |
| Farm animals: cattle, pigs, sheep, goats, and Yaks |
| Nonhuman primates: chimps, rhesus, cynomologus macaques, lemurs, and marmosets |
| Bats: all species |

| Birds                         |
|-------------------------------|
| Canaries, finches, parakeets, parrots, and lovebirds |
| Chickens, ducks, geese, and turkeys |
| Wild birds – at feeders, in shelters, and shot by hunters |

| Reptiles                      |
|-------------------------------|
| Snakes, lizards, turtles, alligators, and horned toads |

| Amphibians                    |
|-------------------------------|
| Frogs, toads, salamanders, and newts |

| Fish                          |
|-------------------------------|
| Aquarium fish, caught, commercial or sport fish, and farmed fish |

*Note: see text for discussion*
Birds

In addition to commonly kept birds, chickens, ducks, turkeys, and geese can carry *C. psittaci* and strains of influenza. The avian flu strain, H3N1 has been isolated from many different birds, but chickens appear to be the primary source of the cases first described. Wild migrating birds often mix with flocks of farmed birds and can carry an organism thousands of miles. Humans who keep bird feeders filled are regularly exposed to bird excreta, which may carry organisms listed in Table 42.3 or in addition to those adenoviruses.

Reptiles

Snakes, lizards, turtles, alligators, or horned toads may all carry enteric pathogens and excrete them into terrarium soil or water sources.

Amphibians

Frogs, Toads, salamanders, or newts may carry the same organisms as reptiles and excrete them into their water or soil.

Fish

Aquarium fish may carry and excrete into their water *Mycobacterium marinum*, which can cause nodular skin lesions or disseminate in immunosuppressed patients. Farmed fish may carry *Vibrio*, vulnificus which causes especially severe gastroenteritis in the presence of immune defects. People handling fish commercially or in home preparation may be exposed to *Streptococcus iniae* or *Erysipelothrix rhusiopathiae*, both of which may cause local skin lesions or disseminate.

Foot Note

For detailed instructions on prevention of infections, which can apply to cancer patients, the CDC has published two compendia [18, 19] on the subject in HIV infected people. These can be applied to children and adults with T-Cell mediated immune defects and these are the patients most likely to develop opportunistic zoonotic infections. These are excellent reference documents.

Summary

Prevention of zoonoses in cancer patients is the theme of this chapter and it is hoped that it will encourage and help doctors caring for such patients in educating them to avoid such infections. Avoidance need not include separation from a pet, or occupation, or recreation, but the use of caution conditioned by knowledge of the sources of infection and the way we may contract them should lead to effective prevention.

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