A 76-year-old man originally from Barbados was admitted to hospital after experiencing one month of progressive generalized weakness that culminated in his inability to carry out independent activities of daily living. The patient’s medical history included hypertension, type 2 diabetes, previous smoking (20 pack-years) and diabetic nephropathy that resulted in a kidney transplant six years earlier. After transplantation surgery, the patient had experienced stage 5 chronic renal insufficiency as a result of progressive allograft dysfunction. The patient was taking an immune suppression regimen consisting of extended release tacrolimus (25 mg/d), mycophenolate mofetil (720 mg, twice daily) and prednisone (5 mg/d). Other medications taken by the patient included labetolol, amlodipine, calcitriol and darbopoietin α.

The patient reported having a decreased appetite and undergoing a 6-kg weight loss during the previous month, without fever, chills or night sweats. Several small painless peripheral nodular skin lesions had also developed over a two-month period. The patient reported no other symptoms during the review of systems. He had not recently travelled outside of Quebec and had no sick contacts. However, he owned several pet fish, which he kept in a fresh water aquarium that he cleaned himself twice each month.

On initial physical examination, the patient had no fever and had normal vital signs. He was alert and oriented, with no lateralizing signs. He had temporal muscle wasting and a body mass index of 19 kg/m². We found six ulcerated lesions, the largest of which was 2 cm in diameter, on the dorsal hand, forearm and legs (Figure 1). We felt no lymphadenopathy or hepatosplenomegaly. The results of initial laboratory investigations are presented in Box 1.

We biopsied a skin lesion on the patient’s left forearm, and microbiological testing showed acid-fast bacilli. Radiography of the patient’s chest showed bilateral nodular densities, and computed tomography confirmed the presence of multiple pulmonary nodules (Figure 2). Gastroscopy showed multiple millimetric black mucosal discolourations in the duodenum (Figure 3A and 3B). The lesions were thought to be evidence of disseminated mycobacterium to the gastrointestinal tract. The patient was

**KEY POINTS**

- Zoonotic infections can be life-threatening for patients with compromised immune systems; knowing the mechanisms of transmission and avoiding exposure to pets with a high risk of transmission can help prevent their acquisition.
- Patients with a high risk of acquiring a zoonotic infection include patients with HIV, patients with a solid or hematologic tumour, and patients who are receiving certain immunesuppressive medications, either alone or in combination.
- In the absence of prevention, early recognition of a zoonotic infection and directed antimicrobial therapy may substantially improve outcomes.
- Physicians and other health care practitioners have an important role in educating patients and family members regarding measures to prevent pet-transmitted infections.
started on empirical treatment consisting of imipenem/cilastin, tigecycline and rifampin. Tuberculosis cultures of the blood showed the presence of *Mycobacterium marinum* within seven days. Extended treatment with monocycline andrifampin was started. In addition, bronchoalveolar lavage fluid grew *Mycobacterium marinum* within three weeks. Fish tank maintenance was considered the culprit source, resulting in disseminated *Mycobacterium marinum* infection in our patient who had a compromised immune system.

Despite receiving appropriate antimycobacterial therapy to which his skin lesions responded, the patient remained deconditioned from a prolonged stay in hospital. He had progressive allograft failure and required intermittent hemodialysis. His stay was further complicated by an asystolic cardiac arrest, with subsequent anoxic brain injury, and multisystem organ failure that resulted in his death. An autopsy confirmed disseminated *Mycobacterium marinum* infection of mediastinal, hilar and subcarinal lymph nodes, the proximal small intestinal mucosa, spleen, liver, lungs and skin (Figure 4).

**Figure 2:** Computed tomography of the chest showing large nodular opacities and diffuse ground glass opacities.
Discussion

The accurate diagnosis of zoonotic infections can be challenging in patients with compromised immune systems owing to the uncommon nature of many of these infections and presenting symptoms that may be subtle during early stages of infection. Our patient’s case exemplifies how zoonotic infections can rapidly become life-threatening in this population. Household pets, such as reptiles, fish and birds, are increasingly encountered in North American households.1 As a greater number of patients are exposed to immune suppression, the possibility of patients with compromised immune systems interacting with pets increases. Among more than 200 known zoonotic infections, 40 are transmitted by pets.2 Thus, patients should be properly informed regarding general measures to prevent transmission.

Risks of zoonosis transmission
Medical conditions and therapies can result in immune deficiency. High-risk immune-compromising conditions include solid organ and hematologic cancers, transplants, HIV infection, congenital immunodeficiencies, and asplenia or splenectomy.3 High-risk medical treatments include high-dose steroids (> 20 mg/d prednisone for ≥ 4 wk), chemotherapy and radiation therapy, tumour necrosis factor inhibitors, antimetabolites, T cell–depleting agents, interleukin-2 receptor antagonists, calcineurin inhibitors and mammalian target of rapamycin inhibitors (Box 2).

Various immunosuppressive drugs and disease states have differential effects on B and T cell function, in addition to complement inhibition. For this reason, not all states of immune deficiency are equal in terms of risk of infection. Data on specific infectious complications associated with certain drug classes prescribed after solid organ transplantation are available through antimicrobe.org.4

Regarding nontuberculous mycobacteria, higher rates of infection are associated with loss of T cell function, decreased production of interferon or tumour necrosis factor α (TNFα), and specific therapies such as moderate to high doses of steroids (> 10 mg/d prednisone), medications targeting TNFα, interleukin-12/23, or Janus kinase (JAK),5,6 and mycophenolate mofetil–containing immune suppression regimens.6

Exposure to pets is common for patients with immune-compromising conditions. In one study, pets were found in 55% of households that included a member with an immune-compromising condition.1 High-risk pets, identified based on higher transmission rates, should be avoided. These pets include cats and dogs aged 6 months or younger, reptiles and amphibians, rodents and young poultry.1 In a study that involved children with cancer, 77% of pets acquired shortly after the diagnosis of cancer were high risk.7

Certain work environments and public spaces increase the risk of transmission of zoonotic infections (Box 2). Pet shop employees may contract salmonellosis or psittacosis from birds and rodents.8 Veterinary clinics are associated with the transmission of Bartonella, Brucella, methicillin-resistant Staphylococcus aureus and Salmonella.9,10 Exposure to cattle on farms can lead to cryptosporidiosis,10 and petting zoo animals should be avoided given their potential for colonization with Salmonella and Campylobacter.2 Additional infectious vectors that are important to consider include plants, fresh flowers and certain foods.10

Physicians play an important role in counselling patients on the risk of zoonosis. Stull and colleagues showed that physicians query pet-ownership in less than 50% of pet-owning families of children with cancer.7 Routine counselling tailored to a patient’s exposure may help with early recognition and prompt treatment of these infections. Veterinary staff are also potential information providers for pet owners with compromised immune systems.3

Measures to prevent transmission
In 2010, the Centers for Disease Control and Prevention (CDC) published guidelines for the prevention of opportunistic infections.11 They recommend the following strategies to reduce zoonotic infections in this population:

- Avoid high-risk pets, identified based on higher transmission rates. These pets include cats and dogs aged 6 months or younger, reptiles and amphibians, rodents and young poultry.2
- Avoid certain work environments and public spaces that increase the risk of transmission of zoonotic infections (Box 2).
- Consult with the patient’s veterinarian before acquiring a new pet.
- Discuss general measures to prevent transmission with patients.

Figure 3: (A) Diffuse millimetric black discoloration of the duodenal mucosa found on gastroscopy; (B) close-up view.

Figure 4: Images taken postmortem showing (A) diffuse large mesenteric necrotic lymphadenopathy in the duodenum and jejunum, (B) bilateral mediastinal, hilar and subcarinal lymphadenopathy and pale brown non-caseating nodules in the lung, (C) massive necrosis of the spleen and (D) Mycobacterium infection (dark blue) of a lymph node (original magnification × 400).
Handling cats and dogs should be done with care to avoid scratches and bites, and cat nails should be kept short. Saliva can transmit *Staphylococcus* species from dogs, and *Bartonella henselae* or *Pasturella multocida* from cats. *Capnocytophaga canimorsus* infection from dog bites is uncommon, but can rapidly progress to shock and death. Handling of rodents, fish and reptiles can transmit *Salmonella* and *Campylobacter*. Patients should be reminded that wounds, venous catheters, rashes and mucositis are examples of high-risk skin barrier rupture. All wounds and portals of entry should be protected from contact with animals and their habitat. *Mycobacterium marinum* can be acquired from fish tanks through skin-barrier rupture, even in patients with competent immune systems, and may start as a single small lesion, before progressing to more severe, disseminated disease.

Finally, pets should not be fed raw meat or eggs, and should only be allowed to drink clean water (not toilet water). Stray animals should not be brought into the home, and cats should stay indoors. As a general rule, sick pets should be brought to the veterinarian, and all pets should undergo routine vaccination.

**Conclusion**

Early recognition and prompt initiation of directed antimicrobial therapy can substantially affect the outcome of pet-transmitted zoonotic infections in patients with compromised immune systems. As shown in our patient’s case, some zoonotic infections can disseminate and have a life-threatening course. Despite a quick diagnosis and targeted therapy, disseminated *Mycobacterium marinum* infection contributed to the death of our patient. Patient education on preventing pet-transmitted infections should be the standard of care for patients at risk of zoonosis because of a compromised immune system.

**References**


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The section Cases presents brief case reports that convey clear, practical lessons. Preference is given to common presentations of important rare conditions, and important unusual presentations of common problems. Articles start with a case presentation (500 words maximum), and a discussion of the underlying condition follows (1000 words maximum). Visual elements (e.g., tables of the differential diagnosis, clinical features or diagnostic approach) are encouraged. Consent from patients for publication of their story is a necessity. See information for authors at www.cmaj.ca.