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CRITICAL REVIEW

Tick-borne diseases: From well-known Lyme disease to deadly Powassan encephalitis

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ABSTRACT

Tick-borne diseases are prevalent throughout central and eastern Canada, including Ontario. Of the many infections transmissible through tick bites, Lyme disease is the most well-known. However, lesser known tick-borne diseases, such as Powassan encephalitis, can have debilitating, or even lethal complications. The incidence of all tick-borne infections has increased over the past decade, with reported cases of Lyme disease seeing a tenfold increase. Identifying both Lyme disease and Powassan encephalitis can be challenging, as patients only show abnormalities in the later stages of disease progression. Even following successful treatment for Lyme disease, patients may continue to suffer from chronic disease sequelae. As tick populations continue to increase, primary prevention is the most effective method of combating tick-borne diseases.

INTRODUCTION

Throughout central to eastern Canada, ticks are frequently found during warmer times of the year, typically in late spring to early fall. In Hamilton, the most commonly encountered tick is the American dog tick (*Dermacentor variabilis*), which does not transmit any tick-borne diseases. However, observation of tick populations in Hamilton in 2017 reported new evidence of blacklegged tick populations.¹ Blacklegged ticks, or *Ixodes scapularis*, are the primary vector for Lyme disease and other infections, including anaplasmosis, babesiosis, ehrlichiosis, tularemia, and Powassan encephalitis.²

LYME DISEASE

Lyme disease is the most well-known tick-borne disease worldwide, and the most prevalent tick-borne disease in North America. By 2020, 80% of central and eastern Canada's population could live in high risk areas for Lyme disease.³ *Borrelia burgdorferi*, a spirochete bacteria transmitted to humans through tick bites, is the primary cause of Lyme disease. Ticks must be attached for at least 24 hours before infection becomes possible. Infection is certain should the tick carrying *B. burgdorferi* be attached for over 72 hours.⁴ Early discovery and removal of ticks is the best way to prevent contraction of Lyme disease.⁴

Lyme disease manifests through progressive stages. The earliest stage of infection is characterized by a localized skin lesion known as erythema migrans. This lesion, also commonly called a target lesion or "bull's-eye" rash, typically appears within a month of infection. Up to 80% of patients with Lyme disease develop this rash and approximately 10-20% of patients develop multiple lesions.^{5,6} Early Lyme disease may sometimes be confused with other conditions involving similar lesions, but the condition is distinguished by specific erythema migrans lesions. Such lesions are typically found on areas of the lower extremities and trunk such as the axilla, inguinal region, and lower abdomen.⁷ In the early disseminated phase, Lyme disease can affect the nervous, cardiovascular, and musculoskeletal systems. If left untreated, Lyme disease may progress to the late disseminated stage, manifesting as arthritis or severe neurological damage.⁸ Even after successful treatment, patients may suffer from post-Lyme disease syndrome; non-specific symptoms such as fatigue may persist. As well, patients may suffer from chronic Lyme disease, a condition where the patient continues to show symptoms, yet it is unclear whether the patient still suffers from Lyme disease.^{9,10} Thus, early diagnosis of Lyme disease is crucial to managing and preventing long-term complications.

Diagnosing Lyme disease can prove challenging. In early stages of Lyme disease, immunoglobulin M and immunoglobulin G may not have developed, making serologic testing a poor determinant of disease.¹¹ Serologic testing is more useful once the disease has progressed. The Centres for Disease Control and Prevention and the Infectious Diseases Society of America recommend using an enzyme-linked immunosorbent assay (ELISA) along with a Western blot, should the ELISA yield positive or non-specific results.¹² Treatment of Lyme disease typically involves oral antibiotics in early localized stages of disease and intravenous regimens in patients with neurologic symptoms. Oral doxycycline is preferred, though macrolide antibiotics can be used when a patient cannot tolerate doxycycline.¹¹

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POWASSAN ENCEPHALITIS

While Lyme disease is the most common tick-borne illness, Powassan encephalitis, transmitted by the Powassan virus, is the most severe. This virus was first discovered in 1958 when a 5-year-old boy from Powassan, Ontario was admitted to the Hospital for Sick Children. Three weeks prior, the child had fallen from a couch and suffered a swelling over his left eyebrow. He complained of dizziness, although his gait was regular. In the day prior to admission, his parents noticed tremor and unsteadiness of his left arm, as well as rhythmic movement of his eyes to the left. On admission, the child had a right-sided headache and was slightly drowsy. Tests returned normal results and an EEG showed a moderately diffusely abnormal pattern. However, two days later the patient became progressively drowsier and developed neck stiffness, eventually becoming unconscious. By the next morning, he was only responsive to painful stimuli. Four days post-admission to the hospital, the child was deeply comatose. An EEG this time showed a highly abnormal pattern indicative of encephalitis. That same day, the child suddenly stopped breathing, dying two days later.¹³

Since then, Powassan virus has been identified in five different tick species: *Ixodes cookei*, *I. marxi*, *I. spinipalpus*, *I. scapularis*, and *Dermacentor andersoni*. Since 2017, *Ixodes* species have expanded their range extensively through central and eastern Canada; the disease's incidence is expected to grow.¹

Diagnosing Powassan encephalitis is difficult. Tick bites can be easily overlooked without careful examination, since *Ixodes* ticks are small and can bite areas that are hard to check, such as the scalp, groin, and armpits. Out of the 27 reported cases of Powassan viral infection from 1958 to 1998, only 26% of patients reported noticing tick bites.¹⁴ The disease also causes non-specific symptoms ranging from headaches, nausea, vomiting, and lethargy, to cranial nerve palsies, aphasia, dysphasia, seizure, confusion, and coma.¹⁵ Results from CT, MRI, and laboratory tests—including blood and cerebrospinal fluid investigations—may be non-specific or negative. After

several weeks, serial serum specimens may be required to accurately identify the antibodies for Powassan virus infection. Even once diagnosed, supportive treatment is the mainstay choice of management. Currently, there is no specific medication available to treat Powassan encephalitis. Often, patients who recover may have already suffered permanent neurological damage. For these reasons, it is important to raise awareness and understanding of the disease so that it can be addressed more effectively.

PREVENTION

Prevention of tick bites is one of the most important defenses against tick-borne diseases. Ticks can be found in grassy or wooded areas, as well as on animals, particularly deer, making camping, gardening, and hunting high-risk activities for tick exposure. Treating clothing or gear with 0.5% permethrin or using EPA-registered insect repellents can help ward off ticks. Finally, avoidance and removal of plant litter and woodpiles, as well as mowing tall grass and fencing off yards, can be useful in reducing tick exposure.¹¹

During and after outdoor activities, it is important to frequently check for ticks and their bites to prevent tick-borne diseases. If a tick is found and removed within 24 hours of attachment, Lyme disease can typically be prevented. Fine-tipped forceps should be used with care to remove the tick as close to the skin as possible without pressing on the tick body, to prevent bacteria being squeezed out of the tick.¹⁶

CONCLUSION

Tick-borne diseases can be most effectively managed with adequate awareness and prevention. Strategies to prevent and treat tick bites are vital in reducing the incidence of both common tick-borne infections such as Lyme disease, as well as rare and disabling conditions such as Powassan encephalitis.

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