Lyme Disease in Dogs

Lyme disease (also called Lyme borreliosis) is a vector-borne infection caused by *Borrelia burgdorferi* bacteria, which are transmitted through the bite of a tick. The disease affects dogs, humans, horses, and cattle.¹ The disease name comes from Old Lyme, Connecticut, where the disease was recognized in children in 1976.¹ The causative bacterium is named after the biologist who discovered it in 1982, Wilhelm Burgdorfer.¹,²

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Lyme disease is the most common tick-borne disease in the United States; it has been found in all 50 states and in the District of Columbia. The geographic distribution is determined by the vectors, ticks of the genus *Ixodes*. In the United States, 2 species of *Ixodes* ticks are capable of spreading the disease: *Ixodes scapularis* ticks (eastern black-legged ticks), which are found in the upper eastern and midwestern United States, and *Ixodes pacificus* ticks (western black-legged ticks), which are found in the western United States. The ranges of these 2 species of ticks, however, have been expanding due to bird migration (which helps transport the ticks), suburban sprawl encroaching onto tick territory, and climate changes leading to warmer winters farther north.

Lyme disease incidence in the individual U.S. states is shown at [capcvet.org/maps/#2020/all/lyme-disease/dog/united-states](capcvet.org/maps/#2020/all/lyme-disease/dog/united-states). Geographic distribution in Canada is similar to that in the United States. *I. scapularis* ticks are found in the eastern provinces of Canada (e.g., Ontario, Quebec, New Brunswick, and Nova Scotia), and *I. pacificus* ticks are found in British Columbia. *Borrelia* species have also been found in ticks in Europe and Asia.

**CAUSATIVE ORGANISM**

*B. burgdorferi* are spirochetes. These gram-negative, motile, cork-screw shaped, microaerophilic bacteria grow at body temperature in broth media. They are fastidious and do not grow well in standard growth media; growth in a special broth medium can take 6 weeks or longer. Being microaerophilic, *B. burgdorferi* prefer an environment with little oxygen, but they are not strictly anaerobic. These spirochetes cannot be viewed by standard microscopy methods; visualization requires dark-field microscopy. Given all of these features, *B. burgdorferi* cannot be cultured in a clinic setting.

**TRANSMISSION**

Although *B. burgdorferi* are transmitted through the bite of infected ticks, ticks do not, themselves, cause the disease. Ticks are vectors only. The infection cycle usually starts when a tick larva obtains its first blood meal from an infected reservoir host, typically a white-footed mouse in the east or a western gray squirrel in the west. Other reservoir hosts for *B. burgdorferi* include shrews, voles, chipmunks, and deer. However, if the tick did not become infected while in the larval stage, it can still become infected through subsequent blood meals as a nymph or adult. Ticks of all 3 life stages—larvae, nymphs, and adults—feed on multiple species of animals, including squirrels, deer (and other medium to large mammals), reptiles, amphibians, and birds. The ticks need to have a new host at each stage of their life before they can transmit *B. burgdorferi* to a dog. If one host is reduced or missing (i.e., fewer squirrels available for larval ticks to feed on), the infection rate goes down. Conversely, in years when reservoir species are abundant, the infection rate goes up.

After infection with *B. burgdorferi*, *Ixodes* species ticks of all 3 life stages are capable of transmitting the bacteria. After the bacteria are inside the ticks, regardless of the tick life stage, the bacteria persist through each molt of the tick (called transstadial transmission). Within Lyme disease–endemic areas, the incidence of *B. burgdorferi* infection in ticks can reach as high as 50% of nymphs and adult ticks.

*B. burgdorferi* transmission to a dog occurs when an infected tick in any 1 of its 3 life stages bites the dog and remains attached long enough. *B. burgdorferi* transmission requires 24 to 52 hours of tick attachment; the peak time for transmission is 48 to 52 hours of attachment. If the tick is carrying causative organisms for other diseases (e.g., anaplasmosis), these organisms can also be transmitted during this feeding period. After *B. burgdorferi* have been transmitted, they begin to replicate and will spread through the connective tissue over the course of days to weeks. This spread pattern explains why the first clinical signs appear in the joints closest to the area of the bite.

Rates of transmission are highest in the late spring, when nymphs and adult ticks are feeding, and in the fall, when adult ticks are feeding. During late fall and winter, *B. burgdorferi* remain dormant inside the immature tick.
Dogs with advanced Lyme disease may experience chronic intermittent arthritis, renal disease, heart disease, and/or neurologic disease.

DIAGNOSIS
Diagnosis of Lyme disease is often based on a history of tick exposure, clinical signs, and a positive antibody test result.\(^1\)\(^3\)

Clinical Signs
In Lyme disease–endemic areas, seroprevalence rates of up to 90% indicate high levels of exposure.\(^1\) However, for most dogs exposed to \(B\) burgdorferi–infected ticks, the developing disease is subclinical; few, if any, signs are noticed.\(^3\) Unlike humans, a skin rash in the typical bull’s-eye pattern does not develop when dogs are bitten by an infected tick.\(^1\)

If clinical signs do appear, they can include abrupt onset of lethargy, fever, lameness, and warm and swollen joints. The lameness may be confined to 1 joint, or it may shift from 1 joint to another.\(^1\)\(^2\) Physical examination may reveal peripheral lymphadenopathy, thin body condition (low body condition score), dehydration, peripheral edema, pleural effusion, or ascites.\(^1\)

Dogs with advanced Lyme disease may experience chronic intermittent arthritis, renal disease, heart disease, and/or neurologic disease. The 2 main clinical manifestations of Lyme disease are arthritis and nephritis. The resulting renal changes are called Lyme nephritis and can include glomerulonephritis and protein-losing nephropathy.\(^1\)\(^3\) Renal failure resulting from Lyme disease is usually fatal.\(^5\)\(^6\) Lyme disease–associated heart conditions may be pericarditis, endocarditis, or conduction disorders. Lyme disease–associated neurologic conditions can produce behavioral changes or seizures.

Antibody Titers
Antibody titers can provide helpful diagnostic information, although antibodies cannot be detected for 4 to 6 weeks after the bacteria have entered the dog.\(^5\)\(^6\)

Diagnostic tests for antibodies to \(B\) burgdorferi are available as immunofluorescence assay, enzyme-linked immunosorbent assay (ELISA), Western blot, and polymerase chain reaction. ELISAs are available for in-house screening.\(^2\) Western blot testing is the gold standard and can be used if the ELISA result and the clinical presentation are discordant (do not indicate the same diagnosis).\(^1\)

Because most infections in dogs are subclinical, infection must be differentiated from previous exposure.\(^1\)\(^3\) In the absence of clinical signs, a positive antibody test result does not indicate disease; rather, a positive test result indicates only previous exposure to \(Borrelia\) bacteria.

Other Diagnostic Tests
For dogs showing active signs of disease, joint cytology can be helpful. Tapping 3 or 4 joints is recommended. In dogs with active disease, nondegenerative neutrophils in joint fluid may be increased. Culturing joint fluid to look for \(B\) burgdorferi bacteria is difficult and takes a long time; thus, culture is not recommended.\(^1\)

Other diagnostic tests that can be performed on symptomatic dogs include blood chemistry analysis, which may indicate azotemia or markedly decreased albumin. A complete blood count might show mild to marked thrombocytopenia and, if the dog has nephritis, mild to moderate anemia and leukocytosis. For dogs with nephritis, a urinalysis may show isothenuria and proteinuria.\(^1\)

The American College of Veterinary Internal Medicine (ACVIM) Consensus group recommends routinely testing dogs in Lyme disease–endemic areas for antibodies by using an in-house screening ELISA, evaluating dogs with a positive ELISA result for signs of joint pain/inflammation, and testing for proteinuria in the urine.\(^3\)\(^4\)

TREATMENT
Treatment with antibiotics is indicated for dogs with a positive ELISA result and clinical signs of Lyme disease. The drug of choice is doxycycline. Although no optimal dose or duration of treatment has been
determined, the Companion Animal Parasite Council recommends a doxycycline dose of 10 mg/kg PO q24h for 30 days, and the recommended course of treatment is usually 4 weeks. If doxycycline is unavailable or is contraindicated for a given patient, amoxicillin or azithromycin can be prescribed. For dogs exhibiting substantial joint pain, nonsteroidal anti-inflammatory drugs or opioids can be used. Glucocorticoids are not recommended.

Because of the low incidence of clinical Lyme disease, prophylactic treatment when a tick has been found attached to a dog is not recommended. Antibody titers are not a helpful guide to treatment because they can remain elevated for years.

More specific information about treatment for Lyme disease can be found in the ACVIM Consensus 2018 update.

**PROGNOSIS**

As mentioned earlier, most dogs exposed to infected ticks remain asymptomatic. For those in which clinical signs do develop, recovery is usually quite rapid after antibiotics have been started. Dogs with polyarthritis usually respond to antibiotics within 24 to 48 hours. However, remind clients that it is important that they give the full course of antibiotics, regardless of how good the dog looks or may seem.

For dogs with Lyme nephritis, the prognosis is guarded to poor; these dogs are usually euthanized within days to weeks of diagnosis. For dogs not euthanized, death can be secondary to systemic thrombosis or oliguric/anuric renal failure.

**PREVENTION**

As with many vector-borne diseases, the most effective prevention technique is avoidance of the vector, in this case ticks.

Protect the Dog from Ticks

The primary ways to protect a dog from infection with *B. burgdorferi* are to keep it out of tick-infested areas, use topical acaricides (products that kill ticks and mites) when living in or visiting areas endemic for
negative effect on the vaccinated dog. Group members felt that the most effective way to prevent infection with *B. burgdorferi* is year-round tick control and that vaccination provides another layer of protection in Lyme disease–endemic areas.

Although preventing Lyme disease can seem overwhelming at first, if taken a step at a time, we can offer clients a good chance of protecting their dogs from infection with *B. burgdorferi* and subsequent development of Lyme disease (BOX 1).

**Zoonotic Risk**
Dogs cannot directly transmit Lyme disease to people (i.e., no zoonotic risk); however, they can carry unfed infected ticks into a household where they might feed on humans. In addition, people are often in the same Lyme disease–endemic areas as the dogs and can independently become infected. Increased incidence of dogs with Lyme disease can be used as an indicator for human risk in the same area.

**Take-Home Points**
- Lyme disease develops when a *B. burgdorferi*–infected *Ixodes* species tick feeds on a dog for 24 to 52 hours.
- Risk for Lyme disease varies according to *Ixodes* species tick prevalence in an area.
- Diagnosis is based on clinical signs and serologic test results.
- Treatment requires antibiotics (usually doxycycline).
- Prevention involves avoiding/reducing exposure to ticks and, for dogs at high risk, vaccination.
- Dogs cannot transmit Lyme disease to humans.

**References**