LYME DISEASE
BY HELEN CHEN

Etiology agent: Lyme disease, is the tick-borne bacterial infection caused by *Borrelia*. *Borrelia burgdorferi* is the predominant causative pathogen in North America; whereas *Borrelia afzelii* and *Borrelia garinii* are also causes of the disease in Europe and Asia (1).

Transmission: Lyme disease is transmitted to humans through the bite of infected deer ticks, *Ixodes* (2). It is not transmissible between people, by other animals, or through food. Tick transmission was confirmed when *B. burgdorferi* spirochetes were identified in tick saliva.

Reservoirs: Lyme disease is a zoonosis, and its natural reservoir are infected rodents (3). Deer ticks cannot acquire Lyme disease spirochetes from deer; rather acquire *Borrelia* microbes from infected rodents.

General characteristics of the microorganism: *Borrelia burgdorferi* is a spirochete, motile, spiral-shaped, 0.2-0.3 µm wide, and 20-30 µm long, surrounded by peptidoglycan and flagella (4). It is double membrane, rather than gram positive or gram negative. It is an obligate parasite, extracellular, thus difficult to culture in the laboratory. Its linear structure of the chromosome is unusual in bacteria. Consistent with its lifestyle as an obligate parasite, the genome of *B. burgdorferi* is relatively small, and it depends on hosts for nucleotides, amino acids, fatty acids, and enzyme cofactors (1).

Key test for identification: CDC currently recommends a two-step testing process on patient’s blood sample in order to confirm a case: enzyme immunoassay and then Western blot, using IgM/IgG for early infection or IgG for late infection (2). Serological tests (Western blot and ELISA) may be negative in early infection, but they are reliable in the diagnosis of later stages of Lyme disease (5). Lyme disease usually presents with a characteristic “bull’s eye rash”, called erythema migrans (EM). The EM rash, occur in 80% cases, is considered sufficient to establish a diagnosis of Lyme disease (5). Diagnosis is based upon symptoms, physical findings (such as EM), history of tick exposure, and possibly testing for specific antibodies in the blood.

Signs and symptoms of disease: Symptoms most often occur from May to September, because the nymphal stage of the tick is responsible for most cases (6). Patients experience flu-like symptoms, such as headache, muscle soreness, fever, and malaise. EM, the classic sign of early local infection develops three to 30 days after the tick bite (5). Within days to weeks after the onset of local infection, the *Borrelia* bacteria may begin to spread through the bloodstream. Untreated patients may develop severe chronic symptoms after several months. Individuals with early disseminated or late infection may have symptomatic cardiac disease, refractory Lyme arthritis, or neurologic symptoms like meningitis or encephalitis (5).

Historical information: Scientists estimated that Lyme disease was present for thousands of years in America (7). Early description of the symptoms and the tick vector dated back to 18th century in Europe. Lyme disease was diagnosed for the first time in 1975 in Old Lyme, Connecticut (8). Dr. Allen Steere and his colleague are credited with discovering and naming
Lyme disease. He first tested antibiotics in adult patients with Lyme disease. The bacterium involved was officially discovered in 1981 by Willy Burgdorfer, and the spirochete was named *Borrelia burgdorferi* in his honor (9). Burgdorfer proved spirochetes isolated from patients with Lyme disease identical to those found in ticks.

**Virulence factors:** *B. burgdorferi* lacks lipopolysaccharide, toxins, and specialized secretion systems as classically-defined virulence factors (1). *B. burgdorferi* outer surface proteins are regulated to infect different hosts: OspA, an adhesion, binds to the tick receptor; OspC evade innate immunity in mammalian host to enhance infection; VlsE, having a role in protection against acquired immunity, is important for persistent infection in rodents (1). Its flagella hidden under the outer membrane are important for motility in host tissue and dissemination. It is one of the few bacteria that do not require host iron.

**Control/treatment:** It requires 36 to 48 hours of attachment for the bacteria to travel from within the tick into its saliva (9). Thus, prompt removal of a deer tick may reduce the risk of serious infection from Lyme disease. Currently, antibiotics are still the primary treatment for Lyme disease: to treat early localized infection, oral administration of doxycycline is the first choice effective against *Borrelia*; intravenous administration of ceftriaxone is recommended for disseminated acute and chronic infection (5). In more complicated cases, Lyme disease can be treated with immunotherapy using neutralizing antibodies (9).

**Prevention/vaccine, new trials:** Wearing protective clothing outdoor and vigilantly avoiding tick exposure in disease endemic area reduce risk of contraction (6). Action can be taken to avoid getting bitten by ticks by using insect repellants and tick killer. Other than chemical pest control method, domesticated guineafowl is an organic approach of disease control because they eat deer ticks. Reducing the deer population lowers the risk of the deer tick-borne disease on a regional level. LYMErix, a recombinant vaccine, based on the outer surface protein A, was approved by the FDA in 1998 (10). LYMErix was withdrawn from the U.S. market in 2002, due to negative media coverage and fears of vaccine side effects (10). New vaccines are being developed using outer surface protein C (OspC). OspC is a better target due to its role in human infection.

**Local cases or outbreaks:** Despite the effort of disease control and prevention by individuals and governments, as well as increased awareness in general public, the outbreak of local and global incidence did not improve in the past 20 years. As demonstrated by the number of reported cases of Lyme disease from 1995 through 2013 in US—the number of confirmed cases ranged from a low of 11,700 in 1995 to high of 29,959 in 2009; the number of confirmed cases in 2013 is 27,203 (2). Lyme disease is concentrated heavily in the Northeast and upper Midwest of US, which represented 95% of confirmed cases in 2013 (2, 5). According to CDC, the top 5 states with highest confirmed cases in 2013 are: Pennsylvania (4981 cases), Massachusetts (3816 cases), New York (3512 cases), New Jersey (2785 cases) and Connecticut (2111 cases). The following state had zero case reported in 2013: Arkansas, Colorado, Hawaii, Louisiana, Mississippi, and New Mexico.

**Global cases or outbreaks:** Lyme disease is the most common disease spread by ticks in the Northern Hemisphere temperate regions. It is estimated to affect 300,000 people a year in the
United States and 65,000 people a year in Europe (2). The presence of forests or forested areas elevated the risk of Lyme disease (11). A 2005 study estimated that global warming would cause a two fold increase in suitable vector habitat by 2080, with northward expansions in Canada, and increased suitability in the central U.S. (12). Lyme disease was reported by more than 80 countries worldwide (13). Reported incidences may increase in the developing countries due to improved disease surveillance.


9 “Lyme Disease” National Institute of Allergy and Infectious Disease, April 17, 2015 http://www.niaid.nih.gov/topics/lymedisease/Pages/lymeDisease.aspx


