BMJ Best Practice

Lyme disease

The right clinical information, right where it's needed

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Summary

- Erythema migrans develops at the site of tick bite usually within 1 to 2 weeks and is a pathognomic feature of Lyme disease.
- Constitutional symptoms such as fever, headache, myalgias, fatigue, and arthralgias may occur.
- Complications of Lyme disease may be neurological, cardiac, or musculoskeletal.
- Mainstay of treatment is antibiotic therapy.
- There is currently no vaccine; prevention is centred around reducing exposure to ticks.

BASICS

Definition

Lyme disease is a zoonotic infection caused by a spirochete of genus *Borrelia* , which is transmitted to humans by ticks. Zoonotic diseases are transmitted between vertebrate animals and humans. Animals serve as the primary reservoir of *Borrelia* . Ticks become infected by feeding on an infected animal. Most common initial manifestation is typical skin lesion known as erythema migrans. Later manifestations may include arthritis, or central nervous system or cardiac involvement.

Epidemiology

Lyme disease can occur at any age, but two peak age groups have been identified: 10 to 19 years and 50 to 59 years.[3] Men and women are equally affected.[3] Onset is usually between May and October, mostly related to increased outdoor activity compared with the rest of the year.[2] [3] [4] Early Lyme disease usually occurs in late spring and early summer, although can sometimes occur in the autumn. Lyme disease occurs in temperate regions in the northern hemisphere including North America, Europe, and Asia. High incidences are reported in endemic areas in the US (Northeast, mid-Atlantic, and upper Midwest regions), Scandinavia, Germany, Austria, Slovenia, Sweden, Russia, China, and Japan.[6]

In Europe, Lyme disease is most common in central European and Scandinavian countries, with an estimated incidence rate of up to 155 cases per 100,000 per year. A higher incidence rate of greater than 450 cases per 100,000 per year was reported from southern Sweden.[7] [8]

Lyme disease is the most common vector-borne infection and one of the most common notifiable diseases in the US. A total of 275,589 people were diagnosed with Lyme disease between 2008 and 2015 in the US; over 30,000 diagnoses (probable and confirmed) were reported each year in that period.[6]

The Centers for Disease Control and Prevention notes that not every diagnosis is reported.[9] Potential contributing factors leading to increased rates of incidence include improved reporting, increased development in wooded areas, spread of ticks to new areas, and growing deer populations.[10] [11] [12]

Co-infection with babesiosis or ehrlichiosis (anaplasmosis) may occur. This is because the *Ixodes scapularis* tick may also transmit *Babesia microti* and *Anaplasma phagocytophila* . One study found that in patients with Lyme disease, approximately 2% were infected with *B microti* and 2% were infected with *A phagocytophila* .[13]

Aetiology

Lyme disease in Europe is caused by *B afzelii* , *B garinii* , and *B burgdorferi sensu stricto* .[2] [3] [14] [15] Lyme disease in Asia is predominantly caused by *B garinii* and *B afzelii* .[2] [3] [14] [15] Lyme disease in the US is caused by *Borrelia burgdorferi* and is transmitted by the ticks *Ixodes scapularis* and *I pacificus* .

Borrelia species are spirochetes that have characteristic 7 to 11 flagella and an outer membrane containing an abundance of outer surface proteins (Osp). These proteins, designated by letters A through F, are encoded by plasmids. OspA and OspC are useful for developing vaccines against Lyme disease.[3] [4] [7]

The major reservoirs for *B burgdorferi* are mice, voles, squirrels, birds, and other small animals. Deer are not a major reservoir of *B burgdorferi* , but they are a major host for adult *Ixodes* ticks, the vectors of transmission.

I scapularis is the vector in the northeastern and midwestern US. The nymphal stage, which is prevalent in spring and early summer, is most likely to transmit the infection, although infection can be acquired at all 3 stages (larval, nymphal, adult). A new pathogenic genospecies of *B burgdorferi* sensu lato (proposed new name: *B mayonii*) has been described in the upper midwestern US. This pathogen was isolated from and genetically identified in both humans and *I scapularis* ticks. *B mayonii* causes Lyme borreliosis with unusually high spirochaetaemia.[16]

I ricinus is the principal vector in Europe, and *I persulcatus* is the principal vector in Asia.[3] [14] On the western coast of the US, *I pacificus* serves as the predominant vector.[3] [14]

[Fig-3]

[Fig-4]

Pathophysiology

B burgdorferi is inoculated into the skin by the feeding *Ixodes* tick, usually after the tick has fed for more than 48 hours. Initial infection is established at the tick bite site. After skin inoculation, *B burgdorferi* moves throughout the extracellular matrix by binding to components such as epithelial cell-derived proteoglycans and interacting with decorin, glycosaminoglycans, and fibronectin. This leads to expansion of the rash.[17] *Borrelia* disseminates from skin to other organs quickly. It replicates, kills host cells, and emerges through the membrane of that cell. Within days to weeks after infection, *Borrelia* has been recovered from blood, cerebrospinal fluid, myocardium, retina, muscle, bone, spleen, liver, meninges, and brain.[18]

The host immune response to *Borrelia* integrates both cell-mediated and humoral mechanisms. Most patients have an IgM antibody response against OspC or the flagellar protein (41-kDa) of *Borrelia* within days of days onset. Humoral immune responses may be initially limited, and a clinically detectable level of antibodies may be delayed. Early antibiotic treatment may delay or abrogate the B-lymphocytic response. In the chronic phase, antibodies against a variety of *Borrelia* epitopes become detectable. Although the B-cell response in the chronic phase is robust, it is not preventive of future infection(s).[19] [17]

Persistent clinical symptoms, such as those of chronic joint inflammation, have been attributed to autoimmunity. Activated T lymphocytes and lymphokines of the helper T-cell phenotype (CD4 cells) play a major role in the pathogenesis of Lyme arthritis.[17]

Primary prevention

To avoid Lyme disease, advise patients to:[20] [21] [CDC: Lyme disease] [CDC: tickborne diseases]

1. Avoid areas infested with ticks.
2. If visiting or living in a tick-infested area:
    - Use protective clothing such as long pants and long sleeves to keep ticks off the skin.
    - Use insect repellent such as DEET 20% to 30% on clothes and exposed skin. Children should use DEET 10%.
    - Use permethrin spray for clothes (pants, shirts, socks, and shoes), tents, and camping gear. Permethrin should not be used directly on skin.
    - Check for ticks daily and remove any attached ticks promptly. A tick should be removed by pulling it away from the skin with the help of tweezers or a similar device. Even if the mouthparts of a tick are left in the skin, it is not able to transmit the bacteria. The area of skin should be washed with soap and water. Avoid crushing the tick's body.
3. Use strategies to reduce the number of ticks in Lyme-infested areas, for example:
    - Apply insecticides (acaricides).
    - Landscape to make it less favourable for ticks (e.g., remove leaf litter, tall grass, and brush around living areas to increase exposure to sun and air and reduce the numbers of ticks).
    - Exclude, or remove, deer.

A vaccine is not available at present. A previously marketed vaccine, which was considered approximately 80% effective, was withdrawn from the US market following poor demand, according to the manufacturer. Concerns had been raised regarding the vaccine's safety and efficacy.[22]

Secondary prevention

Postexposure prophylaxis of a single dose of doxycycline may be used for a significant exposure meeting all of the following:[2] [20] [40] [41]

- An engorged *Ixodes scapularis* tick is removed after at least an estimated 36 hours of attachment.
- Prophylaxis is started within 72 hours of tick removal.
- *B burgdorferi* prevalence in local ticks is known to be greater than 20%.
- Doxycycline is not contraindicated. Contraindications include children <8 years of age (in some countries), pregnancy, or lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] [28]

There is no human-to-human transmission.[2] There are no special measures required for hospital infection control, except for standard universal precautions. [CDC: Lyme disease] [CDC: tickborne diseases]

Case history

Case history #1

An 18-year-old man presents in July with a 1-week history of non-pruritic, erythematous rash with low-grade fever and arthralgias. On examination, the patient has multiple skin lesions, about 4 cm to 10 cm in diameter, with central clearing. The patient had significant outdoor exposure, but there was no recollection of a tick or insect bite.

Other presentations

Early Lyme disease includes erythema migrans and early disseminated infection (multiple erythema migrans lesions, carditis, cranial nerve palsy [most commonly cranial nerve VII], aseptic meningitis, or acute radiculopathy).

Erythema migrans (EM), which is the most common presentation, can be seen in 50% to 90% of patients with Lyme disease. It develops at the site of tick bite usually within 1 to 2 weeks and is a pathognomic feature of Lyme disease. It is a non-tender, non-pruritic annular expanding skin lesion that may be homogeneously erythematous or have central clearing (bull's eye) and is generally 5 cm or greater in diameter.
[Fig-1]

[Fig-2]

Central clearing is less common in patients in endemic areas of the US (approximately 20%) compared with non-endemic areas of the US and Europe (approximately 80%).[1] It is typically accompanied by constitutional symptoms such as fever and arthralgias.[2] [3] [4] Untreated solitary EM lesions usually improve within a few days to a few weeks. Multiple lesions occur as the organism disseminates from the primary site of infection. In Europe, the primary site of skin infection generally shows a more indolent form of EM lesion, with less inflammation and slower progression.[2] [3] [4]

Borrelial lymphocytoma, a rare cutaneous manifestation, presents as a solitary bluish-red swelling commonly on the ear lobe, near the nipple or in the scrotal area. It is seen in Europe and is usually caused by *Borrelia garinii* or *B afzelii* .[2] [3] [4]

Musculoskeletal manifestations include arthralgia and arthritis. Arthritis typically presents with recurrent brief attacks of joint swelling in 1 or more joints, typically involving the knees.

Neurological manifestations include facial (cranial nerve VII) and other cranial nerve palsies, aseptic meningitis, and radiculoneuropathy. The clinical manifestations of meningoradiculoneuritis (Bannwarth's syndrome) are the second most common presentation of early Lyme disease in Europe. Its clinical features include cranial nerve deficits (e.g., facial palsy), paresis, radicular pain and radiculitis, and lymphomonocytic meningitis with a relatively high concentration in the cerebrospinal fluid.[5]

Cardiovascular complications include carditis with atrioventricular block (second- or third-degree) that resolves in days to weeks and, less commonly, myopericarditis.

Late manifestations (>6 months after exposure) of Lyme disease include arthritis (chronic mono- or asymmetrical oligoarthritis), neurological involvement (encephalopathy, encephalomyelitis, peripheral

neuropathy, and chronic progressive meningoencephalitis), and acrodermatitis chronica atrophicans (ACA). ACA is a chronic and slowly progressive skin condition with bluish-red atrophic skin lesions on sun-exposed surfaces of the extremities. It is seen in Europe and is caused by *Borrelia afzelli* .[2] [3] [4]

Step-by-step diagnostic approach

Diagnosis is based on characteristic clinical findings, history of exposure in endemic area, and positive Lyme serology with the caveat that patients with erythema migrans usually do not require positive serology in an appropriate clinical setting. However, a positive serology requires careful correlation with clinical features to avoid treating patients with a false-positive serology.

History and physical examination

Suspect Lyme disease if a tick bite has lasted longer than 48 hours in an endemic area. A characteristic rash of erythema migrans in the setting of exposure to ticks in an endemic area is sufficient for clinical diagnosis; in these circumstances, initiate treatment without any further investigation. Erythema migrans appears in about 50% to 90% of patients with Lyme disease and usually occurs 1 to 2 weeks after a tick bite (range 1 to 36 days).[2] [3] [4]

Patients may rarely present with complications of Lyme disease:

- Musculoskeletal manifestations include arthralgia and arthritis. Arthritis typically presents with recurrent brief attacks of joint swelling in 1 or more joints, typically involving the knees.
- Neurological manifestations include facial (cranial nerve VII) and other cranial nerve palsies, aseptic meningitis, and radiculoneuropathy.
- Cardiovascular complications include carditis with atrioventricular block (second- or third-degree) and, less commonly, myopericarditis.

Co-infection with babesiosis or ehrlichiosis (anaplasmosis) may occur. This is because the *Ixodes scapularis* tick may also transmit *Babesia microti* and *Anaplasma phagocytophila* . One study found that in patients with Lyme disease, approximately 2% were infected with *B microti* and 2% were infected with *A phagocytophila* .[13] There are often no differentiating symptoms.

[Fig-1]

[Fig-2]

[Fig-5]

[Fig-6]

[Fig-7]

Laboratory testing

Serological diagnosis includes IgM and IgG antibodies via a 2-tier approach:[5] [23] [CDC: Lyme disease] [CDC: tickborne diseases]

- Use a standardised Western blot assay to confirm all specimens positive or equivocal by a sensitive enzyme-linked immunosorbent assay (ELISA) or immunofluorescence assay (IFA). For early Lyme disease (first 4 weeks), carry out Western blot for both IgM and IgG antibodies.
- No further testing is needed if specimens are negative by a sensitive ELISA or IFA. However, in a patient with suspected early Lyme disease who has a negative ELISA, carry out a repeat serological test during the convalescent phase (paired sera samples) >2 weeks later.

People with disseminated or late Lyme disease show a strong IgG response to *Borrelia burgdorferi* antigens. Because of this, use IgM blots in only the first month of infection.[23] In patients who are persistently symptomatic and are positive only for IgM, carry out a repeat Western blot after a few weeks. If a repeat test continues to show similar discordant results (IgM+, IgG-), it is likely a false-positive result; consider alternative diagnoses. [CDC: Lyme disease] False-positive Lyme serology can result from cross-reacting antibodies in autoimmune disorders, infectious mononucleosis, and syphilis.[22] An exposure or infection in the distant past can also result in false-positive serology.[5] These serological tests have limited sensitivity and specificity.

Guidelines from the National Institute for Health and Care Excellence in the UK recommend that if Lyme disease is still suspected in people with a negative ELISA:[24]

- In those who were tested within 4 weeks from symptom onset, repeat the ELISA 4 to 6 weeks after the first ELISA test.
- In those who have had symptoms for 12 weeks or more, perform an immunoblot assay.

Patients with neuroborreliosis have over 90% seropositivity. The cerebrospinal fluid (CSF) changes usually show lymphomonocytic leukocytosis with <1000 cells/microlitre, and raised protein and oligoclonal IgG band.[25] In some patients with Lyme disease, antibodies in serum may be passively transferred to CSF; therefore, if neuroborreliosis is suspected, collect CSF and serum on the same day and dilute to match total IgG concentration. A CSF/serum IgG ratio of >1.0 indicates active intrathecal antibody production and thus supports a diagnosis of neuroborreliosis.[26]

Culture of infected tissue is a more direct test than serological diagnosis, but it is not recommended routinely because it is invasive, costly, and more difficult to carry out.[2] Polymerase chain reaction (PCR) is superior to culture for specimens such as joint fluid, but it is not widely available. Sensitivity of PCR is modest (50% to 70%) for joint fluid and skin specimens, but poor for blood and CSF (10% to 30%).[5] [26]

An ECG is indicated only in patients with signs and symptoms of cardiac disease.[2]

Although a vaccine is no longer available, previous vaccination may affect test results, resulting in false-positive ELISA tests and a positive band (or multiple bands) on Western blot tests for IgG.

If co-infection with *B microti* or *A phagocytophila* is suspected, serology is recommended to confirm diagnosis of babesiosis or ehrlichiosis. Peripheral blood smear and PCR are also recommended.

Risk factors

Strong

exposure to infected ticks

- Prevalence of infected ticks varies based on geography.

- Approximately 30% to 40% of adult ticks in the northeastern and midwestern US are infected with *B burgdorferi* .[3] [14]

outdoor activities

- Occupational, recreational, and residential exposure to tick-infested woods, or fields near woods, in endemic areas is a risk factor.
- In general, woods are more risky than fields near woods.

tick bite duration

- Duration of feeding by a tick has to be longer than 48 hours for transmission of infection. History of a tick bite is more common in Europe than in the US.

History & examination factors

Key diagnostic factors

presence of risk factors (common)

- Key risk factors include exposure to infected ticks, tick bite duration, and outdoor activities.

erythema migrans (common)

- Typical rash that occurs 1 to 2 weeks after a tick bite (range, 1 to 36 days).[2] [3] [4]
- Central clearing is classic but not necessary for diagnosis.
- [Fig-1]

[Fig-2]

[Fig-5]

[Fig-6]

constitutional symptoms (common)

- Fever, headache, myalgias, fatigue, or arthralgias may occur after infection.
- Nausea and vomiting are rare.

Other diagnostic factors

facial palsy (uncommon)

- Unilateral facial muscle weakness of the lower motor neuron type (cranial nerve VII) may occur.
- Less commonly, Lyme disease causes bilateral facial nerve palsy.

arthritis or arthralgia (uncommon)

- Mono- or polyarticular joint swelling and pain most commonly involve the knees. [Fig-7]

regional lymphadenopathy (uncommon)

- Enlargement of draining regional lymph nodes may occur.

stiff neck (uncommon)

- Occurs in cases of aseptic meningitis.

lymphocytoma cutis (uncommon)

- Painless bluish-red nodule or plaque on the ear lobe, nipple, or scrotum, which has been reported only in Europe.

acrodermatitis chronica atrophicans (uncommon)

- Red to bluish discolouration on the extensor surfaces of extremities, which ultimately becomes atrophic.
- Occurs in Europe.

atrioventricular (AV) block or myopericarditis (uncommon)

- Cardiovascular complications include carditis with AV block (second- or third-degree) and, less commonly, myopericarditis.

radiculoneuropathy (uncommon)

- Neurological manifestations include radiculoneuropathy.

encephalomyelitis, peripheral neuropathy, encephalopathy (uncommon)

- Late neurological complications usually manifest as encephalomyelitis, peripheral neuropathy, or encephalopathy.
- Peripheral neuropathy presents as mild diffuse polyneuropathy in a glove and stocking distribution.

Diagnostic tests

1st test to order

Test	Result
enzyme-linked immunosorbent assay (ELISA) or immunofluorescence assay (IFA) • Use a standardised Western blot assay to confirm all specimens positive or equivocal by a sensitive ELISA or IFA.[23] • No further testing is needed if specimens are negative by a sensitive ELISA or IFA. However, in a patient with suspected early Lyme disease who has a negative ELISA, carry out a repeat serological test during the convalescent phase (paired sera samples) >2 weeks later. Background seropositivity in highly endemic areas can exceed 4%.[23] • Use IgM blots in only the first month of infection.[23] • Both IgG and IgM may remain positive for a long period (months to years) after previous treatment. • Guidelines from the National Institute for Health and Care Excellence in the UK recommend that if Lyme disease is still suspected in people with a negative ELISA who were tested within 4 weeks from symptom onset, repeat the ELISA 4 to 6 weeks after the first ELISA test. If Lyme disease continues to be suspected in those with a negative ELISA who have had symptoms for 12 weeks or more, perform an immunoblot assay.[24]	**positive**

Other tests to consider

Test	Result
Lyme-specific IgM and IgG • Order immunoblot (Western blot) assays for Lyme-specific IgM and IgG for patients with equivocal or positive ELISA results.[23] • For early Lyme disease (first 4 weeks), carry out Western blot for both IgM and IgG antibodies.[23] • Sensitivity is low in early disease, but specificity is high.[23] • People with disseminated or late Lyme disease show a strong IgG response to *Borrelia burgdorferi* antigens.[23] • Both IgG and IgM may remain positive for a long period (months to years) after previous treatment. • In some patients with Lyme disease, antibodies in serum may be passively transferred to CSF; therefore, if neuroborreliosis is suspected, collect CSF and serum on the same day and dilute to match total IgG concentration. A CSF/serum IgG ratio of >1.0 indicates active intrathecal antibody production and thus supports a diagnosis of neuroborreliosis.[26]	**positive**
skin biopsy culture • Rarely performed. • Culture is performed in Barbour-Stoenner-Kelly medium. • Positive culture is likely from biopsy specimens from erythema migrans lesions, but is less likely in serum and cerebrospinal fluid samples.[15] • There are only anecdotal reports about joint fluid.	**positive**
polymerase chain reaction (PCR) • PCR shows positive results in later stages of infection. Best yield is with synovial fluid.[15]	**positive**
ECG • An ECG is indicated only in patients with signs and symptoms of cardiac disease.[2] • Includes acute onset of varying degrees of intermittent atrioventricular (AV) block. • Myopericarditis occurs rarely.	**AV block**

DIAGNOSIS

Differential diagnosis

Condition	Differentiating signs / symptoms	Differentiating tests
Tickbite allergy	• There is lack of central clearing of the rash.	• There are typically no differentiating tests.
Cellulitis	• There is a homogeneous, warm, tender, indurated area often accompanied by fever and chills in most cases of cellulitis.	• Patients may have leukocytosis or positive blood cultures.

Condition	Differentiating signs / symptoms	Differentiating tests
Erythema multiforme	• Extensive, disseminated rash often occurs with blistering and mucosal involvement in erythema multiforme major.	• Skin biopsy is diagnostic.
Rickettsiosis	• Diffuse, generalised maculopapular rash is present in rickettsiosis.	• Serology for *Rickettsia rickettsii* is positive.
Ehrlichiosis	• There may be no differentiating symptoms. • Co-infection with ehrlichiosis (anaplasmosis) can occur in patients with Lyme disease. • There may be a history of local prevalence. • Absence of rash.	• Serology is positive for *Ehrlichia* species. • There may be leukocytopenia.
Babesiosis	• There may be no differentiating symptoms. • Co-infection with babesiosis can occur in patients with Lyme disease. • There may be a history of local prevalence. • Absence of rash.	• Peripheral smear is positive for intraerythrocytic *Babesia* . • There may be evidence of haemolysis.
Tick-borne encephalitis	• There may be a history of local prevalence. • Absence of rash. • Found in Europe.	• IgM antibody against tick-borne encephalitis virus is present in cerebrospinal fluid.
Southern tick-associated rash illness (STARI)	• Bull's-eye rash on skin after a tick bite from lone star tick (*Amblyomma americanum*). • More commonly reported from different geographical distribution than Lyme disease. • Constitutional symptoms including joint pain may occur similar to Lyme disease, but there are no associated neurological, joint, or cardiac sequelae.	• Lyme serology is negative in most cases, although there have been a small number of cases where it may be false-positive. • A biopsy of skin, identification of the tick as a lone star tick, and a negative Lyme serology aid differentiation.
Chronic fatigue syndrome	• Medically unexplained, persistent fatigue, lasting at least 6 months. No reliable biological causes, objective findings, or laboratory anomalies.	• A standard battery of laboratory testing is typically normal.

Diagnostic criteria

Serologic Diagnostic Criteria recommended by Second National Conference on Serologic Diagnosis of Lyme Disease (1994)[23]

A 2-tier approach is recommended:

- All specimens positive or equivocal by a sensitive enzyme-linked immunosorbent assay (ELISA) or immunofluorescence assay (IFA) should be tested by a standardised Western blot assay. Specimens negative by a sensitive ELISA or IFA need not be tested further.
- For early Lyme disease (first 4 weeks), Western blot should be done for both IgM and IgG antibodies.
- In a patient with suspected early Lyme disease who has a negative ELISA, a repeat serological test should be done during the convalescent phase (paired sera samples) >2 weeks later.

People with disseminated or late Lyme disease show a strong IgG response to *B burgdorferi* antigens.

Diagnostic criteria for CNS Lyme disease Lyme neuroborreliosis recommended by European Federation of Neurological Societies[25]

Criteria for diagnosis of central nervous system (CNS) Lyme disease (excluding late CNS Lyme disease with polyneuropathy):

- Neurological symptoms suggestive of CNS Lyme disease and exclusion of other causes
- Cerebrospinal fluid (CSF) pleocytosis
- Presence of *B burgdorferi* -specific antibodies in CSF (produced intrathecally).

Definite CNS Lyme disease requires all 3 criteria. Possible CNS Lyme disease requires 2 of the 3 criteria; if a third criterion is missing, a repeat test done 6 weeks later needs to be positive.

The following 3 criteria need to be met for definite diagnosis of late CNS Lyme disease with polyneuropathy:

- Peripheral neuropathy
- Clinical diagnosis of acrodermatitis chronic atrophicans
- Presence of *B burgdorferi* -specific antibodies in serum.

Step-by-step treatment approach

Antibiotic therapy is the mainstay of treatment.

Postexposure prophylaxis

Postexposure prophylaxis with a single dose of doxycycline is recommended for significant exposures under the following circumstances:

- An engorged *Ixodes scapularis* tick is removed after at least an estimated 36 hours of attachment.
- Prophylaxis is started within 72 hours of tick removal.
- *Borrelia burgdorferi* prevalence in local ticks is known to be greater than 20%.
- Doxycycline is not contraindicated. Contraindications include children <8 years of age (in some countries), pregnancy, or lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] Previously, use of doxycycline was limited to those aged 8 years and older, but recent comparative data suggest it is not likely to cause visible teeth staining or enamel hypoplasia in younger children and the recommendation has been revised.[28]

Patients who cannot take doxycycline are started on treatment if early symptoms develop.

Erythema migrans

Treatment of Lyme disease associated with erythema migrans in the absence of cardiovascular and neurological manifestations is as follows:[2] [29] [30] [31] [32] [33] [34] [35] [36]

- Amoxicillin or cefuroxime for 14 to 21 days. Doxycycline for 10 to 21 days.
- Pregnant or lactating patients should be treated in the same way, except doxycycline should be avoided.
- Macrolides are not recommended for first-line treatment, but reserved for patients who are intolerant to all 3 first-line antibiotics.
- When erythema migrans cannot be distinguished from community-acquired cellulitis, cefuroxime or amoxicillin/clavulanate, effective for both conditions, is recommended.

Cardiac involvement

Patients with Lyme disease and cardiac complications, but without high-grade heart block, are treated with oral antibiotics.[2] Hospitalisation, intravenous antibiotics, and continuous monitoring are required for patients with chest pain, syncope, dyspnoea, second- or third-degree atrioventricular (AV) block, or first-degree block with PR interval 300 milliseconds or longer. Temporary pacemaker is recommended for patients with advanced AV block.[2] [37]

Lyme arthritis

Treatment depends on the type and extent of infection:[2]

- Patients with Lyme arthritis are treated with oral antibiotics including doxycycline, amoxicillin, or cefuroxime for 28 days; non-steroidal anti-inflammatory drugs (NSAIDs) may be used adjunctively for symptom relief.

- Patients with recurrent or persistent joint swelling should receive an additional 4 weeks of oral (preferred) or 2 to 4 weeks of parenteral therapy.

Arthroscopic synovectomy has been used successfully in patients with antibiotic-refractory Lyme arthritis. Anecdotal use of intra-articular injections of corticosteroids, systemic administration of NSAIDs, or disease-modifying antirheumatic drugs such as hydroxychloroquine have also been reported to help patients with antibiotic-refractory Lyme arthritis. These treatments should be initiated only under consultant supervision.

Neurological Lyme disease (neuroborreliosis)

Although parenteral antibiotics are generally used for patients with neurological complications, oral doxycycline has been shown to be equally effective.

Patients with early neurological Lyme disease confined to the meninges, cranial nerves, nerve roots, or peripheral nerves (Bannwarth's syndrome) can be treated with a 2-week course of either an oral antibiotic (doxycycline) or an intravenous antibiotic (ceftriaxone, cefotaxime, or benzylpenicillin).[25] However, based on available small studies, patients with early neuroborreliosis with manifestations such as myelitis, encephalitis, and vasculitis require intravenous antibiotic for 2 weeks.[25] One Cochrane review found low- to very low-quality evidence that penicillin G, doxycycline, ceftriaxone, and cefotaxime produce similarly good outcomes for treatment of early Lyme neuroborreliosis in Europe; no trials were identified for neurological Lyme disease in the US.[38]

For late Lyme disease with peripheral neuropathy and acrodermatitis chronica atrophicans, the European Federation of Neurological Societies guideline recommends treatment with either oral doxycycline or intravenous ceftriaxone.[25] However, if these patients have central nervous system (CNS) manifestations, such as myelitis, encephalitis, and vasculitis, they should be treated with intravenous ceftriaxone.

The treatment of facial palsies is controversial. There are no definitive data to support whether they need to be treated as neurological complications or acute Lyme disease without CNS manifestation.[39] The authors of this monograph treat isolated facial palsies in patients with Lyme disease as early neuroborreliosis with cranial nerve involvement.

Treatment decisions for patients with both joint and neurological involvement are based on an individual patient's circumstances under consultant supervision.

Treatment details overview

Consult your local pharmaceutical database for comprehensive drug information including contraindications, drug interactions, and alternative dosing. (see Disclaimer)

Initial		(summary)
known tick bite		
	1st	**single-dose antibiotic prophylaxis**

Acute	(summary)

TREATMENT

Acute (summary)

erythema migrans		
classic presentation	1st	oral antibiotic therapy
indistinguishable from cellulitis	1st	oral antibiotic therapy
cardiac complications		
cardiac complications without high-grade heart block	1st	oral antibiotic therapy
cardiac complications with high-grade heart block	1st	intravenous antibiotic therapy
	adjunct	temporary pacemaker
neurological disease		
early symptoms confined to peripheral nervous system	1st	oral or intravenous antibiotic therapy
late symptoms confined to peripheral nervous system	1st	oral or intravenous antibiotic therapy
central nervous system manifestations	1st	intravenous ceftriaxone
arthritis		
	1st	oral antibiotic therapy
	adjunct	non-steroidal anti-inflammatory drugs

Ongoing (summary)

recurrent or persistent arthritis		
	1st	oral or intravenous antibiotic therapy
	2nd	arthroscopic synovectomy
	3rd	pharmacotherapy

Treatment options

Initial

known tick bite

1st **single-dose antibiotic prophylaxis**

Primary options

» doxycycline: children: 4 mg/kg/day orally as a single dose; adults: 200 mg orally as a single dose

» Postexposure prophylaxis with a single dose of doxycycline may be used for a significant exposure meeting all of the following criteria:[2] [20] [40] [41]

» 1. An engorged *Ixodes scapularis* tick is removed after at least an estimated 36 hours of attachment.

» 2. Prophylaxis is started within 72 hours of tick removal.

» 3. *Borrelia burgdorferi* prevalence in local ticks is known to be greater than 20%.

» 4. Doxycycline is not contraindicated. Contraindications include children <8 years of age (in some countries), pregnancy, or lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] [28]

» Patients who cannot take doxycycline are started on treatment if early symptoms develop.

Acute

erythema migrans

classic presentation

1st **oral antibiotic therapy**

Primary options

» doxycycline: children: 2 mg/kg orally twice daily; adults: 100 mg orally twice daily

OR

» amoxicillin: children: 20-50 mg/kg/day orally given in 3 divided doses; adults: 500 mg orally three times daily

Acute

OR

» cefuroxime: children: 15-30 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

Secondary options

» azithromycin: children: 10 mg/kg/day orally once daily; adults: 500 mg orally once daily

OR

» erythromycin base: children: 30-50 mg/kg/day orally given in 4 divided doses; adults: 500 mg orally four times daily

OR

» clarithromycin: children: 15 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

» Oral antibiotics are recommended for patients with Lyme disease (local or disseminated) with erythema migrans, in the absence of cardiovascular or neurological manifestations.

» Doxycycline is contraindicated in children <8 years of age in some countries, and during pregnancy and lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] [28] Amoxicillin and cefuroxime may be used safely in these patients.

» Macrolides (e.g., azithromycin or erythromycin) are not recommended as first-line treatment. They should be reserved for patients with intolerance or allergy to first-line agents, with close monitoring for resolution of symptoms.

» First-generation cephalosporins are ineffective for the treatment of Lyme disease.

» Various studies have used 10 to 21 days of treatment. Although there is no clear consensus, 14 days is adequate in most cases. A recent study conducted in Slovenia showed similar efficacy between 10-day and 15-day courses of doxycycline in patients with typical solitary erythema migrans.[42] Azithromycin is given for only 7 to 10 days.

Acute

indistinguishable from cellulitis — 1st — **oral antibiotic therapy**

Primary options

» cefuroxime: children: 15-30 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

OR

» amoxicillin/clavulanate: adults: 500 mg orally three times daily
Dose expressed as amoxicillin

» When erythema migrans cannot be distinguished from cellulitis, cefuroxime or amoxicillin/clavulanate is recommended.

» Various studies have used 10 to 21 days of treatment, but these have not been compared head to head. In most cases 14 days is adequate, but there is not complete consensus.

cardiac complications

cardiac complications without high-grade heart block — 1st — **oral antibiotic therapy**

Primary options

» doxycycline: children: 2 mg/kg orally twice daily; adults: 100 mg orally twice daily

OR

» amoxicillin: children: 20-50 mg/kg/day orally given in 3 divided doses; adults: 500 mg orally three times daily

OR

» cefuroxime: children: 15-30 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

» Oral antibiotic therapy is recommended for patients with cardiac complications but without any of the following: chest pain, syncope, dyspnoea, second- or third-degree atrioventricular block, or first-degree block with PR interval ≥300 milliseconds.[2] [37] Patients with any of these preceding features are treated with parenteral antibiotic therapy.

» Various studies have used 10 to 21 days of treatment, but these have not been compared head to head. In most cases 14 days is adequate, but there is not complete consensus.

Acute

» Doxycycline is contraindicated in children <8 years of age in some countries, and during pregnancy and lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] [28]

cardiac complications with high-grade heart block — **1st** — **intravenous antibiotic therapy**

Primary options

» ceftriaxone: children: 50-100 mg/kg/day intravenously once daily; adults: 2 g intravenously once daily

Secondary options

» benzylpenicillin sodium: children: 25-50 mg/kg intramuscularly/intravenously every 4-6 hours, maximum 2.4 g every 4 hours; adults: 2.4 g intramuscularly/intravenously every 4-6 hours

OR

» cefotaxime: children: 150-200 mg/kg/day intravenously given in 3 divided doses; adults: 2 g intravenously every 8 hours

Tertiary options

» doxycycline: children: 2 mg/kg intravenously twice daily; adults: 100 mg intravenously twice daily; higher doses have been reported by some consultants

» Intravenous antibiotics, hospitalisation, and continuous monitoring are required for patients with chest pain, syncope, dyspnoea, second- or third-degree atrioventricular block, or first-degree block with PR interval ≥300 milliseconds.

» Ceftriaxone is the drug of choice for both adults and children.

» Alternative agents include cefotaxime or benzylpenicillin.

» Doxycycline is an alternative agent for patients with cardiac complications who are intolerant of penicillins or cephalosporins, but it is contraindicated in children <8 years of age in some countries, and during pregnancy and lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days)

Acute

of doxycycline for Lyme disease in children <8 years old.[27] [28]

» Various studies have used 10 to 28 days of treatment. In most cases 14 days is adequate, but there is not complete consensus.

adjunct **temporary pacemaker**

» Temporary pacemaker is recommended for patients with advanced atrioventricular block.[2] [37]

neurological disease

early symptoms confined to peripheral nervous system

1st **oral or intravenous antibiotic therapy**

Primary options

» doxycycline: children: 2 mg/kg orally twice daily; adults: 100 mg orally twice daily

OR

» ceftriaxone: children: 50-100 mg/kg/day intravenously once daily; adults: 2 g intravenously once daily

OR

» cefotaxime: children: 150-200 mg/kg/day intravenously given in 3 divided doses; adults: 2 g intravenously every 8 hours

OR

» benzylpenicillin sodium: children: 25-50 mg/kg intramuscularly/intravenously every 4-6 hours, maximum 2.4 g every 4 hours; adults: 2.4 g intramuscularly/intravenously every 4-6 hours

» Patients with early neurological symptoms of Lyme disease confined to the meninges (including meningitis), cranial nerves, nerve roots, or peripheral nerves (Bannwarth's syndrome) can be treated with a 2-week course of either an oral antibiotic (doxycycline) or an intravenous antibiotic (ceftriaxone, cefotaxime, or benzylpenicillin).[25] One Cochrane review found low- to very low-quality evidence that penicillin G, doxycycline, ceftriaxone, and cefotaxime produce similarly good outcomes for treatment of early Lyme neuroborreliosis in Europe; no trials were identified for neurological Lyme disease in the US.[38]

Acute

» Doxycycline is contraindicated in children <8 years of age in some countries, and during pregnancy and lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] [28]

» Treatment decisions for patients with both joint and neurological involvement are based on an individual patient's circumstances under specialist supervision.

late symptoms confined to peripheral nervous system — **1st** — **oral or intravenous antibiotic therapy**

Primary options

» doxycycline: children: 2 mg/kg orally twice daily; adults: 100 mg orally twice daily

OR

» ceftriaxone: children: 50-100 mg/kg/day intravenously once daily; adults: 2 g intravenously once daily

» For late Lyme disease with peripheral neuropathy and acrodermatitis chronica atrophicans, the European Federation of Neurological Societies guideline recommends treatment with either oral doxycycline or intravenous ceftriaxone for 3 weeks.[25]

» Doxycycline is contraindicated in children <8 years of age in some countries, and during pregnancy and lactation; in the UK, doxycycline is not recommended for use in children <12 years of age. In the US, the American Academy of Pediatrics endorses short-term use (<21 days) of doxycycline for Lyme disease in children <8 years old.[27] [28]

» Treatment decisions for patients with both joint and neurological involvement are based on an individual patient's circumstances under consultant supervision.

central nervous system manifestations — **1st** — **intravenous ceftriaxone**

Primary options

» ceftriaxone: children: 50-100 mg/kg/day intravenously once daily; adults: 2 g intravenously once daily

» Patients with manifestations such as myelitis, encephalitis, and vasculitis require intravenous ceftriaxone for 2 weeks (for early symptoms) or 3 weeks (for late symptoms).[25]

Acute

» The treatment of facial palsies is controversial. There are no definitive data to support whether they need to be treated as neurological complications or acute Lyme disease without central nervous system manifestation.[39] The authors of this monograph treat isolated facial palsies in patients with Lyme disease as early neuroborreliosis with cranial nerve involvement.

» Treatment decisions for patients with both joint and neurological involvement are based on an individual patient's circumstances under consultant supervision.

arthritis

1st **oral antibiotic therapy**

Primary options

» doxycycline: children ≥8 years of age: 2 mg/kg orally twice daily; adults: 100 mg orally twice daily

OR

» amoxicillin: children: 20-50 mg/kg/day orally given in 3 divided doses; adults: 500 mg orally three times daily

OR

» cefuroxime: children: 15-30 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

Secondary options

» erythromycin base: children: 30-50 mg/kg/day orally given in 4 divided doses; adults: 500 mg orally four times daily

OR

» clarithromycin: children: 15 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

» Lyme arthritis can be treated with the same preferred oral regimens as for uncomplicated Lyme disease, for an extended period of treatment (28 days total).

» Persistence or recurrence of symptoms will require retreatment.

» Doxycycline is contraindicated in pregnancy and lactation, and is not recommended in

Acute

children <8 years old if treatment course is >21 days, as there is a lack of safety data.[27] [28] In the UK, doxycycline is not recommended for use in children <12 years of age.

» Treatment decisions for patients with both joint and neurological involvement are based on an individual patient's circumstances under consultant supervision.

adjunct **non-steroidal anti-inflammatory drugs**

Primary options

» diclofenac potassium: adults: 50 mg orally (immediate-release) three times daily when required

OR

» ibuprofen: children: 10 mg/kg/dose orally every 4-6 hours when required, maximum 40 mg/kg/day; adults: 300-400 mg orally every 6-8 hours when required, maximum 2400 mg/day

» Non-steroidal anti-inflammatory drugs can be used for symptom relief for Lyme arthritis, along with antibiotic therapy.

Ongoing

recurrent or persistent arthritis

1st **oral or intravenous antibiotic therapy**

Primary options

» doxycycline: children ≥8 years of age: 2 mg/kg orally twice daily; adults: 100 mg orally twice daily

OR

» amoxicillin: children: 20-50 mg/kg/day orally given in 3 divided doses; adults: 500 mg orally three times daily

OR

» cefuroxime: children: 15-30 mg/kg/day orally given in 2 divided doses; adults: 500 mg orally twice daily

Secondary options

Ongoing

» ceftriaxone: children: 50-100 mg/kg/day intravenously once daily; adults: 2 g intravenously once daily

» Persistence or recurrence of arthritis symptoms should be retreated with a second 4-week course of oral antibiotics or a 2- to 4-week course of intravenous ceftriaxone.[2] [43] [44]

» Oral treatment is preferable, unless there was no response to oral therapy at all in the first cycle.

» Doxycycline is contraindicated in pregnancy and lactation, and is not recommended in children <8 years old if treatment course is >21 days, as there is a lack of safety data.[27] [28] In the UK, doxycycline is not recommended for use in children <12 years of age.

2nd **arthroscopic synovectomy**

» In patients who did not respond to antibiotic therapy alone (antibiotic-refractory Lyme arthritis), arthroscopic synovectomy has been used successfully.

» It should be initiated only under consultant supervision.

3rd **pharmacotherapy**

» Anecdotal use of intraarticular injections of corticosteroids, systemic administration of non-steroidal anti-inflammatory drugs, or disease-modifying antirheumatic drugs such as hydroxychloroquine have also been reported to help patients with antibiotic-refractory Lyme arthritis.

» It should be initiated only under consultant supervision.

Recommendations

Monitoring

Patients with uncertain initial diagnosis should be followed up with a convalescent phase serology in 2 to 4 weeks.[23]

After the initiation of treatment, patients with Lyme disease, including those with meningitis, should be followed up in 1 to 2 weeks for resolution of symptoms.

People who have removed ticks from themselves (including those who have received prophylactic antibiotics) should be monitored for signs and symptoms of tick-borne disease for up to 30 days.[2]

Patients with Lyme arthritis who have persistent or recurrent symptoms after completing an appropriate treatment course should receive a second course of oral or parenteral antibiotics for 4 weeks.[2]

Patients with Lyme carditis, who have symptoms such as syncope, dyspnoea, or chest pain, or those who have second- or third-degree atrioventricular block, or first-degree heart block with a prolonged PR interval (greater than or equal to 300 milliseconds), should be admitted and continuously monitored in a cardiac unit.[2]

Patient instructions

Complications

Complications	Timeframe	Likelihood
acute neurological complications	**short term**	**medium**
Peripheral nervous system involvement in early Lyme disease includes radiculopathy, cranial neuropathy, and mononeuropathy multiplex. Facial palsy (cranial nerve VII) is the most common type of cranial nerve involvement. Central nervous system involvement includes lymphocytic meningitis and rarely encephalomyelitis. Neurological complications occur in 10% to 15% of untreated Lyme disease patients; however, incidence is decreasing in recent years because of early diagnosis and treatment.[2] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57]		
cardiac complications	**short term**	**low**
Includes acute onset of varying degrees of intermittent atrioventricular (AV) block. Myopericarditis occurs rarely. Cardiac complications occur in 4% to 10% of untreated patients in the US.[2] [37] Hospitalisation and continuous monitoring are required for patients with chest pain, syncope, dyspnoea, second- or third- degree AV block, or first-degree block with PR interval greater than or equal to 300 milliseconds. Although there are no clinical trials comparing different methods of treatment, intravenous antibiotics are generally recommended to treat patients who require hospital admission. Temporary pacemaker is recommended for patients with advanced AV block.[2] [37] [60]		
borrelial lymphocytoma	**short term**	**low**

FOLLOW UP

Complications	Timeframe	Likelihood
Rare cutaneous manifestation seen in Europe. It presents as solitary bluish-red swelling a few centimetres in diameter and is commonly seen on the ear lobe in children and near the nipple area in adults.[2] [61] Treatment consists of doxycycline, amoxicillin, or cefuroxime for 14 to 21 days.[2] [29] [30] [31] [32] [33] [34] [35] [36] Pregnant or lactating women, or children <8 years of age should be treated in the same way, except doxycycline should be avoided. Macrolides are not recommended for first-line treatment but reserved for patients who are intolerant to all 3 first-line antibiotics.		
late musculoskeletal complications	**long term**	**medium**
This usually manifests as monoarticular or oligoarticular arthritis, commonly involving knee joints. Large knee effusions are common, usually resolving in a few weeks to a few months if untreated. Previously, the incidence of Lyme arthritis was 60% in untreated patients in the US, but this number has decreased to 10% in recent years because of early treatment.[2] [43] [44] Non-steroidal anti-inflammatory drugs can be used in conjunction with antibiotic treatment, but intra-articular corticosteroid injections are not recommended because of lack of additional benefit.[2] [43] [44]		
late neurological complications	**long term**	**low**
This usually manifests as encephalomyelitis, peripheral neuropathy, or encephalopathy. Peripheral neuropathy presents as mild diffuse polyneuropathy in a glove and stocking distribution. Cerebrospinal fluid (CSF) shows lymphocytic pleocytosis with moderately elevated protein and normal glucose level. Seropositivity confirmed by enzyme-linked immunosorbent assay and Western blot assays is present. CSF polymerase chain reaction (PCR) is positive for *Borrelia burgdorferi* antibody or DNA. PCR has low sensitivity.[2] [58] [59] Once antibiotic therapy is completed, retreatment is not recommended without objective evidence of infection.[2] [58] [59]		
post-treatment Lyme disease syndrome (PTLDS)	**long term**	**low**
A minority of patients with Lyme disease treated with appropriate antibiotics may complain of subjective symptoms for several months. Patients may describe persistent or recurring non-specific symptoms such as fatigue, diffuse musculoskeletal pains, and cognitive difficulties for more than 6 months after the appropriate antibiotic therapy.[2] However, multiple studies have failed to show that these symptoms are in excess of what is expected in non-infected patients.[62] [63] There is no obvious explanation for why post-Lyme disease syndrome occurs. There is no biological evidence that *B burgdorferi* persists after receiving the appropriate course of antimicrobial treatment. Antibiotic therapy is not recommended for patients with post-Lyme disease syndrome.[2] [62] Re-treatment with antibiotics was found to be of no benefit and may cause serious side effects.[64] [65]		

Prognosis

If patients are diagnosed and treated properly with recommended antibiotic therapy, Lyme disease is usually curable. A small proportion of patients may report subjective symptoms for a month to several months without any evidence of ongoing infection. In one randomised, double-blinded, placebo-controlled clinical

trial, conducted in Europe, longer-term antibiotic treatment did not provide any additional benefit to patients with persistent symptoms attributed to Lyme disease.[45]

In untreated patients, most of the erythema migrans lesions improve spontaneously, but 5% to 10% of patients will have recurrent lesions. Up to 80% of patients develop a chronic joint problem ranging from arthralgia to arthritis, while 20% do not manifest any chronic sequelae. Of the patients with chronic sequelae, about 11% and 4% also develop neurological and cardiac involvement.

Reinfection can occur in patients who have a repeat tick bite. It has been reported to occur at a rate of 1.2% to 14.6% in the endemic areas of US. Relapse has not been reported in patients who received an appropriate antibiotic treatment.

Diagnostic guidelines

Europe

Lyme disease

Published by: National Institute for Health and Care Excellence **Last published:** 2018

Rational diagnostic strategies for Lyme borreliosis in children and adolescents

Published by: German Academy of Pediatrics and Adolescent Health **Last published:** 2012

EFNS guidelines on the diagnosis and management of European Lyme neuroborreliosis

Published by: European Federation of Neurological Societies **Last published:** 2010

North America

Lyme disease

Published by: Government of Canada **Last published:** 2018

The clinical assessment, treatment, and prevention of Lyme disease, human granulocytic anaplasmosis, and babesiosis

Published by: Infectious Diseases Society of America **Last published:** 2006

Recommendations for test performance and interpretation from the Second National Conference on Serologic Diagnosis of Lyme Disease

Published by: Centers for Disease Control and Prevention **Last published:** 1995

Treatment guidelines

Europe

Lyme disease

Published by: National Institute for Health and Care Excellence **Last published:** 2018

EFNS guidelines on the diagnosis and management of European Lyme neuroborreliosis

Published by: European Federation of Neurological Societies **Last published:** 2010

International

Evidence assessments and guideline recommendations in Lyme disease

Published by: International Lyme and Associated Diseases Society **Last published:** 2014

North America

Lyme disease

Published by: Government of Canada **Last published:** 2018

Practice parameter: treatment of nervous system Lyme disease

Published by: American Academy of Neurology **Last published:** 2007

The clinical assessment, treatment, and prevention of Lyme disease, human granulocytic anaplasmosis, and babesiosis

Published by: Infectious Diseases Society of America **Last published:** 2006

Online resources

1. CDC: Lyme disease *(external link)*
2. CDC: tickborne diseases *(external link)*

Key articles

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Images

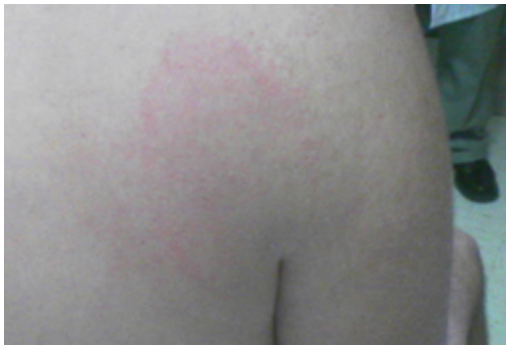

Figure 1: Erythema migrans

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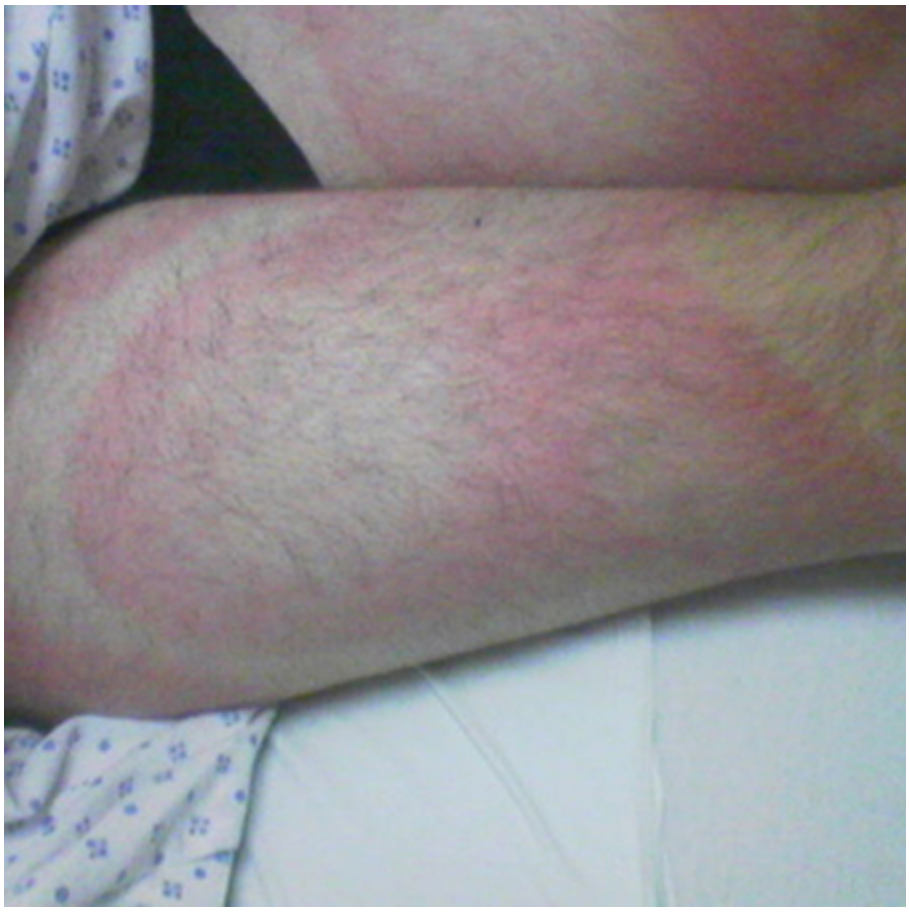

Figure 2: Erythema migrans

From the personal collection of Dr Cristian Speil

Figure 3: Deer tick (or black-legged tick), Ixodes scapularis , as it was questing on a blade of grass

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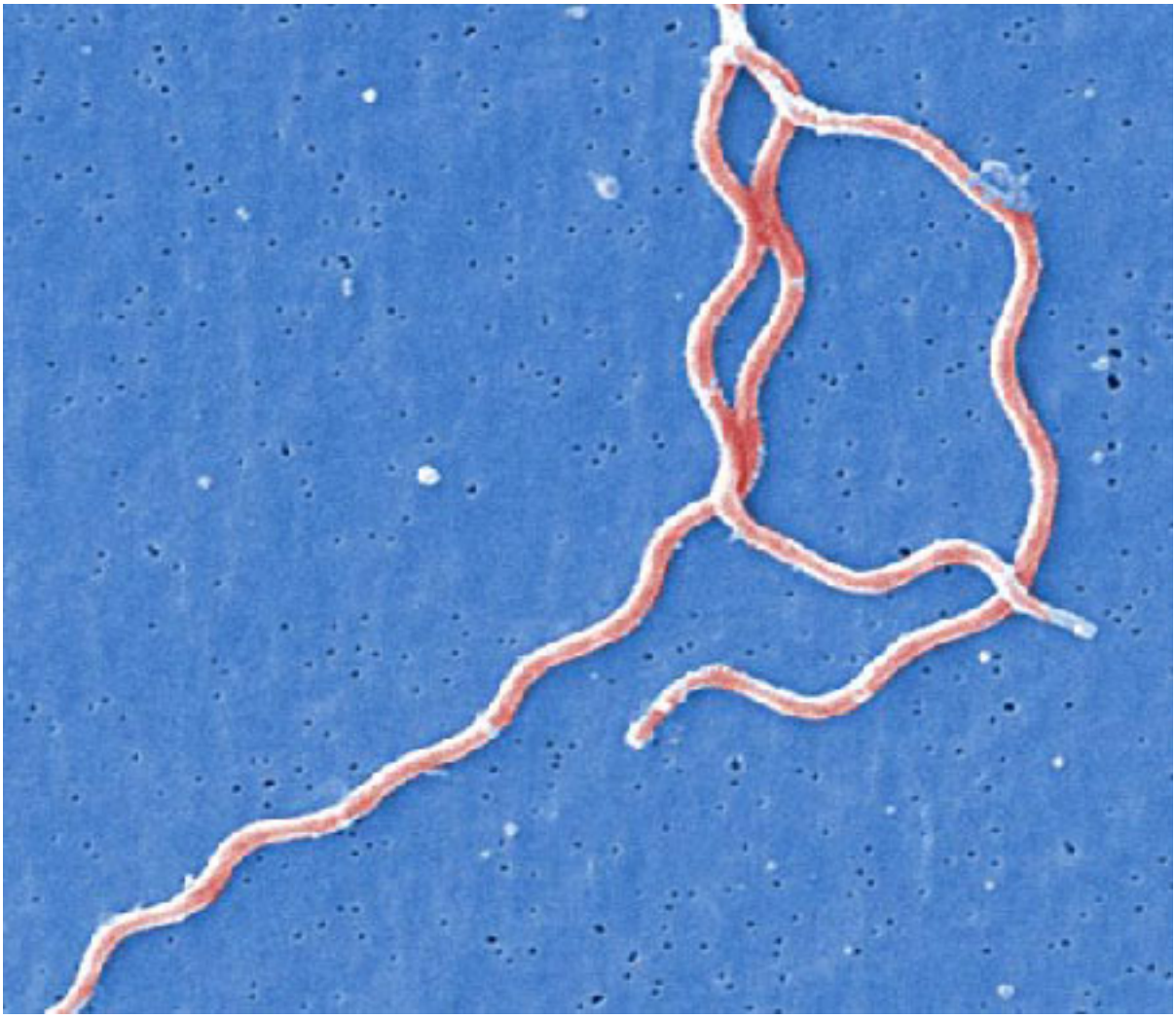

Figure 4: Under a high magnification, this digitally-colourised scanning electron micrograph depicts three gram-negative, anaerobic, Borrelia burgdorferi bacteria, which had been derived from a pure culture

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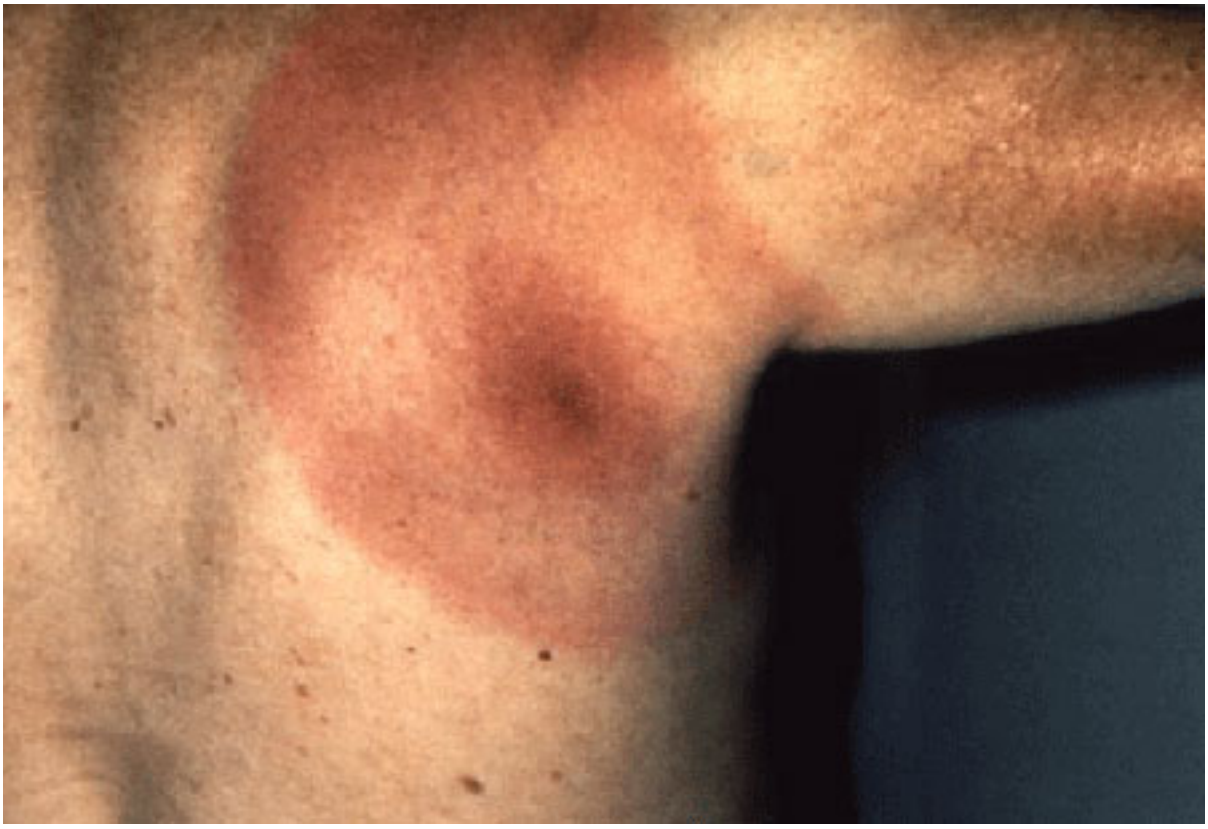

Figure 5: Posterior right shoulder region of a patient with Lyme disease showing erythema migrans

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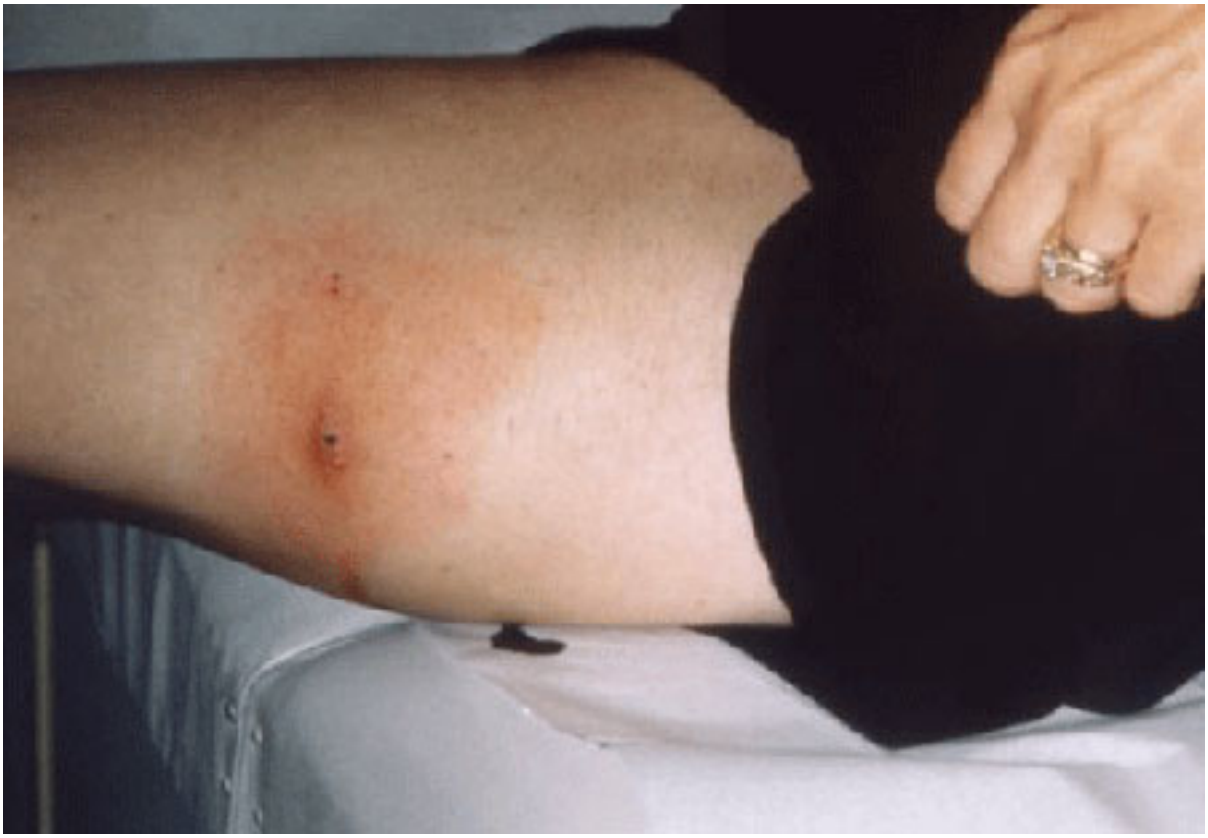

Figure 6: Lateral aspect of the left thigh of a patient who'd presented with what was diagnosed as Lyme disease showing the characteristic red, expanding rash (erythema migrans)

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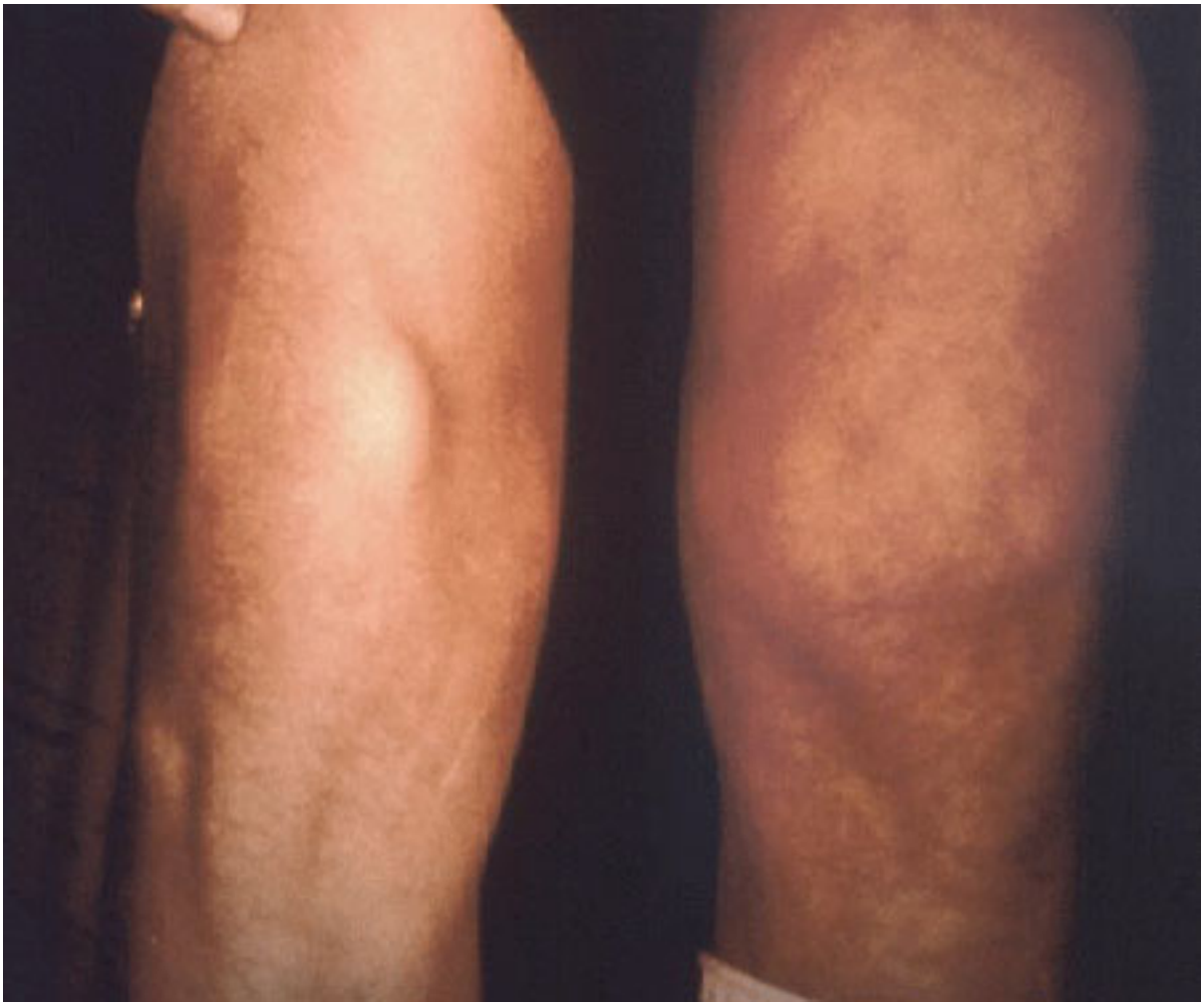

Figure 7: This Lyme disease patient presented with the signs and symptoms indicative of arthritic changes to his right knee due to a Borrelia burgdorferi bacterial infection

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