POWV frequently progresses to encephalitis and/or meningitis, which typically leads to chronic neurological deficit or death.

**DIAGNOSIS:**
POWV diagnosis requires a detailed history of possible exposure, signs and symptoms — and a high clinical suspicion. As the virus is contained in the tick's saliva, transmission can occur within minutes of a bite. Confirmation by laboratory testing may include both blood and spinal fluid.

**TREATMENT:**
Currently, there is no treatment protocol for POWV and therapy is primarily supportive.

**Tularemia**

**ORGANISM:**
This rare and infectious disease is caused by Francisella tularensis.

**VECTOR & DISTRIBUTION:**
Tularemia has become evident worldwide, mainly in rural areas. It is spread by insect bites, deer flies, dog ticks, wood ticks, lyme star ticks, and exposure to sick or dead animals. Occasionally, it can be spread by airborne bacteria found in soil, contaminated food or water, or by eating or handling undercooked meat of an infected animal.

**SYMPTOMS:**
The disease commonly attacks the:
- Skin
- Eyes
- Lymph nodes
- Lungs

**DIAGNOSIS:**
A presumptive diagnosis of tularemia may be made through testing of specimens using direct fluorescent antibody, immunohistochemical staining, or PCR. Confirmation may be made by culture or acute and convalescent serology.

**TREATMENT:**
Currently, there is no treatment protocol for POWV and therapy is primarily supportive.

**Mycoplasmas**

**ORGANISM:**
Mycoplasmas are small, self-replicating organisms found as both commensal and pathogenic bacteria in humans.

**VECTOR & DISTRIBUTION:**
Mycoplasma species are distributed throughout the United States. Direct exposure is the most accepted method of transmission. Certain Mycoplasma species, particularly M. fermentans, have been identified in blood-sucking arthropods, including lyme ticks. Reactivation is possible when the immune system is under attack, such as with Borrelia infection.

**SYMPTOMS:**
Early systemic symptoms include fatigue and myalgias. In addition to atypical pneumonia, M. pneumoniae can also induce autoimmune hemolytic anemia. Late complications may involve the neurologic, cardiovascular, hematologic, gastrointestinal and integumentary systems and include:
- Pericarditis
- Myocarditis
- Nephritis
- Encephalitis
- Meningitis

**TREATMENT:**
For Lyme and Tick-Borne Co-Infections

**NOTE:** These can persist even after treatment with antibiotics.

**DIAGNOSIS:**
Once suspected, diagnosis can be confirmed by antibody testing or PCR. This is complicated by the fact that there are many species of Mycoplasma that can cause disease in humans and most testing is species-specific.

**TREATMENT:**
Because Mycoplasma species do not have a cell wall, they are resistant to many antibiotics. Antibiotics targeting bacterial rRNA in ribosomal complexes are used, including macrolides, tetracyclines, ketolides, and fluoroquinolones which are bactericidal rather than bacteriostatic.
Many tick species are reservoirs or "cesspools" for multiple organisms such as Borrelia, Babesia, Babesia, Ehrlichia, Anaplasma, Chlamydia, Mycoplasma species and viruses such as Powassan. These organisms are often referred to as "co-infections," however, each infection represents a distinct organism, a characteristic pathology and a separate diagnosis. Multiple concurrent infections can amplify patient presentation and may contribute to persistent symptoms and treatment failure. As with Lyme Disease, all tick-borne infections can present with symptoms that are often not explained by common laboratory testing. Critical attention to patient history and the practitioner's clinical judgment are vital to covering the full scope of a tick-borne disease.

The intent of this publication is to increase awareness among practitioners of the prevalence and presentation of the tick-borne infections frequently associated with Lyme disease, but often independent of Lyme. Please note that the signs and symptoms described in this brochure may be altered significantly in the presence of Lyme or other infections.

**Bartonella**

**ORGANISM:** Bartonella is a genus of small gram-negative intracellular organisms. Dozens of species have been identified, but three species are responsible for the majority of human Bartonella infections.

**SYMPTOMS:** Symptoms are frequently neurological/psychological. They may involve a combination of body systems and include:

- Headaches, frequently frontal - Numbness/Tingling - Brain fog
- Muscle twitching - Shin pain/Bone pain - Irritability/Rage
- Depression

**DIAGNOSIS:** Vascular Endothelial Growth Factor (VEGF) may be elevated in active infection.

**TREATMENT:** Oral treatment includes tetracyclines, macrolides and rifampin. 

**Take-Borne Relapsing Fever (TBRF)**

**ORGANISM:** TBRF is caused by at least 16 species of Borrelia – four of which cause the majority of illness: B. hermsii (most common), B. parkeri, and B. turicatae (most likely to present with neurologic involvement). B. miyamotoi is a recent addition to this group. Because of characteristic DNA rearrangement, their antigenic variation allows them to evade the host immune response and cause relapsing episodes of symptoms.

**VECTOR & DISTRIBUTION:** These Borrelia species have been found in a variety of hard- and soft-bodied ticks. Cases of TBRF have been found throughout the United States. Some species of TBRF can be transmitted from tick to host in a matter of minutes.

**SYMPTOMS:** Classic descriptions of TBRF include febrile episodes are accompanied by multiple, non-specific symptoms:

- Headache - Hypesthesia - Abnormal pain - Abdominal pain - Dry cough - Rash - Jaundice - Hepatoplenomegaly lasting about three days separated by 7-day afebrile periods

The end of a febrile episode follows a sequence of events, called a "crisis" in which very high temperatures, delirium and tachycardia are followed by drenching sweats and transient hypotension as body temperature rapidly decreases. 

**DIAGNOSIS & TREATMENT:**

- Rarely, the organism can be visualized in the blood during febrile spikes. More recent studies have demonstrated that TBRF may present independently to Lyme disease, which makes diagnosis difficult as Lyme tests generally do not detect TBRF.

**TREATMENT:**

- Treatment may include atovaquone, malarone, nitazoxanide and several other treatments. According to the 2019 Merck Manual, diagnosis and treatment testing for both is warranted. Asymptomatic patients usually require no treatment.

**Anaplasma Phagocytophilum**

**ORGANISM:** Anaplasma phagocytophilum is an obligate intracellular gram-negative bacteria of the order Rickettsiales. 

**SYMPTOMS:** Patients with Babesia display flu-like symptoms such as:

- Fever/Chills/Sweats/Body aches - Headache, frequently at vertex - Dizziness
- Loss of appetite/Nausea - Chest pain/Palpitations - Air hunger - Fatigue

When Babesia co-infect a Lyme patient, Lyme may become more severe and more treatment-resistant.

If left untreated, patients can develop complications such as:

- Low blood pressure - Hemolysis - thrombocytopenia
- Disseminated intravascular coagulation (DIC) - Malfunction of vital organs - Death

**DIAGNOSIS:**

- If you suspect a patient is infected with Babesia, serology, fluorescence in situ hybridization (FISH) and polymerase chain reaction (PCR)-based tests are available for B. microti and B. duncani and since both manifest similarly, testing for both is warranted. Asymptomatic patients usually require no treatment.

**TREATMENT:**

- Treatment may include atovaquone, malonate, nitazoxanide and several other natural and pharmaceutical antiparasitics.

**Ehrlichia**

**ORGANISM:** Ehrlichia chaffeensis is an obligate intracellular, gram-negative species of Rickettsiales bacteria which is responsible for Human Monocytic Ehrlichiosis.

**SYMPTOMS:**

- Headache
- Nausea, vomiting and anorexia

**DIAGNOSIS:**

- Early diagnosis can be difficult as symptoms are often nonspecific. Confirmatory testing may also be challenging because of the small size of the organism and the relatively short duration of symptoms. 

**TREATMENT:**

- Treatment should begin early, based on clinical suspicion – delay can lead to increased morbidity and mortality. 

**Doxycycline** is the treatment of choice for Ehrlichia, as it is for most tick-borne infections.

**Anaplasma Phagocytophilum**

**ORGANISM:** Anaplasma phagocytophilum is an obligate intracellular gram-negative bacteria of the order Rickettsiales. 

**SYMPTOMS:** In the early stages, within 1-2 weeks after the tick bite, mild to moderate symptoms include:

- Severe headaches - FEVER - Chills - Diaphoresis

**DIAGNOSIS:** Laboratory studies may reveal relative lymphopenia, thrombocytopenia, elevated serum transaminases, elevated C reactive protein and hypoenzymemia. Confirmation may rely on a single elevated Ig G immunofluorescent antibody (IFA) titer or paired acute and convalescent IFA titers.

**TREATMENT:**

- Treatment should begin early, based on clinical suspicion – delay can lead to increased morbidity and mortality. 

**Doxycycline** is the treatment of choice for Ehrlichia, as it is for most tick-borne infections.