Purple Paper

Lyme Disease in Canada: An Update on Case Definitions and Treatments

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1. Introduction

Lyme disease is an emerging vector-borne infection in Canada. Although only 10-20% of the Canadian population will be exposed to this vector in 2014, it is probable that most Canadians will be at risk within a few years, and clinicians will be required to routinely diagnose or exclude Lyme disease in their patients. This paper is an introduction to the challenges of Lyme disease diagnosis and the sensitivities and specificities of both clinical features and laboratory tests. In conjunction with its companion paper on the epidemiology of Lyme disease (Purple Paper #43), this is a review of the clinical and public health framework for diagnosis and management within the Canadian context.

The diagnostic approach to Lyme disease depends upon the duration of infection. In its acute stage Lyme disease can usually be confidently diagnosed from the presence of a single finding, the bull's-eye rash. During this phase diagnostic blood tests are insensitive. Between 4-8 weeks post-infection, serology becomes increasingly reliable, cutaneous features less so, and other symptoms and signs may appear. A proper weighting of symptoms with serology will permit the clinician to diagnose or exclude Lyme with confidence; but there is no approach – particularly in Canada, where the disease has an evolving, patchwork distribution – which is fully sensitive, specific, and universally applicable. In all stages, diagnosis depends upon an index of suspicion which weighs local knowledge of the tick epidemiology, patient history, clinical presentation and diagnostic serology.

An effective public health framework should consider both the evidence-based approaches to true Lyme disease, and develop a rational response to 'chronic Lyme' disease, a phenomenon that has attracted patient activism as well as supporting institutions parallel to the scientific and medical establishment. These support an alternative understanding of the disease, one that emphasizes unsupported diagnostic and treatment protocols and an invalid view of the infection process. This creates a real burden of suffering in people who believe themselves to be infected with a refractory Lyme infection, and seek out sometimes-dangerous treatment. Situations in which the patient's felt needs are strongly at variance with the clinician's informed opinion are rarely simple; here it is helpful to remember that though 'chronic Lyme' is an unproven illness, the symptoms that trigger the diagnosis are frequently real and need empathetic care.

Key Points

- Lyme disease is normally a clinical diagnosis during the first 4-6 weeks and subsequently a serological diagnosis with compatible clinical features; diagnosis of later stages of untreated Lyme disease requires serological support.
- The current testing standard is a two-tiered test, an initial ELISA which (if positive or indeterminate) is confirmed by a Western Blot; but there is good evidence to support a simpler, cheaper, and more reliable sequence of two ELISA tests that identify different immune responses.
- Multiple symptoms can occur following untreated Lyme disease and these generally respond to antimicrobial treatment. However, sustained symptoms refractory to correct antimicrobial treatment are usually due to another illness or the post-Lyme syndrome. Currently there is no evidence of persisting *B. burgdorferi* infection that accounts for these symptoms and these patients should be investigated for other diagnoses.
- Commercially available tests use a number of unvalidated, untrustworthy measurements and should not influence either a diagnosis or the therapeutic approach.

2. Clinical and Serological Diagnosis

Stage I Acute Lyme disease has a single classical sign in about 80% of cases, erythema migrans (the bull's-eye rash, see Figure 1))[1,2] which is nearly pathognomonic if the patient has been exposed to potential tick bites in an endemic area.[1,3] In this instance, a clinical diagnosis is made and treatment should be prescribed urgently. Serology is less important and is often negative. With other symptoms (fever, malaise, headache), serology becomes the diagnostic backstop. However all symptoms and signs during the acute phase are nonspecific with the exception of the classical erythema migrans (Figure 1). If the positive predictive value (PPV) of different symptoms is examined,[a] it can be seen that most have a limited role for diagnosis.[3]

See Tibbles & Edlow (2007) for a review of conditions that can appear similar to erythema migrans.[4]

Figure 1. Erythema migrans (source: Public Health Agency of Canada disease)[5]

Stage I (acute cutaneous disease) *Borrelia burgdorferi* is inoculated via tick bite, and begins to reproduce and spread cutaneously. The primary diagnostic symptom is the erythema migrans. Other symptoms are those of generalized inflammatory processes: chills, low-grade fever, malaise, headache, arthralgia, and myalgia.[6] This stage is considered to last approximately 30 days. Serological tests are insensitive throughout this stage but improve week by week.

Table 1. Sensitivity of serology[7,8] and positive predictive value (PPV)[3] of symptoms (acute stage).

Erythema migrans + exposure	PPV ~100% (with qualifications)
General symptoms + exposure	PPV extremely low, even in endemic areas
Standard two-tier serology[7,8]	27% - 61% sensitivity (with erythema migrans)[7]
Standard serology (1st week)	16% sensitivity[9]
Standard serology (2-4 weeks)	48% sensitivity[9]

Stage II (early disseminated): *B. burgdorferi* disseminates widely, and symptoms may occur weeks to months post-tick-bite. Multiple erythema migrans may appear and various neurological (10-15% of patients),[10] rheumatic, and cardiac symptoms may manifest:[11] Bell's palsy (facial paralysis, unilateral or bilateral), meningitis (head and neck pain), heart palpitations, chest pain and heart block,[12,b] pain and swelling in the large joints.[c] Cognitive issues in Lyme disease do not appear to be due to bacterial invasion of the nervous system.

Table 2. Sensitivity of serology[7,8] and PPV of symptoms[3] (early disseminated phase 4-24 weeks)

Standard two-tier serology[7,8]	73% - 100% sensitivity
Bell's palsy (bilateral)	PPV 46%
Bell's palsy (bilateral, endemic area)	PPV 96%
Cognitive slowing	PPV <1%
Cardiac symptoms (heart block)	PPV low

Stage III (late disseminated): *B. burgdorferi* disseminates to multiple systems and causes muscle and joint pain, weakness, cognitive problems, joint

[a] PPV values will vary based on incidence. Halperin et al.[3] are the source for these three tables, and assume average or high incidence; in Canada PPV will generally be lower.

[b] Though it is extremely unusual for Lyme disease to be fatal, a few deaths may be attributable to this.

[c] Substantial joint involvement is more common in later stages; cardiac involvement is rare.

swelling, and numbness/tingling. This stage is sometimes referred to as Lyme arthritis.

Table 3. Sensitivity of serology[7,8] and PPV[3] of symptoms (late disseminated stage)

Standard two-tier serology[7,8]	96-100% sensitive
Various chronic symptoms	PPV very low[d]
Large-joint oligoarthritis	PPV low

There are qualifications to the pathognomonicity of erythema migrans:

1. Exposure is defined as the possibility of a bite from the tick persisting undetected on the skin for at least 24 hours in an endemic area (see companion Purple Paper). Erythema migrans can occur between 3-30 days post-tick bite, but 7-14 days is considered typical.[13]

2. Only ~25% of patients with proven Lyme remember a tick bite: 'exposure' can be measured by patient behaviour/local conditions (i.e. outdoor activities + documented presence of appropriate ticks + correct season).

3. 'Exposure' requires the presence of an appropriate species of tick. See the companion Purple Paper # 43 for information on which tick species are Lyme disease vectors.

4. The classical appearance of erythema migrans is an expanding erythema with central clearing, red to bluish-red, occasionally raised, and lacking any symptoms aside from heat. Development of the central clearing is dependent upon duration; an early erythema migrans will lack this. The minimum diameter is 5 cm, the median diameter is 16 cm, and the maximum diameter is 70 cm.[4] Erythema migrans is dynamic, and its distinctiveness has been over-estimated.[14] The central clearing may not present immediately; patients with a non-classical rash should monitor its development.

Between 70-90% of Lyme disease patients present with erythema migrans.[1,2] When a clinician encounters a potential illness with erythema migrans, the patient's recent history will estimate exposure. This requires a travel history as well as local endemic conditions that include current information on tick and *B. burgdorferi* epidemiology (see companion Purple Paper #43).

Post-Treatment Lyme Disease Syndrome (PTLDS):
PTLDS is diagnosed in patients who have experienced a *definitive Lyme disease diagnosis which has been treated correctly*, but who are currently experiencing persistent symptoms that lack another explanation. These include severe fatigue, cognitive dysfunction, and musculoskeletal pain.[15] The utility of this category is challenged by the fact that many of its symptoms are common in clinical practice and may be due to a large number of illnesses unrelated to Lyme disease.[13] PTLDS is a diagnosis of exclusion, occurs in 10-20% of patients with definitive Lyme disease, and has not been proved to be a continuing infection. Five trials have found no benefit from extended or continuous antibiotic treatment.[16] No living bacteria have been cultured from PTLDS patients,[8,17] and the symptoms are reminiscent of other chronic malaises which run the gamut from mild to crippling (post-infective fatigue disorder, chronic fatigue syndrome, fibromyalgia). The role of depression among these patients is inconclusive.[15] Supportive therapy is appropriate, but antibiotics have no proven benefit and can cause complications. This syndrome should not be confused with 'chronic Lyme disease' which is discussed later.

3. Issues Around Standard Serological Testing

The current standard test is two-tiered: a sensitive whole-cell sonicate ELISA which (if positive or indeterminate) is followed by a specific Western Blot (WB measures bands of IgM or IgG). WB IgM and WB IgG are both interpreted if infection is thought to be less than 30 days old, and WB IgG is more useful after 30 days.[18] The first tier ELISA increases steadily in sensitivity up to one month and approaches 100% thereafter. According to criteria from the Centers for Disease Control and Prevention, WB IgM become untrustworthy after 30 days, and yields many false positives; this has been found[19] to reduce the utility of standard two-tiered

[d] The incidence of similar conditions, such as chronic fatigue, fibromyalgia, and depression is higher than Lyme disease.

testing significantly, as it can take several more weeks for the WB IgG to register positive with the multiple bands that are required to be diagnostic. Four to six weeks post-tick bite can be an intermediate period for serological analysis that may yield indeterminate or contradictory results.

Serological tests cannot prove infection or cure (owing to the persistence of the antibody response), degree of dissemination, or infection by other *Borrelia* species. Early treatment prevents seroconversion in a minority of patients so a negative test following presumptive treatment of a 'classic' lesion does not rule out resolved acute Lyme disease.

Seronegative patients with symptoms exceeding 8 weeks in duration should be presumed negative. Seronegativity in late Lyme disease is most uncommon, and may not exist.[20]

There are indications that IgM is less specific in practice than it is in controlled test situations. One study[19] found that the false positive rate in a single clinical setting was 27.5%; the authors hypothesize that this is largely owing to over-reading of weak bands, testing for IgM over a month after infection, or using the IgM without a prior WCS ELISA that is positive or indeterminate. It is generally acknowledged[21,22] that replacing the Western Blot with a simpler and cheaper ELISA test reduces false positives with little or no loss of sensitivity; two ELISAs in particular (C6 ELISA or VIsE) have been extensively tested, and should be considered as part of an alternative diagnostic standard. The performance of different combinations of these three tests are compared in Table 4[e] in patients with noncutaneous manifestations.[23]

Table 4. Standardized comparison of different serological tests[23]

Serological Test	Sensitivity	Specificity
WCS ELISA + WB (current standard)	93.7	99.5
WCS ELISA (alone)	97.9	95.2
C6 ELISA (alone)	97.2	98.9
C6 ELISA + WB	93.0	99.5
WCS ELISA + C6 ELISA[f]	96.5	99.5
C6 ELISA + WCS ELISA	96.5	99.5

Porwancher et al. found[21] that using a C6 ELISA or a VlsE1 ELISA as the second tier increases sensitivity during the later acute stage by 20%, and by 12.5% overall.

The current 2-tiered test maximizes specificity – when it was chosen, a WCS ELISA followed by a WB produced less than 1% false positives, and no new test has performed better for this measure. However, other simpler and cheaper options are now available that perform equally well: the C6 ELISA alone is nearly twice as sensitive in patients that present with a single erythema migrans, though slightly less specific overall.[7] A protocol that used the WCS ELISA followed by a C6 ELISA would increase sensitivity, maintain specificity, and reduce cost and complexity. This has also been demonstrated to be a superior approach for diagnosing Lyme disease of European origin.[24]

If the performance[24] of three protocols – the standard two-tiered test, a two-tiered protocol of a WCS ELISA followed by a C6 ELISA, and the standalone C6 ELISA test – are measured against the estimated incidence of Lyme disease in the United States (300,000 annual cases),[25] and the estimated number of Lyme disease tests (3,400,000 in 2008),[21] we would see the following results (assuming each Lyme disease case is tested):

Table 5a. Estimated results for standard 2-tiered test given American epidemiology and performance values from Wormser et al.[26]

	Disease Present	Disease Absent
Positive Tests	281,100	15,500
Negative Tests	18,900	3,084,500

[e] Where two tests are used. In series, the figures given reflect the combination of both.

[f] This is a conservative estimate. In other research (Branda et al.)[7] this combination of ELISA tests was found to be 100% specific.

Table 5b. Estimated results for 2-tiered test with a standard ELISA followed by a C6 ELISA, given American epidemiology and performance values from Wormser et al.[26]

	Disease Present	Disease Absent
Positive Tests	289,500	15,500
Negative Tests	10,500	3,084,500

Table 5c. Estimated results for single-tier C6 ELISA, given American epidemiology and performance values from Wormser et al.[26]

	Disease Present	Disease Absent
Positive Tests	291,600	34,100
Negative Tests	8,400	3,065,900

Deciding which serological approach is appropriate for Canada must take into account the ratio of tests to diagnosed cases, the relative and potential costs of false negatives and false positives, and the relative complexity of Western Blots and ELISAs. It is important to consider the trade-offs involved and how these change in different epidemiological conditions.

Molecular testing for Lyme disease by PCR has improved although it is neither standardized nor widely available; this offers the possibility of a direct test for *B. burgdorferi.* It may be applicable during the very early acute stage (prior to seroconversion). Interested parties should refer to Eshoo et al.[27]

4. Non-Standard Commercial Testing

People who suspect they have Lyme disease may choose private, for-profit testing services; these are largely American-based. Clinicians may have patients who have self-diagnosed or been diagnosed by a doctor, using a combination of symptoms, Internet advice, and commercial tests. PHAC (28) and the CDC (29,30) do not accept the following methods to support a Lyme disease diagnosis:

- capture assays for antigens in spinal fluid or urine
- culture, immunofluorescence staining, or cell sorting of cell wall-deficient or cystic forms of *B. burgdorferi*
- lymphocyte transformation tests
- quantitative CD57 lymphocyte assays
- nucleic acid amplification testing
- PCR tests for *B. burgdorferi* on inappropriate specimens (e.g. blood, urine)
- WB IgM and WB IgG that are interpreted using unvalidated criteria (e.g. fewer bands)
- WB IgM and WB IgG tests without a positive/indeterminate WCS ELISA
- 'reverse Western blots'
- measurements of antibodies in joint fluid

The performance of any testing method depends upon three criteria: the sensitivity and the specificity of the test, and the epidemiology of the population being tested. In Canada the incidence of Lyme disease is low, therefore a substantial rate of false positives can be expected even when using the best available serological tests. Using substandard diagnostic tests could result in erroneous diagnoses and unnecessary treatment.

The CDC standard for serological diagnosis can differ significantly from that used by a commercial laboratory.

<u>CDC interpretation standards[31] for WB IgM and WB IgG</u>

- WB IgM: 2 out of 3 bands[g] = positive (with prior positive/indeterminate WCS ELISA)
- WB IgG: 5 out of 10 bands[h] = positive (with prior positive/indeterminate WCS ELISA)

<u>Commercial lab[32]</u>

- IgM WB: 2 out of 5 bands = positive (no prior WCS ELISA)
- IgG WB: 2 out of 6 bands = positive (no prior WCS ELISA)

[g] 24 kDa (OspC), 39 kDa (BmpA), and 41 kDa (Fla)

[h] *18 kDa, 21 kDa (OspC), 28 kDa, 30 kDa, 39 kDa (BmpA), 41 kDa (Fla), 45 kDa, 58 kDa (not GroEL), 66 kDa, and 93 kDa*

The commercial lab includes 2 bands for both tests, 31 kDa (Osp A) and 34 kDa (Osp B), which are not used by the CDC; and the IgG WB does not include the 18 kDa, 28 kDa, 30 kDa, and 66 kDa bands. It is unclear if a positive/indeterminate ELISA is a requirement for ordering the WB tests.
A urine-based dot-blot assay is available, marketed to patients who have tested negative but are still experiencing symptoms (unreferenced and with no data on sensitivity or specificity).[33] Urine-based tests are not approved by the CDC.

A PCR test for Lyme disease is available, performed on serum, whole blood, urine, CSF, tissue biopsy, joint fluid, and ticks.[34] Blood- and urine-based PCR tests are not approved by the CDC. CSF, tissue biopsies, and joint fluid seem less likely for a patient to provide themselves. PCR tests do not distinguish between living and dead bacteria,[35] and it is unclear what value this test provides to the patient, given that standard serology is cheaper, simpler, and approaches 100% sensitivity and specificity for late-stage disease. Most patients who self-diagnose do not do so within the initial 2-week period when PCR techniques are potentially superior.[i]

5. 'Chronic Lyme' Disease

'Chronic Lyme' is the name given to the theory that *B. burgdorferi* infection is able to conceal itself from detection and is responsible for a wide spectrum of symptoms. Supporters of this diagnosis hypothesize that the bacterium is cryptic, able to conceal itself from the immune system, occasionally emerge, and both cause severe symptoms and avoid triggering a positive serology test (on CDC approved standards).[17] Desired treatment includes long-term IV antibiotic therapy and a wide variety of alternative regimens. The Infectious Disease Society of America (IDSA) was taken to court over their 2006 diagnostic and treatment guidelines (which did not recognize 'chronic Lyme');[13] a court-ordered review exonerated and upheld their evidence and procedures.[36] This conflict over standards of evidence led to the formation of the rival International Lyme and Associated Diseases Society (ILADS), an advocacy group for 'Chronic Lyme'. This diagnosis has received considerable support from politicians, the media, and some in the scientific and health professional community. It has become the diagnosis of choice for individuals with a range of poorly understood symptoms that are not well explained by our current knowledge.
There are several steps that the clinician can consider when working with a patient who is concerned that they are ill due to 'chronic Lyme'.

<u>Verify the diagnosis of Lyme</u>
This is necessary to distinguish between PTLDS and 'chronic Lyme'. A large proportion of people presenting with 'chronic Lyme' have no history of tick bite, serological diagnosis, treatment, or even potential exposure. In the United States, Lyme disease referral centres report that as many as 75% of their patients fit this profile.[37] This does not invalidate their symptoms, but should inform clinical approaches.

Positive serology following treatment is not indicative of infection. To reiterate, there is no definitive evidence of infection following complete treatment.[8] There is no evidence that 'chronic' Lyme is caused by *Borrelia* variants, cysts, round bodies, or a number of hypothesized stages that are believed to conceal themselves in the body and sporadically emerge.[17] Since the symptoms of Lyme disease are caused by the immune response and not the pathogen, it is highly unlikely that a minimal cryptic infection would cause significant disease, particularly in the absence of a positive test.
Patients who have been diagnosed by commercial laboratories, compliant physicians, or their peers, are very possibly unaware that their diagnosis is contested.

<u>Select appropriate treatment</u>
People find the diagnosis of 'chronic Lyme' a possible alternative for the symptoms they are experiencing, often a significant burden of suffering; the symptoms of 'chronic Lyme', as they are popularly recognized, are very similar to non- infectious maladies such as fibromyalgia, chronic pain syndrome, and depression.[13] If these had been successfully resolved, it is unlikely that they would undertake the expensive and sometimes debilitating 'cures' that are marketed to 'chronic Lyme' patients.

[i] Potentially superior only as described by Eshoo et al.,[27] not in the general sense.

The primary goal of treatment is to address these symptoms.

A secondary goal when treating patients who believe themselves infected with a persistent case of Lyme disease is to avoid long-term antibiotic therapy, particularly by intravenous administration. Several studies have looked for evidence to support this intervention and found none; such treatment has resulted in one recognized death and an unknown number of dangerous adverse medical events. Documented side effects of long-term antibiotic therapy include death from candidemia,[38,39] non-fatal anaphylaxis, and biliary complications requiring cholecystectomy.[40] Again, there is substantial evidence of risks – between 1.6% and 26.1% of patients experience severe and sometimes life-threatening adverse events.[41,42]

Evaluate the patient

Feder et al. identify four categories of patients who might present with chronic Lyme.[43]

1. Patients with no objective clinical manifestations and a negative serology, and a diagnosis that is based on non-specific symptoms: arthralgia, disturbed concentration, night sweats, swollen glands, nausea, poor sleep, etc.

2. Patients who have identifiable maladies other than Lyme disease, who may have been misdiagnosed or are looking for an alternate diagnosis.

3. Patients with no history of objective symptoms for Lyme disease, but positive serology.

4. Patients who have symptoms appropriate for a diagnosis of Post Treatment Lyme Disorder Syndrome.

Studies of 'chronic Lyme' sufferers suggest that the majority of patients fall into one of these first two categories.[43] People who present with' chronic Lyme' have significantly higher rates[37] of psychiatric comorbidity and relevant psychological factors (catastrophizing, low positive affect, and high negative affect). The non-specific symptoms that are routinely used to support a clinical diagnosis of 'chronic Lyme' are common in the general population; one study found that a majority of the patients presenting with 'chronic Lyme' suffered from another illness.[40]

It should not be assumed that patients in the first category know that 'chronic Lyme' is a diagnosis that has no scientific validity (there are instances of patients who received intravenous antibiotic treatment who did not find this out until they presented at a hospital with life-threatening complications).

PPV of a positive test in the general population for category 3 is low, and antibiotics may have effects that offer temporary relief. When they are discontinued, the patient can reasonably and incorrectly assume that the original 'infection' was not eliminated. For category 4, diagnosis of PTLDS should be accompanied by a discussion of what it is (residual inflammation) and what it is not (continued infection).

Educate the patient

'Chronic Lyme' may be similar to parasitosis, a delusion of persistent and intractable infection; online forums devoted to the subject show the burden of illness, fear, and risk that these patients experience. Many are extremely knowledgeable about highly technical aspects of Lyme disease and different serological approaches; they reject a single fact, their negative diagnosis and the non-persistence of infection following treatment. Others with a variety of symptoms are ill-equipped to resolve the conflict between different authorities: the mainstream medical and scientific establishment, the alternative mainstream of LLMDs and commercial labs, and the online community of 'chronic Lyme' activists.

Consider alternate diagnoses

A significant proportion of *I. scapularis* ticks are infected with other transmittable diseases that are much less common than Lyme: Babesia, Tick Borne Relapsing Fever, HGA, *Borrelia miyamotoi*, and others. Patients who have a documented history of exposure, subjective symptoms, and negative Lyme serology can be investigated for these pathogens if the clinical features are present. Tick-borne diseases are more varied than can be covered here. The companion to this Purple Paper includes some of the ones most relevant to Canada, along with

references that cover a wider North American range.

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Prevention and Treatment of Tick Bites

Lyme disease prevention essentially means either preventing tick bites or extracting ticks within 24 hours of being bitten. More advanced interventions are possible, but have not been evaluated. The following measures are considered effective:

- wearing protective clothing: long sleeves, long pants, boots, shirts tucked into pants and pants tucked into socks
- checking clothing and exposed skin for ticks every two or three hours, and for a week afterwards
- wearing clothes treated with permethrin, and use a repellant containing PMD or DEET (this practice may be most realistic for outdoor workers)
- if bitten, remove ticks properly
- if bitten, monitor for rash, facial palsy, headache or flu-like symptoms, or arthralgia
- if bitten in a location in which Lyme disease is endemic, preserve the tick and consult your GP or public health office about the appropriateness of prophylactic antibiotics.

There is good evidence that most people *resist* adopting these interventions. They are technically effective (e.g. repellant use; treated clothing, mass spraying) but their use in health promotion is not based in strong evidence.

Public health measures should recognize that risk is not evenly distributed and that people often do not comply with the recommendations for avoiding ticks, but that educating people on checking for ticks seems to be accepted. Tailoring messages for people who are most likely to be exposed to ticks has been found valuable. For example people who spend a great deal of time outdoors are at risk, but do not need general information on how to remove ticks; instead, they should receive information on the symptoms of Lyme disease and how to avoid tick habitats.

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