Diagnosis and Management of Lyme Carditis

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Abstract

Lyme carditis most commonly manifests as cardiac conduction abnormalities, specifically high-degree atrioventricular block, which may require temporary pacing in conjunction with early intravenous antibiotic therapy. The Suspicious Index in Lyme Carditis (SILC) score has been developed to assess the likelihood that a patient with atrioventricular block has Lyme carditis. Other manifestations of Lyme disease include endocarditis, myocarditis, pericarditis, myopericarditis, pancarditis, and dilated cardiomyopathy. Antibiotics are the mainstay of treatment for Lyme carditis, but cardiovascular dysfunction should be treated according to guidelines for non-lyme disease patients.

Keywords

Lyme carditis • Lyme disease • Atrioventricular block • Dilated cardiomyopathy

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1 Introduction

Lyme disease (LD) is a tick-borne illness caused by pathogenic species of the *Borrelia* genus, most commonly *Borrelia burgdorferi* (B. *burgdorferi*). In Europe, other genospecies such as B. *afzelli* and B. *garinii* cause significant human disease and are associated with chronic skin infection and neurologic disease, respectively [1]. For further details on the epidemiology of LD, refer to Chap. 2.

The systemic manifestations of LD vary widely and include cardiovascular, neurological, and joint involvement [2]. Lyme carditis (LC) refers to LD manifestations involving the heart. LC most commonly presents as high-degree atrioventricular block (AVB) in 90% of cases [3, 4]. However, endocarditis, myocarditis, pericarditis, myopericarditis, pancarditis, and dilated cardiomyopathy (DCM) have also been reported [5, 6]. Thus, practitioners in regions of high prevalence must be able to detect and treat LC. An overview of the diagnosis and management of LC is presented in this chapter (Table 1). The presentation of LC in the pediatric population is discussed in Chap. 11.

2 Signs and Symptoms

Patients with LC and conduction abnormalities may present with cardiac symptoms including pre-syncope, syncope, and palpitations, but also non-specific findings such as erythema migrans (50%), fatigue (40%), and/or fever (28%). Other patients may be completely asymptomatic. [3, 4] The non-specific nature of these symptoms contributes to the uncertainty when detecting LC (Table 2).

Similarly, patients with myocarditis, pericarditis, myopericarditis, and pancarditis may be asymptomatic or report chest pain, syncope, dyspnea, and other symptoms of cardiac dysfunction [7, 8]. Notably, myopericarditis related to LD in particular can present with symptoms mimicking acute coronary syndrome (ACS) [10].

Lyme endocarditis should be considered for cases of endocarditis in endemic regions with no other identifiable cause, as well as endocarditis in the context of a recently reported tick bite. Signs and symptoms of LD endocarditis are non-specific, and patients may present with increasing fatigue, palpitations, dyspnea, intermittent fevers, anorexia, unproductive cough, or be asymptomatic [6, 9–11].

Emerging literature suggests that DCM may be a rare manifestation of LC, occurring in the late disseminated stage of LD months to years after initial infection. Significantly, severe DCM can progress to heart failure and subsequent transplantation. Patients present with typical symptoms of DCM, such as reduced exercise capacity, dyspnea, and chest pain, although some may be asymptomatic [12].

Table 1 Clinical presentation, diagnosis, and treatment strategies for manifestations of Lyme carditis

Lyme Carditis Manifestation	Clinical Presentation	Diagnosis	Treatment
All Causes **Lyme carditis may be symptomatic*	Erythema migrans Fever Fatigue Malaise Syncope	Enzyme-linked immunosorbent assay Western blot	Doxycycline Intravenous ceftriaxone
Conduction Abnormalities	Palpitations	Electrocardiogram	Pacing Temporary pacemaker Permanent pacemaker
Dilated Cardiomyopathy	Dyspnea Reduced exercise capacity Peripheral edema Chest pain Palpitations Coughing when supine (orthopnea, paroxysmal nocturnal dyspnea)	Real-time polymerase chain reaction of blood or endomyocardial biopsy Electron microscopy	Heart transplantation Standard treatment if heart failure occurs
Endocarditis	Cardiogenic Shock Chest pain Dyspnea Peripheral edema Chills Night sweats	Real-time polymerase chain reaction of blood or endomyocardial biopsy 16S rRNA polymerase chain reaction and sequencing Blood culture Tissue culture Electrocardiogram Echocardiogram Cardiac Computed Tomography Cardiac magnetic resonance	Surgical valve repair Surgical valve replacement Pericardiocentesis if progression to pericardial effusion occurs

(continued)

Table 1 (continued)

Lyme Carditis Manifestation	Clinical Presentation	Diagnosis	Treatment
Myocarditis	Palpitations Chest pain Dyspnea Peripheral edema	Electrocardiogram Echocardiogram Cardiac Computed Tomography Cardiac magnetic resonance	Corticosteroids in refractory disease or if resolution does not occur with antibiotics
Pancarditis	Palpitations Positional dyspnea Chest pain		Pericardiocentesis if progression to pericardial effusion occurs Corticosteroids in refractory disease
Myopericarditis	Palpitations Chest pain Dyspnea		
Pericarditis	Palpitations Pleuritic chest pain Dyspnea Peripheral edema	Electrocardiogram Echocardiogram Cardiac Computed Tomography Cardiac magnetic resonance	

Table 2 Signs and symptoms, electrocardiographic presentation, treatment, and resolution of patients with Lyme carditis presenting with atrioventricular block

	Reported frequency (%)
Signs and Symptoms	
Erythema migrans	50
Fever	28.4
Fatigue/malaise	39.8
Electrocardiographic Presentation	
Third degree atrioventricular block	77.3
Second degree atrioventricular block	33
Asystole/sinus pauses	12.5
Treatment	
Antibiotics	93.2
Pacemaker	44.3
Temporary	71.8
Permanent	17.9
Temporary-Permanent	10.3
Resolution	
Atrioventricular block resolved	94.3

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3 Diagnosis

3.1 Conduction Abnormalities

The most common conduction abnormality is AVB, which typically occurs in the first two months after LD exposure but may be seen as early as the first week after infection [2]. AVB can develop transiently but when present, can progress rapidly to life-threatening rhythm disturbances. Accordingly, patients are at risk of developing a fatal third-degree block without early antibiotic intervention [13, 14]. The Suspicious Index in Lyme Carditis (SILC) score has been developed to assess the likelihood that a patient presenting with AVB has LC (Chap. 7). Risk factors used in this scoring tool can be remembered with the mnemonic CO-STAR: Constitutional symptoms, Outdoor activity/endemic area, Sex (LC more likely in males), Tick bite, Age, and Rash. Patients are classified as low risk (0–2), intermediate risk (3–6), or high risk (7–12), as demonstrated in Table 3 (sensitivity 93.2%)[3, 4].

Other conduction abnormalities seen in LC include intra-atrial block, supraventricular tachycardia, sinus node disease and dysfunction, ventricular and atrial fibrillation, bundle branch block, and ventricular tachycardia. An electrocardiogram (ECG) should be considered in all patients with LD.

Table 3 The Suspicious Index in Lyme Carditis (SILC) for evaluated the risk of Lyme carditis in patients with atrioventricular block. The variables of interest can be remembered using the acronym "CO-STAR". Based on the score, patients can be classified as having low (0–2), intermediate (3–6), or high (7–12) suspicion of Lyme carditis

Variable	Value
Constitutional symptoms*	2
Outdoor activity/endemic area	1
Sex: Male	1
Tick bite	3
Age < 50 years	1
Rash: Erythema migrans	4

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*fever, malaise, arthralgia, and dyspnea

Myocarditis, Myopericarditis, Pericarditis, and Pancarditis

ECG changes in patients with myocarditis, pericarditis, myopericarditis, and pancarditis may include abnormal left ventricular depolarization and repolarization, manifesting as ST segment and T wave abnormalities. Comparison with a prior baseline ECG is helpful to detect new conduction abnormalities [7, 8]. In up to 60% of LC patients, ST changes and T wave inversion are seen primarily in the inferolateral leads, with rare elevation of serum cardiac biomarkers [7, 8, 15]. Patients with myopericarditis related to LD may have ECG changes mimicking an acute myocardial infarction and elevated cardiac troponin levels [10]. In these patients, a troponin is indicated to assess for myocardial injury. It is also essential that ACS be ruled out with coronary angiography.

When myocarditis and/or pericarditis is suspected, appropriate cardiac imaging should be pursued. A chest x-ray should be used to look for alternative diagnoses and to assess for cardiomegaly. All patients should have an echocardiogram to assess cardiac function parameters such as ejection fraction, pericardial fluid accumulation, and wall motion abnormalities. Diffuse ventricular hypokinesis, associated with decreased ejection fraction, may be seen with myocarditis rather than the regional wall motion abnormalities which are expected in ACS. [5] Cardiac magnetic resonance imaging may help to characterize ventricular functional parameters, wall edema secondary to inflammation (i.e. late gadolinium enhancement), and signs of pericarditis (i.e. pericardial thickening and effusion)[4]. Endomyocardial biopsy (EMB) is the gold-standard for diagnosing myocarditis; however, due to the inherent risks of tissue sampling, EMB is only currently recommended for cases which do not respond to antibiotic management to clarify diagnosis and degree of tissue damage [16].

3.2 Endocarditis

Classic findings of endocarditis include new heart murmur, new valvulopathy on echocardiography, and positive blood cultures [17, 18]. Comorbidities, such as immunosuppression, diabetes and indwelling catheters may increase the risk of contracting endocarditis during LD. [9] Lyme endocarditis has previously been detected in patients with existing structural abnormalities including mitral valve prolapse and regurgitation, bicuspid aortic valve, and tricuspid valve regurgitation [6, 10, 11].

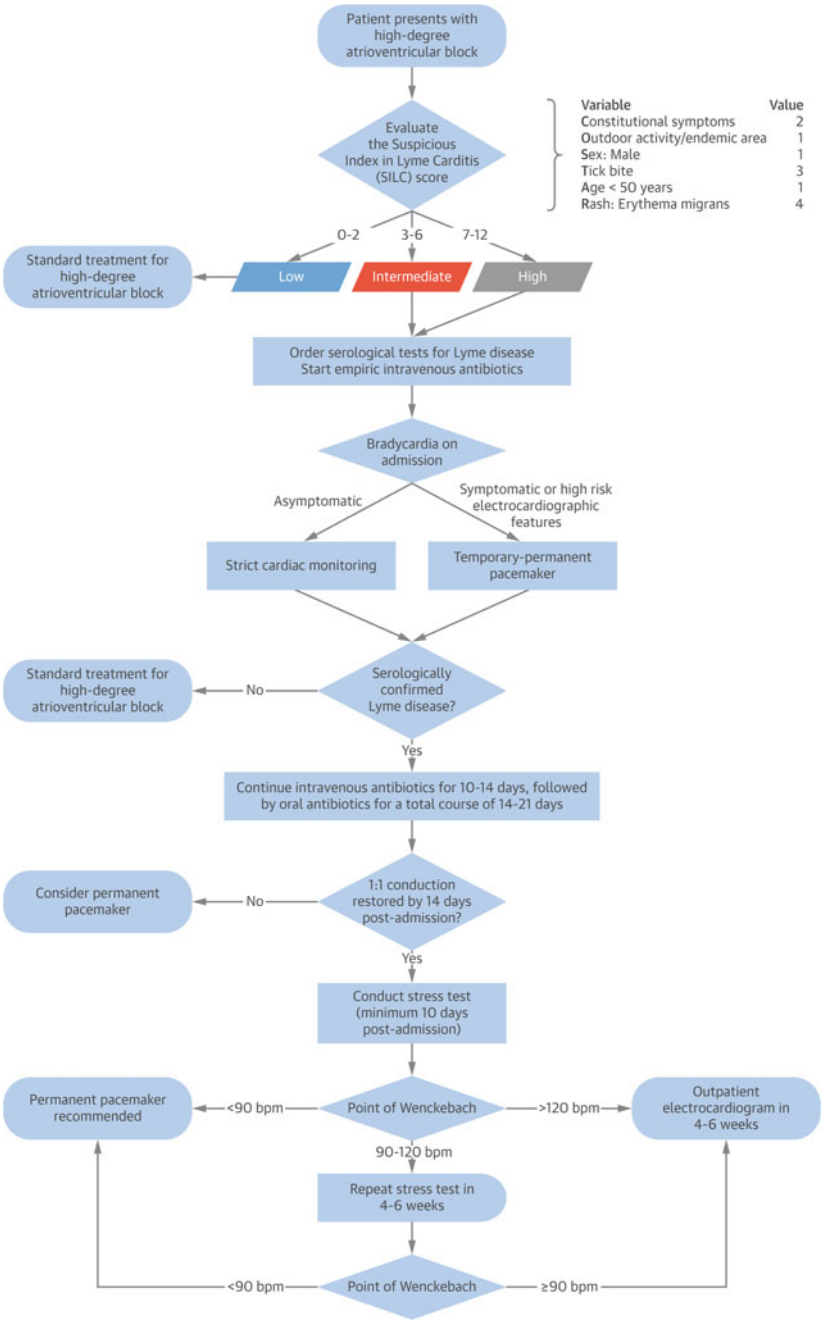
Lyme endocarditis may also occur with accompanying ECG changes, such as AV block [19]. If surgical intervention is required, tissue DNA taken from the valve of interest should be tested with real-time polymerase chain reaction (PCR), as blood and tissue culture may be negative. Limitations of tissue and serological evaluation include the low sensitivity of ELISA in the early stages of LD, persistence of LD seropositivity in resolved infections, susceptibility to cross-reaction with non-LD antibodies, and subjective nature of Western immunoblot assay interpretation. Thus, diagnosis initial should be confirmed with a second test (16S rRNA PCR and sequencing, ELISA, and/or Western blot) [10, 11, 18, 19].

3.3 Dilated Cardiomyopathy

Echocardiography is the mainstay investigation to diagnose DCM once LD has been confirmed. Findings include ventricular dilation and systolic dysfunction characterized by an ejection fraction below 40%. Abnormalities may also be seen on ECG, including indicators of hypertrophy, bundle branch block, left axis deviation, and ventricular dysrhythmias [20]. LC-DCM is further discussed in Chap. 14.

4 Management

Due to a paucity of literature on LC, there are no validated guidelines for management. Typically, temporary pacing and supportive therapy are the mainstays of treatment of patients with symptomatic high-degree AVB. In LC, AVB can spontaneously reverse and treatment predominantly involves the early administration of appropriate antibiotic therapy [4]. Permanent pacemakers are rarely required as most cases of LC resolve with appropriate antibiotic therapy, underscoring the critical importance of early detection and management. Pacemaker insertion has inherent risks, requires lifelong follow-up, and introduces unnecessary cost to the healthcare system [4, 21]. Given the aforementioned, we present a previously published algorithm for the diagnosis and management of LC (Fig. 1) [4].


Patient presents with high-degree atrioventricular block
Evaluate the Suspicious Index in Lyme Carditis (SILC) score
Variable Value
Constitutional symptoms 2
Outdoor activity/endemic area 1
Sex: Male 1
Tick bite 3
Age < 50 years 1
Rash: Erythema migrans 4
0-2
3-6
7-12
Low
Intermediate
High
Standard treatment for high-degree atrioventricular block
Order serological tests for Lyme disease
Start empiric intravenous antibiotics
Bradycardia on admission
Asymptomatic
Symptomatic or high risk electrocardiographic features
Strict cardiac monitoring
Temporary-permanent pacemaker
Serologically confirmed Lyme disease?
No
Standard treatment for high-degree atrioventricular block
Yes
Continue intravenous antibiotics for 10-14 days, followed by oral antibiotics for a total course of 14-21 days
1:1 conduction restored by 14 days post-admission?
No
Consider permanent pacemaker
Yes
Conduct stress test (minimum 10 days post-admission)
Point of Wenckebach
<90 bpm
Permanent pacemaker recommended
>120 bpm
Outpatient electrocardiogram in 4-6 weeks
90-120 bpm
Repeat stress test in 4-6 weeks
Point of Wenckebach
<90 bpm
≥90 bpm

◀**Fig. 1** Systematic approach to the diagnosis and management of Lyme carditis and high-degree atrioventricular block. The Suspicious Index in Lyme Carditis score is evaluated for patients presenting with high-degree atrioventricular block. Patients at intermediate-to-high risk have Lyme disease serological tests sent and are started on empiric intravenous antibiotics. Asymptomatic bradycardia is followed by strict cardiac monitoring, whereas symptomatic bradycardia or high-risk electrocardiographic features (such as alternating bundle branch block) are indications for a temporary-permanent pacemaker. Patients with serologically confirmed Lyme disease continue with 10–14 days of intravenous antibiotics, followed by 4–6 weeks of oral antibiotics. If 1:1 conduction is restored by 14 days post-admission, then the stability of AV conduction is assessed by a stress test. Reproduced with permission, Yeung et al. 2019

4.1 SILC Score and Antibiotic Therapy

Patients with a low SILC score should receive antibiotic therapy upon confirmation of Lyme serology. In cases of intermediate to high SILC score, antibiotic therapy should be initiated immediately, while awaiting Lyme serology results [4]. Most commonly, an intravenous course of ceftriaxone is required until the resolution of acute symptoms and conduction abnormalities (typically 10–14 days), followed by an oral antibiotic, such as doxycycline, on discharge for a total duration of 14–21 days [11, 17, 18]. The use of intravenous amoxicillin and gentamicin for two weeks, followed by a month-long course of oral amoxicillin, has also been effective in a minority of cases [10, 22]. The majority of LC cases will resolve with antibiotic treatment of LD. Antibiotic regimens are summarized in Table 4. For patients with high-degree AVB, within the first 14 days of antibiotic therapy, they typically progress to Wenckebach second-degree block, then to first-degree block, decreasing PR interval, and finally to a normal rhythm (Fig. 2). [4, 5, 23, 24].

Table 4 Antibiotic treatment recommendations for Lyme carditis in adults

Antibiotic	Dose	Duration	
		Serious presentation	Mild presentation
Intravenous			
Ceftriaxone	2 g intravenous once daily	10–14 days (up to 28 days)	-
Oral			
Doxycycline	100 mg oral twice daily	*After intravenous regime*,	14–21 days
Amoxicillin	500 mg oral three times daily		
Cefuroxime axetil	500 mg oral twice daily		

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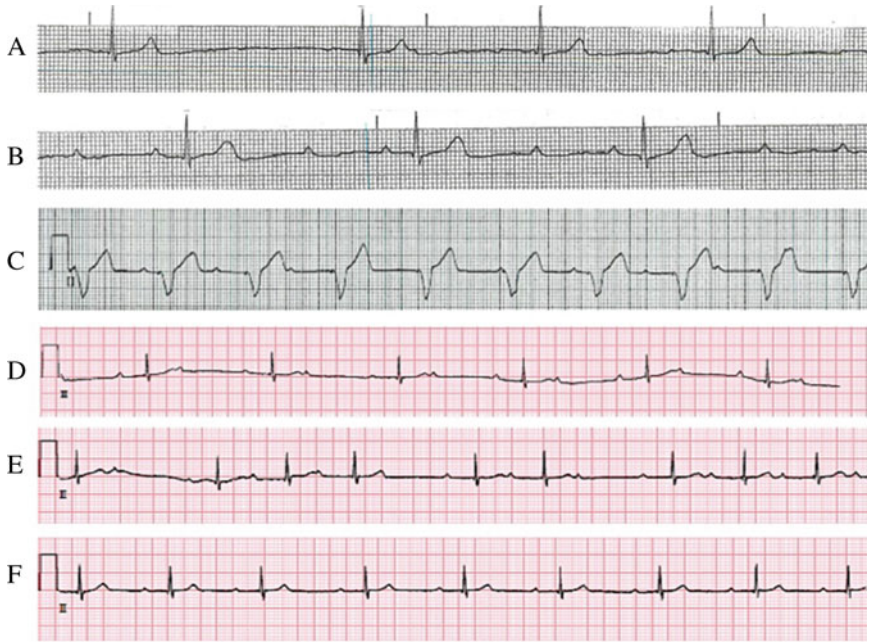

Fig. 2 The electrocardiographic progression of a patient with Lyme carditis presenting with high-degree atrioventricular block (AVB). **a** High-degree AVB (day 1). **b** Third-degree AVB with a junctional escape rhythm (day 1). **c** Temporary transvenous pacemaker placed through the jugular vein due to hemodynamic instability (day 1). **d** 2:1 AVB with a narrow conducted QRS (day 5). **e** Second-degree type I AVB (Wenckebach 4:3 and 3:2; day 7). **f** First-degree AVB with PR interval of 280 ms (day 10). Reproduced with permission, Yeung et al. 2019

4.2 Pacing for High Degree AVB

Temporary pacing is only indicated for patients with symptomatic or high-risk bradycardia. In these cases, standard transvenous temporary or modified temporary-permanent transvenous pacing can be utilized. In order to encourage early ambulation for hospitalized patients with LC, the modified temporary-permanent transvenous pacing device uses an active fixation lead, attached to a re-sterilized permanent pacemaker generator taped to the skin as an external device [4, 5, 25, 26]. Once AV conduction has been restored, an exercise stress test should be conducted to ensure 1:1 AV conduction at a heart rate of > 120 bpm. Permanent pacemaker is only recommended if 1:1 AV conduction is not restored at 14 days after admission. Patients with a point of Wenckebach at > 90 bpm should receive a follow-up ECG four to six weeks post-discharge. If the point of Wenckebach occurs at a heart rate of < 90 beats per minute, permanent pacemaker should be considered. [4] Temporary-permanent pacing in Lyme carditis is discussed further in Chap. 9. If patients undergo implantation of a permanent pacemaker, follow-up

with a cardiac device clinic is necessary to screen for restoration of normal AV conduction and consideration of device explanation, which is detailed in Chap. 13.

4.3 Additional Considerations

Generally, the management of patients with complicated LC should follow guidelines for cardiac patients without LD. For example, in case of pericarditis progressing to cardiac tamponade, pericardiocentesis should be performed. Patients with pericarditis should also be treated with anti-inflammatory medications including colchicine and non-steroidal anti-inflammatories drugs (NSAIDs) with careful consideration of additional gastric protection medications. In severe cases of LD endocarditis, surgical valve replacement may be required [11, 19, 27]. Indications for surgical valve replacement are clearly outlined in societal valve guidelines [28, 29]. All patients with LD endocarditis require early involvement of a multidisciplinary team which includes cardiac surgery, infectious disease specialists and allied health professionals. For severe or refractory post-surgical cases of endocarditis, ongoing outpatient intravenous ceftriaxone should be considered and re-operation may be required [6, 11, 30]. Patients with ventricular dysfunction related to myocarditis or dilated cardiomyopathy should be seen by a heart failure specialist for education, optimization of guideline-directed heart failure therapy and monitoring of volume status.

5 Conclusion

Patients living in LD endemic regions are at risk for LC-related morbidity and mortality. The primary presentation of LC is AVB, but several other LC manifestations may impact LD patients, including myocarditis, pericarditis, and endocarditis. LC may also play a role in the development of DCM. Practitioners treating patients from endemic regions with symptomatic LD or cardiovascular symptoms without identifiable etiology should apply the SILC score. Antibiotics are the mainstay of treatment, but cardiovascular dysfunction should be treated according to guidelines for non-LD patients. Early detection and intervention are crucial to prevent long-term cardiovascular damage.

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