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ORIGINAL ARTICLE

# Advanced Heart Block in Children with Lyme Disease

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## Abstract

**Background** The clinical course of children with advanced heart block secondary to Lyme disease has not been well characterized.

**Objective** To review the presentation, management, and time to resolution of heart block due to Lyme disease in previously healthy children.

**Methods** An IRB approved single-center retrospective study was conducted of all patients < 21 years old with confirmed Lyme disease and advanced second or third degree heart block between 2007 and 2017.

**Results** Twelve patients (100% male) with a mean age of 15.9 years (range 13.2–18.1) were identified. Six patients (50%) had mild to moderate atrioventricular valve regurgitation and all had normal biventricular function. Five patients had advanced second degree heart block and 7 had complete heart block with an escape rate of 20–57 bpm. Isoproterenol was used in 4 patients for 3–4 days and one patient required transvenous pacing for 2 days. Patients were treated with 21 days ($n = 6$, 50%) or 28 days ($n = 6$, 50%) of antibiotics. Three patients received steroids for 3–4 days. Advanced heart block resolved in all patients within 2–5 days, and all had a normal PR interval within 3 days to 16 months from hospital discharge.

**Conclusion** Symptomatic children who present with new high-grade heart block from an endemic area should be tested for Lyme disease. Antibiotic therapy provides quick and complete resolution of advanced heart block within 5 days, while steroids did not appear to shorten the time course in this case series. Importantly, no patients required a permanent pacemaker.

**Keywords** Lyme disease · Advanced atrioventricular block · Complete heart block · Lyme carditis · Pediatrics

## Introduction

Lyme carditis manifests during the early disseminated phase of Lyme disease, which typically occurs days to months after initial exposure to the spirochete *Borrelia burgdorferi* from deer ticks [1]. According to the Center for Disease Control (CDC), Lyme carditis is defined as acute onset of high-grade (second or third degree) atrioventricular (AV) conduction defects due to Lyme disease [2]. According to the European Union Concerted Action on Lyme Borreliosis (EUCALB), however, any degree of heart block, including 1st degree AV block, is included in the definition of Lyme carditis [3]. While the most common manifestation of Lyme carditis is new fluctuating AV conduction disease [1], the management of advanced heart block due to Lyme disease in children has not been well described. Our institution previously published a 2-patient case series of high grade heart block due to Lyme disease [4]; however, this study expands further to present the clinical course and management of advanced second degree or complete heart block secondary to Lyme disease in previously healthy pediatric patients.

## Purpose

This study aims to describe the presentation, management, and time to resolution of advanced heart block in children with Lyme disease.

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## Methods

### Study Design

A retrospective chart review was conducted of all patients < 21 years of age with advanced second degree or complete heart block and Lyme disease at our institution between 2007 and 2017. Advanced heart block was defined as 2:1 AV block or more than one consecutive non-conducted P wave. Patients with structural heart disease, or only first degree or Mobitz I second degree AV block were excluded. Only patients with confirmed Lyme disease by Western blot were included in the study. For patients with complete heart block, a junctional escape beat was defined as having a narrow QRS with a similar morphology to the conducted beat, and a ventricular escape beat had a wide QRS with a different morphology than the conducted beat. Basic demographic information, clinical presentation, laboratory data, electrocardiograms (ECG), echocardiograms, and treatment details were extracted from the medical record. This study was approved by the institutional review board (IRB) at Columbia University Medical Center and the need for informed consent was waived as formal consent was not required for this study.

### Data Analysis

Standard descriptive statistics and univariate analysis were used.

## Results

### Patients

Twelve patients (100% male) with a mean age of 15.9 years (range 13.2–18.1) met inclusion criteria. All patients lived in endemic regions for Lyme disease: New York ($n=7$), New Jersey ($n=4$) or Connecticut ($n=1$). All patients were admitted with continuous cardiac monitoring for an average of 4.8 days (range 3–8). The most common cardiac symptoms at presentation in the emergency department included chest pain ($n=5$), dyspnea ($n=4$), syncope ($n=3$), dizziness or lightheadedness ($n=3$), fatigue ($n=2$), or palpitations ($n=1$). Non-cardiac symptoms included a target rash ($n=3$), headache ($n=3$), and history of tick bite ($n=1$).

### Electrocardiogram Findings

Five patients had advanced second degree heart block and 7 patients had complete heart block with an average escape rate of 40 beats per minute (range 20–57 bpm). Fig 1a shows an example of advanced second degree AV block with a 4.5 s pause in a 13-year-old male, and Fig 1b shows an example of complete heart block with an escape rate of 37 bpm in a 16-year-old male. Of the patients with advanced second degree AV block, the average PR interval on initial ECG was 390 milliseconds (range 235–530 msec), the average QRS duration was 105 msec (range 88–140 msec), the average atrial rate was 90 bpm (range 70–120 bpm), and the average ventricular rate was 65 bpm (range 41–91 bpm).

Of the 7 patients with complete heart block, 3 had a ventricular escape rhythm and 4 had a junctional escape rhythm. While the average escape rate of the ventricular rhythm patients was lower than the junctional rhythm patients, 36 bpm versus 44 bpm, respectively, this was not statistically significant, $p=0.48$. Only 2 of the 7 patients with complete heart block had a pause $\geq 2$ s; one with junctional rhythm had a 2.4 s pause while another with a ventricular rhythm had a 2 s pause. The one patient who required temporary pacing had complete heart block with a junctional escape rate of 35 bpm that did not respond to isoproterenol.

### Echocardiogram Findings

On initial echocardiogram, all 12 patients had normal intracardiac anatomy with normal biventricular systolic function without pericardial effusion. Seven of 12 patients (58%) had minor abnormalities, including mild to moderate tricuspid and mitral regurgitation in 6 of 7 patients and mild mitral regurgitation alone in 1 of 7 patients. These 7 patients had follow up echocardiograms done within 0–39 days (average 9 days). The degree of tricuspid and mitral regurgitation had improved to a mild degree in 2 of the 7 patients and it had resolved in the remaining 5 patients.

### Lyme Disease Management

Patients were treated with either 21 days ($n=6$, 50%) or 28 days ($n=6$, 50%) of total antibiotics, as recommended by infectious disease consultants. Intravenous ceftriaxone was used in all patients for an average of 19.3 days (range 3–28), and 5 of 12 patients also received oral doxycycline to complete the antibiotic course. One patient received empiric intravenous methylprednisolone (60 mg twice daily) and 2 patients were treated with oral prednisolone (60 mg twice daily) for a total of 3–4 days, as they had symptomatic bradycardia. There was no statistically significant difference in the time to resolution of advanced heart block in the 3 patients who received steroids (2 days) compared to the 9 patients who did not (3 days), $p=0.32$.

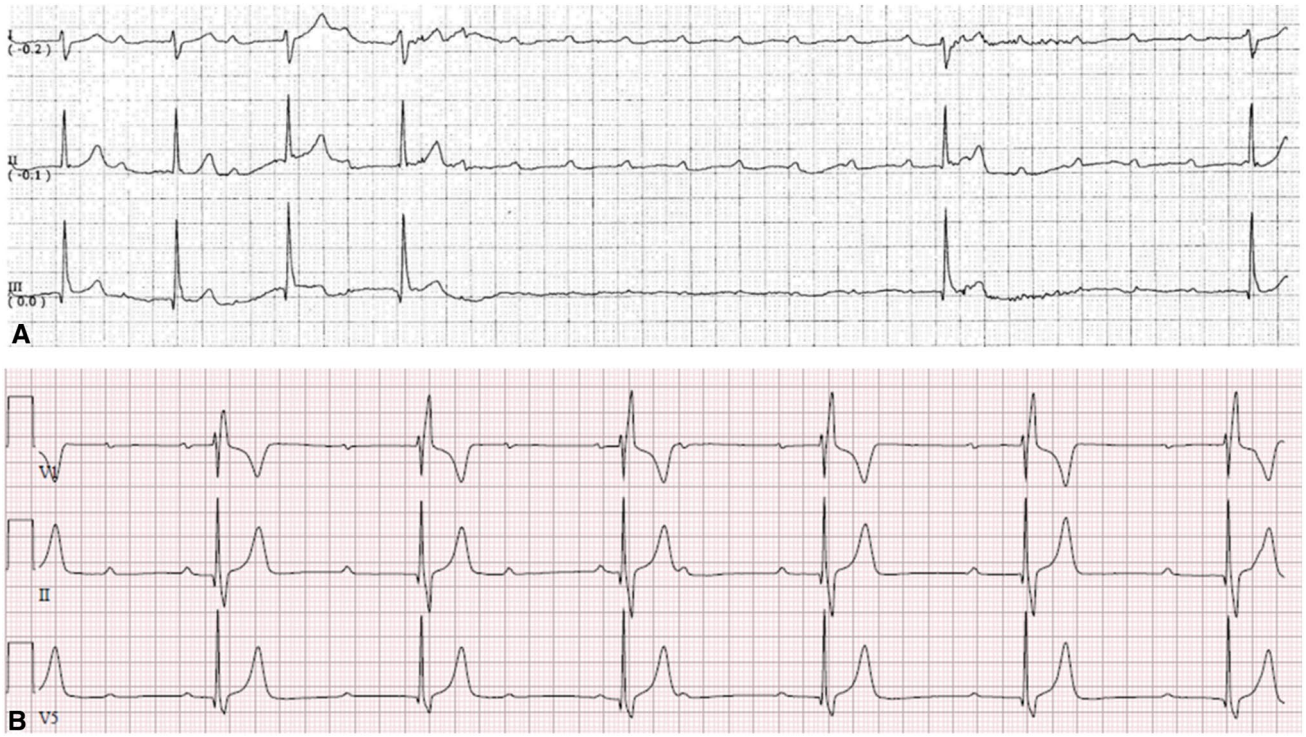


**Fig. 1** **a** Advanced second degree atrioventricular block with a pause of 4.5 s in a 13-year-old male with Lyme disease. **b** Complete heart block with ventricular rate of 37 bpm in a 16-year-old male with Lyme disease

## Heart Rhythm Management

Isoproterenol (0.01–0.03 mcg/kg/min) was used in 4 patients for an average of 3.3 days (range 3–4). The dose was titrated to a ventricular rate of approximately 80 bpm. One of the 12 patients, who presented with complete heart block with a junctional escape rate of 35 bpm, required temporary transvenous pacing via the right internal jugular vein for 2 days due to failure of isoproterenol to increase the heart rate. This patient was 1 of the 3 patients to receive empiric steroids as well.

## Time to Resolution of Heart Block

Advanced heart block resolved in all patients in a mean of 2.8 days (range 2–5). Intermittent second-degree AV block (Mobitz I or Mobitz II) with single non-conducted p-waves improved to first degree AV block after an additional 2 days on average (range 1–4). All patients had normal conduction with a normal PR interval at follow-up within 3 days to 16 months from hospital discharge. All 11 patients who had follow up within 3 months had complete normalization of their PR intervals on outpatient ECGs (Fig. 2). There was a single patient discharged from the hospital with marked first-degree AV block (PR interval was 360 msec) on hospital day 4 who had a normal PR interval (140 msec) the next time

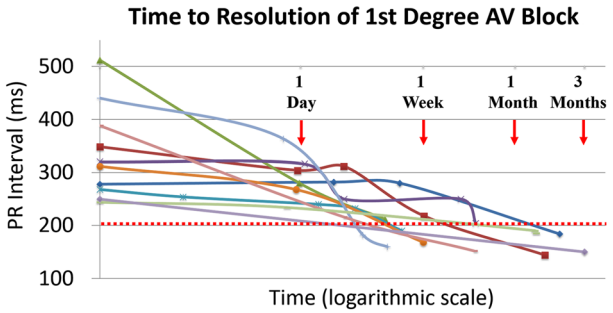


**Fig. 2** Eleven of 12 patients showed normalization of the PR interval within 3 months. Each line represents a different patient. Two of 12 patients are not displayed as 1 went immediately from advanced heart block to PR < 200 ms within 3 days, and the second patient had PR < 200 ms at 16-month follow up. *AV* atrioventricular, *ms* milliseconds

that he was seen in follow-up 16 months later. Importantly, none of the patients needed a permanent pacemaker.

## Discussion

Advanced heart block is a rare cardiac manifestation of Lyme disease, especially in children. In this 11-year review of hospitalizations for advanced second degree or complete

heart block due to Lyme disease at our pediatric referral hospital, only 12 patients met inclusion criteria. As expected from similar patient series [5–7], resolution of high-grade AV block occurred in all patients within 5 days of starting antibiotic therapy. In patients with adequate early follow-up, even first-degree AV block resolved within 3 months. Some patients with advanced AV block had evidence of transient carditis manifesting as reversible AV valve insufficiency. Fortunately, none had marked heart failure at presentation, which can occur rarely in this patient population [7]. This information is helpful for anticipatory guidance and counseling of patients and their families.

The role of steroids for treatment of heart block remains controversial. In cases of heart block due to maternal autoimmune antibodies, limited data suggests potential benefit of antenatal steroid administration for prevention of progression of PR prolongation to complete heart block in fetuses at risk for hydrops [8]. However, the majority of studies lack improvement in outcomes with prenatal steroids in fetuses with isolated atrioventricular block [9]. The use of postnatal steroids for treatment of complete heart block was limited to case reports of patients with associated autoimmune disorders, such as lupus, sarcoidosis [10], or acute rheumatic fever [11]. Furthermore, steroids have not demonstrated an effect on the natural history of Lyme carditis in adults [12]. In our study, steroids were used empirically in a quarter of the patients with hemodynamic instability. In this small case series, steroids did not appear to shorten the time to resolution of advanced heart block, although the patients with more severe clinical presentation were the also the ones that received steroids. A larger sample size is needed to determine if steroids have any benefit in recovery of AV conduction in Lyme carditis in children.

Gender may play a role in the development of high-grade heart block in patients with Lyme disease. Prior studies found that the male gender was a predictive factor for development of Lyme carditis in children [7]. Additionally, a systematic review of 45 published adult cases of complete heart block due to Lyme disease found 84% of patients were male [13]. Our patients were all male, which is consistent with the published literature.

Study limitations include retrospective design and small sample size. While this report is one of the largest case series of advanced heart block in children due to Lyme disease, multicenter studies are beneficial to better understand the outcomes and management of this clinical entity. Furthermore, the time to resolution of first-degree AV block may be overestimated as it depended on how soon an ECG was obtained after hospital discharge. It is likely that the PR interval may have normalized before the follow-up appointment.

In conclusion, symptomatic children who present with new advanced heart block from an endemic area should be tested for Lyme disease. In these children treated with antibiotics, there was rapid and complete resolution of advanced heart block without the need for a permanent pacemaker. There was no clear benefit to steroid therapy in this series, and indeed may not be useful or otherwise indicated in these patients.

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## Compliance with Ethical Standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional review board at Columbia University Medical Center and the need for informed consent was waived as formal informed consent was not required for this retrospective study.

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