Detection of *Borrelia burgdorferi* DNA in urine of patients with ocular Lyme borreliosis

Uwe Pleyer, Susanne Priem, Lars Bergmann, Gerd Burmester, Christian Hartmann, Andreas Krause

**Abstract**

*Purpose*—To evaluate the diagnostic value of the polymerase chain reaction (PCR) to detect *Borrelia burgdorferi* DNA in patients with ocular Lyme borreliosis.

**Methods**—Of 256 consecutive uveitis patients six selected individuals with clinical evidence for Lyme borreliosis and 30 patients with non-Lyme uveitis were enrolled. Lyme serology was performed by ELISA and western blotting. Urine samples were examined by an optimised nested polymerase chain reaction (PCR) protocol.

**Results**—Only four of six uveitis patients suspected for Lyme borreliosis were ELISA positive, while all six subjects showed a positive western blot. *B. burgdorferi* PCR was positive in all of these six patients. Whereas two of the 30 controls had a positive Lyme serology, *B. burgdorferi* DNA was not detectable by PCR in any sample from these patients.

**Conclusions**—PCR for the detection of *B. burgdorferi* DNA in urine of uveitis patients is a valuable tool to support the diagnosis of ocular Lyme borreliosis. Moreover, these patients often show a weak humoral immune response which may more sensitively be detected by immunoblotting.

**Patients and methods**

We studied 256 consecutive uveitis patients from areas that are highly endemic for Lyme borreliosis. The diagnosis of uveitis was based on clinical characteristics according to the criteria of the IUSG. Detailed ophthalmic examination included biomicroscopy, three mirror contact lens examination of the eye, and fluorescein angiography in patients with retinal involvement and choroiditis. Patients were evaluated according to our in-house diagnostic standard for uveitis including complete history and physical examination in all patients and, depending on the clinical findings, neurological examination.

Lyme borreliosis is a systemic infectious disease caused by the tick borne spirochaete *Borrelia burgdorferi* sensu lato. If not treated in early phases it may persist causing dermatitis, arthritis, and neuritis. Ocular involvement is less frequently (<5%) reported but may lead to persistent visual impairment. Therefore, early diagnosis and treatment are of clinical importance. However, the clinical diagnosis is often difficult since the majority of patients do not recall a tick bite or an erythema migrans.

Serology is of limited value, because antibody titres are usually not detectable before 4–6 weeks after infection and may never become positive. Contrarily, positive Lyme serology may just indicate a past borrelial infection without proof of actual disease. Since detection of *B. burgdorferi* is insensitive, polymerase chain reaction (PCR) is increasingly being used to support the diagnosis. Various studies were able to demonstrate borrelial DNA in clinical specimens with a sensitivity between 20% and 100%, depending on disease stage, organ manifestation, and samples analysed. Interestingly, urine PCR seems to be of particular value.

Recently, we were able to establish an optimised PCR protocol which allows the detection of *B. burgdorferi* DNA in urine of 45% of patients with neuroborreliosis and 79% of patients with Lyme arthritis. Since diagnostic difficulties still exist in ocular Lyme disease and PCR has not been systematically employed so far, we aimed to evaluate its diagnostic value.

**Table 1**  Oligonucleotide primer sequences (from 5’ to 3’)

<table>
<thead>
<tr>
<th>Target gene</th>
<th>Primer</th>
<th>Sequence</th>
<th>Base no</th>
<th>Amplication length (bp)</th>
<th>EMBL accession no</th>
</tr>
</thead>
<tbody>
<tr>
<td>ospA</td>
<td>Outer primer 1</td>
<td>ggg aat aag tct aat att agc c</td>
<td>18–39</td>
<td>665</td>
<td>X66065</td>
</tr>
<tr>
<td></td>
<td>Outer primer 2</td>
<td>Cac taa tgg tta aag tgg aag t</td>
<td>660–682</td>
<td>392</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nested primer 1</td>
<td>Gca aaa tgp tag ccc gtc tga t</td>
<td>54–75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nested primer 2</td>
<td>Ctg tgt att caa gtc tgc tcc c</td>
<td>423–444</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p66</td>
<td>Outer primer 1</td>
<td>cga aag tca taa atc tgg</td>
<td>9–26</td>
<td>371</td>
<td>M58429</td>
</tr>
<tr>
<td></td>
<td>Outer primer 2</td>
<td>gat caa ata ttt cag tgt</td>
<td>362–379</td>
<td>236</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nested primer 1</td>
<td>tgt aca aac acc ctt tga at</td>
<td>30–49</td>
<td>671–690</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nested primer 2</td>
<td>aat cag ccc cca tgt gca</td>
<td>142–161</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDH</td>
<td>primer 1</td>
<td>ggt atg gat gac gga gga cag gcc ctc act aac ctt gct</td>
<td>142–161</td>
<td>185</td>
<td>J03576</td>
</tr>
<tr>
<td></td>
<td>primer 2</td>
<td>ggt atg gat gac gga gga cag gcc ctc act aac ctt gct</td>
<td>218–257</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
human immunodeficiency virus, Epstein-Barr virus, and cytomegalovirus were performed. Six selected patients with clinical evidence for Lyme borreliosis were enrolled in the study. All patients reported to have had a tick bite and an erythema migrans and complained about constitutional symptoms. Five patients had arthralgias and one patient suffered from headache and fatigue. Thirty patients with various forms of uveitis not related to Lyme borreliosis served as controls.

Lyme serology was carried out using full antigen ELISA (Seramun Diagnostics, Dolgenbrod, Germany). Western blotting (DPC Biermann, Bad Nauheim, Germany) was done in patients with positive or indeterminate ELISA results and in patients with clinical symptoms suggestive of Lyme borreliosis but negative ELISA. Nested PCR was performed as described previously using two primer sets (TIB Molbiol, Berlin, Germany) targeting the plasmid located ospA gene (ospA primer) and a chromosomal gene encoding a 66 kD protein (p66 primer) (Table 1).

### Results

The median duration of ocular disease was 6 months and even exceeded 3 years in four patients (Table 2). In all patients uveitis was present bilaterally, classified as posterior uveitis in four patients, two patients each showed perivasculitis and choroidal lesions (Figs 1 and 2). Anterior uveitis and intermediate uveitis were diagnosed once. In all patients extraocular manifestations of Lyme borreliosis could be observed including arthritis (n=4), cranial nerve palsy, peripheral neuropathy (n=1), and

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**Table 2: Clinical data of patients with ocular Lyme borreliosis**

<table>
<thead>
<tr>
<th>Patient, initials, age (years), sex</th>
<th>Ocular manifestation</th>
<th>Systemic symptoms</th>
<th>Tick bite</th>
<th>Steroid treatment before dx.</th>
<th>Treatment treatment-response</th>
<th>Visual acuity before/after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 RK 48, M</td>
<td>Bilateral uveitis posterior (&gt;10 years), secondary (steroid) glaucoma, relapse</td>
<td>Arthritis, myalgia</td>
<td>+</td>
<td>2 weeks ceftriaxone IV, 4 weeks doxycycline PO</td>
<td>RE: 20/32 20/20</td>
<td>LE: 20/40 20/25</td>
</tr>
<tr>
<td>2 RHF 54, F</td>
<td>Bilateral uveitis posterior, (&gt;3 years), relapse</td>
<td>Arthritis, fatigue</td>
<td>+</td>
<td>2 weeks ceftriaxone IV, 4 weeks doxycycline PO</td>
<td>RE: 20/125 20/50</td>
<td>LE: 20/80 20/50</td>
</tr>
<tr>
<td>3 SR 59, F</td>
<td>Bilateral uveitis intermedia, (&gt;5 years)</td>
<td>Arthritis</td>
<td>+</td>
<td>2 weeks ceftriaxone IV, 4 weeks doxycycline PO</td>
<td>RE: 20/25 20/25</td>
<td>LE: 20/25 20/25</td>
</tr>
<tr>
<td>4 UN 53, F</td>
<td>Bilateral uveitis posterior (&gt;3 years)</td>
<td>Arthritis, peripheral neuropathy</td>
<td>+</td>
<td>3 weeks clindamycin PO, 2 weeks ceftriaxone IV</td>
<td>RE: 20/32 20/25</td>
<td>LE: 20/80 20/50</td>
</tr>
<tr>
<td>5 FH 37, M</td>
<td>Bilateral uveitis posterior</td>
<td>Hepatitis</td>
<td>+</td>
<td>3 weeks ceftriaxone IV, 4 weeks doxycycline PO</td>
<td>RE: 20/32 20/20</td>
<td>LE: 20/32 20/20</td>
</tr>
<tr>
<td>6 KE 76, F</td>
<td>Bilateral uveitis anterior</td>
<td>Headache</td>
<td>+</td>
<td>4 weeks doxycycline PO</td>
<td>RE: 20/64 20/50</td>
<td>LE: 20/64 20/32</td>
</tr>
</tbody>
</table>

IV = intravenous; PO = by mouth.

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**Figure 1** Fundus photograph. Patient 1 presenting with bilateral posterior uveitis and arthritis. Left eye at initial presentation (VA 20/40) with optic disc swelling, choroiditis, and vitritis. Seroblots were positive for immunoglobulin G and B burgdorferi DNA (p66) was detectable in urine of this patient.

**Figure 2** Patient 2 presenting with recurrent bilateral posterior uveitis and arthritis. Left eye at initial presentation (VA 20/80) with papillitis, optic disc swelling, and multiple choroidal lesions. A positive Lyme ELISA for IgG and western blots for IgM and IgG were detected. Urine PCR disclosed B burgdorferi DNA (ospA) that became negative following the initial treatment course. She developed recurrent uveitis, became PCR positive again during relapse of inflammation and eventually became stable after a second treatment course.
hepatitis (n=1), ELISA was positive in four patients while two patients were repeatedly seronegative. However, western blots were positive in all patients (Table 3). In the control group only 2/30 patients (7%) showed positive ELISA and/or western blot results.

*B burgdorferi* PCR was positive in all urine samples from patients with ocular Lyme borreliosis. In contrast, in none of the 30 urine specimens from controls could *B burgdorferi* DNA be detected. After antibiotic treatment, PCR became negative in all patients. Marked improvement of the ocular manifestation was seen in our patients with anterior uveitis, and a more protracted response was observed in all individuals with posterior manifestation. Uveitis relapsed in two of these cases. Both had received systemic corticosteroids which may have contributed to treatment failure. One patient temporarily became PCR positive again during relapse. After a second treatment course, a stable reduction of intraocular inflammation was achieved.

### Discussion

The results of the present investigation showed that in six uveitis patients with a history and clinical signs of Lyme disease *B burgdorferi* DNA could be detected in urine samples. Since we only analysed highly selected patients and not all patients with findings compatible with Lyme borreliosis, our results do not allow us to calculate the sensitivity of urine PCR in the diagnosis of Lyme uveitis. However, PCR was negative in all 30 patients with none-Lyme uveitis giving a specificity of 100%.

Although a positive PCR does not prove an infection with viable organisms, the positive results in our patients with clinical manifestations that resolved after antibiotic therapy strongly suggest spirochaetal persistence. In view of the current discussion about persistent infection versus infection induced immunopathology as the main mechanisms of chronic Lyme borreliosis, our results point towards a direct infectious cause of ocular Lyme disease. In one patient affected by a recurrent episode of bilateral chorioretinitis, urine PCR became positive again during relapse. The second treatment course not only improved the clinical manifestation of uveitis, but also led to a negative urine PCR on repeated tests. This may indicate that PCR might be of value in following the infectious course of the disease. Adequate negative controls were run with each test to rule out false positive results. In addition, we already proved by sequencing of the PCR products that with our protocol *B burgdorferi* DNA is amplified exclusively.

Serological analysis in our PCR positive patients revealed that only four patients had a positive Lyme serology as determined by ELISA. In contrast, IgG immunoblots were positive in all six patients. It is well known that serological reactions may vary considerably and that a negative serology does not exclude the infection. Possible explanations for this phenomenon include the invasion of spirochaetes into immunologically privileged sites. Several investigators have reported impaired immune responses in uveitis patients with confirmed diagnosis of Lyme borreliosis. Moreover, most of our patients had received immunosuppressive therapy such as corticosteroids that probably led to negative or weak immune responses and delayed diagnosis even for years.

Taken together, Lyme borreliosis has to be considered as a (rare) cause of intraocular inflammation even with negative ELISA findings. Additional laboratory tests, in particular immunoblots, are indicated in suspicious individuals—for example, in patients with extraocular manifestations compatible with Lyme disease. Nested PCR appears to be a valuable tool to identify patients with long standing disease. Moreover, PCR may also help to monitor the efficacy of anti-infectious therapy in patients with intraocular borrelial infections. However, the clinical value of this diagnostic tool, especially its sensitivity, still needs to be determined in subsequent studies.

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### Table 3 Laboratory findings of patients with ocular Lyme borreliosis

<table>
<thead>
<tr>
<th>Patient, age (years), sex</th>
<th>Lyme serology</th>
<th>Lyme seroblot (kDa)</th>
<th>Urine PCR before treatment</th>
<th>Urine PCR after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 RK, 48, M</td>
<td>IgM negative</td>
<td>IgG negative</td>
<td>positive for p66</td>
<td>negative</td>
</tr>
<tr>
<td>2 RHF, 54, F</td>
<td>IgM negative</td>
<td>IgG positive</td>
<td>positive for ospA</td>
<td>negative, after recurrence</td>
</tr>
<tr>
<td>3 SR, 59, F</td>
<td>IgM negative</td>
<td>IgG negative</td>
<td>positive for ospA</td>
<td>positive again for ospA</td>
</tr>
<tr>
<td>4 UN, 53, F</td>
<td>IgM negative</td>
<td>IgG negative</td>
<td>positive for ospA</td>
<td>negative</td>
</tr>
<tr>
<td>5 FJH, 37, M</td>
<td>IgM negative</td>
<td>IgG positive</td>
<td>positive for p66</td>
<td>negative</td>
</tr>
<tr>
<td>6 KE, 76, F</td>
<td>IgM negative</td>
<td>IgG negative</td>
<td>positive for p66</td>
<td>negative</td>
</tr>
</tbody>
</table>

ND = not done.
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