

## Lyme borreliosis—an unusual cause of vertigo

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### Abstract

A total of 2055 consecutive vertigo patients were examined in a prospective study in an area endemic for Lyme borreliosis for clinical signs of Lyme borreliosis or serum antibodies against *Borrelia burgdorferi*. Of these, 41 patients (2%) had positive levels of serum antibodies against *B. burgdorferi*. The incidence of seropositivity against *B. burgdorferi* among the vertigo patients did not differ from the incidence of the normal Finnish population. In addition to seropositivity the criteria used for Lyme borreliosis included previous erythema migrans, a positive polymerase chain reaction (PCR) or positive serum immunoblot. Eight patients were diagnosed as having Lyme borreliosis. This disease is a rare but possible cause of vertigo. Seropositivity alone is an insufficient finding for the diagnosis of Lyme borreliosis and should be supported by the clinical findings, the patient's history and other laboratory findings, such as immunoblotting or PCR. Although Lyme borreliosis seems to be a rare cause of vertigo, it must be kept in mind in the differential diagnosis of vertigo. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

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### 1. Introduction

The neurological symptoms of Lyme borreliosis were reported in Europe over 70 years ago [1] and in North America patients were diagnosed with this disease soon after its description by Steere

and his colleagues. [2] Lyme borreliosis can affect the peripheral and central nervous system either singularly or in combination. The neurological symptoms can begin in either the early or the late phase of the disease. The neurological involvement can be divided into three often overlapping categories: (1) infection of the cranial and peripheral nerves; (2) infection of the meninges; and (3) infection of the brain and spinal cord [3].

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Cranial neuropathies develop in about 60% of patients in early neuroborreliosis and in 45% of patients in the late phase of this disease [4]. Facial palsy is the most common symptom, followed by VI, V and VIII cranial nerve neuropathies in the early phase of the disease [5] and VIII cranial nerve neuropathies in the late disease [6]. Both cochlear and vestibular portions of the VIII cranial nerve can be affected. Hearing loss can be uni- or bilateral, temporary (improving after antimicrobial therapy) or permanent. The vestibular dysfunction associated with Lyme borreliosis can be of central or peripheral origin [7].

Vertigo is not an uncommon symptom among patients with late Lyme borreliosis. In a Finnish series of patients with late LB, vertigo was present in 8% [8], whereas in another study in early LB VIII cranial nerve neuropathies accounted for 5% of all cranial neuropathies [4]. However, few studies or case reports concerning Lyme borreliosis among vertigo patients appear in the literature [7,9].

The aim of this study was to determine the incidence of Lyme borreliosis among patients with vertigo and to analyze otoneurological findings among these patients. Strict criteria were applied for the diagnosis of Lyme borreliosis.

## 2. Patients and methods

### 2.1. Patients

From 1 January 1993 to 31 December 1994, 2055 patients visiting the Department of Otolaryngology of the University Hospital of Helsinki, consecutively, with vertigo as the sole or major symptom were enrolled in the study. The patients were routinely asked about earlier tick bites, erythema migrans, arthritic symptoms, fever of unknown origin and headache.

### 2.2. Serology

Antigen for the measurement of antibodies against *Borrelia burgdorferi* flagellin was obtained from a commercial kit (Dakopatts,

Glostrup, Denmark), which includes ELISA plates coated with the endoflagellum of *B. burgdorferi*. Sera were diluted serially in 3-fold steps for the test and applied to the plates for overnight incubation. The bound antibodies were detected by biotin-labeled goat anti-human immunoglobulin (Ig) G (Zymed, Los Angeles, CA) and streptavidin alkaline phosphatase (Zymed). An end-point titer was obtained at an optical density level determined by a cut-off control provided with the kit. The titer limit for a positive IgG antibody level was 500 and for positive IgM the level was 2500. This cut-off conforms with the level of the mean + 3 S.D. of a reference population living in central Finland [10].

*B. burgdorferi* IgG antibodies were further analyzed for IgG1 antibodies by Western immunoblot using a Finnish *Borrelia* strain (*B. afzelii* strain KS 1) as the antigen to confirm the serological result. The method used has been described elsewhere by Seppälä and his associates [10]. The sample was considered positive when at least four bands, those most regularly found in Finnish patients with Lyme borreliosis, were observed. These proteins included proteins with molecular masses of 17, 19, 21, 30, 41, 48, 52 and 83 kDa. The applicability of the criteria for interpretation of immunoblots published in North America is questionable in the diagnosis of LB in Europe. However, the immunoblotting results were also evaluated according to criteria described by Dressler et al. [11]

Antibodies in the cerebrospinal fluid (CSF) were studied by the same method used for the serum antibodies. To demonstrate the intrathecal anti-*B. burgdorferi* antibody production, the ratio between *B. burgdorferi* IgG antibody titer in CSF and serum was compared with corresponding ratio of total IgG. CSF was examined also for cells, protein, albumin, IgM and IgG and the IgG index [12] was calculated.

As a means for ruling out syphilis as a source of a false positive serological result sera were examined for *Treponema pallidum* antibodies (hemagglutination assay, Porton Cambridge, Newmarket, UK).

### 2.3. Polymerase chain reaction

PCR analyses were done in the National Public Health Institute Department in Turku. The target of the PCR amplification was a segment of the gene encoding 41-kDa flagellin of *B. burgdorferi*. The primers were modifications from those described by Picken et al. [13,14]. Oligonucleotides were synthesized by an automatic DNA synthesizer (Model 391 PCR-Mate™ DNA Synthesizer; Applied Biosystems, Foster City, CA) based on phosphoamidite chemistry. The reaction mixture contained 50 mM KCl, 10 mM Tris-HCl (pH 8.8), 1.5 mM MgCl<sub>2</sub>, 0.1% Triton© X-100, 200 μM deoxyribonucleotides (Pharmacia P-L Biochemicals, Milwaukee, WI), 20 pmol of each oligonucleotide primer, 1 U of polymerase (DynaZyme™, FINNZYMES, Espoo, Finland) and purified DNA. The reaction volume was 50 μl and a total of 40 cycles was carried out in a thermal cycler (HB-TR1, Hybaid, Middlesex, UK). The temperatures were 94°C for 1 min (denaturation), 50°C for 1 min (annealing) and 72°C for 1.5 min (extension). After amplification, a 20-μl volume of the reaction mixture was run in a 1.5 or 2% agarose gel. After staining with ethidium bromide and destaining with water, the PCR products were visualized and photographed under ultraviolet light.

Rigorous measures were undertaken to avoid carry-over contamination and contamination caused by amplicon. Pre- and post-PCR stages of the process were carried out in physically separate rooms and by separate technicians. Each PCR-run included a positive control containing DNA extracted from a reference strain B31 of *B. burgdorferi* sensu stricto (ATCC 35210). Furthermore, every fifth or sixth tube of each was used as a negative control subjected to all sample treatment procedures.

### 2.4. Otoneurological test battery

The otoneurological tests included the evaluation of saccades, pursuit eye movements, posturography and the caloric test. [15]

### 2.5. Audiological evaluation

Pure tone audiometry was recorded at frequencies of 0.125, 0.250, 0.5, 1, 2, 4 and 8 kHz for both ears. A Nicolet compact auditory electrodiagnostic system was used for measuring the brainstem auditory response. The stimuli were transduced by TDH-39 earphones.

### 2.6. Criteria for the clinical diagnosis of Lyme borreliosis

In addition to vertigo and seropositivity, at least one of the following findings was required for the diagnosis of Lyme borreliosis: (1) erythema migrans in the patient's history; (2) a positive PCR finding; and (3) a positive serum immunoblot.

## 3. Results

### 3.1. Laboratory findings

A total of 41 (2%) of the 2055 patients had positive levels of serum antibodies against *B. burgdorferi* on admission. A total of 17 of them showed IgG antibodies, four patients had both IgG and IgM antibodies and 19 patients showed IgM reactivity only. The mean positive IgG titer was 1590 (range 510–3200) and the mean positive IgM titer was 3240 (range 2500–9500). The Western blot analysis was available on 26 of the 41 seropositive cases only. According to the Finnish criteria, the test was positive for eight patients and negative for 17. The interpretation of the immunoblotting patterns according to the criteria published by Dressler et al. [11] produced identical results. The serum *T. pallidum* hemagglutination assay (TPHA) test was negative for all 15 of the cases studied. The serum *Borrelia*-PCR was positive for two of the 18 cases analyzed.

CSF from 16 cases were analyzed. Three patients showed anti-*B. burgdorferi* antibodies. Nevertheless, none of the three showed intrathecal antibody production against *B. burgdorferi*. *Borrelia*-PCR of the CSF was negative in all cases. Protein content, leukocyte count, intrathecal syn-

Table 1  
Clinical and laboratory data obtained from the eight patients with vertigo and Lyme borreliosis

Patient (age/sex)	Elisa <sup>a</sup> IgG/IgM	EM	Serum immunoblot	Serum-PCR	Previous tick-bite	Response to treatment	Interval between onset of vertigo and diagnosis (days)
1 (62/M)	980/<1800	No	Positive	Negative	Yes	Good	90
2 (50/F)	1100/<1800	No	Positive	Negative	Yes	Moderate	284
3 <sup>b</sup> (54/M)	1900/1800	No	Positive	NA	No	NA	NA
4 (52/F)	1400/<1800	No	Positive	Negative	Yes	Good	192
5 (8/F)	1100/<1800	Yes	Positive	Negative	No	Good	150
6 (57/F)	3200/2300	Yes	Positive	Negative	Yes	Moderate	60
7 (70/F)	500/<1800	Yes	Positive	Positive	Yes	Moderate	810
8 (38/F)	1100/2200	No	Negative	Positive	No	Moderate	90

NA, data not available.

<sup>a</sup> Cut off for positivity is 500 for IgG and 2500 for IgM.

<sup>b</sup> The patient refused the treatment and further examinations.

Table 2  
Clinical and otoneurological findings obtained from the eight patients with vertigo and Lyme borreliosis

Patient	Type of vertigo	Tinnitus	Sensorineural hearing loss	Brain stem audiometry	Caloric test	Other otoneurological tests <sup>a</sup>
1	Rotational	None	Yes	Abnormal	NA	NA
2	Positional	None	No	Normal	Normal	Normal
3 <sup>b</sup>	Rotational	Left	Yes	NA	Normal	Normal
4	Drop attacks	Bilat	Yes	Abnormal	Abnormal	Normal
5	Rotational	Bilat	No	NA	Normal	Abnormal <sup>c</sup>
6	Rotational	None	Yes	Normal	Normal	Normal
7	Rotational	Left	Yes	Normal	NA	Not done
8	Rotational	Right	Yes	Normal	Normal	Normal

NA, data not available.

<sup>a</sup> Saccades, pursuit eye movements, posturography and electronystagmography.

<sup>b</sup> The patient refused the treatment and further examinations.

<sup>c</sup> Abnormal posturography.

thesis of total IgG and IgM and the IgG index was within normal limits.

Ten of the seropositive patients recalled previous tick bites and three patients previously had erythema migrans.

### 3.2. Diagnosis of Lyme borreliosis

According to our criteria Lyme borreliosis was diagnosed for eight patients. Six of them were women and two men (age range 7–70 years). In addition to vertigo and seropositivity, three of the patients recalled erythema migrans, two had a positive serum PCR result and seven had a positive serum immunoblot. All eight of the patients with Lyme borreliosis had positive levels of IgG antibodies against *B. burgdorferi*, none of them had an increased level of IgM antibodies. The test for *T. pallidum* antibodies was negative for all cases. Five of the eight (62%) patients with Lyme borreliosis recalled a previous tick bite (Table 1), whereas only six of the 33 (18%) seropositive patients had one. Antimicrobial treatment for Lyme borreliosis was given to seven of these eight patients—one patient refused to be treated.

Six of the patients had rotational vertigo, one had positional vertigo and one patient had drop attacks of the Tumarkin type. The interval between the onset of symptoms and the treatment ranged from 2 months to over 2 years. Two of the patients had unexplained fatigue at the time of the diagnosis and two patients had oligoarthritis.

Six patients had sensorineural hearing loss and five had concomitant tinnitus, two bilateral and three unilateral. The brainstem auditory response was measured in six cases. The recordings of two patients were abnormal, see case reports below (Table 2).

The results of the otoneurological tests were available for six of the eight patients with Lyme borreliosis. Saccades, pursuit eye movements, posturography, the caloric test and electronystagmography were normal for four of them. One patient had normal otoneurological tests except pathologically decreased caloric responses in the left ear and a pathological result in the posturography.

### 3.3. Treatment

Intravenous treatment with ceftriaxone was given for 2 weeks to the seven patients with Lyme borreliosis (Table 1). One patient refused all further examinations, the follow-up and the treatment. The treatment with ceftriaxone of one patient was discontinued after 12 days because of a high fever that was assumed to be an allergic reaction to the medication. Her treatment was continued with amoxicillin (500 mg) and probenecid (500 mg) three times a day for 3 months. The treatment of two patients continued with amoxicillin and probenecid for 3 months. Two patients were retreated because of relapsing symptoms, one with ceftriaxone for 4 weeks plus

doxycyclin for three months and the other with doxycyclin for 3 months.

#### 3.4. Response to treatment and follow-up

The mean follow-up of the patients after the treatment was 30 (range 12–48) months. The clinical response to antimicrobial therapy was assessed as good when the vertigo disappeared after the therapy and the patient was asymptomatic at the end of the follow-up. The response was moderate, when the patient reported a distinct decrease of vertigo after treatment. The result was poor when the treatment had no favorable effect. At 9 months after the first course of ceftriaxone one patient was re-treated with ceftriaxone, followed by doxycyclin for 3 months because of relapsing attacks of vertigo and a rise in serum *Borrelia* antibodies. For three of the seven patients treated for Lyme borreliosis the result was good and for four it was moderate. The treatment also cured the arthralgia of one patient with moderate response to vertiginous symptoms. After the treatment the titers of flagellar IgG antibodies declined below the cut-off level in two cases. One patient remained seropositive despite of decline of the titer. Three patients were constantly seropositive.

The mean follow-up time of the 33 initially seropositive patients who were left untreated was 9 (range 4–12) months. Eight of these patients remained seropositive and 15 turned seronegative. Serological follow-up data was not available for nine patients. In this group, vertigo was absent in 12 patients, relieved in five patients, but it remained unchanged for eight patients. Data concerning the relief of vertigo was not available for eight patients.

## 4. Case reports

### 4.1. Patient 1

A 62-year-old male presented with progressive fatigue and rotational vertigo attacks for 3 months. At 6 months after the onset of vertigo he displayed a left sided facial paralysis. He had a history of multiple tick bites, but no erythema

migrans. In serum he had elevated antibodies (IgG and IgM) against *B. burgdorferi* confirmed with a positive result in an immunoblot. The CSF tests were normal. Audiological tests revealed abnormal auditory brain stem responses with bilateral prolongation of the Jewett V wave latency (0.5 ms) and poor reproducibility of the V wave bilaterally. In pure tone audiometry the patient had symmetrical high frequency hearing loss (PTA left ear, 30 dB HL and right ear, 33 dB HL). After the treatment with ceftriaxone (2 g once a day for 2 weeks) fatigue and vertigo disappeared. Six months after the treatment fatigue and vertigo reappeared. He is re-treated with doxycyclin (200 mg daily for 100 days) with immediate good response. At 4 years after the onset of symptoms the patient got new tick bites with migrating arthralgia. He showed a 4-fold rise of serum antibodies against *B. burgdorferi*, but had no further vertigo. He was re-treated with doxycycline (200 mg once a day for 30 days). In the follow-up (48 months) the patient has been free of vertigo, fatigue or arthralgia. The facial paralysis has recovered only partially (House-Brackmann grade III).

### 4.2. Patient 2

A 50-year-old female presented with sinusitis, painful arthralgia, headache and sudden onset of non-rotational vertigo precipitated by head movements. Her history included tick bites but no erythema migrans. She had elevated levels of antibodies (IgG) against *B. burgdorferi*, confirmed with immunoblotting. The CSF sample as well as hearing in pure tone audiometry and auditory brain stem responses were normal. The otoneurological tests (including saccades, pursuit eye movements, posturography and electronystagmography) were normal. She was treated with ceftriaxone (2 g once a day for 2 weeks) and amoxicillin with probenecid 500 mg three times a day each for 3 months. Arthralgia disappeared as well as vertigo. During the follow-up (31 months) the patient reported occasional BPPV-like attacks of vertigo by lateral head tilt towards right ear, but has not suffered anymore from arthralgia and headache.

#### 4.3. Patient 3

A 54-year-old male presented with sudden rotational vertigo, left sided sensorineural low frequency hearing impairment (PTA 21 dB HL) and left sided tinnitus. He could not recall any tick bites nor any erythema migrans. Serum antibodies (IgG) against *B. burgdorferi* were elevated and confirmed with immunoblotting. In a vestibular test he had symmetrical caloric responses. For unknown reasons the patient refused further examination and treatment and was not available for follow-up.

#### 4.4. Patient 4

A 52-year-old female presented with sudden non-rotational vertigo, bilateral tinnitus, aural fullness and spontaneous nystagmus. The patient recalled several tick bites, but no erythema migrans. She had positive levels of serum antibodies (IgG) against *B. burgdorferi* with positive result in immunoblotting. The CSF sample was normal. The auditory brain stem responses were abnormal, with bilaterally prolonged I–V interval (4.30 ms) and right sided poor reproducibility of the V wave. In pure tone audiometry she had a left sided high frequency sensorineural hearing loss (PTA right ear, 11 dB HL and left ear, 19 dB HL). In MRI scan of the brain a small lacunar infarctation was seen on the right side. In the otoneurological tests the posturography was abnormal and the caloric response was reduced on the right side. She was treated with ceftriaxone (2 g once a day for 2 weeks). After the treatment (follow-up 27 months) she became free of vertigo. At 9 months after the treatment she had an episode of arthralgia in multiple joints without any signs or laboratory findings of active borrelial infection. The arthralgia recovered spontaneously in 3 months.

#### 4.5. Patient 5

An 8-year-old previously healthy girl started to suffer from rotational vertigo and tinnitus attacks lasting from 10 s to 1 min, 4–5 times a week. She could not recall any previous tick bites, but she

had a history of untreated erythema migrans 4 months before the onset of symptoms. In serum she had positive levels of antibodies (IgM and IgG) against *B. burgdorferi* confirmed with a positive immunoblotting result. The CSF parameters were normal. The pure tone audiometry was normal. In the otoneurological tests posturography was abnormal. She was treated with ceftriaxone (100 mg/kg once a day for 2 weeks) and became symptom free after the treatment (follow-up 37 months).

#### 4.6. Patient 6

A 57-year-old female suffered from sudden onset rotational vertigo attacks recurring several times a week with a duration of about 1 min. After 7 months she got right sided tinnitus, aural fullness, fatigue and headache. The patient had a history of numerous tick bites and an erythema migrans treated with peroral penicillin 9 years ago. In serum the patient had positive levels of IgG antibodies against *B. burgdorferi* confirmed with immunoblotting. The cerebrospinal fluid sample as well as *Borrelia*-PCR in serum and cerebrospinal fluid were normal or negative. Auditory brain stem responses and electrocochleography were normal. In audiometry she had a minor left sided high frequency and minor right sided mid frequency sensorineural hearing impairment (PTA left ear, 3 dB HL and right ear, 4 dB HL). The otoneurological tests were normal. The patient was treated for 2 weeks with ceftriaxone (2 g once a day for 2 weeks) and there after for 100 days with doxycycline 200 mg once a day. During the follow-up (18 months) the patient became free of headache and fatigue. Rotational vertigo spells are absent, but some daily disequilibrium is left. Aural fullness and tinnitus continues.

#### 4.7. Patient 7

A 70-year-old female started to have recurrent rotational vertigo attacks lasting for several hours for 2 years. Additionally she had tinnitus in her left ear and fatigue. The patient had a history of tick bite and a skin rash identified to erythema migrans. Erythema migrans resolved without any

medication and preceded the onset of vertigo. In serum the patient had positive levels of IgG antibodies against *B. burgdorferi* and a positive immunoblot result. The serum *Borrelia*-PCR was positive. The audiogram showed a high frequency sensorineural hearing loss in the right ear (PTA 39 dB HL) and a flat-type sensorineural hearing loss (PTA 60 dB of HL) affecting the left ear. Auditory brain stem responses were normal. The patient was treated with ceftriaxone (2 g once a day for 2 weeks) for 2 weeks. At 10 months after the treatment the vertigo attacks are still present, but with lesser frequency. The fatigue disappeared after the treatment and has been absent during the follow-up (12 months).

#### 4.8. Patient 8

A 38-year-old female presented with rotational vertigo, tinnitus, right sided hearing loss, fatigue, arthralgia and tenderness in muscles. She could not recall any tick bites, nor any erythema migrans. In serum she had positive levels of antibodies against *B. burgdorferi* (IgG only) and the result of immunoblotting was negative. The CSF tests were normal and the serum and CSF *Borrelia*-PCR tests were negative. The auditory brain stem responses were normal, but in pure tone audiometry she had a right sided fluctuating low frequency sensorineural hearing loss (PTA right ear 5 dB HL and left ear fluctuating between 9 and 40 dB HL). The otoneurological tests as well as the electrocochleography were normal. The patient was treated with ceftriaxone (2 g once a day) for 2 weeks and thereafter peroral amoxicillin and probenecid for 3 months. After the beginning of the treatment the patient had no vertigo for 4 months, but during the following 6 months the patient developed left sided tinnitus and hearing loss, rotational vertigo attacks and left sided aural and facial pain. The serum *Borrelia*-antibodies remained in stable increased level but the repeated serum *Borrelia*-PCR became positive. The brain MRI was normal. The patient was retreated with ceftriaxone (2 g once a day) now for 4 weeks and thereafter with peroral doxycycline (200 mg a day) for 3 months. During the follow-up (36 months) the patient had slight sensation of aural fullness in

her right ear, no rotational vertigo attacks, but sometimes sensation of unsteadiness.

## 5. Discussion

Our results show that Lyme borreliosis is a rare cause of vertigo in Finland. Although the vertigo patients studied are living in an area where ticks are abundant, frequently infested with *B. burgdorferi* [16] and Lyme borreliosis is endemic, only 41 (2%) of the 2055 vertigo patients enrolled had positive levels of serum antibodies against *B. burgdorferi* and a diagnosis of LB was made only for eight of the 41 seropositive patients (0.4% of the whole material). The incidence of seropositivity among our vertigo patients did not differ from the incidence of the general Finnish population [10]. Elevated serum antibody titer against *B. burgdorferi* and vertigo in a given patient does not prove a causal relationship. Nor does seronegativity rule out the possibility of Lyme borreliosis. However, the previous reports of vertigo among patients with late Lyme borreliosis demonstrate, that vertigo can be the presenting symptom of Lyme disease [4,7–9]. Thus, a careful inquiry into a vertigo patient's clinical history, with special emphasis on questioning about erythema migrans, arthritis, neurologic symptoms related with LB and tick bites is more important than the screening of antibodies against *B. burgdorferi*. Modern genetic technological and immunological methods can be valuable in the differential diagnosing of vertigo patients.

Other research groups have reported clearly higher seropositivity incidences for patients with vertigo: 14% by Rosenhall et al. [7] and 17% by Riechelmann et al. [9]. However, in the latter study the prevalence of seropositivity was high also among the control subjects and the vertigo patients did not differ statistically significantly from the controls. Therefore, Riechelmann et al. concluded that Lyme borreliosis is hardly a major cause of vertigo [9]. Although Lyme borreliosis seems to be a rare cause of vertigo, the disease affects the VIII cranial nerve rather often. Krejcová et al. showed vestibular abnormality in 13 of 39 patients suffering from Lyme borreliosis [17].



A Finnish study of 100 patients with late Lyme borreliosis reported vertigo in eight cases [8].

All results based solely on serological findings must be interpreted with caution. The suboptimal specificity of serological tests can cause excessive diagnosing of Lyme borreliosis. On the other hand, the poor sensitivity of serological tests may lead to definite cases being missed, especially in the early stages of the disease and *Borrelia* antibodies may—on rare occasions—be totally absent even in late disease.

All eight patients with Lyme borreliosis had elevated levels of IgG antibodies and seven of them had a positive result in the immunoblotting test. Of the 33 untreated seropositive patients, 19 had positive levels of IgM antibodies. However, the levels were only modestly elevated and in all except one serum they were close to borderline. None of these 19 patients fulfilled our criteria for Lyme borreliosis. The IgG dominance was expected because the infection has usually continued for some time prior to the appearance of vestibular symptoms and of the diagnosis. Our results suggest that IgM antibody measurement may not provide valuable information with respect to the diagnosis of vestibular manifestations of Lyme borreliosis.

The PCR was positive for the serum of two of the seropositive patients, whereas negative results were obtained from all the CSF specimens tested. PCR is a powerful method, but has its limitations. Rigorous measures are needed to prevent amplicon contamination and extensive use of negative controls is necessary for the detection of procedure errors. When properly carried out, a positive PCR result provides reliable evidence of Lyme borreliosis. Although this method is very sensitive, a negative result does not rule out Lyme borreliosis. Despite its limitations we strongly advocate the use of PCR in the diagnosis of Lyme borreliosis and the testing of several samples and sample types from each suspect with this method.

Of interest was that six of our eight patients with LB were women. The reports on the sex distribution of erythema migrans show male dominance [18]. The more common outdoor activities of men than women in the habitats of the tick are assumed to be the reason for the sex difference.

Seven of the eight seropositive patients with Lyme borreliosis were given antimicrobial treatment. The vertigo of all of them was relieved and three of them became asymptomatic after antimicrobial treatment. The long-lasting arthralgia of one patient was also relieved. Spontaneous recovery from the vertigo was frequent (12/33) also in the group of seropositive patients without Lyme borreliosis. Although the Lyme borreliosis diagnosis of our patients was firmly based, spontaneous recovery from their vertigo cannot be ruled out either. Because data on spontaneous recovery was not available for all the patients, we cannot draw the conclusion that the treatment given to the Lyme borreliosis patients enhanced their recovery. Furthermore, the small number of Lyme borreliosis patients did not allow reliable comparisons to be made.

The vertigo was rotational in six of the eight Lyme borreliosis patients, positional in one, whereas one had drop attacks of the Tumarkin type. Only two patients showed evidence of central nervous system affection in the otoneurological tests. The otoneurological and audiological tests did not reveal any consistent battery of findings. Three patients had unilateral sensorineural hearing impairment concomitantly with vertigo. This finding agrees with the results of Rosenhall et al. [7], who reported sensorineural hearing loss for four out of ten seropositive vertigo cases. One of our patients showed abnormality in the caloric test. She also had an abnormal brainstem auditory response that indicated retrocochlear hearing loss or an affected brainstem. In contrast to the results of Rosenhall et al. [7], our patients did not have positional nystagmus.

Five of our Lyme borreliosis patients had symptoms resembling Meniere's disease including vertigo, tinnitus and sensorineural hearing loss. Three of them had aural fullness. Syphilis is a bacterial infection caused by *T. pallidum*, which belongs to the same *Spirochaetales* order than *B. burgdorferi*. Syphilis is a well documented cause of symptoms mimicking classic Meniere's disease [19]. There are many similarities in the clinical course of syphilis and Lyme borreliosis [20]. In this respect it is interesting, but not surprising, that our patients share similar otoneurological

symptoms with the patients with syphilis and Meniere's disease. The small number of patients with Lyme borreliosis does not allow for further conclusions about otoneurological findings in association with Lyme borreliosis.

This study presents the idea that Lyme borreliosis is a rare cause of vertigo. Despite the infrequency, even the rare cases of Lyme borreliosis presenting with vertigo should be found, because the disease is curable and, on the individual level, undiagnosed chronic borreliosis is always a tragedy. The prevalence of elevated antibodies against *B. burgdorferi* in this study did not differ from that of the general population and only a few (19%) of the seropositive cases fulfilled the criteria for Lyme borreliosis. Thus a positive antibody level against *B. burgdorferi* revealed by ELISA-type assays is not alone sufficient for making the diagnosis of LB. Positive serological findings should be supported by the clinical history of the patient and confirmed by immunoblotting. According to our experience Lyme borreliosis seems to be able to mimic Meniere's disease. The detection of the *B. burgdorferi* DNA by modern genetic technological methods show promise in the clinical diagnostics of Lyme borreliosis.

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