

# The outcome of pars plana vitrectomy in horses with equine recurrent uveitis with regard to the presence or absence of intravitreal antibodies against various serovars of *Leptospira interrogans*

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## Summary

**Purpose:** To evaluate the outcome of pars plana vitrectomy (PPV) in eyes with clinical signs of equine recurrent uveitis (ERU) testing positive or negative for intravitreal antibodies against various serovars of *Leptospira interrogans*. 47 eyes of horses with ERU in which intraoperative vitreous samples were tested by microagglutination (MAT) for various serovars of *Leptospira interrogans* between 2001 and 2009 were included in a retrospective study. The presence or absence of postoperative ERU was evaluated by repeated ocular examinations, as well as by interrogation of referring veterinarians and owners. The absence of recurrent episodes of active uveitis was considered a success irrespective of the visual performance of the operated eyes. 85% of eyes of horses with ERU had antibodies against *L. interrogans* in their vitreous. The most common serovar was *L. grippothyphosa*. The majority of horses testing positive for antibodies against *L. interrogans* (40/47; 82.5%) showed no further episodes of ERU, while 6/7 (85.7%) of horses testing negative continued to experience episodes of ERU. This difference is statistically significant. It appears that PPV is an effective treatment for *Leptospira*-associated ERU but not for eyes testing negative for antibodies against *L. interrogans*. Vitreal and aqueous humor samples of horses suffering from ERU should be tested by MAT before performing a PPV.

**Keywords:** Equine recurrent uveitis, vitrectomy, *Leptospira interrogans*, antibodies, ophthalmology

## Die Resultate der Pars-Plana-Vitrektomie bei Pferden mit rezidivierender Uveitis in Abhängigkeit von Antikörpern gegen verschiedene Serotypen von *Leptospira interrogans* im Glaskörper

Die Untersuchung sollte einen möglichen Zusammenhang zwischen dem Erfolg der Pars Plana Vitrektomie (PPV) und dem Vorhandensein von intravitrealen Antikörpern gegen verschiedene Serotypen von *Leptospira interrogans* bei Pferden mit equiner rezidivierender Uveitis (ERU) klären. In einer retrospektiven Studie wurden zwischen 2001 und 2009 intraoperative Glaskörperproben von 47 Augen mit ERU mittels Mikroagglutinationstest (MAT) auf Antikörper gegen verschiedene Serovars von *L. interrogans* untersucht. Das Wiederauftreten von ERU nach der PPV wurde durch wiederholte Augenuntersuchungen, sowie durch Befragungen überweisender Tierärzte und Pferdebesitzer ermittelt. Das Fehlen von rezidivierenden Uveitisschüben nach der Vitrektomie wurde als Therapieerfolg eingestuft, unabhängig von der Sehleistung des betroffenen Auges. 85% der Augen von Pferden mit ERU hatten intravitreale Antikörper gegen *L. interrogans*. Die häufigste Serotyp war *L. grippothyphosa*. Die Mehrheit der Pferde (40/47; 85.5%), welche positiv auf Antikörper gegen *Leptospira* spp. waren, zeigten postoperativ keine Entzündungsschübe mehr, während 6/7 (85.7%) der Augen mit negativem Test weiterhin Uveitis zeigten. Dieser Unterschied ist signifikant. Es scheint, dass PPV eine Erfolg versprechende Behandlungsmethode ist für Pferde mit *Leptospiren*-assoziiierter ERU, aber nicht für Pferde, welche negativ sind für Antikörper gegen *L. interrogans*. Vor einer allfälligen chirurgischen Behandlung sollten Kammerwasser- und Glaskörperproben auf Antikörper gegen *Leptospiren* spp. untersucht werden.

**Schlüsselwörter:** Equine rezidivierende Uveitis, Vitrektomie, *Leptospira interrogans*, Antikörper, Ophthalmologie

## Introduction

Equine recurrent uveitis is one of the most common causes of blindness in horses worldwide with a prevalence of 8 to 10% in horses in Western Europe (Szemes and Gerhards 2000, Deeg et al. 2002). There is mounting evidence, that various serovars of *Leptospira interrogans* are at least the triggering factor for ERU (Roberts et al. 1952, Yager et al. 1952, Bryans 1955, Roberts 1958, Roberts 1969, Trap 1979, Hathaway et al. 1981, Davidson et al. 1987, Matthews et al. 1987, Sillerud et al. 1987, Dwyer et al. 1995, Wollanke et al. 1998, Wollanke et al. 2001, Wollanke 2002, Wollanke et al. 2004a, Niedermaier et al. 2006, Gilger Salmon et al. 2008) and it has been shown, that vaccination with a specific vaccine was successful in preventing new cases in an endemic horse population (Rohrbach et al. 2002, Wollanke et al. 2004b, Rohrbach et al. 2005).

ERU is the most common form of uveitis seen in horses. The clinical presentation is variable. The vast majority of horses are presented with clinical signs of anterior uveitis, which are easily recognizable by owners and referring veterinarians. Some of them may also have Panuveitis, although examination of the posterior segment is initially precluded by the intense miosis. A small number of patients exhibit a less obvious form of ERU, usually intermediate uveitis (pars planitis) with marked inflammatory changes of the posterior segment (vitreous). Since the clinical signs are subtle in these cases, they are usually only presented because of visual deficits at a late stage of the disease. There appears to be no correlation between the form of uveitis and the *Leptospira* status of an individual patient (Tömördy 2009). The association between peripapillary choroidal degeneration (butterfly lesions) and ERU is unclear (Mat-

thews et al. 1990). However, in ponies experimentally infected with *Leptospira* spp. peripapillary chorioretinitis developed along with anterior uveitis (Williams et al. 1971). The diagnosis of ERU is based on the clinical signs of uveitis and a documented history of recurrent episodes of inflammation. In central Europe it is prudent to consider any equine uveitis to be ERU until proven otherwise. There are of course, other forms of uveitis, especially those associated with blunt or sharp trauma (Habin 1994, Moore et al. 1998, Grahn and Cullen 2000). Iridocyclitis and chorioretinitis have been seen in foals with septicemia (Latimer and Wyman 1985), and we have seen bilateral anterior uveitis in a foal with an umbilical infection and bacteremia. Uveitis may also be the result of multicentric neoplasms (Germann et al. 2008). Most forms of equine ulcerative keratitis are accompanied by some degree of anterior uveitis (Nasisse and Nelms 1992).

Symptomatic treatment of ERU (i.e., corticosteroids, mydriatics, and non-steroidal anti-inflammatory medications) aims to reduce inflammation and minimize permanent ocular damage at each episode of active uveitis, but it is not effective in preventing recurrence of disease. Corticosteroids are used topically or subconjunctivally, together with topical 1% atropine sulfate. Non-steroidal anti-inflammatory medications are usually given systemically. Intracameral injection of tissue plasminogen activator (tpa) may be used to dissolve organized fibrinous exudates in the anterior chamber (Spiess 1997). Other medications, such as aspirin, phenylbutazone, used by some clinicians to possibly prevent or decrease severity of recurrent episodes of uveitis have limited efficacy and potential detrimental side effects when used chronically in the horse.

Most veterinary ophthalmologists agree that long-term prognosis for ERU with medical therapy alone is poor. Even aggressive therapy is often insufficient to prevent recurrent painful inflammatory episodes. Cumulative intraocular damage often leads to phthisis bulbi, glaucoma, or loss of vision as a result of cataract formation or retinal detachment. Pars plana vitrectomy (PPV) has first been described in 1991 for the management of equine recurrent uveitis (Werry and Gerhards 1991). PPV has since been increasingly employed in the treatment of ERU in Europe (Werry and Gerhards 1991, Winterberg 1997, Frühauf et al. 1998, Gilger and Spiess 2006).

In a study of 43 eyes post PPV, 42 remained free of recurrent uveitis during the follow-up period of 67 months. 70% of these eyes retained some vision. The most common complication was cataract formation in 19/43 (44%) eyes, followed by phthisis bulbi in 6 eyes, and retinal detachment in 4 eyes (Winterberg 1997). In another study of 38 cases 5 eyes showed recurrence of uveitis between 10 days and 3 years post-operatively (Frühauf et al. 1998). Thirty-three eyes showed no recurrence during a follow-up period of up to 5 years. Vision remained stable in 28 eyes and improved in one eye. The remaining eyes showed marked vision loss as a result of cataracts (3), phthisis bulbi (1), or unknown cause (1). Of the 5 eyes with recurrent uveitis 2 demonstrated marked loss of vision, while 3 maintained preoperative vision.

In the present retrospective study we evaluated the outcome of PPV in relation to the *Leptospira* spp. status of each patient.

## Animals, materials and methods

Between March 2001 and March 2009 59 eyes of 54 horses with ERU underwent a vitrectomy procedure. There were 23 mares, 28 geldings and 3 stallions representing 23 breeds. Five horses were operated bilaterally. Six unilaterally operated horses were lost to follow-up, leaving 53 eyes in the study for which follow-up information was available. The follow-up period ranged from 3 months to 7.5 years. The results of microagglutination tests (MAT) for various serovars of *Leptospira interrogans* were available for 47 eyes. Diluted vitreous samples were collected at the time of surgery and submitted to MAT<sup>1</sup>.

The outcome of vitrectomy was evaluated with regards to the *Leptospira*-status of the individual patient. The presence or absence of postoperative ERU was determined by repeated ocular examinations, as well as by interrogation of referring veterinarians and owners. A vitrectomy was considered successful if no recurrent episodes of active uveitis were observed during the follow-up period. Visual performance was not assessed and patients with mature cataracts but no recurrent uveitis were listed as successful.

Data editing and all the statistical analyses were done using Stata Software<sup>2</sup>. Analyses were carried out using the `clrcchi` command. A p-value of  $\leq .05$  was considered as significant. If not otherwise mentioned, a power of  $> .8$  was considered.

## Results

Forty of the 47 (85%) horses with ERU tested positive for *Leptospira* antibodies by MAT. Only 7 horses tested negative. For 6 horses this information was not available. The following serovars were identified in order of decreasing frequency: *L. grippothyphosa*, *L. pomona*, *L. canicola*, *L. bratislava*, *L. pyrogenes*, *L. copenhageni*, *L. icterohaemorrhagiae*, *L. saxkoebing*, *L. javanica*, *L. tarassovi* (Table 1). Most horses tested positive for more than one serovar. The overall success rate after vitrectomy (no recurrent uveitis) was 73,6%. The remaining 26,4% of patients experienced one or more episode of active uveitis postoperatively.

Of the 40 horses testing positive for *Leptospira* 33 (82.5%) showed no further uveitis, while the remaining 7 (17.5%) had at least one documented relapse of uveitis.

Of the seven horses testing negative for *Leptospira* antibodies, only 1 (14.3%) was considered a success, while the remaining 6 (85,7%) patients continued to show recurrent episodes of uveitis (Table 2).

## Discussion

The most important goal of therapy for ERU is to prevent recurrent painful episodes of active uveitis. In addition, therapy should aim at preserving, restoring or at least stabilizing vision. For the purpose of this retrospective study the absence of recurrent episodes of active uveitis was considered a success.

Medical therapy alone is usually insufficient to prevent recurrent uveitis on a long-term basis. PPV has proven to be an effective surgical therapy for ERU with a high success rate (Winterberg 1997, Frühauf et al. 1998, Gilger and Spiess 2006).

**Table 1** Antibodies against different serovars of *L. interrogans* identified by MAT in intraoperative vitreous samples  
*Antikörper gegen verschiedene Serovare von L. Interrogans aus intraoperativen Glaskörperproben*

Serovars of <i>L. interrogans</i>	Number of isolates
<i>L. grippothyphosa</i>	30
<i>L. pomona</i>	15
<i>L. canicola</i>	14
<i>L. bratislava</i>	12
<i>L. pyrogenes</i>	9
<i>L. copenhageni</i>	7
<i>L. icterohaemorrhagiae</i>	5
<i>L. saxkoebing</i>	2
<i>L. javanica</i>	2
<i>L. tarassovi</i>	1
<i>L. hardjo</i>	0

The role of *Leptospira interrogans* in the pathophysiology of ERU has been cause for controversy. While some authors consider ERU to be a purely immune-mediated disease (Hines and Halliwell 1991, Deeg et al. 2001, Deeg et al. 2002a, Deeg et al. 2002b, Deeg et al. 2004, Deeg et al. 2006a, Deeg et al. 2006b, Deeg et al. 2007a, Deeg et al. 2007b, Deeg et al. 2007c, Deeg 2008, Deeg et al. 2008), others consider *Leptospira* to be the cause or at least the triggering factor for ERU (Matthews et al. 1987, Brem et al. 1998, Wollanke et al. 1998, Brem et al. 1999, Faber et al. 2000, Rohrbach et al. 2002, Wollanke 2004a, Wollanke 2004b, Rohrbach et al. 2005).

In our caseload 85% of horses with clinical signs of ERU have *Leptospira* antibodies in the vitreous of the affected eyes. In a study in Great Britain, only 11.1% of horses with uveitis had positive titers against *L. interrogans* antibodies (Matthews et al. 1987). The most common serovar was *L. sejroe*. In our study the most common serovar of *L. interrogans* was *grippothyphosa* followed by *pomona*, *canicola*, and *bratislava*. This is in accordance with another study from continental Europe (Brem et al. 1999). Similar reports from North America identified most commonly *L. interrogans* serovar *pomona* (Halliwell et al. 1985, Dwyer et al. 1995).

The most important result of the present study was the significantly different outcome of PPV of horses testing positive or negative for *L. interrogans* antibodies. It is interesting to note, that the vast majority of eyes testing negative experienced recurrent episodes of ERU postoperatively. In view of these findings we now routinely submit serum, aqueous humor and vitreous samples of eyes with clinical signs of ERU for MAT for *Leptospira interrogans* antibodies before deciding to perform a PPV. Of 10 eyes testing positive, 9(90%) had no further recurrence of ERU (Spiess, in preparation). These numbers are still too small to draw any conclusions. In future studies the presence of *Leptospira* in the vitreous of horses with ERU should be determined by PCR. Preoperative testing of a larger number of horses should show, whether the present assumption that PPV is primarily successful in cases of *Leptospira*-

associated ERU is true. In a prospective study, the optimal treatment for horses with ERU not associated with *Leptospira* spp. should be evaluated. It is possible, that these horses benefit from the suprachoroidal implantation of a CSA-releasing device (Gilger et al. 2000a, Gilger et al. 2000b, Gilger et al. 2001, Gilger and Spiess 2006, Gilger et al. 2006).

## Addresses

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- <sup>2</sup> StataCorp., 2009; Stata Statistical Software: Release 11.0; College Station, TX, USA: StataCorp LP

## Literature

- Brem S., Gerhards H., Wollanke B., Meyer P. and Kopp H. (1998) Intraokularer Leptospirennachweis bei 4 Pferden mit rezidivierender Uveitis (ERU). *Berl. Münch. Tierärztl. Wschr.* 111, 415-417
- Brem S., Gerhards H., Wollanke B., Meyer P. and Kopp H. (1999) 35 Leptospirenisolationen aus Glaskörpern von 32 Pferden mit rezidivierender Uveitis (ERU). *Berl. Münch. Tierärztl. Wschr.* 112, 390-393
- Bryans J. (1955) Studies on equine leptospirosis. *Cornell Vet.* 45, 16-50
- Davidson M. G., Nasisse M. P. and Roberts S. M. (1987). Immunodiagnosis of leptospiral uveitis in two horses. *Equine Vet. J.* 19, 155-157
- Deeg C. A. (2008) Ocular immunology in equine recurrent uveitis. *Vet. Ophthalmol.* 11 Suppl 1, 61-65
- Deeg C. A., Altmann F., Hauck S. M., Schoeffmann S., Amann B., Stangassinger M. and Ueffing M. (2007a) Down-regulation of pigment epithelium-derived factor in uveitic lesions associates with focal vascular endothelial growth factor expression and breakdown of the blood-retinal barrier. *Proteomics* 7, 1540-1548
- Deeg C. A., Amann B., Raith A. J. and Kaspers B. (2006a) Inter- and intramolecular epitope spreading in equine recurrent uveitis. *Invest. Ophthalmol. Vis. Sci.* 47, 652-656
- Deeg C. A., Ehrenhofer M., Thurau S.R., Reese S., Wildner G. and Kaspers B. (2002a) Immunopathology of recurrent uveitis in spontaneously diseased horses. *Exp. Eye Res.* 75, 127-133
- Deeg C. A., Hauck S. M., Amann B., Kremmer E., Stangassinger M. and Ueffing M. (2007b) Major retinal autoantigens remain stably expressed during all stages of spontaneous uveitis. *Mol. Immunol.* 44, 3291-3296
- Deeg C. A., Hauck S. M., Amann B., Pompetzki D., Altmann F., Raith A., Schmalz T., Stangassinger M. and Ueffing M. (2008) Equine recurrent uveitis - a spontaneous horse model of uveitis. *Ophthalmol. Res.* 40, 151-153
- Deeg C. A., Kaspers B., Kaspers B., Gerhards H., Thurau S.R., Wollanke B. and Wildner G. (2001) Immune responses to retinal autoantigens and peptides in equine recurrent uveitis. *Invest. Ophthalmol. Vis. Sci.* 42, 393-398
- Deeg C. A., Marti E., Gaillard C. and Kaspers B. (2004) Equine recurrent uveitis is strongly associated with the MHC class I haplotype ELA-A9. *Equine Vet. J.* 36, 73-75
- Deeg C. A., Pompetzki D., Raith A. J., Hauck S. M., Amann B., Suppmann S., Goebel T. W., Olazabal U., Gerhards H., Reese S., Stangassinger M., Kaspers B. and Ueffing M. (2006b) Identification and functional validation of novel autoantigens in equine uveitis. [erratum appears in *Mol. Cell Proteomics* 5,1718]. *Mol. & Cell. Proteomics* 5, 1462-1470
- Deeg C. A., A. J. Raith, et al. (2007c) CRALBP is a highly prevalent autoantigen for human autoimmune uveitis. *Clin. Develop. Immunol.* 39, 245

**Table 2** Outcome of PPV in eyes testing positive or negative for antibodies against serovars of *L. interrogans*  
*Ergebnisse der PPV an auf Antikörper gegen Serovare von L. interrogans positiv oder negativ getesteten Augen*

Leptospira positive		Leptospira negative		Leptospira unknown	
N = 40		N = 7		N = 6	
No recurrence	Recurrence	No recurrence	Recurrence	No recurrence	Recurrence
33 (82.5%)	7 (17.5%)	1 (14.3%)	6 (85.7%)	5 (83.3%)	1 (16.7%)

- Deeg C. A., Thurau S. R., Amann B., Crabb J. W., Thurau S. R., Hauck S. M., Ueffing M., Wildner G. and Stangassinger M. (2002b) Uveitis in horses induced by interphotoreceptor retinoid-binding protein is similar to the spontaneous disease. *Europ. J. Immunol.* 32, 2598-2606
- Dwyer A. E., Crockett R. S. and Kalsow C. M. (1995) Association of leptospiral seroreactivity and breed with uveitis and blindness in horses: 372 cases (1986-1993). *J. Am. Vet. Med. Assoc.* 207, 1327-1331
- Faber N. A., Crawford M., Crawford M., LeFebvre R. B., Buyukmihci N. C., Madigan J. E. and Willits N. H. (2000) Detection of *Leptospira* spp. in the aqueous humor of horses with naturally acquired recurrent uveitis. *J. Clin. Microbiol.* 38, 2731-2733
- Frühaufl B., Ohnesorge B., Deegen E. and Boeve M. (1998) Surgical management of equine recurrent uveitis with single port pars plana vitrectomy. *Vet. Ophthalmol.* 1, 137-151
- Germann S. E., Richter M., Schwarzwald C. C., Wimmershoff J. and Spiess B. M. (2008) Ocular and multicentric lymphoma in a young racehorse. *Vet. Ophthalmol.* 11 Suppl 1, 51-56
- Gilger B. and Spiess B. M. (2006) Surgical Management of Equine Recurrent Uveitis. *Equine Surgery*. J. A. Auer, Stick, J. A. Philadelphia, WB Saunders: 749-755
- Gilger B. C., Malok E., Stewart T., Ashton P., Smith T., Jaffe G. J. and Allen J. B. (2000a) Long-term effect on the equine eye of an intravitreal device used for sustained release of cyclosporine A. *Vet. Ophthalmol.* 3, 105-110
- Gilger B. C., Malok E., Stewart T., Horohov D., Ashton P., Smith T., Jaffe G. J. and Allen J. B. (2000b) Effect of an intravitreal cyclosporine implant on experimental uveitis in horses. *Vet. Immunol. Immunopath.* 76, 239-255
- Gilger B. C., Salmon J. H., Wilkie D.A., Cruysberg L. P., Kim J., Hayat M., Kim H., Yuan P., Lee S. S., Harrington S. M., Murray P. R., Edelhauser H. F., Csaky K. G. and Robinson M. R. (2006) A novel bioerodible deep scleral lamellar cyclosporine implant for uveitis. *Invest. Ophthalmol. Vis. Sci.* 47, 2596-2605
- Gilger B. C., Salmon J. H., Yi N. Y., Barden C. A., Chandler H. L., Wendt J. A. and Colitz C. M. (2008) Role of bacteria in the pathogenesis of recurrent uveitis in horses from the southeastern United States. *Am. J. Vet. Res.* 69, 1329-1335
- Gilger B. C., Wilkie D. A., Davidson M. G. and Allen J. B. (2001) Use of an intravitreal sustained-release cyclosporine delivery device for treatment of equine recurrent uveitis. *Am. J. Vet. Res.* 62, 1892-1896
- Grahn B. H. and C. L. Cullen (2000) Equine phacoclastic uveitis: the clinical manifestations, light microscopic findings, and therapy of 7 cases. *Can. Vet. J.* 41, 376-382
- Habin D. (1994) Equine traumatic uveitis. *Equine Vet. Educ.* 6, 122-127
- Halliwell R. E., Brim T. A., Hines M. T., Wolf D. and White F. H. (1985) Studies on equine recurrent uveitis. II: The role of infection with *Leptospira interrogans* serovar pomona. *Curr. Eye Res.* 4, 1033-1040
- Hathaway S., Little T. W. A., Finch S. M. and Stevens A. E. (1981) Leptospiral infection in horses in England: a serological study. *Vet. Rec.* 108, 396-398
- Hines M. and R. Halliwell (1991) Autoimmunity to Retinal S-Antigen in Horses with Equine Recurrent uveitis. *Prog. Vet. Comp. Ophthalmol.* 1, 283-290
- Latimer C. A. and M. Wyman (1985) Neonatal ophthalmology. *Vet. Clin. North Am. Equine Pract.* 1, 235-259
- Matthews A. G., Crispin S. M. and Parker J. (1990) The equine fundus. III: Pathological variants. *Equine Vet. J. Suppl 10*: 55-61
- Matthews A. G., Waitkins S. A. and Palmer M. F. (1987) Serological study of leptospiral infections and endogenous uveitis among horses and ponies in the United Kingdom. *Equine Vet. J.* 19, 125-128
- Moore C. P., Halenda R. M., Grevan V. L. and Collins B. K. (1998) Post traumatic keratouveitis in horses. *Equine Vet. J.* 30, 366-372
- Nasissé M. P. and S. Nelms (1992) Equine ulcerative keratitis. *Vet. Clin. North Am. Equine Pract.* 8, 537-555
- Niedermaier G., Wollanke B., Hoffmann R., Brem S. and Gerhards H. (2006) Darstellung von Leptospiren im Glaskörper augengesunder und an ERU erkrankter Pferde mittels Transmissions-Elektronenmikroskopie. *Dt. Tierärztl. Wschr.* 113, 418-422
- Roberts S. J. (1958) Sequela of leptospirosis in horses on a small farm. *J. Am. Vet. Med. Assoc.* 133, 189-194
- Roberts S. J. (1969) Comments on equine leptospirosis. *J. Am. Vet. Med. Assoc.* 155, 442-445
- Roberts S. R., York C. J. and Robinson J. W. (1952) An outbreak of leptospirosis in horses on a small farm. *J. Am. Vet. Med. Assoc.* 121, 237-242
- Rohrbach B. W., Hendrix D. V., Ward D. A. and Cawrse M. A. (2002) Effect of an inactivated vaccine against leptospira interrogans on the frequency and severity of uveitis in horses with equine recurrent uveitis. Annual Meeting of the American College of Veterinary Ophthalmologists, Denver, Colorado
- Rohrbach B. W., Ward D. A., Hendrix D. V. and Cawrse-Foss M. A. (2005) Effect of vaccination against leptospirosis on the frequency, days to recurrence and progression of disease in horses with equine recurrent uveitis. *Vet. Ophthalmol.* 8, 171-179
- Sillerud C. L., Bey R. F., Ball M. and Bistner S. I. (1987) Serologic correlation of suspected *Leptospira interrogans* serovar pomona-induced uveitis in a group of horses. *J. Am. Vet. Med. Assoc.* 191, 1576-1578
- Spiess B. (1997) Equine recurrent uveitis. Current therapy in equine medicine. N. Robinson. London, WB Saunders Company. 1, 363-366
- Szemes P. A. and Gerhards H. (2000). Untersuchungen zur Prävalenz der equinen rezidivierenden Uveitis im Grossraum Köln-Bonn. *Der prakt. Tierarzt* 81, 408-420
- Tömördy E. (2009) Long-term results after pars plana vitrectomy in horses with recurrent uveitis. *Vetsuisse Faculty, Section of Ophthalmology. Zürich, Dr.med.vet.* 98
- Trap D. (1979) Leptospirose equine. Enquete sur la presence d'agglutinines antileptospire chez les chevaux en France. *Pratique Vet. Equine XI* 3, 149-153
- Werry H. and Gerhards H. (1991) Technique and indications for surgical treatment of equine recurrent uveitis. *Pferdeheilkunde* 7, 321-331
- Williams R. D., Mörter R. L., Freeman M. J. and Lavignette A. M. (1971) Experimental chronic uveitis. Ophthalmic signs following equine leptospirosis. *Invest. Ophthalmol. Vis. Sci.* 10, 948-54
- Winterberg A. and Gerhards H. (1997) Longterm results of pars plana vitrectomy in equine recurrent uveitis. *Pferdeheilkunde* 13, 377-383
- Wollanke B. (2002) Die equine rezidivierende Uveitis (ERU) als intraokulare Leptospirose. *Tierärztliche Fakultät. München, Ludwig-Maximilians-Universität*
- Wollanke B., Brem S., Meyer P., Forbig T., Grassi P., Gerhards H. and Koop H. (2004b) Prophylaxis of equine recurrent uveitis (ERU): First results with a leptospiral vaccine in horses. *Pferdeheilkunde* 20, 447-454
- Wollanke B., Gerhards H., Brem S., Kopp H. and Meyer P. (1998) Intraokulare und Serumantikörper titer gegen Leptospiren bei 150 wegen equiner rezidivierender Uveitis (ERU) vitrektomierten Pferden. *Berl. Münch. Tierärztl. Wschr.* 111, 134-139
- Wollanke B., Gerhards H., Brem S., Meyer P. and Kopp H. (2004a) "Etiology of equine recurrent uveitis (ERU): Autoimmune disease or intraocular leptospiral infection? *Pferdeheilkunde* 20, 327-340
- Wollanke B., Rohrbach B. W. and Gerhards H. (2001) Serum and vitreous humor antibody titers in and isolation of *Leptospira interrogans* from horses with recurrent uveitis. *J. Am. Vet. Med. Assoc.* 219, 795-800
- Yager R., Gochenour W. S. and Wetmore P. M. (1952) Recurrent iridocyclitis (periodic ophthalmia) of horses. *J. Am. Vet. Med. Assoc.* 117, 207-209

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