A retrospective study on 195 horses with contaminated and infected synovial cavities

Een retrospectieve studie van 195 paarden met gecontamineerde en geïnfecteerde synoviale ruimten

[1]F. Pille, [1]A. Martens, [1]M. Oosterlinck, [1]M. Dumoulin, [2]J. Dewulf, [1]F. Gasthuys

[1]Department of Surgery and Anaesthesiology of Domestic Animals, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, 9820 Merelbeke, Belgium
[2]Department of Obstetrics, Reproduction and Herd Health, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, 9820 Merelbeke, Belgium

Frederik.Pille@UGent.be

ABSTRACT

This study analyzes the clinical aspects of contaminated and infected synovial cavities in horses and evaluates their prognosis after treatment. The medical records of 195 affected horses referred between June 1999 and July 2004 were reviewed. Twenty-six horses were euthanized or returned home without further treatment. Therapeutic strategies for the remaining 169 horses were not different from those reported in other recent studies, except that lavage was performed predominantly without endoscopic visualization. Follow-up was obtained by questionnaire for 150 of 169 treated horses. The outcome was considered successful (survival without residual lameness) in 109 of 150 horses (72.7%). Iatrogenic synovial infection, the presence of radiographic signs on admission and the use of regional antibiotic perfusion were significantly related with non-successful outcome. Overall, the outcome in the present study appeared to be slightly less favorable compared to other recent reports, although it certainly improved for horses with deep nail puncture wounds.

SAMENVATTING

In deze studie worden de klinische aspecten betreffende de behandeling van paarden met gecontamineerde en geïnfecteerde synoviale ruimten retrospectief geanalyseerd en de prognose na de behandeling geëvalueerd.
De dossiers van 195 aangetaste paarden aangeboden tussen juni 1999 en juli 2004, werden bestudeerd. Zesentwintig paarden werden geëuthanaseerd of zonder een behandeling meegenomen door de eigenaar. De behandelingsstrategieën in de resterende 169 gevallen verschilden niet van diegene die in de recente literatuur beschreven worden, behalve dat in de huidige studie spoeling hoofdzakelijk zonder endoscopische visualisatie werd uitgevoerd. Honderdvijftig van de 169 behandelde paarden konden op lange termijn opgevolgd worden. Een succesvolle behandeling (overleving zonder persisterende kreupelheid) werd vastgesteld bij 109 paarden (72,7%). Iatrogene infectie, de aanwezigheid van radiografische afwijkingen en het gebruik van regionale perfusie met antibiotica waren significant gerelateerd aan een slechte afloop. De algemene prognose bleek in deze studie iets minder gunstig dan in andere recente studies, hoewel een betere prognose kon worden vastgesteld bij paarden met nageltred.

INTRODUCTION

Bacterial contamination and infection of synovial cavities are common disorders in horses. The principles of aetiopathogenesis, diagnosis and treatment are similar for diarthrodial joints, tendon sheaths and bursae. Bacterial contamination of synovial cavities can arise from penetrating wounds, from hematogenous spread or iatrogenically.

The inflammatory response after synovial contamination or infection is the primary target for diagnosis. However, large variations in the results of synovial fluid analysis exist between affected individuals due to differences in bacterial virulence and host responses. In a clinical situation, infection should be presumed from the moment the number of synovial fluid white blood cells exceeds 30 x 10^9/L with ≥ 80% neutrophils and the amount of TP increases to ≥ 40 g/L. In chronic cases, WBC counts may be less (5 x 10^9 to 10 x 10^9 cells/L), but large amounts of proteins are usually present (> 50 g/L) in the synovial fluid (Bertone, 1996).

Bacterial culture of synovial fluid is used to confirm the bacterial etiology of synovial infections, though the technique is reported to suffer from a high degree of false negative results (Madison *et al.*, 1991, Schneider *et al.*, 1992a). Recently, more positive results were reported for the incubation of synovial fluid in blood culture medium and direct molecular detection of bacterial DNA in synovial fluid by broad range 16S rRNA gene PCR with reverse line blot hybridization (Pille *et al.*, 2004).

Therapeutic strategies for the treatment of synovial

infection in horses aim at the elimination of bacteria and the control of the detrimental inflammatory response. In equine medicine, it is well accepted that lavage of the synovial cavity is of paramount importance in treating synovial contamination or infection, as it effectively reduces the number of bacteria and the amount of inflammatory mediators and proteolytic enzymes. Open drainage has been advocated for longstanding synovial infections, though it is often complicated by secondary bacterial infections and the formation of excessive scarring (Bertone *et al.*, 1992, Schneider *et al.*, 1992b). Lavage is always combined with systemic antibiotic therapy. Several recent studies have focused on the administration of antibiotics by intrasynovial injection and regional perfusion to optimize local drug concentrations (Mills *et al.*, 2000, Butt *et al.*, 2001, Scheuch *et al.*, 2002, Werner *et al.*, 2003, Pille *et al.*, 2007).

The purpose of the present study was to describe the clinical aspects and the outcome of synovial contamination and infection in a large group of horses and to determine possible prognostic factors.

MATERIALS AND METHODS

The medical records of all horses referred to the Department of Surgery and Anesthesiology of Domestic Animals, Faculty of Veterinary Medicine, Ghent University between June 1999 and July 2004 with contaminated and infected synovial cavities were reviewed for patient details, history, clinical findings and treatment. Similar to Pille et al. (2007), synovial cavities were considered contaminated and/or infected if a penetrating lesion was present or if > 3 of the following criteria were met: lameness, joint distention, synovial fluid white cell counts in excess of 30 x 10^9 cells/L, differentials > 80% neutrophils, total protein in excess of 40 g/L, or the presence of predisposing circumstances (septicemia in foals, recent surgery or injection of the synovial cavity, penetrating synovial injuries). Horses with additional significant trauma (fractures, sectioned ligaments or tendons) were not included.

For the present study, the cases were grouped by etiology. The traumatic cases were classified either into group PW ('penetrating wound') or group NPW ('nail puncture wound'). Foals < 6 months old that developed synovial infection in association with septicemia were classified in group F ('foals'). Group IA ('iatrogenic') included all horses that developed synovial infection as a sequel to intrasynovial injection or surgery. Horses > 6 months old with synovial infection without evidence of a wound, injection or surgery were classified in group I ('idiopathic').

Follow-up information was obtained by questionnaire. The outcome was evaluated between 6 months and 5 years after discharge from hospital, with a mean of 2.3 years (SD 1.3). The outcome was considered successful when the horse survived without residual lameness.

Associations between etiology, clinical findings, treatment and outcome were statistically analyzed. Relations between independent factors and binary outcomes were analyzed using logistic regression (SPSS 11.0). Relations between categorical independent factors and a continuous dependent variable were analyzed using ANOVA (SPSS 11.0), and Scheffé post hoc tests were performed. Statistical significance was set at $p < 0.05$.

RESULTS

Patient details

A total of 195 horses and 236 synovial cavities were included in the study. Table 1 summarizes the distribution of age, sex and breed for the different groups of the study population. A survey of the affected synovial cavities is presented in Table 2. In groups NPW and F, 26.7 and 37.1% of the horses, respectively, had multiple affected synovial cavities, whereas for groups PW, IA and I, this was only 6.2%.

Clinical signs and synovial fluid pathology

The average time between onset of clinical symptoms and referral was 7 (SD 10) days for group PW, NPW and F horses, compared to 18 (SD 25) and 12 (SD 13) days for group IA and I horses, respectively. On admission of a case, the diagnostic procedure always included a thorough clinical exam and synoviocentesis of the presumably affected synovial cavity. Lameness, joint distension and fever were common findings. Only in group IA did the majority of horses (82%) have a normal body temperature. Synovial fluid was collected for macroscopic evaluation, laboratory analysis (cellularity and protein content) and culture. The collection of synovial fluid was not possible in 51.4% of the PW and NPW cases because most of the fluid had already drained through an open wound.

The mean synovial fluid white blood cell count was 71.7 x 10^9 cells/l (SD 51.8 x 10^9), and in 72.7% of the samples these cell counts exceeded 30 x 10^9 cells/l. The percentage of neutrophils averaged 93 (SD 8), with 92.31% of the samples containing ≥ 80% of neutrophils. No significant differences in synovial fluid white blood cell counts ($p=0.55$) and percentage of neutrophils ($p=0.68$) were observed between groups. The mean total protein content was 45 g/l (SD 11), and 66.7% of the samples had a total protein content ≥ 40 g/l. The synovial fluid total protein content in group F (mean 37 g/l, SD 6) was significantly lower ($p=0.03$) than in groups PW (mean 48 g/l, SD 12) and I (mean 51 g/l, SD 9).

Culture of synovial fluid consisted of inoculation on solid agar and was rarely performed (23 horses). Only 30.4% of these cultures were positive. Throughout the period of this retrospective study, the techniques for microbiologic analysis were improving, and from 2002 onward (second half of the period of the study), both inoculation of synovial fluid into the blood culture medium and broad range 16S rRNA

Table 1. Population characteristics presented per group.

	Group PW NPW n=95	PW NPW n=30	Group F n=35	NPW IA n=11	Group I n=24	All groups n=195
Mean age	6.2Y	7.9Y	27D	6.4Y	6.5Y	6.6Y*
(SD)	*(4.5)*	*(5.1)*	*(36)*	*(2.5)*	*(5.1)*	*(4.6)**
Sex						
Mare	56	19	12	5	11	103
Stallion	13	0	20	1	5	39
Gelding	25	10	0	5	7	47
Not recorded	1	1	3	0	1	6
Breed						
Warmblood	51	21	23	4	10	109
Standardbred	8	2	1	5	3	19
Thoroughbred	2	0	0	0	1	3
Drafthorse	1	1	3	0	3	8
Pony	7	4	1	0	1	13
Other	8	0	1	0	3	12
Not recorded	18	2	6	2	3	31

Groups PW and NPW: horses suspected of synovial infection after a penetrating wound or nail puncture wound, respectively; Group F: foals < 6 months old suspected of infectious polysynovitis; Group IA: horses suspected of iatrogenic synovial infection; Group I: horses > 6 months old suspected of idiopathic synovial infection; D, days; Y, years; SD, standard deviation.
* Group F: horses not included.

Table 2. Type, identification and localization of all 236 affected synovial cavities presented per group.

	Group PW n=100	Group NPW n=39	Group F n=57	Group IA n=13	Group I n=27	All groups n=236	%
Type							
Joints	83	10	54	13	16	176	*74.6*
Tendon sheaths	14	3	3	0	4	24	*10.2*
Bursae	3	26	0	0	7	36	*15.2*
Identification							
Fetlock joint	29	0	8	5	4	46	*19.5*
Tarsocrural joint	16	0	12	3	1	32	*13.6*
Carpal joints	14	0	10	0	5	29	*12.3*
Navicular bursa	1	26	0	0	0	27	*11.4*
Coffin joint	6	10	1	5	1	23	*9.8*
Stifle joints	3	0	16	0	2	21	*8.9*
Digital flexor sheath	9	3	1	0	3	16	*6.8*
Elbow joint	3	0	6	0	3	12	*5.1*
Pastern joint	7	0	1	0	0	8	*3.4*
Tarsal sheath	4	0	1	0	1	6	*2.5*
Distal tarsal joints	5	0	0	0	0	5	*2.1*
Acquired precarpal bursa	0	0	0	0	3	3	*1.3*
Carpal extensor sheath	1	0	1	0	0	2	*0.9*
Bicipital bursa	1	0	0	0	1	2	*0.9*
Acquired calcaneal bursa	0	0	0	0	2	2	*0.9*
Intertendinous calcaneal bursa	1	0	0	0	1	2	*0.9*
Localization							
Front limb	42	11	24	10	16	103	*43.6*
Hind limb	58	28	33	3	11	133	*56.4*

PW, NPW, F, IA, I: see legend of Table 1 for explanation.

gene PCR were added to the standard protocol. In this period when the extended protocol was used, microbiologic analysis was performed in 31 of 68 animals (45.6%) with penetrating injuries (groups PW and NPW) and in 34 of 41 animals (82.9%) of the other groups. A bacterial etiology was proved in 84.1% of the samples by at least one positive test.

Standard radiography was performed in 156 of 195 cases. Radiographic signs consistent with joint infection or extensive degenerative joint damage were found in 50% and 60% of the group F and IA horses, respectively. This was significantly different ($p=0.03$ and $p=0.02$, respectively) from the other groups, where only 21% of the horses showed radiographic lesions.

Peripheral blood was collected in 32 group F animals. The mean white blood cell count was 23.2×10^9 cells/l (SD 13.5). The amount of gamma globulins was determined either by the glutaraldehyde coagulation test (17 foals) or peripheral protein electrophoresis (4 foals), or else by both techniques (11 foals). Using an 8 g/l threshold, the detection rate for hypogammaglobulinemia was 25% (7 of 28 cases) for the coagulation test, compared to 73.3% (11 of 15 cases) for electrophoresis. Twelve of 17 foals diagnosed with hypogammaglobulinemia were administered plasma prior to treatment.

Treatment details

After consultation with the owners, 169 of the 195 horses (86.7%) diagnosed with synovial contamination or infection were treated and hospitalized at the clinic. The average hospitalization period was 24 days (SD 17). Twenty-six horses (13.3%) were not treated and were either taken back home or euthanized immediately after diagnosis, mainly for financial reasons. The proportions of horses that were not treated did not significantly differ ($p=0.94$) between groups. One hundred sixty-seven of 169 horses (98.8%) were treated surgically, which consisted mainly of through-and-through lavage of the affected synovial cavities. Two of 169 horses (1.2%) were treated by systemic and intrasynovial injection of antibiotics without joint lavage. Lavage was generally performed under general anesthesia (163 horses) using customized re-usable large bored needles (144 horses). In 23 horses, lavage was performed endoscopically. The wounds were debrided and closed whenever possible. On occasion, lavage was combined with open surgical exploration of the synovial cavity in order to remove excessive amounts of fibrin or to debride an osteochondral focus of infection (16 horses). This was either followed by primary wound closure (8 horses), or else the wound was left open to heal by second intention (8 horses), thus allowing a continuous drainage of synovial fluid. The decision for a second or third lavage (27 and 14 horses, respectively) was based on the clinical evolution of the patient and/or the results of repeated synovial fluid analysis. In one horse with unresponsive infection of the tarsal sheath, tenectomy of the intrathecal part of the deep digital flexor tendon was performed. Another horse with unresponsive infection of the coffin joint and osteomyelitis of the third phalanx following solar puncture was treated with extensive joint curettage in order to promote bony fusion of the middle and distal phalanx.

At the end of lavage, antibiotics were administered intrasynovially in 144 horses. In 12 of them, local injection was repeated for 4 days after surgery. Amikacin (100 to 500 mg) was administered most frequently (123 horses). Regional perfusion with 1-3 g ceftiofur was performed peroperatively in 47 of 145 cases that involved synovial cavities of the lower limb, carpus or tarsus. Eight horses had more than 1 antibiotic perfusion. In 6 horses with synovial penetration (groups PW and NPW), gentamicin-impregnated collagen sponges (Duracoll® Implant, Schering-Plough) were implanted in the wound. All affected areas were covered with a bandage to control perisynovial swelling and to protect the wounds from further contamination. Casts were used when protection of puncture wounds of the hoof ('foot cast', 28 horses) or immobilization of the lower limb ('lower limb cast', 34 horses) was intended.

All horses were administered antibiotics parenterally for a mean period of 14 days (SD 8). Adult horses commonly received a combination of intravenous (IV) gentamicin and penicillin during the first week, followed by intramuscular (IM) injection of neomycin-penicillin during the second week. In foals, mainly IM injection of amoxicillin-clavulanic acid or ceftiofur, sometimes in combination with amikacin, were used. Parenteral administration of antibiotics was routinely followed by oral administration of trimethoprim-sulfa for a mean period of 11 days (SD 12). Antimicrobial selection was changed based on bacterial culture results and antimicrobial susceptibility testing, or when specific therapeutic indications were present (e.g. osteochondral infection). All the horses received NSAID's until the inflammation and (severe) lameness subsided. If necessary, morphine (0.1 mg/kg q. 8h IM) was administered for additional analgesia. All medication used in this study is summarized in Table 3.

Outcome

Nineteen of the 169 treated horses were lost for follow-up because they were sold or they died for unrelated reasons within 6 months after discharge from hospital or their owners could no longer be reached. The outcome for the remaining 150 horses is summarized in Table 4. Overall, the outcome was considered successful (survival without residual lameness) in 109 of the 150 horses (72.7%). Sixty-seven of the 109 horses with successful outcome had been used for riding or exercise prior to injury. According to the owners, 58 of them (86.6%) resumed full activity. It was found that the frequency of a successful outcome was significantly smaller ($p=0.01$) within group IA compared to the other groups. The presence of radiographic abnormalities and the use of regional antibiotic perfusion were significantly related ($p<0.001$ and

Table 3. Antibiotics and non-steroidal anti-inflammatory agents (NSAID's) used in horses with contaminated and infected synovial cavities.

Drug	Route	Dose	Specific indications
Antibiotics			
Amikacin	IV or IM	6.6 to 15 mg/kg q 24h	Foals
	Intrasynovial	100-500 mg	-
Amoxicillin-clavulanic acid	IV or IM	15 mg/kg q 8h	Foals
Ceftiofur	IV or IM	2.2 to 4.4 mg/kg q 6 to 24h	-
	Intrasynovial	0.5 to 1 g	-
	Perfusion	1 to 3 g	-
Enrofloxacin	IV	5 mg/kg q 24h	Bone infection
	Oral	7.5 mg/kg q 24h	Bone infection
Gentamicin	IV	6.6 mg/kg q 24h	-
	Intrasynovial	150 mg	-
Kanamycin	IM	3 mg/kg q 24h	(with penicillin)
Neomycin	IM	5 mg/kg q 24h	(with penicillin)
Oxytetracycline	IV	6.6 mg/kg q 12h	Bone infection
Procaine penicillin	IM	15000 IU/kg q 12h	-
Rifampin	Oral	5 mg/kg q 12h	Foals
Sodium penicillin	IV	20000 IU/kg q 6 to 8h	-
Trimethoprim-sulfa	Oral	30 mg/kg q 12h	-
NSAID's			
Carprofen	IV or IM	1.1 mg/kg q 24h	Foals
Flunixin meglumine	IV or Oral	1.1 mg/kg q 24h	-
Phenylbutazone	IV or Oral	1.1-8.8 mg/kg q 24h	-
Vedaprofen	IV or Oral	2.2 mg/kg q 24h	-

Table 4. Outcome of 150 horses treated for synovial contamination or infection.

	Group PW n=72	Group NPW n=26	Group F n=22	Group IA n=11	Group I n=19	All groups n=150
Survived	67 (93.1%)	23 (88.5%)	15 (68.2%)	7 (63.6%)	18 (94.7%)	130 (86.7%)
Sound	57 (79.2%)	19 (73.1%)	13 (59.1%)	4 (36.4%)	16 (84.2%)	109 (72.7%)

PW, NPW, F, IA, I: see legend of Table 1 for explanation.

Table 5. Frequency of successful and unsuccessful case outcome with treatment of 183 contaminated or infected synovial cavities in 150 horses.

		Unsuccessful case outcome		Successful case outcome	
Carpal joints	(n=17)	0	(0%)	17	(100%)
Distal tarsal joints	(n=3)	0	(0%)	3	(100%)
Acquired precarpal bursa	(n=3)	0	(0%)	3	(100%)
Carpal extensor sheath	(n=2)	0	(0%)	2	(100%)
Bicipital bursa	(n=2)	0	(0%)	2	(100%)
Acquired calcaneal bursa	(n=2)	0	(0%)	2	(100%)
Tarsocrural joint	(n=20)	4	(20%)	16	(80%)
Navicular bursa	(n=23)	5	(21.7%)	18	(78.3%)
Pastern joint	(n=4)	1	(25%)	3	(75%)
Fetlock joint	(n=40)	12	(30%)	28	(70%)
Digital flexor sheath	(n=13)	5	(38.5%)	8	(61.5%)
Elbow joint	(n=9)	4	(44.4%)	5	(55.6%)
Coffin joint	(n=21)	10	(47.6%)	11	(52.4%)
Intertendinous calcaneal bursa	(n=2)	1	(50%)	1	(50%)
Stifle joints	(n=17)	10	(58.8%)	7	(41.2%)
Tarsal sheath	(n=5)	4	(80%)	1	*(20%)*
Global	**(n=183)**	**56**	**(30.6%)**	**127**	**(69.4%)**

$p<0.05$) with the probability of unsuccessful outcome. No significant relations were found between outcome and the type of affected synovial cavity (joint, tendon sheath or bursa) or between outcome and the method of lavage (by needles or endoscopically). Table 5 details the frequency of successful and unsuccessful case outcome for the different synovial cavities affected.

Within group PW, the duration of clinical signs prior to treatment was significantly shorter ($p<0.01$) in horses with a successful outcome (mean 4 days, SD 8) compared to non-successful cases (15 days, SD 12). Although not significant, the same tendency was observed in horses of the NPW group. Within the NPW group, the success rate tended to be smaller for horses that had a coffin joint (63.6% successful) or front leg affected (50% successful), compared to cases that did not involve the coffin joint (80% successful) or that had a hind leg affected (83.3% successful). Compared to group F cases with a non-successful outcome, foals with a successful outcome had lower glutaraldehyde test results (mean 6 g/l, SD 2.9 versus 8.2 g/l, SD 2.2) and received plasma more frequently (61.54 % of cases versus 33.33%). Furthermore, successful outcome in foals seemed to be related to mono-articular involvement (76.9% in successful cases versus 33.3% in non-successful cases), high synovial fluid white cell counts (mean 106 x 10^9 cells/l, SD 59 x 10^9 in successful cases versus 55 x 10^9 cells/l, SD 32 x 10^9 in non-successful cases) and repeated lavage (75% in successful cases versus 44.4% in non-successful cases). Only the relation between successful outcome and high synovial fluid white cell counts was significant ($p<0.01$). Within groups IA and I, no specific risk factors for unsuccessful outcome were observed.

DISCUSSION

The distribution of breeds presented in this study reflects the clinic population, which consists predominantly of warmbloods and miscellaneous breeds. This is different from other studies, which included mainly standardbreds and thoroughbreds (Lapointe *et al.*, 1992, Schneider *et al.*, 1992a, Steel *et al.*, 1999, Wright *et al.*, 2003). In non-racing breeds, the decision whether to resume full activity or not is multi-factorial and often depends more on the owner's personal opinion than on economics and the ability of the horse to be functional again. Therefore we preferred to define outcome as 'successful' when the horse survived without residual lameness, irrespective of whether it resumed full activity or not. Besides, the present population differs from other published series of synovial infection (Schneider *et al.*, 1992a, ter Braake *et al.*, 2002, Wright *et al.*, 2003) because it includes a large proportion of nail puncture wounds (group NPW). Group I was used to classify cases that developed infection without obvious etiology. Most likely, those cases developed infection after hematogenous contamination of synovial cavities (Schneider *et al.*, 1992a, Meijer *et al.*, 2000, Wright *et al.*, 2003). One horse of this group developed a *Pseudomonas* infection of a rear fetlock and tendon sheath 1 week after upper respiratory tract surgery. It was presumed that, similar to the report of Schneider *et al.* (1992a), the infection developed as a sequel to blood pressure monitoring with an intra-arterial line in the affected leg.

Negative bacterial culture results have been reported in 21 to 45% of horses with synovial contamination or presumed infection (Madison *et al.*, 1991, Schneider *et al.*, 1992a, Meijer *et al.*, 2000). In the present study, a bacteriologic etiology could be confirmed in the majority of cases (only 15.9% negatives), probably due to the inclusion of a bacterial PCR. A recent study at our laboratory investigated the sensitivity and specificity of both bacterial culture and 16S rRNA gene PCR for confirming presumed synovial infection in horses (Pille *et al.*, 2007). In that controlled study, a bacterial etiology was confirmed in 91.8 % of the cases with a specificity > 90 % when the results for bacterial culture and PCR were combined.

As was expected, hypogammaglobulinemia was a common finding in group F. The accuracy of the glutaraldehyde coagulation test has been demonstrated previously for normal neonates (Clabough *et al.*, 1989). However, from the low sensitivity observed in the present study, the reliability of the test in diseased foals seems questionable. Presumably, in foals with infectious disease, excess serum fibrinogen together with lots of other protein-like precursors and inflammatory mediators cause unspecific reaction in the coagulation test.

The therapeutic strategies in the present study were not different from other studies, except that the recent literature focuses on endoscopic lavage (Wright *et al.*, 1999, ter Braake *et al.*, 2002, Wright *et al.*, 2003), whereas in the present study lavage was performed predominantly without endoscopic visualization. Wright *et al.*, (2003) suggested endoscopic lavage to reduce the period of systemic antimicrobial medication. The period of parenteral administration of antibiotics in the present study (mean 14 days) was comparable to that reported after endoscopic lavage (mean 13 days) (Wright *et al.*, 2003), but it was routinely prolonged by follow-up treatment with oral antibiotics according to earlier recommendations (Baxter 1996). At present, it is the opinion of the authors that prolonged administration of antibiotics is possibly more inspired by a 'feel safe' attitude than by the conviction that it is essential. In addition, it is difficult to determine the appropriate time for the cessation of antibiotics when the administration of nonsteroidal anti-inflammatory drugs is continued, which limits the use of clinical signs to monitoring the response to treatment.

The survival rates in the present study (globally 86.7%) are in line with previous reports (Schneider *et al.*, 1992a, ter Braake *et al.,* 2002, Wright *et al.*, 2003). Nevertheless, it was found that 'success rates' (survival without residual lameness) were lower in the present study compared to studies that focused on outcome after endoscopic lavage (ter Braake *et al.,* 2002, Wright *et al.*, 2003). Although a tendency to im-

proved prognosis after endoscopic treatment of synovial infection might exist, its significance can only be proven after comparison of non-endoscopic and endoscopic lavage in one and the same study. At least in the present study, no significant relation could be demonstrated between outcome and the type of lavage. The relation between unsuccessful outcome and the use of regional antibiotic perfusion has been demonstrated previously and can be explained from its frequent use in cases of established infection (Wright *et al.*, 2003).

The low prevalence of radiographic signs observed in the present study suggests that radiography is not a sensitive tool for the detection of synovial infection, except possibly in foals, where radiographic changes are known to develop quickly (Bertone 1999). Nevertheless, the results of this study confirm that the routine use of radiography in patients with presumed synovial infection is recommended, as the detection of bone or physeal involvement predicts unsuccessful outcome.

It might be surprising that overall no significant relation was found between outcome and duration of clinical symptoms. However, this was also reported in previous studies about synovial infection in horses (Lapointe *et al.*, 1992, Wright *et al.*, 2003). In the present study, only horses of the PW group with successful outcome had significantly shorter durations of clinical signs prior to treatment compared to horses with unsuccessful outcome. The same was found in other studies that investigated open synovial injuries in horses (Gibson *et al.*, 1989), which most likely can be explained in terms of the logic that recent contamination of a synovial cavity is easier to cure than established infection.

The observations of the present study do not support the conclusions of Schneider *et al.* (1992a) that infective tenosynovitis has a significantly better prognosis than infective arthritis. Nevertheless, the number of horses in this study was too low to draw statistical comparisons for the outcomes for all the different synovial cavities. The successful outcome for penetrating injuries of the carpal joints is remarkable, and in contrast with an earlier report (Peremans *et al.*, 1991), as these joints are recognized to have a more complex anatomy and thus may be less effectively lavaged. The unsuccessful outcome for penetrating injury of the tarsal sheath is not surprising to the authors, as the sustentaculum tali is often affected. Nevertheless, recent reports suggest a fair to good outcome for the condition, even in the presence of osteomyelitis of the sustentaculum (Santschi *et al.*, 1997, Hand *et al.*, 2001). In the most recent case of tarsal sheath infection in this study, the entire intrathecal part of the lateral digital flexor tendon was surgically removed. Although it was classified as 'unsuccessful', the horse is very comfortable at pasture and can be used for light riding without being completely sound. Therefore, tenectomy of the intrathecal part of the lateral digital flexor might be considered a salvage procedure in cases of unresponsive infection of the tarsal sheath involving the sustentaculum and/or tendon.

The results of the present study suggest a good outcome for horses affected with nail puncture wounds that involve the navicular bursa and possibly the coffin joint and/or digital sheath (73.1% success rate). After correct anatomical identification of all structures involved and extensive trimming of the surrounding horn to the dermo-epidermal junction, the contaminated or infected synovial cavities had been thoroughly lavaged and the puncture tract carefully resected. The 'Streetnail' operation, which consists of an aggressive exploration over one-half to two-thirds of the frog to expose the deep digital flexor tendon, is in the opinion of the authors too invasive as a standard procedure. Its use was restricted to the treatment of horses that presented with extensive tendon necrosis and/or osteomyelitis of the navicular bone. None of the cases was treated endoscopically. The success rate for the procedure reported here is similar to that reported for endoscopic treatment (Wright *et al.*, 1999) and markedly better than that reported for the 'Streetnail' procedure (Richardson *et al.*, 1986). The tendency towards a better outcome for hind limb involvement and shorter duration between injury and surgery is consistent with the findings of both the other studies (Richardson *et al.*, 1986, Wright *et al.*, 1999).

According to the reports of Schneider *et al.*, (1992), Meijer *et al.*, (2000) and ter Braake et al., (2002), low success rates are found in foals with hematogenous synovial infection. The tendency towards a worse prognosis for cases involving multiple synovial cavities seems logical and was also found to be a negative prognostic factor in the study of Steel *et al.*, (1999). The possibly positive prognostic value of a low glutaraldehyde test result observed in the present study is conflicting at the first sight, though it might illustrate once again that in the presence of a normal glutaraldehyde test, hypogammaglobulinemia is often not detected and therefore left untreated. Because the administration of plasma and repeated lavage seem related to successful outcome in foals with a low glutaraldehyde test result and high synovial fluid white cell counts, it is suggested that sustained therapy can be useful.

The lowest success rate in the present study was found in iatrogenic cases. The outcome reported here was markedly worse than that reported by Lapointe *et al.*, (1992) and Schneider *et al.*, (1992). However, it was felt that the success rate in group IA was consistently limited by pre-existing joint disease and lameness, which is partially illustrated by the high proportion of degenerative joint disease that was detected radiographically on admission.

From the results of the present study, it can be concluded that the prognosis for the treatment of contaminated and infected synovial cavities in a predominantly non-racing population is fair. Although the results of the present study are less optimistic compared to other recent studies, they confirm the authors' impression that in the individual horse the outcome remains uncertain, despite radical therapy. For horses

with nail puncture wounds, it was found that since the 'Street Nail' procedure was no longer being used as a standard treatment, the prognosis improved significantly.

REFERENCES

Baxter G.M. (1996). Instrumentation and techniques for treating orthopaedic infections in horses. *Veterinary Clinics of North America Equine Practice 12*, 303-335.

Bertone A.L., Davis D.M., Cox H.U., Kamerling S.S., Roberts E.D., Caprile K.A., Gossett K.A. (1992). Arthrotomy versus arthroscopy and partial synovectomy for treatment of experimentally induced infectious arthritis in horses. *American Journal of Veterinary Research 53*, 585-591.

Bertone A.L. (1996). Infectious arthritis. In: McIlwraith C.W. and Trotter G.W. (editors), Joint Disease in the Horse, W.B. Saunders Company, Philadelphia, p. 397-409.Bertone A.L. (1999). Update on infectious arthritis in horses. *Equine Veterinary Education 11*, 143-152.

Butt T.D., Bailey J.V., Dowling P.M., Fretz P.B. (2001). Comparison of 2 techniques for regional antibiotic delivery to the equine forelimb: intraosseous perfusion vs. intravenous perfusion. *Canadian Veterinary Journal 42*, 617-622.

Clabough D.L., Conboy H.S., Roberts M.C. (1989). Comparison of four screening techniques for the diagnosis of equine neonatal hypogammaglobulinemia. *Journal of the American Veterinary Medical Association 194*, 1717-1720.

Gibson K.T., McIlwraith C.W., Turner A.S., Stashak T.S., Aanes W.A., Trotter G.W. (1989). Open joint injuries in horses: 58 cases (1980-1986). *Journal of the American Veterinary Medical Association 194*, 398-404.

Hand D.R., Watkins J.P., Honnas C.M., Kemper D. (2001). Osteomyelitis of the sustentaculum tali in horses: 10 cases (1992-1998). *Journal of the American Veterinary Medical Association 219*, 341-345.

Lapointe J.M., Laverty S., Lavoie J.P. (1992). Septic arthritis in 15 standardbred racehorses after intra-articular injection. *Equine Veterinary Journal 24*, 430-434.

Madison J.B., Sommer M., Spencer P.A. (1991). Relations among synovial membrane histopathologic findings, synovial fluid cytologic findings, and bacterial culture results in horses with suspected infectious arthritis: 64 cases (1979-1987). *Journal of the American Veterinary Medical Association 198*, 1655-1661.

Meijer M.C., Van Weeren P.R., Rijkenhuizen A.B.M. (2000). Clinical experiences of treating septic arthritis in the equine by repeated joint lavage: a series of 39 cases. *Journal of Veterinary Medicine 47*, 351-365.

Mills M.L., Rush B.R., St. Jean G., Gaughan E.M., Mosier D., Gibson E., Freeman L. (2000). Determination of synovial fluid and serum concentrations, and morphologic effects of intraarticular ceftiofur sodium in horses. *Veterinary Surgery 29*, 398-406.

Peremans K., Verschooten F., De Moor A., Desmet P. (1991). Monoarticular infectious arthritis in the horse: 34 cases. *Equine Veterinary Science 11*, 27-32.

Pille F., Martens A., Schouls L.M., Peelman L., Gasthuys F., Schot C.S., De Baere C., Desmet P., Vandenberghe F. (2004). Detection of bacterial DNA in synovial fluid from horses with infectious synovitis. *Research in Veterinary Science 77*, 189-195.

Pille F., De Baere S., Ceelen L., Dewulf J., Croubels S., Gasthuys F., De Backer P., Martens A. (2005). Synovial fluid and plasma concentrations of ceftiofur after regional intravenous perfusion in the horse. *Veterinary Surgery 34*, 608-615.

Pille F., Martens A., Schouls L.M., Dewulf J., Decostere A., Vogelaers D., Gasthuys F. (2007). Broad range 16S rRNA gene PCR compared to bacterial culture to confirm presumed synovial infection in horses. *The Veterinary Journal 173*, 73-78.

Richardson G.L., O'Brien T.R., Pascoe J.R., Meagher D.M. (1986). Puncture wounds of the navicular bursa in 38 horses; a retrospective study. *Veterinary Surgery 15*, 156-160.

Santchi E.M., Adams S.B., Fessler J.F., Widmer W.R. (1997). Treatment of bacterial tarsal tenosynovitis and osteitis of the sustentaculum tali of the calcaneus in five horses. *Equine Veterinary Journal 29*, 244-247.

Scheuch B.C., Hoogmoed L.M., Wilson W.D., Snyder J.R., MacDonald M.H., Watson Z.E., Steffey E.P. (2002). Comparison of intraosseus or intravenous infusion for delivery of amikacin sulfate to the tibiotarsal joint of horses. *American Journal of Veterinary Research 63*, 374-380.

Schneider R.K., Bramlage L.R., Moore R.M., Mecklenburg L.M., Kohn C.W., Gabel A.A. (1992a). A retrospective study of 192 horses affected with septic arthritis/tenosynovitis. *Equine Veterinary Journal 24*, 436-442.

Schneider R.K., Bramlage L.R., Mecklenburg L.M., Moore R.M., Gabel A.A. (1992b). Open drainage, intra-articular and systemic antibiotics in the treatment of septic arthritis/tenosynovitis in horses. *Equine Veterinary Journal 24*, 443-449.

Steel C.M., Hunt A.R., Adams P.L.E., Robertson I.D., Chicken C., Yovich J.V., Stick J.A. (1999). Factors associated with prognosis for survival and athletic use in foals with septic arthritis: 93 cases (1987-1994). *Journal of the American Veterinary Medical Association 215*, 973-977.

Ter Braake F. (2002). Improved prognosis by immediate endoscopic approach of septic-synovitis in the horse. *Tijdschrift voor Diergeneeskunde 127*, 444-449.

Werner L.A., Hardy J., Bertone A.L. (2003). Bone gentamicin concentration after intra-articular injection of regional intravenous perfusion in the horse. *Veterinary Surgery 32*, 559-565.

Wright I.M., Phillips T.J., Walmsley J.P. (1999). Endoscopy of the navicular bursa: a new technique for the treatment of contaminated and septic bursae. *Equine Veterinary Journal 31*, 5-11.

Wright I.M., Smith M.R.W., Humphrey D.J., Eaton-Evans T.C.J., Hillyer M.H. (2003). Endoscopic surgery in the treatment of contaminated and infected synovial cavities. *Equine Veterinary Journal 35*, 613-619.