Synovial Fluid Changes in Induced Infectious Arthritis in Calves

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The objective was to develop an experimental model of septic arthritis in calves and to evaluate the effect of treatment on cytologic and bacteriologic variables of synovial fluid. The right tarsus of 7 healthy Holstein bull calves were inoculated with 10^8 colony-forming units of viable *Escherichia coli* of a *pap*-positive strain (day 1). On day 2, joint lavage was performed and antibiotic treatment was instituted. Cytologic examinations, bacterial cultures, and *pap* factor determinations by polymerase chain reaction (PCR) were performed on synovial fluid samples that were collected daily until day 4, then every 4 days until day 24. Results of physical examination, the severity of lameness, and swelling were recorded. Clinical signs of septic arthritis appeared on day 2 and persisted until day 9 for all calves. Bacterial cultures from all calves were positive for *E coli* on day 2, and remained positive until day 3 for 1 calf and until day 4 for 5 calves. In addition, PCR results were positive for all calves, with 6 positive through day 3 and 1 positive through day 4, after which a positive result was again obtained on day 24. Synovial fluid neutrophil counts and white blood cell counts were significantly increased on days 2–4; however, synovial total protein concentrations were increased ($P < .05$) throughout the experiment in comparison to day 1. Results of all bacterial cultures were negative on day 8, although clinicopathologic signs of inflammation persisted until day 20. This model successfully induced acute septic arthritis in calves. Rapid recovery occurred within 1 week when an appropriate treatment was instituted early in the course of the disease.

Key words: Bacterial culture; Cattle; Cytology; *Escherichia coli*; Polymerase chain reaction; Septic arthritis.

S eptic arthritis may occur by direct trauma or contamination of the joint, extension from periarticular infection, or hematogenously.[1] An acute inflammatory response occurs after bacterial contamination of the joint.[2] This reaction initiates a rapid influx of inflammatory cells, mostly neutrophils, as well as activation of synoviocytes and chondrocytes, release of many inflammatory mediators, and finally decreased proteoglycan synthesis.[2] This cascade of events ultimately leads to a reduction in joint lubrication and an increase in cartilage destruction, thus contributing to the process of joint disease.[2] Chronic septic arthritis may develop and may be attributed to persistent bacterial infection, presence of bacterial wall materials, or an immune-mediated process.[3]

Diagnosis of septic arthritis is based on the combination of clinical signs, radiographic examination, bacterial culture, and cytologic analysis of synovial fluid.[4] A bacterium is isolated in only 60% of cases of septic arthritis in bovine medicine.[a] Consequently, synovial fluid cytologic analysis is very useful for the differentiation between infectious and noninfectious arthritis.[4] Treatment of septic arthritis in cattle is based on the early administration of antibiotics for a duration of 2–3 weeks combined with joint lavage.[5,6] Antiinflammatory drugs also are recommended to reduce pain and swelling.[7]

Frequency of persistence of bacteria in the joint after infection and treatment is unknown in cattle. *Staphylococcus aureus* was isolated in up to 70% of joints after 20 days of systemic antibiotic treatment in induced equine arthritis.[8] Polymerase chain reaction (PCR) analysis of human synovial samples revealed that bacterial DNA cannot be detected after 26 days of treatment,[9] although results of Gram stain and cultures usually become negative 3 days after the initiation of therapy. In a clinical report of a human patient with septic arthritis caused by *S aureus,* bacterial DNA could be detected up to 10 weeks after the initiation of an adequate antibiotic treatment.[10]

PCR techniques that apply pathogen-specific primers[10] or broad-range 16S ribosomal RNA and subsequent DNA sequencing[9] are used for the diagnosis of septic arthritis in human medicine. The advantages of these techniques are their rapidity, their capacity to detect fastidious organisms, and their capacity to detect bacteria during antibiotic treatment.[11]

The objectives of this study of induced septic arthritis in calves were to create a reproducible model of induced septic arthritis, to describe synovial fluid components before and after treatment, and to estimate the average survival time of bacteria after the initiation of an effective antibiotic treatment by using standard bacterial culture and PCR techniques.

Materials and Methods

The experimental protocol was approved by the Université de Montréal Institutional Animal Care.

Calf Selection

Seven male Holstein calves taken from normal calvings and originating from 1 dairy herd were selected for the study. Within 2 hours of calving, calves were brought to the Centre Hospitalier Universitaire Vétérinaire de l'Université (CHUV) de Montréal and upon arrival the umbilicus was disinfected with iodide tincture 5%. Each calf received 6 L of pooled colostrum (60 mg/mL of immunoglobulin G) within the first 24 hours of life. Antibodies to bovine coronavirus and *Escherichia coli*[b] were administered orally within 6 hours of calving. A CBC and a biochemistry profile were performed for each calf at 2 days of age to evaluate adequate transfer of passive immunity (total protein concentrations > 52 g/L) and general health status. At this time, bovine viral diarrhea antigen detection was performed by using an immuno-

Table 1. Lameness, pain, and join swelling grade scale used for clinical assessment of calves.

Grade	Lameness	Pain	Joint Swelling
0	Normal	Normal	Normal
1	Mild lameness	Head movement during leg manipulation	Mild swelling compared to the normal joint
2	Easily detectable lameness without difficulty in ambulation	Withdrawal of the leg during leg manipulation	Easily detectable swelling
3	Moderate lameness making ambulation difficult	Head movement during joint palpation	Easily detectable swelling and joint capsule under tension
4	Severe lameness with reluctance to bear weight on the affected limb	Withdrawal of the leg during joint palpation	Grade 3 including edema

fluorescence technique on cellular culture.[c] A physical examination was performed daily until the beginning of the study. At the end of the study, all calves were kept in a farm near the CHUV where they were observed. After 1 year, the calves were slaughtered.

Infectious Arthritis Model

The right tarsus of each calf was inoculated with 10^8 colony-forming units (CFU) of a viable *E coli* ECL 1018 O116:K?:H9 strain suspended in 1 mL of phosphate-buffered saline solution. Inocula were prepared just before inoculation by dilution of aliquots of 10^{10} CFU.

The strain used in the inocula was collected from a septicemic calf with septic arthritis. The inoculum was prepared by harvesting bacteria after an overnight stay at 37°C with agitation in tryptic soy broth. The bacteria were suspended in tryptic soy broth with 30% glycerol. The inoculum was divided into 1-mL aliquots of 10^{10} CFU and stored (−80°C) until needed for inoculation.

Virulence factors of this strain were studied by using previously described methods,[12] including *pap* genes. Organisms were susceptible to ceftiofur, with a minimal inhibitory concentration (MIC) value of 0.25 μg/mL.

This bacterial inoculum was adapted from previously described septic arthritis models.[13–15] In a preliminary experiment in calves (n = 2), the intra-articular dosage of 10^8 CFU induced clinical evidence of septic arthritis.

To reduce pain, a caudal epidural injection of 0.2 mg/kg of morphine sulfate[d] diluted in 5 mL of sterile physiologic saline solution was performed just before inoculation. Five milligrams of butorphanol[e] also was administered IV every 4 hours beginning 12 hours after inoculation until pain was judged to be mild based on a pain clinical score. This clinical score was adapted from pain evaluation protocol used for large animals after orthopedic surgery.[16] Appetite, modifications in heart and respiratory rates, as well as pain associated with leg manipulations were evaluated (Table 1). A pain score was determined 4 times each day during the first 6 days then once daily for the remaining study period.

Synovial Fluid Sampling Procedure

Calves were sedated with xylazine[f] (0.05 mg/kg IV) and placed in left lateral recumbency. The right tarsocrural joint was prepared for aseptic surgery by using standard procedures.[18] An 18-gauge needle was placed in the dorsomedial pouch of the tarsocrural joint and 5 mL of synovial fluid was obtained with a 5-mL syringe. Synovial fluid samples were collected on day 1 (before inoculation), on day 2 (before joint lavage), and on days 3, 4, 8, 12, 16, 20, and 24 (3 days after the end of the antibiotic treatment).

Inoculation Procedure

All calves had their right tarsocrural joint inoculated on day 1. At this time, a long-term catheter[g] was placed into the left jugular vein after aseptic preparation of the area. The right tarsocrural joint was prepared for aseptic surgery.[18] One milliliter of the phosphate-buffered saline solution containing 10^8 CFU of *E coli* was injected into the joint with an 18-gauge needle placed into the dorsomedial pouch of the tarsocrural joint.

Treatment Procedure

Treatment began 24 hours after bacterial inoculation. Ceftiofur[h] (1 mg/kg IV q12h) was administered during 20 days (days 2–21). This antibiotic regimen was based on the ceftiofur MIC against this isolate and ceftiofur pharmacokinetic properties in calves.[19]

On day 2, a through-and-through joint lavage was performed on all calves with 1 L of lactated Ringer's solution.[i] After preparation of the joint for aseptic surgery,[18] an 18-gauge needle was placed in the dorsomedial pouch of the tarsocrural joint, and distension was achieved with a lactated Ringer's solution. A second 18-gauge needle was placed into the plantar lateral pouch and a 3rd needle was placed in the plantar medial pouch of the tarsocrural joint. A hand-pumped pressure bag was used to keep a steady fluid flow into the joint. At the end of lavage, the needle in the dorsomedial pouch was removed, fluid was expressed manually from the joint, and the needles from the plantar lateral and medial pouch were then removed. The tarsus was not bandaged. The treatment regimen instituted in this study was based on commonly accepted recommendations for the treatment of septic arthritis.[4,5]

Clinical Assessment

Each calf was evaluated by the same investigator for joint heat, swelling, pain, and lameness 3 times per day for the first 6 days, then once daily until day 24. A grading scale was used to classify calves (Table 1). Appetite also was monitored. Heart rate, respiratory rate, and rectal temperature were measured 4 times each day for the first 6 days then twice daily until day 24.

Synovial Fluid Analysis

One milliliter of the synovial fluid sample was placed into a 3-mL evacuated glass container containing ethylenediaminetetraacetic acid.[j] All specimens were analyzed for total protein concentration (refractometer), white blood cell (WBC) count, and differential count. White blood cell count was determined manually by using a Unopette[k] technique by following the manufacturer's recommendations. Differential count was determined by the same clinical pathologist by using a modified Wright-Giemsa stain. All these procedures were performed within 1 hour of sampling.

Bacteriologic Culture

Two milliliters of synovial fluid was inoculated into a blood culture bottle[l] immediately after collection. Blood culture bottles were incubated at 35°C and culture was performed according to the manufacturer's recommendations.

PCR Procedures

Synovial Fluid Samples. One milliliter of synovial fluid was placed aseptically into a 1-mL Eppendorf tube and stored at $-25°C$ until assayed.

DNA Extraction and Purification. DNA was extracted from samples (200 μL of synovial fluid) with the QIAamp DNA Mini Kit[m] according to the manufacturer's recommendations. Because a small quantity of bacterial DNA was expected, a carrier (polydeoxyadenylic acid) was added to the kit by following the manufacturer's recommendations.

Enzymatic Amplification. The primer used in the PCR for DNA amplification was previously described.[12] PCR was done in a total volume of 50 μL containing 10 μL of the template DNA, 25 pM of *pap* primer, 5 μM of each deoxynucleoside triphosphate, 100 mM Tris HCl, 15 mM $MgCl_2$, and 0.4 U of AmpliTaq DNA polymerase.[n] PCR amplifications consisted of 2 minutes at $95°C$, followed by 1 cycle of 30 seconds at $94°C$, 30 seconds at $68°C$, and 30 seconds at $72°C$. During every cycle, the annealing temperature was lowered by $1°C$, until the final annealing temperature of $63°C$ was reached. At this temperature, an additional 30 cycles were run, followed by 10 minutes at $72°C$. All PCRs were carried out in a thermal cycler.[o]

Detection of PCR Product. Fifteen microliters of the reaction mixture was analyzed by electrophoresis on a 2% agarose gel, and the reaction products were visualized by staining with ethidium bromide.

Positive and Negative Controls. Positive and negative controls were included in each experiment. Positive control consisted of an *E coli* strain B carrying a *pap* operon, and negative control consisted of sterile water. Determination of *pap* virulence factor was performed at least 2 times for each sample.

Statistical Analysis

Mean values were calculated for WBC count, neutrophil count, neutrophil percentage, and total protein concentration for each day. The repeated-measures linear model was used to evaluate the influence of the day on WBC count, neutrophil count, neutrophil percentage, and total protein concentration. For statistical analysis, neutrophil percentages were transformed by the square root of arcsine. Values obtained after inoculation (day 2 and more) were compared to day 1 by using Dunnett's post hoc tests. The effect of "treatment stop" was evaluated by comparing the results of day 20 and day 24. Slopes between day 2 and day 3, as well as day 3 and day 4 were calculated for WBC count, total protein concentration, and differential count for each calf to evaluate the effect of joint lavage. Comparisons were performed by using Wilcoxon's signed ranks test. Differences were considered statistically significant when $P < .05$.

Results

Clinical Signs

Joint distension and periarticular soft-tissue swelling were observed in all animals within 4–8 hours after inoculation. On day 2, 6 calves had a grade 3 lameness and 1 calf had a grade 4 lameness. Lameness improved rapidly and all calves became sound by day 9. They remained sound until the end of the study. On day 2, the pain score was grade 3 for 1 calf and grade 4 for 6 calves. Pain decreased rapidly to remain at grade 1 until day 11 for all calves except 1, for which it remained at grade 1 until day 16. On day 2, a joint distension of grade 4 was observed for all calves. A grade 1 or 2 joint distension was noted for all calves on day 6 and remained until day 19 for 4 of the calves. One of the 3 other calves had a persistent grade 1 joint distension until day 23. The final 2 calves had joint distension of grade 1 and 2 until the end of the experiment.

Five calves developed thrombophlebitis of the jugular vein. The diagnosis was based on high rectal temperature ($39.8–40.9°C$), pain, and swelling observed by palpation of the vein. The diagnosis was confirmed by ultrasound examination that revealed a thickened vessel wall. The thrombophlebitis was located at the insertion point of the long-term catheter in all calves. The thrombophlebitis was 1st diagnosed on day 4 for 1 calf, day 15 for 2 calves, day 18 for 1 calf, and day 21 for 1 calf. In 2 of 5 calves, thrombophlebitis was observed when the catheter was accidently removed by the calf. One catheter was submitted for bacterial culture and was positive for *Arcanobacterium pyogenes*.

Synovial Fluid Cytology

The analyses of synovial components during the study for each calf are presented in Figures 1–4. Mean values of WBC count, neutrophil count, neutrophil percentage, and total protein concentration increased significantly on day 2, and decreased progressively during the experiment. The decrease of WBC and neutrophil counts were inconsistent for each calf. Each of the measured parameters increased at least once between 2 consecutive samples for all calves. The repeated-measures linear model indicated a significant effect of day on each parameter ($P < .0001$). The Dunnet's post hoc tests revealed that WBC and neutrophil counts were significantly lower on day 1 compared to days 2–4, and that neutrophil percentage and total protein concentration were significantly lower on day 1 compared to all other samples. No significant difference was observed between day 21 and day 24 for the 4 parameters studied. Slopes between day 2 and day 3, and day 3 and day 4 were only statistically different for total protein concentration ($P < .031$).

Routine Bacterial Culture

On day 1, results of all synovial fluid cultures were negative, except for 1 calf for which a *Citrobacter* sp. was cultured and considered a contaminant. Results of all synovial bacterial cultures were positive for *E coli* on day 2 and remained positive until day 3 and day 4 for 1 and 5 calves, respectively. No other synovial culture results were positive during the remaining of the experiment except on days 8 and 20, when an *Enterobacter* sp. was cultured and considered a contaminant.

PCR Results

On day 1, all synovial fluid samples were negative by PCR. All synovial fluid samples were positive by PCR on day 2 but only 6 were positive on day 3 and 1 was positive on day 4. PCR results remained negative from day 8 to day 20, and were positive for 1 calf on day 24.

Discussion

Septic arthritis induced by *E coli* is a reliable and reproducible model of infectious synovitis in laboratory animals and horses.[13–15] In the present study, clinical signs of moderate to severe septic arthritis were observed in the early stages of infection. These signs were consistent with those

associated with naturally acquired infectious arthritis in cattle as well as those described in *E coli*[14] or *S aureus*[8] models of arthritis in horses. Improvement of clinical signs after initiation of treatment was similar to that observed in induced septic arthritis in horses. Lameness and joint pain improved rapidly, whereas distension was observed throughout the study.[8,14,20]

On day 1, all calves had normal synovial fluid and sterile tarsocrural joints. Results of cytologic analysis of synovial fluid were considered normal.[21] Results of bacteriologic cultures were considered negative because *Citrobacter* sp. is an opportunistic pathogen that can be isolated in animal feces and soil.[22] On day 2, all cytologic synovial fluid values were significantly different from day 1 and results of all synovial fluid cultures and PCR analyses were positive for *E coli.* The experimental protocol used in this study produced septic arthritis in 100% of cases.

E coli was not cultured after day 4 from calves in this study. Results of synovial fluid bacterial culture are reported to become negative 3 days after the beginning of antibiotic treatment in humans.[9] In cases of human patients with treated septic arthritis, synovial bacterial culture results could be negative despite presence of viable bacteria.[23] These negative results could be explained by low bacterial count, leukocyte activity, or direct effect of antibiotics.[23] As previously recommended,[23] blood culture bottles were used in the current study to improve ability to isolate *E coli.* Blood culture bottles enhance bacterial culture by using a rich medium, additives to eliminate endogenous and exogenous antimicrobial factors, and a large inoculum to ensure against a low microbial density.[23]

At the end of the experiment, results of all bacterial cultures of synovial fluid were negative despite termination of treatment 3 days earlier. Consequently, joints were considered sterile after day 21, and the treatment instituted in this study appears effective in eliminating joint infections. In models of equine septic arthritis induced by *S aureus,* results of most synovial fluid cultures remained positive for 21 days after the beginning of the experiments and 1 day after stopping an effective antibiotic treatment.[8,20] These results can be explained by virulence and tropism differences between *S aureus* and *E coli. S aureus* has a higher tropism for synovium and can survive intracellularly.[24]

The use of PCR may be helpful in monitoring the presence of bacterial DNA in the synovial fluid during antibiotic treatment in addition to measuring the efficacy of this treatment. PCR has already been used in human medicine for the detection of bacterial DNA in septic synovial fluid samples by using pathogen-specific primers[10] or broad-range 16S ribosomal RNA.[9] In our study, pathogen-specific primers were used to estimate the average isolation time of bacterial DNA. The concordance between the PCR results and the bacteriologic results on days 1 and 2 indicated the reliability of the PCR.

Results of bacterial cultures were positive whereas results of synovial fluid PCR were negative on days 3 and 4. Others have already reported positive results of synovial fluid bacterial cultures and negative results of synovial fluid PCR.[25] It appears very unlikely that the strain of *E coli* cultured on days 3 and 4 was different from the initial strain, but it could have explained positive bacterial culture and negative PCR results. Unfortunately, virulence factors were not evaluated to test this hypothesis of *E coli* cultured on days 3 and 4.

Despite presence of bacterial DNA in the specimen, negative PCR results can be explained by the presence of inhibitor agents in synovial fluid samples, and a low inoculum of microorganisms in the sample.[11] Presence of inhibitor agents appears to be the most likely cause of negative PCR results. Substances (glycoproteins, polysaccharides, and lipids) inhibit nucleic acid extraction or amplification in septic joints.[26,27] PCR also may lack sensitivity when a low inoculum of bacteria is present in the sample. This may be exacerbated when only a very small specimen volume (ie, <20 μL) is available.[11] Centrifugation was used in previous reports to concentrate bacterial DNA in the sample.[10,25,26] Primary reports in this study did not demonstrate any differences between centrifuged and noncentrifuged samples. These samples originated from only 1 site in the joints, and consequently may not have cellular and bacterial components representative of the entire joint, thus explaining certain negative results.

Results of synovial fluid PCR were positive in 1 calf on day 24, whereas results of synovial fluid bacterial culture were negative in all calves. Negative PCR results from synovial fluid or synovial tissues that became positive several days later have already been reported.[9,10] A decrease in concentration of inhibitory substances consecutive with decreased inflammation could explain why 1 synovial fluid PCR became positive again on day 24. Antibiotic treatment was stopped between day 20 and day 24. It is very unlikely that antibiotic treatment interfered with PCR procedures. On day 4, 2 calves had positive PCR results, whereas they had received 2 days of antibiotic treatment. Ceftiofur is not known to inhibit polymerases. Ceftiofur behaves like beta-lactam antibiotic by binding to and inactivating the penicillin-binding proteins.[28]

The significance of the presence of DNA of *E coli* for 1 calf on day 24 is uncertain. Because results of the bacterial culture were negative, this result may indicate that nonviable bacteria were present in the synovial fluid. Because pathogen-specific primers were used in this study, and all PCRs were performed twice, these positive PCR results could not be interpreted as false positive. In humans, bacterial DNA has been found to be able to persist for a few weeks[9] and up to 10 weeks[10] after the initiation of antibiotic therapy. The presence of bacterial DNA can explain the persistence of cytologic evidence of inflammation.

Synovial fluid analysis is important in the diagnosis of septic arthritis. Cytologic reference values have been established for the differentiation of infectious and noninfectious arthritis.[4] Based on those values, all calves had cytologic values consistent with infectious arthritis on day 2 except for 1 calf, where total protein concentration remained below 45 g/L. After day 2, some calves had cytologic values compatible with infectious arthritis but results of their synovial fluid bacterial culture and PCR were negative. Joints with synovial fluid modifications compatible with values previously reported[4] could be considered as septic or as convalescents joints.

Total protein concentration and neutrophil percentage were statistically different from day 1 throughout the ex-
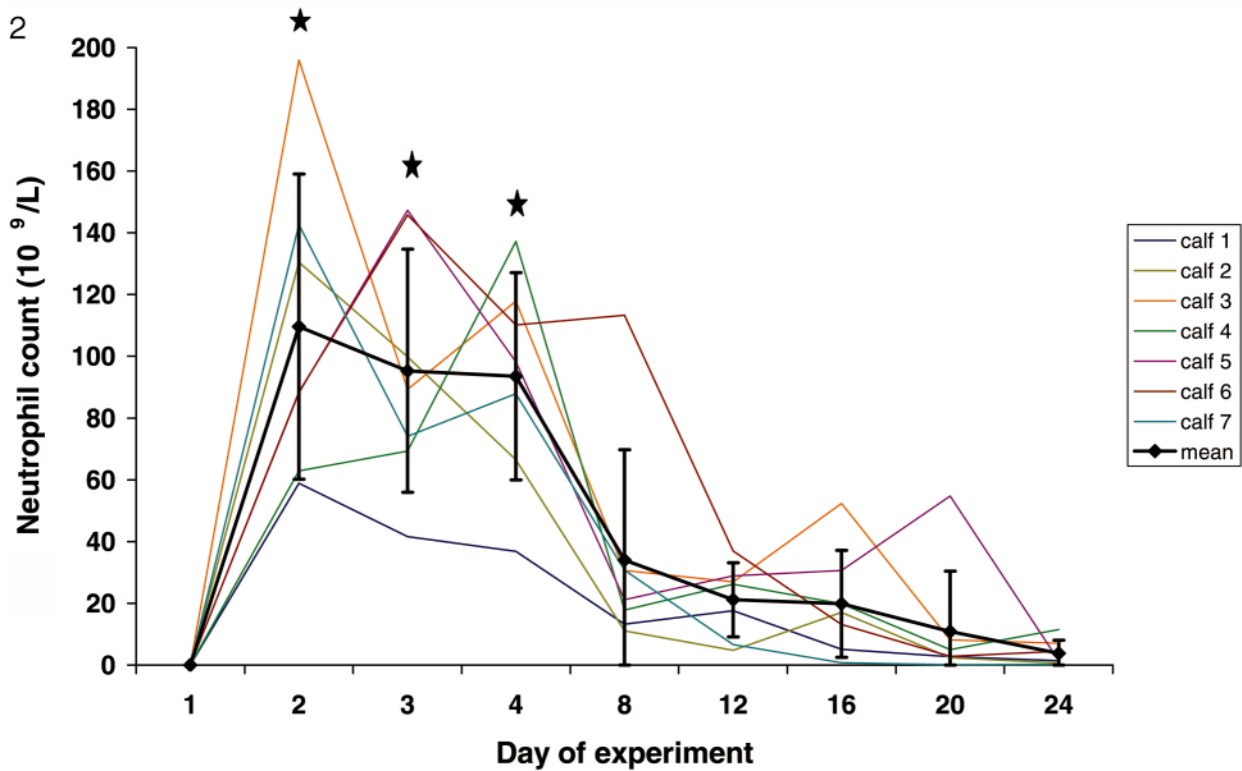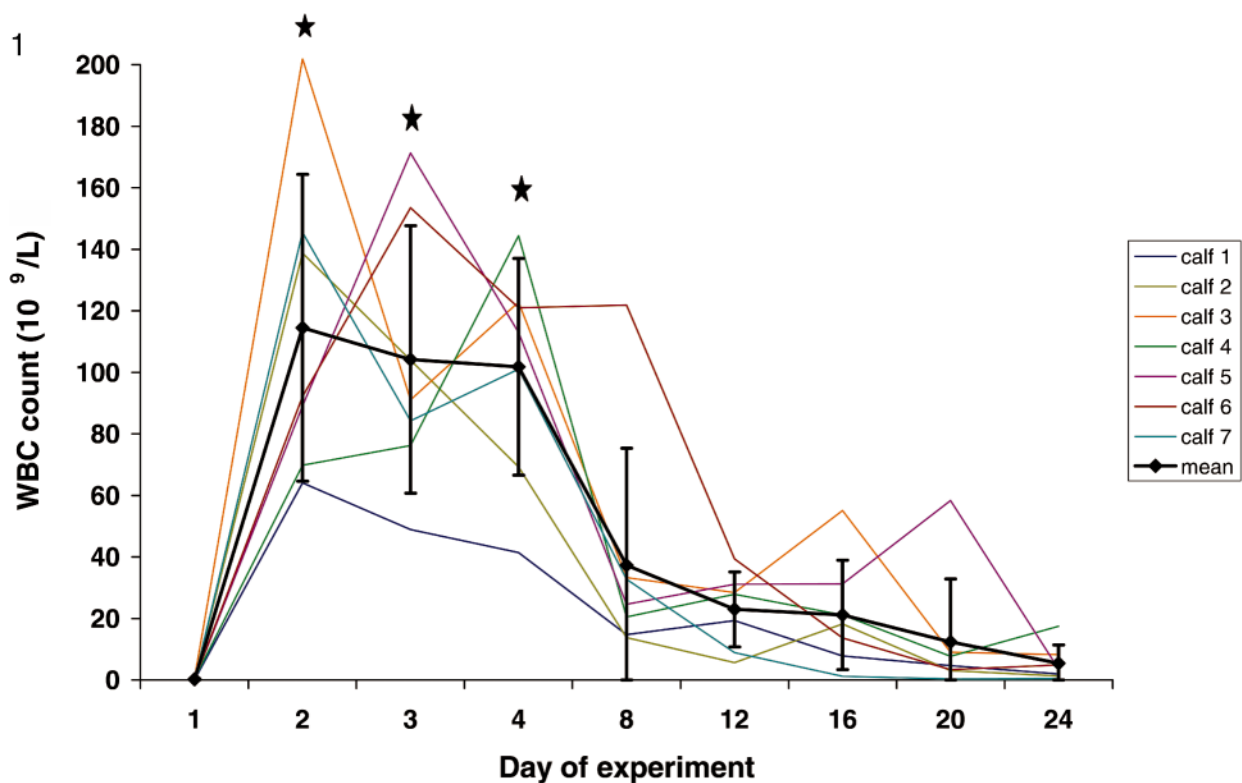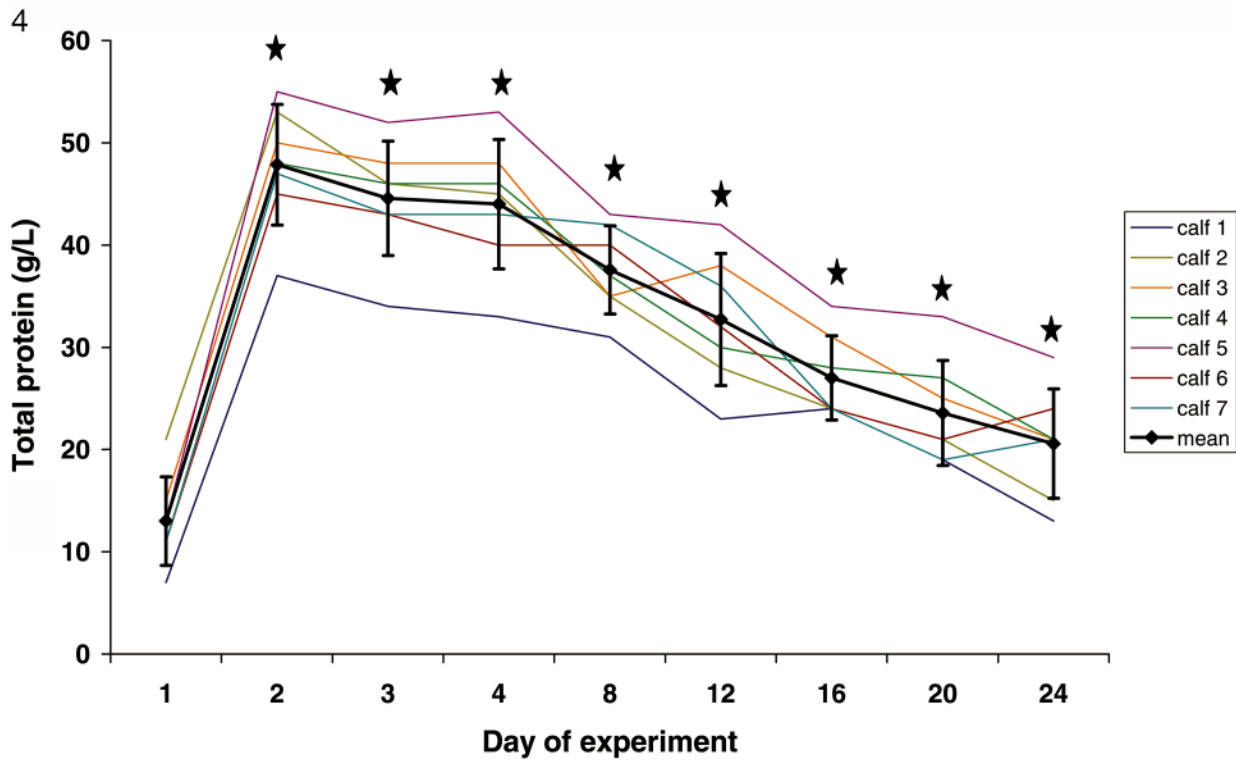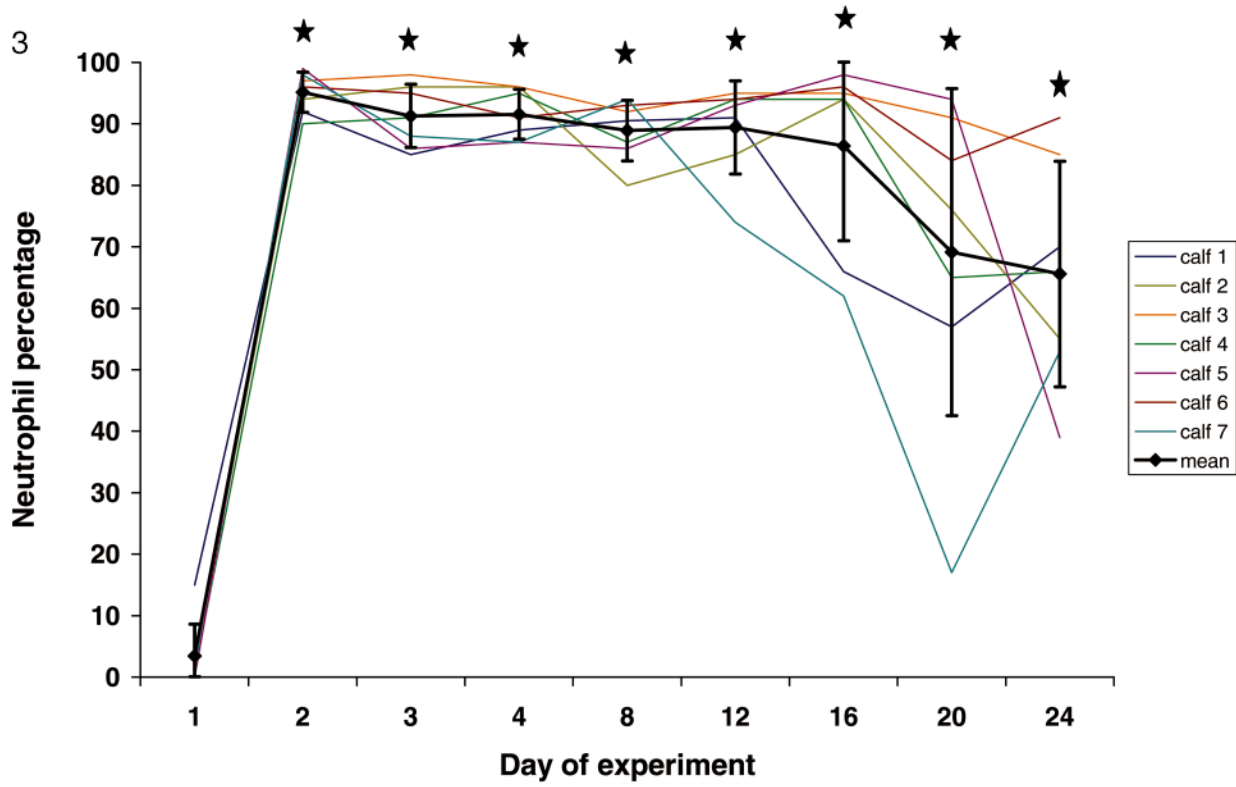
Fig 1. Change in synovial fluid white blood cell count for each calf during the experiment. A star (★) indicates a result that is statistically different from day 1.

Fig 2. Change in synovial fluid neutrophil count for each calf during the experiment. A star (★) indicates a result that is statistically different from day 1.

Fig 3. Changes in synovial fluid neutrophil percentage for each calf during the experiment. A star (★) indicates a result that is statistically different from day 1.

Fig 4. Changes in synovial fluid total protein concentration for each calf during the experiment. A star (★) indicates a result that is statistically different from day 1.

periment. This reflects the inflammatory process occurring in the joint. Repeated arthrocentesis alone could not explain the persistence of increased total protein concentration and neutrophil percentage. In a previous study, total protein concentration and neutrophil percentage returned to within reference ranges 36 hours after arthrocentesis.[29] Signs of joint inflammation persisted throughout the current study despite absence of viable bacteria.

A decrease in synovial cell counts was not constant in all calves during the experiment. This phenomenon appears to be reliable and unrelated to technical errors. Nucleated cell counts can be determined either manually or automatically. Both techniques give similar results, except when a cell count is lower than the threshold level of electronic cell counters.[30] White blood cell count was performed manually in this study by using an hemacytometer, which can lead to error. It is reported that for a leukocyte count of 7,000 leukocytes/μL, the total inherent error is 21%.[31] Error in manual counting procedures can be minimized by adequate procedures and experience of the manipulator.[31] Another possible explanation is that the synovial fluid is not homogeneous and only a portion was evaluated at each sampling. Consequently, during the course of a septic arthritis treatment, an increase in synovial cytologic values should not be misinterpreted as a nonresponse to treatment or a relapse.

Five calves developed jugular thrombophlebitis despite standard care of the intravenous catheter.[32] One possible explanation for this high rate of thrombophlebitis is the important rate of catheter extravasation. Phlebitis could have also been a consequence of hematogenous spread of *E coli* from the joint, although in this study, thrombophlebitis was diagnosed an average of 2 weeks after initiation of antibiotic treatment and *E coli* was not cultured from the jugular vein catheter. The thrombophlebitis may have interfered with systemic signs of inflammation and minimal effects on local joint inflammation.

Treatment of septic arthritis is essentially based on long-term antibiotic treatment and joint lavage or arthrotomy. Long-term systemic administration of antibiotics and joint lavage was effective in treating septic arthritis caused by *E coli* in calves in this study. Duration of antibiotic administration in acute septic arthritis remains empirical. Certain authors considered that it must be at least 3 weeks in cattle.[7] The duration of antibiotic treatment in humans[33] and horses[8] is usually 4 weeks. Results of this study were in favor of a short-term antibiotic therapy based on improvement in clinical signs and negative results of bacterial culture soon after the induction of septic arthritis. Nevertheless, extrapolation to naturally acquired septic arthritis must be made cautiously. The treatment instituted in this study was based on pharmacologic properties of ceftiofur[19] and susceptibilities of *E coli.* Moreover, treatment was instituted early in the course of the disease. Joint lavage and debridement are important steps in the treatment of septic arthritis in order to remove the potential deleterious enzymes and their cellular sources.[2] Despite no effect on cellular count, results of this study are in favor of the use of joint lavages because these significantly reduce protein concentrations. The persistence of cytologic signs of inflammation and joint distension were suggestive of an important persistent inflammatory process secondary to the infection. Therefore, anti-inflammatory drugs should always be considered in the treatment of septic arthritis as an adjunct to systemic antibiotics. Further studies are necessary to refine their use in clinical cases.

Cytologic examination and bacterial culture of synovial fluids were very useful ancillary tests for the diagnosis of septic arthritis in this study; however, they should be used with caution in the evaluation of response to treatment. PCR techniques presented several limitations compared to bacterial culture, and further studies are needed to facilitate their utilization and interpretation in clinical cases of septic arthritis in cattle.

Footnotes

[a] Francoz D, Desrochers A, Fecteau G, et al. A retrospective study of joint bacterial culture in 172 cases of septic arthritis in cattle. American College of Veterinary Internal Medicine 20th Annual Forum 2002;774 (abstract). May 29–June 1, 2002.
[b] First Defense, Immunocell Corporation, Portland, ME
[c] Immunofluorescence technique, Institut Armand Frappier, Laval, Québec, Canada
[d] Morphine HP 25, Sabex 2002 Inc, Boucherville, Québec, Canada
[e] Torbugesic, Wyeth Canada, Saint-Laurent, Québec, Canada
[f] Rompun, Bayer Santé Animale, Toronto, Ontario, Canada
[g] Central venous catheterization set with Blue Flextip catheter, Arrow International Inc, Reading, PA
[h] Excenel, Pharmacia Animal Health, Orangeville, Ontario, Canada
[i] Lactated Ringer's injection USP, Baxter Corporation, Toronto, Ontario, Canada
[j] Blood collection tubes, BD Vacutainer, Franklin Lakes, NJ
[k] Unopette, Becton-Dickinson, Rutherford, NJ
[l] OXOID SIGNAL Blood Culture System, Oxoid Limited, Basingstoke, Hampshire, UK
[m] QIAamp DNA Mini Kit, Qiagen, Valencia, CA
[n] AmpliTaq DNA polymerase, Amersham Biosciences Corp, Baie d'Urfé, Quebec, Canada
[o] Thermal cycler, MJ Research PTC 200, Waltham, MA

Acknowledgments

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