



Peritonitis in a llama caused by *Streptococcus equi* subsp. *zooepidemicus*

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Abstract — A 7-month-old, male llama was diagnosed with peritonitis caused by *Streptococcus equi* subsp. *zooepidemicus*. Clinical findings, medical treatment, and case outcome are described. Hematogenous dissemination from suspected pneumonia is proposed as the route of infection in this case. Possible transmission of the organism through contact with horses is discussed.

Résumé — Péritonite à *Streptococcus equi* subsp. *zooepidemicus* chez un lama. Une péritonite causée par *Streptococcus equi* subsp. *zooepidemicus* a été diagnostiquée chez un lama mâle de 7 ans. Les trouvailles cliniques, le traitement médical et l'évolution du cas sont décrits. La voie d'infection proposée dans ce cas est une dissémination hématogène à partir d'une pneumonie soupçonnée. Une possible transmission de l'organisme par contact avec des chevaux est discutée.

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A 7-month-old, 47-kg, intact male llama was admitted to the Atlantic Veterinary College following 4 d of anorexia and decreased fecal production. Additional history included tenesmus, lethargy, and increased time spent in sternal recumbency. Diarrhea had been observed on the day prior to admission. The llama had been treated with unspecified doses of procaine penicillin G, flunixin meglumine, mineral oil by orogastric tube, and oxfendazole without clinical improvement. The llama was from a farm with 14 other llamas of varying ages and several horses that shared pasture, as well as barn space. No other animals were affected.

The llama was quiet but alert on admission and remained recumbent throughout most of the examination. Physical examination revealed marked bilateral ventral abdominal distension. Rectal temperature was 38.7°C (reference range, 37.5 to 38.9°C), pulse rate 96 beats/min (reference range, 60 to 90 beats/min), and respiratory rate 24 breaths/min (reference range, 10 to 30 breaths/min). Clinical dehydration was not detected; oral mucous membranes were moist and had a capillary refill time of less than 2 s. Forestomach motility was absent, although normal feces were passed during the examination. A painful response was elicited upon palpation of the abdomen. Auscultation of the thorax identified increased bronchovesicular sounds cranioventrally on both sides.

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The results of venous blood gas analysis were within reference ranges. A severe degenerative left shift was evident on a complete blood cell (CBC) count [mature neutrophils, $2.1 \times 10^9/L$ (reference range, 4.2 to $13.0 \times 10^9/L$); band neutrophils, $4.2 \times 10^9/L$ (reference range, 0 to $0.09 \times 10^9/L$); metamyelocytes, $2.25 \times 10^9/L$ (reference range, $0 \times 10^9/L$); myelocytes, $1.8 \times 10^9/L$ (reference range, $0 \times 10^9/L$)] with toxic degeneration of neutrophils. Serum biochemical analysis revealed hyponatremia (sodium, 122 mmol/L; reference range, 150 to 156 mmol/L), hypochloremia (chloride, 81 mmol/L; reference range, 101 to 119 mmol/L), azotemia [urea, 31.7 mmol/L (reference range, 4.3 to 11.1 mmol/L); creatinine, 672 $\mu\text{mol/L}$ (reference range, 106 to 256 $\mu\text{mol/L}$)], and hyperphosphatemia (phosphate, 4.59 mmol/L; reference range, 1.07 to 3.16 mmol/L). Marked hypoproteinemia was also detected [total protein, 36 g/L (reference range, 48 to 70 g/L); albumin, 22 g/L (reference range, 31 to 52 g/L)]. Urinalysis demonstrated proteinuria and a urine specific gravity of 1.016. No casts were detected on urine sediment examination.

Transrectal palpation could not be performed due to the small size of the animal. Trans-abdominal ultrasonography using a 5-mHz linear probe revealed a large volume of free peritoneal fluid with a pattern of mixed echogenicity. Forestomach fluid obtained by orogastric intubation had a normal chloride concentration (12 mmol/L; reference range, < 35 mmol/L). Thoracic radiographs demonstrated a caudoventral alveolar pattern suggestive of pneumonia. Abdominal paracentesis yielded a turbid yellow fluid with a high nucleated cell count (66.5×10^9 nucleated cells/L; reference range, < 5.0×10^9 nucleated cells/L) and normal protein concentration. Cytological analysis indicated 80% granulocytes, many of which were band neutrophils, metamyelocytes, and occasional myelocytes.

Extracellular and intracellular gram-positive cocci were seen. Aerobic and anaerobic bacteriologic culture of the peritoneal fluid obtained at admission yielded a pure growth of *Streptococcus equi* subsp. *zooepidemicus*.

A diagnosis of septic peritonitis was made, based on clinical signs and analysis of peritoneal fluid. Possible causes for peritonitis included bacterial leakage from a compromised gastrointestinal viscus, direct inoculation by a penetrating wound, or hematogenous dissemination of bacterial organisms to the abdomen (1). Although gastrointestinal accidents are the most common cause, camelids with obstructions have more pronounced colic signs or metabolic abnormalities and do not normally pass feces. Camelids with gut rupture also tend to show more signs of septic shock (1). The homogeneous population of bacteria found on cytologic examination and bacteriologic culture was more compatible with seeding of the abdomen from another infected site than with gross contamination through either a penetrating wound or compromised gut. Also, there was no evidence of external trauma. Hematogenous spread from the respiratory tract to the abdomen could not be confirmed but would be compatible with the behavior of this organism in other species (2); it would also be supported by the radiographic evidence of pneumonia in this llama. Specific attempts to isolate the organism from the respiratory tract were not attempted due to the llama's good response to initial treatment and our belief that we had already isolated the primary pathogen.

In the absence of suspicion of a surgical abdominal lesion, medical management was instituted to combat the peritonitis. Intravenous sodium penicillin (22 000 IU/kg BW, IV, q6h) and ceftiofur sodium (2 mg/kg BW, IV, q12h) were administered. Treatment for peritonitis in other species has included peritoneal lavage in addition to antibiotic administration, performed either surgically or by placement of indwelling abdominal catheters. The efficacy of this procedure in the treatment of peritonitis has not been scientifically investigated in camelids (3), but the technique has been performed successfully (1). Peritoneal lavage was not attempted in this llama because of its apparent good response to conservative treatments during the initial stages of medical management. Lactated Ringer's solution was given, IV (60 mL/kg BW/24 h), supplemented with potassium chloride (20 mmol/L) and sodium chloride (500 mmol total) to correct electrolyte derangements. Due to marked azotemia, hyperphosphatemia, and proteinuria, a protein-losing nephropathy was also suspected. Possible causes included ischemic damage or septic pyelonephritis from bacteremia, although no organisms were detected on urine sediment examination. In the presence of abnormal renal function, administration of a nonsteroidal anti-inflammatory drug was withheld. A source of plasma was not available for plasma transfusion to treat the hypoproteinemia.

Over the following 6 d of hospitalization, the llama's demeanor and appetite improved. Normal urination and defecation were observed, and normal forestomach motility was detected. Intravenous fluid administration was discontinued on day 2, and antibiotic administration was changed to the IM route. Reassessment of a CBC count, serum biochemical analysis, and urinalysis on

day 4 showed marked improvement, with a regenerative left shift, resolution of the electrolyte disturbances and the azotemia, and only minimal proteinuria.

The llama was discharged on day 6 with instructions to the owner to continue administration of ceftiofur and penicillin for 5 d. Treatment was discontinued after only 3 d, based on a perceived injection reaction. The llama rapidly deteriorated 2 d later, with lethargy and anorexia that did not respond to reinstitution of antibiotics. The llama died within 24 h, and a field necropsy was performed. Diffuse suppurative peritonitis was detected, with extensive fibrinous adhesions present throughout the abdominal cavity. An underlying cause for the original peritonitis was not detected within the abdomen. Bacteriologic culture was not repeated at the time of necropsy, and examination of the thorax was not conducted.

Septic peritonitis has been identified as an important cause of morbidity and mortality in New World Camelids (NWC). A prevalence of 16% has been reported (4) and it was diagnosed as the cause of 3% of all NWC deaths in one survey (personal communication, A. Kennel, International Llama Association Research Committee). Peritonitis in NWC, secondary to abdominal contamination, is well recognized in the literature, including reports of ruptured gastrointestinal ulcers, penetrating injuries, anastomosis failure, urolithiasis with bladder rupture, and uterine tear during parturition. However, reports of peritonitis occurring in the absence of viscus compromise are rarely recognized in North America (1,5).

Streptococcus equi subsp. *zooepidemicus* has been associated with bacterial septicemia in alpacas in South America ("Alpaca fever"), causing a fibrinopurulent pleuritis and peritonitis in these animals (6). Hematogenous dissemination is thought to occur associated with such stressors as shearing, transport, or processing, resulting in fulminant systemic infection. The organism is postulated to be a commensal of the gastrointestinal tract of camelids in South America (7); however, this has not been identified in North American camelids (8). The organism can be found in the lower respiratory tract of camelids with pneumonia, but not normal camelids (9). This suggests that transmission from another animal may be the source of infection; horses, in particular, are known to carry this organism in the nasopharynx (2). The llama in this report was housed with horses. In another report, a llama infected with *Streptococcus equi* subsp. *zooepidemicus* mastitis also had contact with horses (10). The suspicion of pneumonia in this case supports the hypothesis that the organism was acquired through the respiratory tract. Experimental inoculation of the lower respiratory tract with very small numbers of *Streptococcus equi* subsp. *zooepidemicus* has been shown to cause fulminant systemic disease in camelids (6).

Peritonitis due to *Streptococcus equi* subsp. *zooepidemicus* should be differentiated from conditions such as viscus rupture or forestomach ulceration through cytology and culture of abdominal fluid obtained by paracentesis. A uniform population of gram-positive organisms may help to support this diagnosis while awaiting culture results. Due to the possibility of systemic dissemination from a respiratory infection, thoracic

radiographs should be performed on suspect cases and transtracheal aspiration may be helpful to diagnose pneumonia. Culture of blood prior to institution of antibiotics may have value in identifying dissemination of the infection.

As the number of llamas and alpacas continues to increase in North America, veterinarians are required to become familiar with common diseases and conditions in these species. Although peritonitis secondary to abdominal contamination is well recognized in NWC, this case report emphasizes the need to recognize hematogenous inoculation as a possible cause of peritonitis in camelids. The possibility of interspecies transmission of *Streptococcus equi* subsp. *zooepidemicus* from horses to camelids remains speculative but merits further investigation. Due to the increasing prevalence of llamas and alpacas on multispecies farming operations and hobby farms in Canada, these animals are often housed in close vicinity to horses. Current management recommendations should be made to prevent cross-contamination between horses and camelids, particularly during periods of stress, until the pathogenesis of *Streptococcus equi* subsp. *zooepidemicus* infections in NWC can be better understood through careful documentation of future cases.

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