Neurological Disease in Camelids

David E Anderson, *DVM, MS, Diplomate ACVS;* **Claire Whitehead,** *DVM&S, MRCVS*
Associate Professor, Food Animal Medicine and Surgery, College of Veterinary Medicine, The Ohio State University, 601 Vernon L Tharp Street, Columbus, OH 43210

Introduction

The presentation of neurological disease in camelids, as in other species, varies widely. There are many different causes of neurological signs and the clinician must be aware that metabolic and musculoskeletal disease can also present with neurological signs. These conditions must be differentiated from those of true neurological origin by careful history taking, physical examination and use of appropriate diagnostic tests.

Approach to the Neurological Case

1.) Determine whether the neurological signs are due to a lesion in the nervous system
History: especially acute/chronic, duration of clinical signs, worming program (meningeal worm), diet, signalment. How did the problem begin?
Clinical exam: especially look for evidence of cranial nerve deficits, postural/proprioceptive deficits, ataxia. This may be difficult to assess in the recumbent animal, especially adults. Sometimes, it may be hard to distinguish one condition from another clinically or two conditions may be present together, e.g., meningeal worm with secondary heat stress in summer.
Diagnostic testing: haematological and biochemical profiles may help identify metabolic causes. A spinal tap is easily performed in camelids and changes in the CSF will help establish whether a disease process involves the CNS.

2.) Localization of a lesion within the nervous system
A continuation of the clinical exam.

Differential Diagnoses of Neurological Disease

Congenital Diseases
Hydrocephalus
Kyphosis
Atlanto-occipital malalignment

Traumatic
Vertebral body sub/luxation*
Vertebral body fracture*
Trauma without sub/lux/fracture*

Degenerative
Degenerative myelopathy
Spondylosis

Other
Hypo/hyperthermia*
Mega-oesophagus
Brain/spinal cord neoplasia
Facial nerve paralysis

Infectious/Parasitic Diseases
Meningeal worm*
Listeriosis
Otitis media/interna*
Brain abscess
Vertebral body abscess
Septicaemia/meningitis*
Viral, eg EHV-1, West Nile
Clostridial myositis
Rabies

Toxicities
Tetanus
Botulism
Rye grass staggers
Cerebral hypoxia
Tick paralysis
Ionophore toxicosis

Metabolic Diseases
Pregnancy toxaemia*
Hypo/hyper-glycaemia
Hepatic encephalopathy
Uremic encephalopathy
Hypomagnesaemia
Nutritional problems

Musculoskeletal
Bilaterally luxating patellae
Hip problems
Peripheral nerve damage
Gait abnormality

Observe the resting animal – preferably while unstimulated. Assess mental status. Look for head tilt, circling behaviour, leaning to one side or head-pressing. A head tilt may be due to otitis, a vestibular lesion or possibly neck pain. Are there tremors/seizures? If the animal can walk, look for weakness versus ataxia, single/multiple limb involvement, whether the problem is unilateral/bilateral, or one side/half is worse than the other. Heat stress can present with an animal that tends to be weak first in the forelimbs: in meningeal worm, it is the hindlimbs that become weak first normally. Assess gait and ability to turn in circles, etc.

Palpation: look for muscle atrophy (symmetrical vs non-symmetrical) and general body condition. Proprioceptive positioning assessment is difficult in camelids since they often resent having their feet touched, but is possible.

Reflexes: withdrawal reflex, anal tone, patellar reflex, gastrocnemius reflex, etc.

- Normal: indicates that sensory and motor function are working normally
- Absent or reduced: indicates partial/complete loss of sensory or motor parts of the reflex (LMN)
- Exaggerated: indicates that there is an UMN defect

Cranial nerves: palpebral reflex, facial sensation, menace response, PLRs, pupil size and symmetry. Nystagmus or strabismus. Facial symmetry, ptosis, enophthalmos, rotation of the globe. Hearing.

Sensation: panniculus reflex. Difficult in heavy-fleeced animals.

Lower or upper motor neuron?

Characteristics of UMN lesions:

- paresis
- normal or exaggerated reflexes
- increased extensor tone
- muscle atrophy is slow to appear

Characteristics of LMN lesions:

- paresis
- loss of tone and reflexes
- muscle atrophy appears quickly (within a week)

Which region is affected?

i. The brain, include brainstem and cranial nerves
Depression, seizures, cortical blindness, head tremors (cerebellum), slow PLRs (not ophthalmic in origin)...

ii. C1-5
UMN signs to all 4 limbs

iii. C6-T2 = brachial plexus (thoracic limb)
LMN signs to FL: UMN to HL

iv. T3-L3
normal FL: UMN to HL

v. L4-S2 = lumbosacral plexus (pelvic limb)
normal FL: LMN to HL

vi. S1-3
1partial LMN to HL, incontinence

3.) Determine the cause of the neurological lesion

Once the clinician has established that he/she is dealing with a neurological disease and then determined what neurological deficits are present, further diagnostics will be helpful in reaching a specific diagnosis.

See list of differential diagnoses above.

i. **Spinal Tap**

Normally CSF is taken from the lumbosacral space. Lumbosacral and atlanto-occipital CSF samples were compared in llamas that were experimentally infected with *P tenuis*.[13] This study concluded that the site chosen would depend on the suspected location of the lesion. Welles *et al*[17] stated that, based on work in horses, CSF from the lumbosacral space was more likely to have compositional abnormalities in neurological disease and that more useful information would therefore be obtained. In another report, samples from three llamas with suspected meningeal worm were collected simultaneously from the LS and AO spaces: the CSF collected from the LS space showed more significant elevations in protein and cell count.[14]

The lumbosacral tap is an easy procedure to perform and usually requires only a little local anaesthetic, whereas the atlanto-occipital tap requires sedation or anaesthesia, which may be detrimental in a sick animal. A small area is clipped and prepped over the LS space. The landmarks are the dorsal spinous process of L7 and the two wings of the ilia which form a triangle within which an obvious depression can be palpated. Before the final scrub, inject 0.5-1ml local anesthetic at the site using a 22 gauge one-inch needle. Use an 18G 3.5 inch spinal needle in adults (20G in crias) and insert the needle perpendicular to the skin on the midline about 3-5 mm in front of an imaginary line drawn between the two ilia. It helps to anchor the wrist on the animal as this is done. In an adult, the needle needs to be advanced normally 4-6 cm and "two pops" are usually felt as the needle goes through the dura into the subarachnoid space. When the stylet is removed, CSF will be observed in the hub. If difficulty is encountered collecting the fluid, holding off the jugular vein will increase intracranial pressure and CSF flow. Collect 2-3 ml CSF and split the

sample into a plain tube for CSF profile (protein/CK, etc.) and an EDTA tube for cytology (red and white cell counts and differential counts). Welles et al[17] observed rapid deterioration of leukocytes in CSF after collection and advised careful handling and refrigeration as soon as possible following collection. Their method did not indicate that any preservative was used: it is likely that collecting CSF into EDTA tubes will reduce the deterioration of cells.

The most important variables to consider in the CSF are protein, creatine kinase and the cytology, but in certain disease situations other variables such as sodium and glucose may be useful. Normal values in camelids are:

CK	<10 IU/L
Protein	< ~45 mg/dL
White cell count	< 3 cells/µl
Differential WCC	May be predominantly lymphocytes or predominantly neutrophils, depending on the amount of blood contamination (more neutrophils with increasing blood contamination). In the absence of blood contamination there should be no eosinophils. In camelids, the proportion of eosinophils increases in meningeal worm[2,12,13,14,17] and can be up to 99% of total WCC. However, a normal eosinophil count does not necessarily rule out meningeal worm: in experimental infection of llamas with *P tenuis,* the time post-inoculation at which eosinophils increased in CSF varied. Also, prior treatment with anthelmintics may affect cell counts. Meningeal worm is the only parasitic myelitis so far reported in camelids.

Increased CK reflects demyelination. Increased protein indicates a disturbance of the blood-brain-barrier[10,17]: if protein electrophoresis shows increased globulin only, this indicates intrathecal synthesis of globulins. Welles et al[17] found in their study that in healthy llamas with red cell counts <1400/µl, the protein concentration was only minimally altered.

Glucose concentration in llama CSF is approximately 40% of serum concentration.[17] This compares with cattle in which CSF glucose is approximately equivalent and monogastric species in which it is 60-80% of serum concentrations: rapid changes in serum glucose, as in stress for example, will take 30 mins to 3 hours to equilibrate in CSF.[17] Bacterial infections will decrease CSF glucose and also increase neutrophil count.

ii. **Radiographs**
Depending on the clinical signs, localization of lesion, and CSF findings, spinal or skull x-rays may be useful. These may show obvious luxations, fractures or soft tissue injuries as well as demonstrate congenital malformations such as kyphosis. Two views are essential as single view films may not pick up subluxations, etc. For more subtle lesions, a **myelogram** may be indicated.

iii. **Ultrasonography**
May be useful in soft tissue injuries and hydrocephalus.

iv. **Computed tomography**
(CT) may be required to visualise a suspect area. We have found that, in the case of suspected otitis interna, CT gives a much clearer image of the tympanic bullae and the extent of soft tissue involvement can be delineated using contrast CT. CT also guides the surgical approach in these cases. It is also useful if a brain mass/abscess or vertebral body abscess is suspected. General anaesthesia is required.

v. **EMG**
Measures the electrical activity of muscle. It is useful to detect denervation and to differentiate UMN and LMN disease. It may be used to direct the clinician to a particular problem area.

vi. **Muscle biopsy**
Can be used if a myopathy is suspected rather than a neuropathy.

Common Neurological Diseases in Camelids

Meningeal worm is a relatively common condition in camelids in the Eastern United States. Nearly one third of cases presented at The Ohio State University between 1993 and 2003 for neurological signs were diagnosed with Meningeal worm. It is caused by the nematode parasite *Parelaphostrongylus tenuis,* whose definitive host is the white-tailed deer (*Odocoileus virginianus).*[5,8,12,13,14,15] When camelids ingest infected molluscs (the intermediate host), aberrant migration in the CNS causes neurological signs. Experimental infection of six llamas with the parasite caused clinical signs of meningeal worm 45-53 days post-inoculation.[13]

Characteristic C/S of Meningeal Worm:

- normally hindlimbs affected first
- may be acute or gradual in onset
- often a wide-based HL stance
- affected animals usually have good appetites unless C/S are advanced.
- 'Atypical' meningeal worm: small proportion of cases. Parasitic migration extends into the brain. Rapid progression of C/S normally with vestibular signs (circling, leaning, head tilt), seizures. Can resemble listeriosis.
- CSF findings: eosinophilia with elevated protein

and/or CK (variable)

- Hematological and serum biochemisty findings are often normal unless there are secondary issues, e.g heat stress, which often exacerbates meningeal worm, or dehydration. CK and AST are often elevated, dependent on the duration of the condition and how much time the animal spends lying down.

Our experience with meningeal worm cases at The Ohio State University is that the prognosis is usually good while the affected animal is able to stand and continues to have a good appetite. Recumbent, inappetant animals usually have a poorer prognosis. Animals presenting with atypical signs have a guarded prognosis: only a very small proportion of cases seen at OSU survived. Those that died had intracranial migration diagnosed or confirmed at necropsy.

Therapy includes: fenbendazole at 50 mg/kg for five days, NSAIDS (flunixin meglumine at 1 mg/kg q12-24 hrs), DMSO in severe cases, vitamin E (antioxidant), B vitamins, fluid therapy as required and omeprazole to reduce the risk of C3 ulceration. Hydrotherapy or hanging in a sling may be required. Improvement occurs rapidly within a fews days of beginning therapy and then more gradually: any neurological deficits remaining at six months post-treatment are likely to remain permanently.

Heat Stress

Common in much of the United States except the Rocky Mountains.[5] Llamas and alpacas are not well adapted to hot or humid climates. In summer in Ohio, the ambient temperature often exceeds 85°F and this is often accompanied by high humidity. The tendency of llama breeders to only barrel-clip rather than shear completely like alpaca breeders, together with a higher body volume: surface area ratio, means that llamas seem to be more susceptible to heat stress. Camelids may cope with chronic heat stress for a while and the introduction of any new stressor, such as transportation or meningeal worm, may precipitate a sudden deterioration into clinical hyperthermia.[4] Therefore, downer camelids presenting in hot weather must be thoroughly evaluated for presence of other disease conditions.

Characteristics of heat-stress:

- elevated body temperature (often >105°F, sometimes <108°)
- severe distress – tachypnoea, tachycardia
- normally unable to rise
- often forelimbs are weaker than hindlimbs
- often ↑↑↑ CK/AST, + low protein (leaks out of cells due to heat damage) despite dehydration (hemoconcentration) + electrolyte imbalances, esp potassium and metabolic acidosis
- subsequent wide fluctuations in body temperature due to upset thermoregulatory center.

Therapy: cooling (ice packs in axillary/inguinal areas, shearing – don't use a cold water hose in the rectum!), exercise caution in fluid therapy due to hypoalbuminaemia (may cause pulmonary edema), correct acidosis and electrolyte imbalances, NSAIDS, meningeal worm treatment, vitamin E, floating or hanging to allow damaged muscles to rest.

Cervical Vertebral Injuries

Owner's complaint is often of a "bump" on the neck or that the neck has a kink in it. These animals will often be walking around normally for some time following an injury: owners may not even notice a defect until shearing. Therefore, cases may be present acutely or chronically. In chronic injuries, the neurological symptoms are caused by progressive callus formation or fibroplasias of the longitudinal ligaments of the spinal column.[1] Most injuries seem to be associated with fencing although traumatic events are often not observed. Affected animals will begin to show abnormal head/neck posture and may then develop neurological deficits, UMN to the HLs and UMN/LMN to the FLs. Note that muscle weakness can also cause a "kinky" neck appearance, especially in hypokalaemia. In young animals, the effects of cervical spinal injuries are more severe as any defect will worsen as the animal grows, producing more severe neurological defects.

Radiographs are required to determine the location and severity of the lesion and whether or not surgical intervention is appropriate. Articular facet fractures are commonly associated with sub/luxations. Myelography is not normally required. CSF analysis helps to rule out parasitic myelitis and to support a traumatic etiology: protein elevation is often marked.

Therapy: non-surgical vs surgical. Non-surgical management involves placing stall rest and NSAIDs. This is appropriate when there are minimal to no neurological signs in an acute subluxation. Surgical intervention is normally a stabilization procedure with the aim of producing fusion between neighboring cervical vetebrae. It is difficult to produce perfect re-alignment.

Several cases treated at The Ohio State University have subsequently developed secondary luxations at cervical joints either side of a fused joint.

Otitis interna/media

Aetiology: extension of otitis externa or ascending infection up the Eustachian tubes. Check for ear ticks/mites also.[16]

These cases normally present with a head tilt with or without facial nerve deficits (droopy ear, flaccid fa-

cial muscles – animals tend to pack food in the affected cheek, drop food or drool saliva – ptosis, inability to blink +/- exposure keratitis). Vestibular signs can be more severe including nystagmus, circling and leaning to one side. One case seen personally also exhibited a head "tick" which was thought to be an exaggeration of the vestibular nystagmus: all signs resolved following surgical drainage and intensive medical management of an abscess that had ruptured from the tympanic bulla into the surrounding tissues. This animal had extensive bulla osteitis, but had presented for acute onset of neurological signs with no prior history of ear pain or head tilt.

CSF analysis is useful to rule out listeriosis or other causes of vestibular disease. Radiographs are useful if bony changes are present: however, soft tissue involvement can be extensive and only CT will show these adequately. Even impressive abscessation may not be palpable in these cases. We usually recommend CT for this reason and CT is also advised for guiding surgical treatment (lateral approach to a bulla osteotomy). NB hemorrhage and permanent facial nerve deficits are potential complications of this surgery although prognosis is generally good.

Listeriosis

Not particularly common in camelids since silage feeding is not common but it does occur. As in other small ruminants, the prognosis in camelids is guarded. Cases seen at OSU have been acute in onset with rapid progression of clinical signs including seizures. CSF may show increased protein and CK and characteristic monocytosis. One reported case of listeriosis in a llama cria[16] also exhibited rapid progression of clinical signs with uncontrollable seizures and was ultimately euthanazed. The CSF in the described case had a very high WCC with 41% monocytes.

Septicemia/Meningitis

May be a sequel to failure of passive transfer in neonates. If neonatal septicaemia is not recognised and controlled early enough, development of meningitis dramatically worsens prognosis. Broad spectrum antibiosis such as penicillin/gentamicin combinations should be used while awaiting blood and/or CSF culture results together with intensive fluid and electrolyte therapy. Cryptococcal meningitis was reported in an eight year old alpaca in Australia which was possibly related to an episode of metritis six months earlier, although the actual cause was not identified in this case.[6] *Cryptococcus* is an opportunistic pathogen and usually only produces disease in immunocompromised animals. CSF cytology will identify the yeasts if present in reasonable numbers. Since it is rare, cryptococcosis is often not diagnosed until late in the disease process so that therapy is often ineffective.[6]

Rye Grass Staggers/Toxicity

Caused by ingestion of an endophyte growing within ryegrass species.[7] This endophyte produces tremorgenic toxins called lolitrems, and toxin levels are increased during dry weather. Normally a diagnosis of exclusion based on history and characteristic clinical appearance of head tremor since it is difficult to demonstrate toxic levels of endophyte in pasture. Also the toxic dose in camelids is not known. Animals normally recover when removed from affected pasture: however, permanent damage manifested by ataxia and head tremor may remain following prolonged exposure.[9]

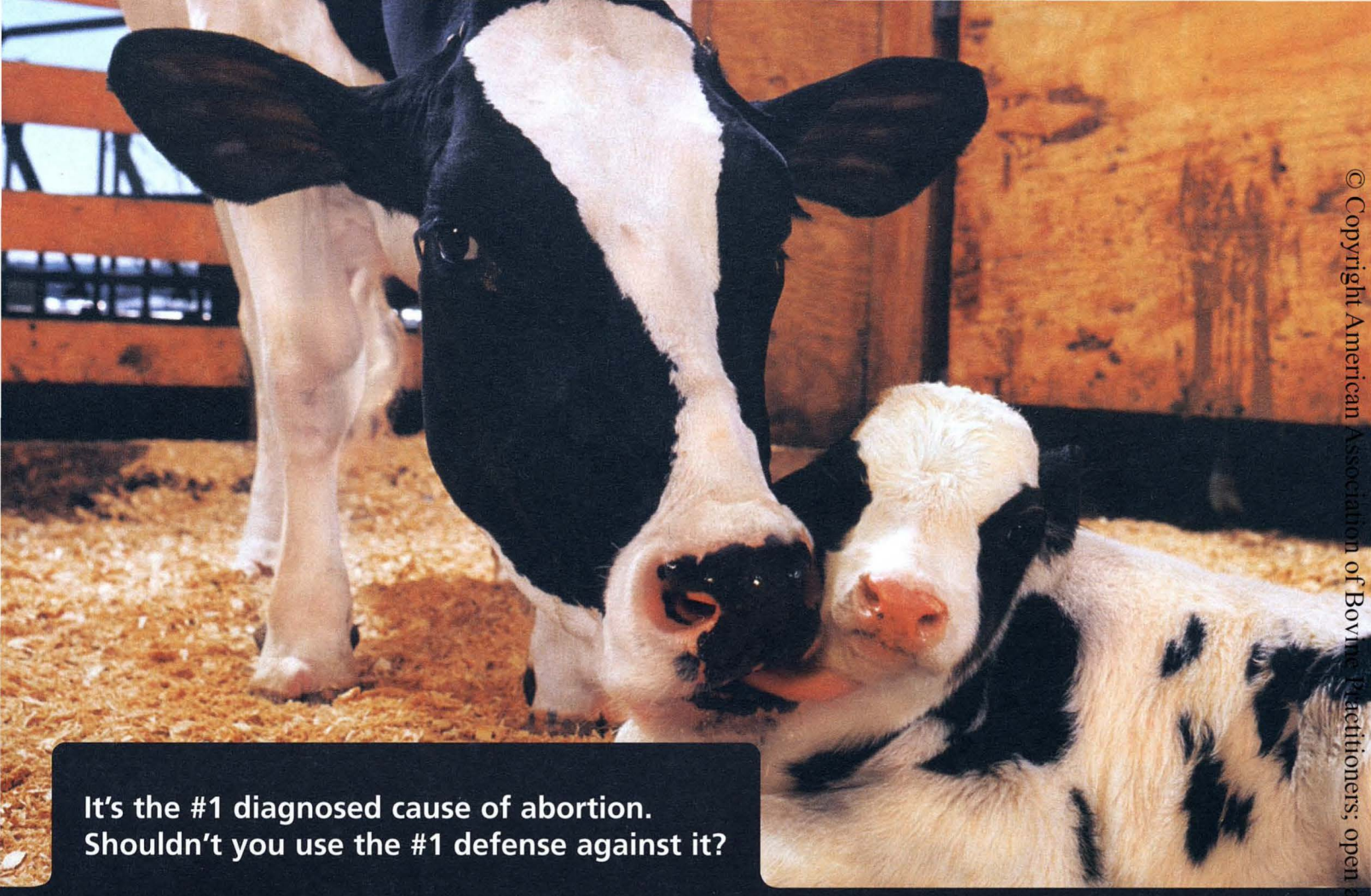
Polioencephalomalacia

Cases of polioencephalomalacia have been described in the literature.[3,11] Often the cause of polio in camelids is unknown but has been associated with dietary changes and excessive carbohydrate ingestion. We have seen it also as a result of inadvertant coccidiostat overdosage. Typically, animals present with acute onset blindness and depression. Affected animals will usually be spotted wandering aimlessly or into fencing and other objects. Later, circling and head tremors may develop. Neurologic examination of the cranial nerves will typically show an absent or reduced menace response with normal/reduced PLRs: ophthalmic examination will reveal no obvious cause for the absent menace suggesting cortical blindness. Depending on the severity of the polio, the patient may also have reduced facial sensation and palpebral reflex. Bloodwork may be normal: acidosis was common in the cases seen at OSU with amprolium toxicity. Spinal fluid is also usually unremarkable. When we have performed CT exams in affected animals, diffuse encephalitis is a typical finding. Response to therapy is often used to make a diagnosis in these cases. Treatment includes thiamine hydrochloride at 10 mg/kg every four hours initially and thiamine administration should be continued until several days after resolution of clinical signs. When patients are not eating or drinking, IV fluid therapy is usually initiated and the thiamine added to the intravenous fluids. Methylprednisolone may be used in animals exhibiting depression to help reduce any cerebral oedema.

References

1. Anderson DE. Unpublished.
2. Baumgärtner W, Hull BL, Andrews F, Garry F: Parelaphostrongylosis in llamas. *J Am Vet Med Assoc* 187(11):1243-1245, 1985.

3. Beck C, Dart AJ, Collins MB, Hodgson DR, Parbery J: Polioencephalomalacia in two alpacas. *Aus Vet J* 74(5):350-352, 1996.
4. Fowler ME: Hyperthermia in llamas and alpacas. *Vet Clin North Am Food Anim Pract* 10(2):309-316, 1994.
5. Frezzo M, Anderson DE: *P tenuis* (meningeal worm) infection in llamas and alpacas. *NEJLAH* 2(1):15-18, 2002.
6. Goodchild LM, Dart AJ, Collins MB, Dart CM, Hodgson JL, Hodgson DR: Cryptococcal meningitis in an alpaca. *Aust Vet J* 74(6):428-430, 1996.
7. Holmes LA, Frame NW, Frame RK, Duff JP, Lewis GC: Suspected tremorgenic mycotoxicosis (ryegrass staggers) in alpacas (*llama pacos)* in the UK. *Vet Rec* 145:462-463, 1999.
8. Kocan AA: The use of ivermectin in the treatment and prevention of infection with *P. tenuis* in white-tailed deer. *J Wildlife Dis* 21(4):454-455, 1985.
9. Mackintosh C, Orr M: Ryegrass staggers in alpacas? *Vet Rec* 132:120, 1993.
10. Oliver, Lorenz, Kornegay: Localisation of lesions in the nervous system, in *Handbook of Veterinary Neurology*, ed 3. pp 47-72.
11. Pugh DG: Polioencephalomalacia in a llama herd. *Equine Pract* 15(2):24-26, 1993.
12. Pugh DG, Blagburn BL, Causey MK, Wolfe DF: Clinical parelaphostrongylosis in llamas. *Comp Cont Ed Pract Vetn* 17(4):600-605, 1995.
13. Rickard LG, Smith BB, Gentz EJ, Frank AA, Pearson EG, Walker LL, Pybus MJ: Experimentally induced meningeal worm *(P tenuis)* infection in the llama *(lama glama)*: clinical evaluation and implications for parasite translocation. *J Zoo Wildlife Med* 25(3):390-402, 1994.
14. Scarratt WK, Karzenski SS, Wallace MA, Crisman MV, Saunders GK, Cordes DO, Sponenberg DP: Suspected parelaphostrongylosis in five llamas. *Prog Vet Neurology* 7(4):124-129, 1996.
15. Soulsby EJL: *Helminths, Arthropods and Protozoa of Domesticated Animals*, ed 7, 275-276, 1982.
16. Van Metre DC, Barrington GM, Parish SM, Tumas DB: Otitis media/interna and suppurative meningoencephalomyelitis associated with *Listeria monocytogenes* infection in a llama. *J Am Vet Med Assoc* 199(2):236-240, 1991.
17. Welles EG, Pugh DG, Wenzel JGW, Sorjonen DC: Composition of cerebrospinal fluid in healthy adult llamas. *Am J Vet Res* 55(8):1075-79, 1994.



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