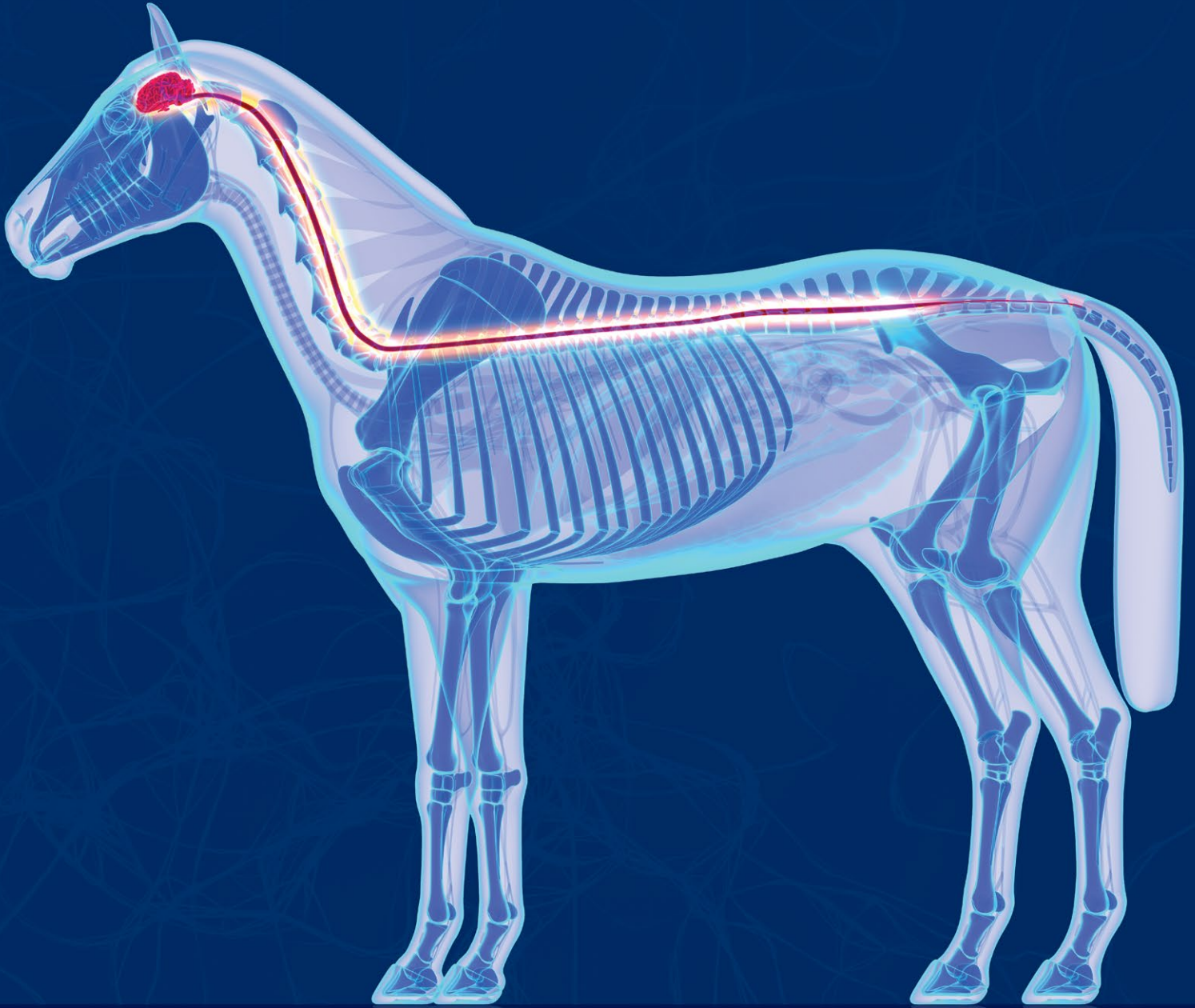


CENTER FOR EQUINE HEALTH

HorseReport

SCHOOL OF VETERINARY MEDICINE • UNIVERSITY OF CALIFORNIA, DAVIS

FALL 2021



Equine Neurology



UCDAVIS
VETERINARY MEDICINE
Center for Equine Health

DIRECTOR'S Message

Welcome to the fall 2021 Horse Report! We have chosen to close out this year with an examination of the fascinating, and sometimes frustrating, topic of equine neurology.

This is actually a very personal issue for me since my own research revolves around investigating the genetic basis for [eNAD/EDM](#) and the interaction of [vitamin E deficiency](#) with neurologic disease. As a clinician, I spent many hours speaking with owners about horses that were presented to the veterinary hospital with a non-infectious neurologic disease. With limited diagnostic capabilities, and perhaps more frustrating, the inability to treat or prevent these diseases, I decided to pursue advanced training in comparative genetics in order to identify some molecular tests and biomarkers to assist us in diagnosing and treating these horses in the clinic.

For this issue, we enlisted the help of one of my mentors and long-time collaborators, Dr. Monica Aleman, chief of the equine internal medicine service at the [UC Davis veterinary hospital](#). UC Davis is one of the only veterinary hospitals in the country with a board-certified equine neurologist, and we are grateful to Dr. Aleman for sharing her time and expertise.

We hope the 2021 Horse Reports have provided information that is valuable to your equine knowledge and look forward to returning with all new topics in 2022!

Carrie J. Finno, DVM, Ph.D., Diplomate ACVIM
CEH Director



Dr. Monica Aleman

Thanks to Our Collaborator

Dr. [Monica Aleman](#) obtained her veterinary degree at the University of [UNAM-Mexico](#). She completed residencies in large animal internal medicine (equine emphasis) and neurology and neurosurgery at UC Davis, and achieved board certification for both specialties by the American College of Veterinary Internal Medicine. She completed a Ph.D. in comparative pathology of neuromuscular diseases at UC Davis. Her research and clinical interest has focused on neurology, neuromuscular and muscle disorders in all species, with an emphasis on horses. Currently, she holds the Terry Holliday Equine and Comparative Neurology Endowed Presidential Chair and is the Director of the [Neuromuscular Disease Laboratory](#) at UC Davis. Dr. Aleman is one of the founding members of the [Comparative Neurology Research Group](#), and is also affiliated with the Clinical Neurophysiology Laboratory.

EQUINE

Neurologic Evaluation



Presenting complaints/ Clinical signs	<ul style="list-style-type: none"> • Abnormal sleep • Collapse 	<ul style="list-style-type: none"> • Seizures • Tremors 	<ul style="list-style-type: none"> • Abnormal behavior 	<ul style="list-style-type: none"> • Incoordination • Paralysis 	<ul style="list-style-type: none"> • Muscle weakness/ stiffness 	<ul style="list-style-type: none"> • Lameness
Potential Causes (Examples)	<ul style="list-style-type: none"> • Sleep deprivation • Narcolepsy • Heart condition 	<ul style="list-style-type: none"> • Epilepsy • Mass in brain • EEE/WEE, WNV • Metabolic disease • Low glucose 	<ul style="list-style-type: none"> • Injury/Trauma • Hearing loss • Eye problems • EPM 	<ul style="list-style-type: none"> • Injury/Trauma • “Wobbler” • Vitamin E deficiency • EHV1, WNV, EPM 	<ul style="list-style-type: none"> • Genetic • Vitamin E deficiency • Toxin 	<ul style="list-style-type: none"> • Injury/Trauma • Kissing spines • Joint disease
Potential Diagnostic Tests and Procedures	<ul style="list-style-type: none"> • Blood work (CBC/Chem) • Heart evaluation • Measure brain wave activity (EEG) • Imaging – CT, MRI 	<ul style="list-style-type: none"> • Blood work (CBC/Chem) • Infectious disease testing • Measure brain wave activity (EEG) • Imaging – CT, MRI • CSF analysis 	<ul style="list-style-type: none"> • EPM testing • Examination of inner ear structures • Eye examination • Test hearing • Measure brain wave activity (EEG) • Imaging – CT, MRI • CSF analysis 	<ul style="list-style-type: none"> • Infectious disease testing • EPM testing • Test blood vitamin E levels • Protein biomarker (pNfH) test • Imaging – X-rays, CT/ myelogram • CSF analysis 	<ul style="list-style-type: none"> • Genetic testing (HYPP, PSSM, MH, MYHM, GBED) • Test blood vitamin E levels • Toxin investigation – blood, feces, dietary analysis • Measure muscle activity (EMG) • Muscle biopsy 	<ul style="list-style-type: none"> • Nerve block, joint block • Muscle activity (EMG) • Imaging – X-rays, ultrasound, CT, MRI, PET scan

This chart targets some of the most common causes for issues related to equine neurology. Tests are generally presented from least invasive to more invasive. Some tests may occur concurrently and the order of diagnostic tests may vary based on findings. Rabies should always be considered in cases of sudden onset, rapidly progressive neurologic disorders.

Abbreviations: CBC/Chem = complete blood count/chemistry profile, CSF = cerebrospinal fluid, CT = computed tomography, EEE/WEE = Eastern/Western equine encephalitis, EEG = electroencephalogram, EHV1 = equine herpesvirus type 1, EMG = electromyogram, EPM = equine protozoal myeloencephalitis, GBED = glycogen branching enzyme deficiency, HYPP = hyperkalemic periodic paralysis, MH = malignant hyperthermia, MRI = magnetic resonance imaging, MYHM = MYH1 Myopathy, PSSM = polysaccharide storage myopathy, WNV = West Nile virus

EQUINE NEUROLOGIC CONDITIONS: Common Causes

Increased understanding of neurologic conditions has enabled earlier diagnosis and improved outcomes, and vaccines have reduced the spread of infectious diseases. However, diagnosis and treatment remain challenging in some cases.

Neurologic issues can affect horses at any age, and clinical signs can result from infectious and non-infectious causes.



Mosquitoes, flies, and other insects can spread infectious diseases.

Infectious

Infectious neurological disorders are well known due to highly publicized outbreaks.

Viral neurologic diseases are often vector-borne, commonly spread by mosquitoes. Vaccines are available to prevent infection in many cases. Vector control and biosecurity practices can also help stem the spread of these diseases, which include:

- **Eastern/Western/Venezuelan equine encephalitis (EEE/WEE/VEE)**, which cause inflammation of the brain. Although rare, EEE has a high mortality rate in horses and humans. Outbreaks of WEE have resulted in significant numbers of deaths in both species. Venezuelan equine encephalitis occurs in Central and South America, Mexico, and the southern U.S., and is considered a possible bio-warfare agent since it can be transmitted from animals to humans (zoonosis). The EEE/WEE vaccine is recommended annually and the VEE vaccine is risk-based.

- **Equine herpes myeloencephalopathy (EHM)**, caused by the neurological form of equine herpesvirus 1 (EHV-1), which attacks the spinal cord and brain and can be fatal. Infected horses can act as carriers and shed the virus. Available EHV-1 vaccines are not labelled as neuroprotectant. However, vaccination is recommended to provide herd immunity against EHV-1 and potentially reduce cases with neurologic disease.
- **Rabies**, which has the highest case fatality rate of any infectious disease. It is a significant threat in South and Central America. Vaccination is recommended annually.
- **West Nile virus (WNV)**, which can cause inflammation of the brain and spinal cord, and possibly death. Many infected horses do not show signs of illness, but others develop neurologic disease. Vaccinate against WNV annually.

Aside from viral diseases, horse owners are acutely aware of **equine protozoal myeloencephalitis (EPM)**, caused by infection of the central nervous system with the protozoa *Sarcocystis neurona* or *Neospora hughesi*. Clinical signs of *S. neurona* infection depend on the area of the central nervous system with the parasite and the type of damage caused. Cases due to *N. hughesi* have a range of clinical signs.

Although bacterial infections of the nervous system, such as meningitis and abscesses, are rare in horses, toxins produced by *Clostridium* bacteria can result in severe diseases:

- **Botulism** is caused when *Clostridium botulinum* spores are ingested or infect a wound and release a neurotoxin, resulting in flaccid paralysis. It is highly fatal unless treated with antitoxin. A vaccine against type-B is available for horses in high risk areas, but there is no cross-protection between other types.
- **Tetanus** is a potentially fatal disease that occurs when *Clostridium tetani* spores enter open wounds where they release a neurotoxin. Clinical signs include stiffness, muscle spasms, and the inability to open the mouth (“lockjaw”). Treatment is challenging and annual vaccination is recommended.

Non-infectious

Non-infectious neurological disorders can be caused by injury, congenital and developmental defects and genetic conditions, as well as by dietary and environmental factors.

Inherited neurological conditions are known to include:

- **Cerebellar abiotrophy (CA)**, which is found in Arabians. Foals appear normal at birth, but exhibit neurological deficits within six months of age. Affected horses may be dangerous as they are prone to accidents and injuries. A [DNA test](#) is available.

- **Juvenile idiopathic epilepsy (JIE)**, which is found in Egyptian Arabian foals during the first year of life. Clinical signs include recurrent seizures characterized by loss of consciousness and rapid muscle contractions. A causative mutation has not been identified. After one year of age, foals no longer experience seizures, but problems related to head trauma can have lasting effects.

- **Occipitoatlantoaxial malformation (OAAM)**, which is caused by a developmental defect of the first two vertebrae of the neck and the base of the skull. This causes compression and damage to the spinal cord, resulting in abnormal head and neck movement. A mutation has been identified that causes one form (OAAM1) and a [DNA test](#) is available.



OAAM affected foal with an arrow indicating the asymmetric atlas.

Some neurological conditions likely have an inherited component, but modes of inheritance and genetic mutations have not been identified.

- **Vitamin E deficiencies** – Equine neuroaxonal dystrophy ([eNAD](#))/[equine degenerative myeloencephalopathy \(EDM\)](#) result from abnormalities of neurons in the brainstem and spinal cord and affect young horses (6 to 36 months of age). A genetic predisposition is likely, but insufficient dietary vitamin E is required for the onset of clinical signs. There is no effective treatment. [Equine motor neuron disease \(EMND\)](#) occurs in older horses vitamin E deficient for more than 18 months. It affects lower motor neurons, leading to muscle trembling and weakness. Treatment via supplementation has varying success.

- **Cervical vertebral compressive myelopathy (CVCM)**, “wobbler syndrome”, is caused by lesions that lead to compression of the spinal cord. Medical management, surgical treatment, and prognosis depend on the age of the horse, and duration and severity of clinical signs.

Other common noninfectious neurological conditions include:

- **Headshaking**, which is characterized by uncontrollable shaking, flicking, or jerking of the head without apparent cause. UC Davis researchers confirmed the involvement

of the trigeminal nerve, which runs across the face. In affected horses, it fires too often, causing tingling, itching, or burning sensations.

- **Neonatal maladjustment syndrome** is characterized by foals that appear healthy at birth, but quickly exhibit neurological abnormalities (“dummy foals”). The “Madigan Squeeze Technique” was developed at UC Davis to create pressure that mimics the normal birth canal and reduce symptoms.

The neurological status of any horse varies by day, environment, and situation. When neurological signs are subtle, multiple examinations over several days and under different conditions may be needed for an accurate assessment.

Encephalitis = inflammation of the brain

Encephalopathy = disease of the brain

Myelitis = inflammation of the spinal cord

Myelopathy = disease of the spinal cord

Myeloencephalitis = inflammation of the brain and spinal cord

Myeloencephalopathy = disease of the brain and spinal cord



Green grass is a primary source of vitamin E in equine diets.

NEUROLOGICAL EXAMINATION in the Horse

Equine neurological examinations* evaluate horses from head to tail. They are performed to evaluate signs consistent with neurologic disease or to establish that a horse is neurologically normal, such as during a pre-purchase exam. A neurological exam can be divided into two parts: static and dynamic.

The Static Examination occurs while the horse is standing still.

- The horse is observed to determine its behavior (docile, aggressive, etc.) and mentation (bright or lethargic).
- The functions of the cranial nerves, which run in 12 pairs from the brainstem along each side of the head and transmit everything from smell to swallowing, are assessed. Abnormal reflexes can help pinpoint the location of any damage.

- The posture of the head, neck, trunk, tail, and limbs is also observed to evaluate proprioception (the horse's ability to know where its body is positioned in space).
- The horse's body is palpated to assess pain, loss of muscle, numbness, localized heat, and swelling. Joints are flexed/extended. These tests can indicate damage to specific nerves.

The Dynamic Examination occurs while the horse is in motion. These steps should be performed on the ground, not while riding. These steps determine if a horse knows where its feet are and can control its limbs. As opposed to a normal horse who keeps its limbs under its body and can maintain a consistent rhythm, neurologically impaired horses may step on themselves, swing their limbs wide, pivot, drag their toes, easily lose balance, and exhibit gait abnormalities.



Walk in a straight line



Walk in a zig-zag



Walk with head elevated



Back up at the walk



Walk in small circles to the left and right

**These steps outline a general neurological examination. Individual veterinarians may favor slight modifications.*



Walk on different surfaces



Tail pull/body push



Walk up and down a curb or hill

MAYHEW'S GRADING SYSTEM for Ataxia

Grade 0: Normal strength and coordination

Grade 1: Subtle/mild neurological deficits only noted under special circumstances (e.g. while walking in tight circles)

Grade 2: Mild neurological deficits apparent at all times/gaits

Grade 3: Moderate deficits at all times/gaits that are obvious to all observers regardless of expertise

Grade 4: Severe deficits with tendency to buckle, stumble spontaneously, trip, and fall

Grade 5: Recumbent, unable to stand

SEVERITY

KEY POINTS

1. Safety first
2. Observation is essential
3. Know what is normal (e.g. different gaits according to breed)
4. Tailor the exam to the individual horse
5. Perform more than one exam



CHECKING UNDER THE HOOD: The Role of Neurological Evaluations in Pre-purchase Examinations

Buying a horse can be a lot like buying a car; both are significant investments. Regardless of the sticker price, it's a good idea to take a peek under the hood before you drive off the lot. A pre-purchase examination (PPE, or "vet check") can be minimal or extensive, but it should always include a neurological evaluation.

Pre-purchase Exam: What It Is and What Its Not

A pre-purchase examination is an assessment of a horse by a veterinarian and is usually requested by the potential buyer prior to purchase. The exam is intended to help the buyer make an informed decision based on their specific situation, needs, and expectations by evaluating a variety of parameters and potentially uncovering pre-existing conditions and warning signs of any potential problems.

The thoroughness of the pre-purchase examination varies and typically depends on several factors, including the age and breed of the horse, its performance and veterinary history, purchase price, and the buyer's expectations for the horse's intended use, among other considerations. Data from the exam can also be used for comparison to aid in diagnosis should issues arise in the future.

The veterinarian's role is to objectively provide information about the horse. The ultimate decision to purchase or pass lies with the buyer and is based on the levels of risk and potential management that they are comfortable accepting.

Contrary to popular belief, a pre-purchase examination is not a pass or fail test, nor a guarantee of health, soundness, performance, or longevity. It is important to recognize that there are limits to what can be determined by examination, and acknowledge that a pre-purchase examination represents a snapshot of the horse at a particular moment in time.

Neurological Evaluation

Most horse owners are aware of physical examinations, lameness evaluations, and joint flexion tests as components of a pre-purchase exam. Since neurological conditions can ultimately present safety issues for horses and handlers, a neurological evaluation should also be included. Whereas minor findings on a lameness exam in an older horse can be managed, for example, findings on a neurological exam have significant implications.

Some specific tests and findings that a veterinarian will look for during a neurological examination include:

- **Circles/serpentine** – The horse may exhibit circumduction (swinging the outside hind leg out from the body) or interference (stepping on itself) while walking, both of which are indicative of ataxia.
- **Ascending/descending a hill or step** – The horse may consistently stab their toes into the hill (ascending) and buckle their hindlimbs (descending) while making repeated mistakes in foot placement on the curb, all indicative of ataxia.

- **Walking with the head elevated** – An ataxic horse will demonstrate an exaggerated gait with the front limbs (i.e. “floaty”) while walking. Another possible finding is that a non-gaited horse that is neurologically abnormal may start pacing.
- **Backing** – Horses with cervical vertebral compressive myelopathy (CVCM) may drag their front legs while backing, whereas horses with shivers may demonstrate hyperflexion or hyperextension only when backing.
- **Tail pull** – Weakness associated with neuromuscular disease can become evident if the horse has trouble maintaining its balance during this part of the examination.

Additional testing and diagnostics may be recommended by the veterinarian to further explore any findings.

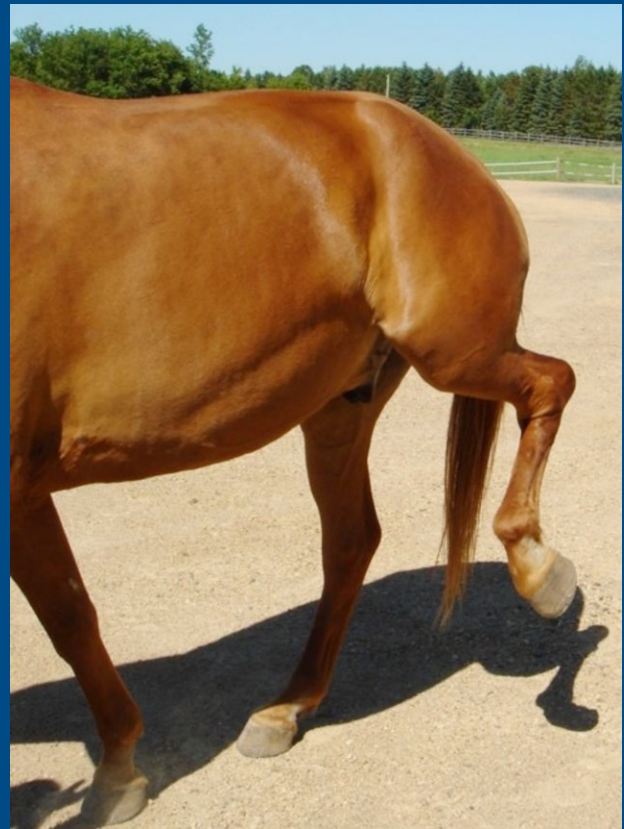
Although there is no way to predict future issues or eliminate all risks, a pre-purchase examination can help the buyer make an informed decision and keep things running smoothly.

Backing it Up

An important part of the neurological exam is backing the horse. Horses naturally back in a two beat gait, similar to a trot in reverse. For example, the right front moves with the left hind, and the left front moves with the right hind. Neurological impairments can interfere with this gait.

The classic example is the neuromuscular disease Shivers, which is characterized by an abnormal gait when backing up. Affected horses typically exhibit hyperflexion (hindlimb is held up and away from the body and often trembles) or hyperextension (feet are placed further back than normal) of the hind limbs when backing.

Horses that are more severely affected and/or showed clinical signs of Shivers at an early age may experience decreased performance over time. It can become increasingly challenging to perform farrier work on affected horses, which may have implications for hoof health and soundness.



A horse with Shivers exhibiting hyperextension of a hind limb while backing.






Photo courtesy of Dr. Stephanie Valberg.

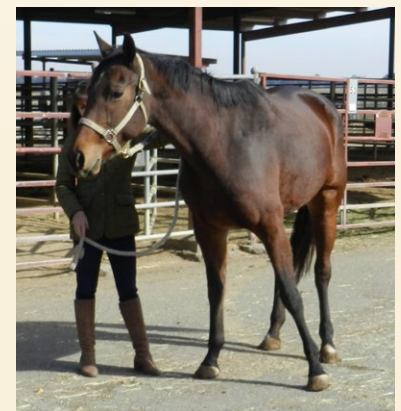


10 THINGS

You Might Not Know About Equine Neurology

UC Davis professor and Terry Holliday Equine and Comparative Neurology Endowed Presidential Chair Dr. Monica Aleman shared her extensive expertise on these facts about equine neurology.

-  **1 A horse's brain weighs 1.5 pounds, half that of a human brain, but is still one of the largest brains among land mammals.** The encephalization quotient (EQ), a ratio of observed brain size to predicted brain size based on body size, is used to compare intelligence across species. The EQ for horses is between 0.8 and 0.9. The ratio for livestock species ranges from 0.5 to 0.8. Dogs and cats are around 1, with chimpanzees at 2.5 and humans at 7. However, current thinking suggests that the number of neurons and sizes of specific brain regions may be better predictors of intelligence.
-  **2 Equine protozoal myeloencephalitis (EPM) is an uncommon cause of ataxia for California horses.** UC Davis researchers [recently reported](#) the most common causes of spinal ataxia in horses euthanized and necropsied at the UC Davis veterinary hospital over twelve years. The prevalence of [cervical vertebral compressive myopathy \(CVCM\)](#) was 2.7%, [equine neuroaxonal dystrophy/equine degenerative myeloencephalopathy \(eNAD/EDM\)](#) was 1.3%, trauma was 0.9%, and cases of unknown origin were 2.0%, with the remainder diagnosed as other neurologic diseases. In contrast to older studies, EPM was not a leading cause of ataxia. Two previous studies also reported CVCM and eNAD/EDM among the top three causes of ataxia in horses.
-  **3 Vitamin E deficiency at different ages and duration can lead to distinct health conditions.** [Equine motor neuron disease \(EMND\)](#) occurs in older horses that are vitamin E deficient for more than 18 months. With supplementation, 40% improve; 40% stabilize; and 20% get worse. Clinical signs of [eNAD/EDM](#) appear by two years of age. Supplementation may slow the progression of neurological deficits, but they cannot be reversed. Vitamin E deficient myopathy occurs in horses with a shorter duration of vitamin E deficiency. They generally recover quickly with supplementation.
-  **4 Testing is needed to differentiate eNAD/EDM from CVCM.** Ataxia, a wide-base stance, and uncoordinated movement are signs of various neurological issues. Some, such as [EPM](#) and trauma, can be determined based on clinical tests. It is not possible to definitively differentiate [eNAD/EDM](#) from [CVCM](#) based on clinical signs. The only way to conclusively diagnose eNAD/EDM is by examination of the brainstem and spinal cord after euthanasia. UC Davis researchers are working to develop [biomarker](#) and genetic tests that would improve eNAD/EDM diagnosis.
-  **5 Shivers can occur in the front limbs, but only if the hind legs are also affected.** [Shivers](#) is characterized by muscle tremors and exaggerated movement of the limbs during backing or lifting of a hind leg. Muscles of the head, neck and forelimbs are rarely affected. "Shivers" that appear to occur only in the forelimbs are more likely caused by lower neck pain, pinched nerves or other causes.



A horse with eNAD exhibiting abnormal proprioception.

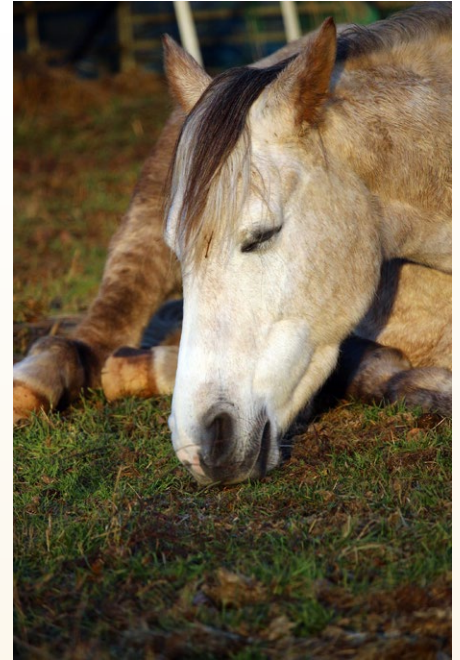
6 **Cancer of the central nervous system is rare in horses.** Details about central nervous system tumors in horses are restricted to individual case reports. Clinical signs in affected horses vary based on the location of the tumor(s). Therapy options are extremely limited and the prognosis for diagnosed animals is very poor.

7 **Horses that become drowsy and “catch” themselves before falling often suffer from sleep deprivation, not narcolepsy.** Although horses can famously “sleep standing up”, they have to lie down to complete a full sleep cycle. Horses that cannot lie down due to factors such as pain, fear, being in a new location, presence or absence of other horses, lights, sounds, and changes in diet become sleep-deprived. Narcolepsy is characterized by excessive sleepiness and spontaneous rapid eye movement (REM) sleep triggered by excitement. It is rare in most species. In horses, it is a genetic disorder that has been documented in families of miniature horses and Lipizzaners.

8 **First described over 100 years ago, equine headshaking is still not well understood.** UC Davis researchers confirmed that the trigeminal nerve, a large nerve that runs across the face, fires too often in affected horses, causing tingling, itching, or burning. It is seasonal in approximately 60% of cases, and signs can be triggered in response to wind, light, or increased exercise intensity. In severe cases, horses may experience self-inflicted trauma or interference with eating, leading to compromised welfare.

9 **Horses should be vaccinated against West Nile virus (WNV) to help prevent neurologic disease.** Horses represent 96.9% of non-human cases of WNV. This mosquito-borne virus is now found nation-wide. Vaccines are effective in protecting horses against infection and have resulted in a marked decline in cases since the peak in 2004. The American Association of Equine Practitioners (AAEP) recommends WNV as a core vaccine.

10 **Horses with non-healing ulcers in the cornea of the eye should be evaluated for temporohyoid osteoarthropathy (THO).** A progressive syndrome, THO results in bone thickening and the eventual fusion of the temporohyoid joint to the skull. Once fused, actions such as swallowing and chewing can cause fractures. In addition to a head tilt and signs of facial nerve paralysis, including deviation of the muzzle to one side and/or a droopy ear, damage to nerves that affect the eye can lead to decreased tear production and abnormal blinking, which can cause significant ulceration of the cornea. Affected horses might also have balance problems and commonly become deaf on the affected side. Long-term antibiotic treatment, and possibly surgery, is needed to treat the ulcers.



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EQUINE NEUROLOGY at UC Davis

Equine neurology at the UC Davis veterinary hospital is part of the [equine internal medicine service](#). Available neurology-related services include comprehensive neurologic examinations, cerebrospinal fluid collections, myelograms, CT scans, brain wave (EEG), electromyography (EMG), and slinging capabilities for horses that are unable to stand unassisted. Diagnostics and treatments for neurological conditions are aided by UC Davis's wide range of in-house testing capabilities and pharmaceutical service.

Board-certified in large animal neurology and neurosurgery, UC Davis equine neurologist Dr. Monica Aleman is specially trained to diagnose and treat a variety of conditions, providing a comprehensive approach to managing diseases of the equine nervous system. As one of the only clinics with a board-certified equine neurologist, UC Davis is proud to offer this unique expertise to our clients and referring veterinarians.

Dr. Aleman, along with other UC Davis faculty, also actively conducts research in neurology, neuromuscular and muscle disorders. Additionally, Dr. Finno is actively conducting research into the underlying genetic cause for some of these neurologic disorders. These researchers work closely with the [UC Davis Veterinary Center for Clinical Trials](#) to continue to advance knowledge in the field of equine neurology.



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