

PERIPHERAL NERVE ASSESSMENT AND DYSFUNCTION



BASICS

OVERVIEW

- Causative lesions can be localized using the principles outlined below
- Diagnostic rule-out lists are generated based on neuroanatomic localization, history, and signalment

SYSTEMS AFFECTED

- Nervous

PATHOPHYSIOLOGY

- Peripheral nerve disorders may be classified according to the modified MIIND system (malformation/genetics, injury, inflammation, neoplasia, degeneration, and idiopathic).
 - Motor axons of peripheral nerves undergo wallerian degeneration distal to, and several millimeters proximal to, the site of injury
 - Axons may regenerate by axon sprouting from the proximal nerve stump and growth within the endoneurium of the degenerate distal segment.
 - Regrowth rates of 1 mm/day can be expected
- *Neuroanatomic Divisions*
 - *Spinal nerves* are formed by the union of *dorsal and ventral nerve roots* at the points of exit from the spine. There are 8 cervical, 13 thoracic (12 in camelids), 6 lumbar (7 in camelids and some sheep), 5 sacral, and variable numbers of caudal spinal nerves.
 - Motor axons pass from cell bodies in spinal cord gray matter into ventral nerve roots. Sensory fibers pass into the spinal cord via dorsal nerve roots; cell bodies are in *dorsal root ganglia*.
 - Each spinal nerve immediately divides into dorsal and ventral branches. The *dorsal branches* are distributed to the epaxial muscles and skin of the back. The much larger *ventral branches* pass to muscles of the limbs and trunk below the spine and convey sensory information from the body below the spine.
 - Combinations of ventral branches within the *brachial (C6 to T2; C6 to T1 in sheep and goats) and lumbosacral (L4 to S2) plexuses* form *peripheral nerves* to the limbs. Ventral branches of C5 to C7 combine to form the *phrenic nerves*.
 - Peripheral nerves are *mixed*, containing both motor and sensory fibers.
 - *Cauda equina* – The roots of all spinal nerves caudal to S1. These travel caudally in a bundle from points of spinal cord origin to sites of exit along the sacrocaudal spine.
 - *Sympathetic outflow* – 2-neuron sympathetic LMN originate in the *thoracolumbar* spinal cord gray matter, exit in ventral nerve roots, and synapse in the ganglia of the sympathetic trunks on each side of the body. Sympathetic nerves supply the smooth muscle of blood vessels and organs including the GI and genitourinary tracts.

- *Parasympathetic outflow* – Parasympathetic LMN axons exit from *caudal sacral* segments and, via the pelvic plexuses, innervate the bladder, distal colon, rectum, and genital organs.
- *Neuromuscular junctions* – Each motor axon branches repeatedly to terminate in more than 100 neuromuscular junctions. Depolarization of these nerve endings causes release of preformed acetylcholine which in turn depolarizes myofibers by binding to and opening sodium channels.
- *Selected Functional Units*
 - *Reflex pathways* – Sensory fibers enter the spinal cord via dorsal roots and pass either directly (patella reflex) or via interneurons in the spinal cord gray matter to synapse on LMN to begin the motor arm of the reflex. Cutaneous trunci and perineal (i.e., anal, tail flexion) reflexes are spinal reflexes that can be elicited in standing ruminants. Patella and flexor (withdrawal) reflexes can only be reliably obtained in recumbent patients
 - *Autonomous zones (AZ)* – Areas of skin innervated by only one sensory nerve. These have been described for cattle. *Thoracic limb* – Radial, ulnar and musculocutaneous nerves have AZ over the craniolateral, caudal, and medial forearm; below the knee, AZ for median and ulnar nerves are present on medial and lateral surfaces, respectively. *Pelvic limb* – Large AZ for the saphenous nerve medially and the sciatic nerve caudally are found over the thigh and gaskin; there are AZ for peroneal and tibial nerves over the dorsolateral and caudal surfaces, respectively, of the limb below the hock.

PHYSICAL EXAMINATION FINDINGS

- *Ataxia* – Impaired awareness of body position at rest and motion. Manifests as delayed initiation of forward strides, overly long strides, base-wide or -narrow postures, excessive swaying and swiveling of hindquarters, circumduction of pelvic limbs, and interference between pairs of limbs during tight circling
- *Flaccid weakness* – In contrast to UMN weakness, limbs of animals with LMN lesions are floppy (hypotonic) and tend to collapse when weightbearing. Strides are short and shuffling, and muscles may tremor.
- *Hyporeflexia*
- *Muscle atrophy*
- *Reduced skin sensation (hypoesthesia)*

Signs of motor dysfunction related specifically to injury location (nerve root origin of nerves given in parentheses). Expected sensory deficits are given in the “Autonomous Zones” description above.

- *Suprascapular (C6, C7)* – Atrophy of the infraspinatus and supraspinatus over the scapula; outward shoulder rotation, adduction of the limb
- *Radial (C7 - T1)* – High – dropped elbow, non-weightbearing; distal – knuckled carpus, fetlock, walk on dorsum of fetlock
- *Femoral (L4 - L6)* – Non-weightbearing due to quadriceps weakness
- *Obturator (L4 - L6)* – Splayed pelvic limbs, especially on slippery surfaces
- *Sciatic (L6 - S2)* – Hyperflexion of hock joint, knuckling onto dorsum of the fetlock joint; *peroneal* – slight hock extension, knuckling of distal limb; *tibial* – hyperflexion of hock and fetlock, hoof remains flat on ground
- *Sacrocaudal (S2 - Ca)* – Tail hypotonia, gaping anus, prolapsed penis, urinary incontinence, fecal obstipation hypoesthesia of tail and perineum

CAUSES AND RISK FACTORS

A listing of the more important causes of spinal cord disorders by category follows. The species that are affected – C, cattle; S, sheep; G, goat; Ca, alpaca or llama are indicated in parentheses. If all ruminants are affected there is no species indication.

- *Malformations/genetic* – myasthenia gravis (S), familial peripheral neuropathy (C), primary peripheral myelinopathy (C)
- *Injuries* – Predator injuries, trapping leg in fence, feeder (radial), splaying legs on slippery surface – *thoracic* (brachial plexus); *pelvic* (obturator), forced fetal extraction - *thoracic* (brachial plexus); *pelvic* (femoral), downer cows struggling to stand (femoral), calf-roping injury (femoral), stanchion/squeeze chute (suprascapular), fractures – *humeral* (radial); *pelvic* (sciatic); *sacral* (tibial, cauda equina), intramuscular injection (suprascapular, sciatic, tibial), calving (sciatic, obturator), recumbency (peroneal, tibial, radial)
- *Inflammation* – polyradiculoneuritis (G), botulism, tick paralysis, elapid snake bites (S,G,Ca)
- *Degeneration (metabolic and toxic)* – organophosphate toxicity, hypocalcemia, hypomagnesemia, hypokalemia, coyotillo toxicity (G), phrenic nerve degeneration (Ca), acrylamide toxicity (C),
- *Neoplasia* – schwannoma, neurofibroma
- *Idiopathic* - kangaroo gait (S)



DIAGNOSIS

DIFFERENTIAL DIAGNOSES

- Brain disorders may be classified according to the MIIND system - malformation, injury, inflammation, neoplasia, and degeneration.

CBC/BIOCHEMISTRY/URINALYSIS

- Important for screening for metabolic diseases (e.g., hypocalcemia), but generally nonspecific

OTHER LABORATORY TESTS

- NA

IMAGING

- *Radiography* – Useful to explore the possibility of fractures as a cause or complication of nerve paralysis syndromes
- *Cross-sectional imaging (CT, MRI)* – Limited application in peripheral nerve disorders
- *Ultrasonography* – Limited application but can be used in pelvic/sacral fractures, and vertebral malformations.

OTHER DIAGNOSTIC PROCEDURES

- Cerebrospinal fluid can be collected from the lumbosacral site; the atlantooccipital site can be used in highly obtunded or anesthetized patients (description under Brain Assessment and Dysfunction)
- Needle electromyography (EMG) is a specialized procedure wherein spontaneous abnormal electrical activity is recorded via an electrode needle inserted into muscle. Abnormal potentials begin about seven days after onset of LMN disease.
- Motor nerve conduction velocity usually is only determined at referral hospitals. A nerve (e.g., the tibial nerve) is stimulated proximally and the evoked muscle response is measured distally by an

EMG recording electrode. Normal conduction velocities are 50 to 60 m/s. Diminished velocity and evoked potential are characteristics of peripheral neuropathies.



MISCELLANEOUS

Suggested Reading

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