



Comparative Anatomy of the Horse, Ox, and Dog: The Vertebral Column and Peripheral Nerves

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ABSTRACT: Knowledge of the peripheral nervous system and vertebral column anatomy is important in veterinary medicine. This article describes the vertebral column anatomy, vertebral column biomechanics, and peripheral nerve distribution in the horse, ox, and dog. Clinical signs of nerve dysfunction and selected nerve block sites are also described. Specific attention is paid to special reflexes of the horse.

VERTEBRAL COLUMN

The Cervical Vertebrae

Horses, oxen, and dogs have seven cervical vertebrae (Table 1). The first cervical vertebra, known as the *atlas*, has large wings and a thick ventral arch instead of a true vertebral body.¹ In the horse and dog, each wing of the atlas is perforated by a transverse foramen that conveys the vertebral artery. On the dorsal cranio-lateral surface of the wing, the horse and ox possess an alar foramen that conveys the ventral ramus of the C1 spinal nerve. The dog

has an alar notch instead of a true foramen.² In the horse and dog, the alar foramen or notch also conveys a branch of the vertebral artery.^{1,3}

The axis is the longest vertebra in most species.⁴ Its cranioventral aspect has a bony projection called the *dens*, which represents an embryonic fusion of the centrum of the proatlas and centrum 1 of the axis (which is phylogenetically the body of the atlas).⁴⁻⁷ The dens rests in a fovea located in the ventral portion of the vertebral foramen of the atlas, where it is held in place by the apical ligament, alar ligaments, and the transverse ligament of the atlas. The dens of the ox is wider than that of the horse; the dog's dens is relatively narrower and longer than that of large domestic species.

The third through the seventh cervical vertebrae are relatively similar in architecture in all species. These vertebrae are long, have a thick

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Table 1. Vertebral Formulas and Spinal Nerve Roots Supplying Major Peripheral Nerves in the Horse, Ox, and Dog^a

	Horse	Ox	Dog
Vertebral Formula	C ₇ T ₁₈ L ₅₋₆ S ₅ Cd ₁₅₋₂₁	C ₇ T ₁₃ L ₆ S ₅ Cd ₁₈₋₂₁	C ₇ T ₁₃ L ₇ S ₃ Cd ₅₋₂₀
Brachial Plexus Nerves^{28,34,b}			
Suprascapular	C6, C7 (10/10)	C6, C7 (10/10)	C6, C7 (6/6)
Subscapular	C6 (3/10) C7 (10/10)	C6, C7 (10/10)	C6, C7 (6/6)
Musculocutaneous	C7, C8 (10/10)	C6 (9/10) C7 (10/10) C8 (9/10)	C6–8 (6/6) T1 (2/6)
Axillary	C6 (1/10) C7 (10/10) C8 (10/10)	C7, C8 (10/10)	C6 (5/6) C7 (6/6) C8 (2/6)
Radial	C7 (1/10) C8 (10/10) T1 (10/10)	C7–T1 (10/10)	C6 (5/6) C7–T1 (6/6) T2 (3/6)
Median	C7 (1/10) C8–T2 (10/10)	C8–T1 (10/10)	C7 (5/6) C8, T1 (6/6) T2 (4/6)
Ulnar	T1 (10/10) T2 (9/10)	C8–T2 (10/10)	C7 (1/6) C8, T1 (6/6) T2 (4/6)
Lumbosacral Plexus Nerves^{1,50,c}			
Obturator	[L3], L4, L5, [L6]	L4, L5, L6	[L4], L5, L6
Femoral	[L3], L4, L5, [L6]	[L4], L5, [L6]	L4 (5/11) L5 (11/11) L6 (9/11)
Sciatic	[L5], L6, S1, [S2]	L6, S1, [S2]	[L5], L6–S1, [S2]
Common peroneal	—	—	[L5], L6, L7
Tibial	—	—	L6–S1, [S2]

^aNumbers in parentheses designate the number of animals containing particular fiber distributions out of the total number studied. In some cases, conflicting data or no numerical data are available on nerve root distribution. In these instances, brackets are used to denote less frequently seen contributing nerves according to the cited references.

^bSharp JW, Bailey CS, Johnson RD, Kitchell RL: Spinal nerve root origin of the median, ulnar and musculocutaneous nerves and their muscle nerve branches to the canine forelimb. *Anat Histol Embryol* 19:359–368, 1991.

^cLangley JN, Anderson HK: The innervation of the pelvic and adjoining viscera. III. External generative organs. *J Physiol (Lond)* 19:85–121, 1895.

dorsal arch, and possess large articular processes with facets that lie in a dorsoventral plane. The transverse processes of C3 through C6 contain a transverse foramen. C6 has especially prominent transverse processes with distinct ventral laminae; C6 and C7 are shorter

and wider than the other cervical vertebrae.

The Thoracic and Lumbar Vertebrae

The horse has 18 thoracic vertebrae, whereas the dog and ox have 13. In all species, the thoracic vertebrae are

short bodied with small arches; they decrease in length and width caudal to T1. The transverse processes of the thoracic vertebrae are small, and the spinous processes are caudally inclined between T1 and the anticlinal vertebra (T16 in the horse, T11 in the dog, and T11 to T13 in the ox).^{1,2,4} Caudal to the anticlinal vertebra, the spinous processes are cranially inclined.

The horse has six lumbar vertebrae, but some breeds, especially Arabians, may have five.¹ Oxen and dogs have six and seven lumbar vertebrae, respectively. The articular processes of lumbar vertebrae have large facets oriented in the sagittal plane. The transverse processes are plate-like and flattened dorsoventrally. In the horse, unlike other species, the transverse processes of L5 articulate with those of L6 at so-called *intertransverse joints*.^{1,8} The sixth lumbar vertebra may in turn articulate

The Intervertebral Disk

The boundary between the nucleus pulposus and annulus fibrosis is less distinct in the horse than in many other species.¹⁰ In the horse, the nucleus pulposus is composed of a fibrocartilagenous matrix unlike the gelatinous, glycosaminoglycan-laden structure found in oxen, dogs, and humans.¹⁰ Although the notochord participates in the formation of the nucleus pulposus in other species, no notochord cells have been found at any age in horses, suggesting the possibility of a different developmental program in this species.¹⁰ Disk herniation has been reported in the horse infrequently, usually occurs in the cervical vertebral column, and has always consisted of disk protrusion (Hansen's type II herniation).¹¹

The structure of the disk in the ox is very similar to that in humans and dogs. Studies of bovine disk mor-

The vertebral column of the horse and ox is relatively rigid compared with that of the dog. The regions of greatest mobility in the horse are the cervical spine and the lumbosacral junction.

with the wing of the sacrum in the horse.^{1,8} The six lumbar vertebrae of the ox are much longer than those of the horse and are very narrow midbody.

The Sacrum and Caudal Vertebrae

The sacrum of the horse represents the fusion of four to six sacral vertebrae (usually five). Each fused vertebra has a prominent spine on the dorsal surface; these spines occasionally have bifid summits.^{1,9} On either side of the spinous processes lie four paired foramina. The concave ventrum of the sacrum has four larger foramina. The sacrum of the ox is longer than that of the horse and also comprises five fused vertebrae.¹ Fusion of the spinous processes creates a median crest; the articular processes are also fused, forming lateral crests. The sacrum of the ox, like that of the horse, possesses dorsal foramina.

The horse has 15 to 21 caudal vertebrae,^{1,4} of which only the most cranial have transverse processes. There are no articular processes. The ventral surfaces of these vertebrae are grooved for the median caudal artery. The ox has 18 to 20 caudal vertebrae.⁴ These are longer and better developed than those of the horse. The second, third, and sometimes fourth caudal vertebrae of the ox possess ventrally located hemal arches (which represent the fusion of hemal processes) along their ventromedial aspects.⁴

phometry note that the annulus is composed of concentrically arranged lamellae of type I collagen.^{12,13} The nucleus pulposus is a viscoelastic matrix of glycosaminoglycans and disordered type II collagen fibrils.¹² Despite the frequent use of ex vivo ox disks to model human disk degeneration, we were only able to find one report of in vivo clinical intervertebral disk disease in this species.¹⁴

Biomechanics

A knowledge of vertebral column biomechanics is important to understanding normal gait as well as pathologic stress on the spine. The major types of motion observed in the vertebral column are longitudinal bending in a vertical plane (dorsoventral flexion and extension), axial rotation, and lateral bending.^{15,16} The horse and ox have a relatively rigid vertebral column compared with the dog; this may be due to their need to stand for long periods.¹⁷ This rigidity may also facilitate the galloping gait in the horse.¹⁸

The cervical vertebral column in the horse can be divided into three basic motion segments based on joint morphology: atlanto-occipital, atlantoaxial, and C3 through C7.^{15,19} The atlanto-occipital joint permits a significant amount of dorsoventral flexion and extension (raising and lowering the head) as well as considerable

lateral bending (44°) and axial rotation (27°).¹⁵ The atlantoaxial joint is responsible for 73% of the axial rotation of the equine cervical spine; it has limited dorsoventral flexion or extension.¹⁵ The C3 through C7 vertebrae possess associated intervertebral disks and dorsally oriented cranial articular processes, allowing minimal axial rotation and moderate amounts of lateral bending, dorsoventral flexion, and extension.¹⁵ The neck of a galloping horse undergoes 28° of vertical motion, which aids in generating thoracic limb protraction.²⁰

Townshend and Leach²¹ suggest that the equine thoracolumbar spine can be divided into four regions based on articular facet geometry: T1 and T2, T2 through T16, T16 through L6, and L6 and S1. The T1–T2 vertebral motion unit has the greatest amount of dorsoventral flexion and extension of any region of the thoracic vertebral column; this may facilitate movement of the head and neck. The articular processes of T2 through

In the horse, dog, and ox, the **suprascapular nerve** travels between the subscapularis and supraspinatus muscles. It emerges over the cranial border of the neck of the scapula and courses caudolaterally toward the infraspinatus muscle. In all species, the suprascapular nerve innervates the supraspinatus and infraspinatus muscles; no cutaneous zone has been identified. In the horse, the nerve is not protected by an acromion and thus is susceptible to injury by compression against the edge of the scapula.^{24–26} Animals with suprascapular nerve palsy (sweeney) will have marked atrophy of the supraspinatus and infraspinatus, lateral shoulder instability, and limb abduction.^{24–26} Supraspinatus/infraspinatus contracture in the dog has a similar presentation but is believed to result from compartment syndrome leading to localized muscle injury.²⁷

The **musculocutaneous nerve** of all domestic mammals originates just caudal to the subscapular nerve and

The brachial plexus consists of the ventral rami of spinal nerves C6 to T2.

T16 are much smaller than those of the T1–T2 vertebral motion unit; thus, only minimal dorsoventral movement is permitted.²¹ A substantial amount of axial rotation and lateral bending is possible in the T2–T16 segment, especially between T9 and T14.^{16,21} Relatively little movement occurs from T16 through L6. This is likely the result of recessed cranial articular facets, vertebral shape, and articulation between caudal lumbar transverse processes.²¹ The L6–S1 joint has the greatest degree of dorsoventral flexion and extension of any vertebral motion unit in the horse.^{16,21,22} This movement is permitted by the arrangement of the annulus fibrosus at the L6–S1 disk space, the cranially directed L6 spinous process and caudally directed S1 spinous process, and the special position of the lateral joints of the L6–S1 transverse processes relative to the disk space.²³

PERIPHERAL NERVES

Innervation to the Thoracic Limb

The brachial plexus of the horse, ox, and dog consists of the ventral rami of the C6 through T2 spinal nerves and is situated between the scalenus and subscapularis muscles. The major nerves that emanate from the brachial plexus are the suprascapular, subscapular, musculocutaneous, axillary, radial, median, and ulnar nerves (Table 1).

innervates the flexor muscles of the elbow. Selective lesions lead to minimal paresis or ataxia when the animal walks on flat ground.³ In the horse and ox, this nerve travels distocaudally from the brachial plexus, crosses the lateral aspect of the axillary artery,²⁸ sends a proximal muscular branch to the biceps brachii and coracobrachialis muscles, and joins the median nerve just distal to the axillary artery, forming a loop (ansa axillaris) that is absent in the dog.^{1,3} Distal to the ansa axillaris, the musculocutaneous and median nerves cannot be grossly divided until just above the elbow, where they separate. The musculocutaneous nerve sends branches to the brachialis muscle and terminates in the medial cutaneous antebrachial nerve, which supplies general somatic afferent fibers to the medial and cranial antebrachium, dorsomedial carpus, and the dorsomedial metacarpus (cannon) as far distal as the fetlock.^{3,28,29} The medial cutaneous antebrachial nerve can be palpated and anesthetized as it crosses the lacertus fibrosus in the horse.³⁰ In the ox, the medial cutaneous antebrachial nerve overlaps the radial nerve, making an autonomous zone that is difficult to evaluate^{1,3} (Figure 1).

The **axillary nerve** supplies motor function to the teres major, teres minor, deltoideus, and a portion of the subscapularis muscle in all species.¹ This nerve may also contribute to motor function of the cleidobrachialis

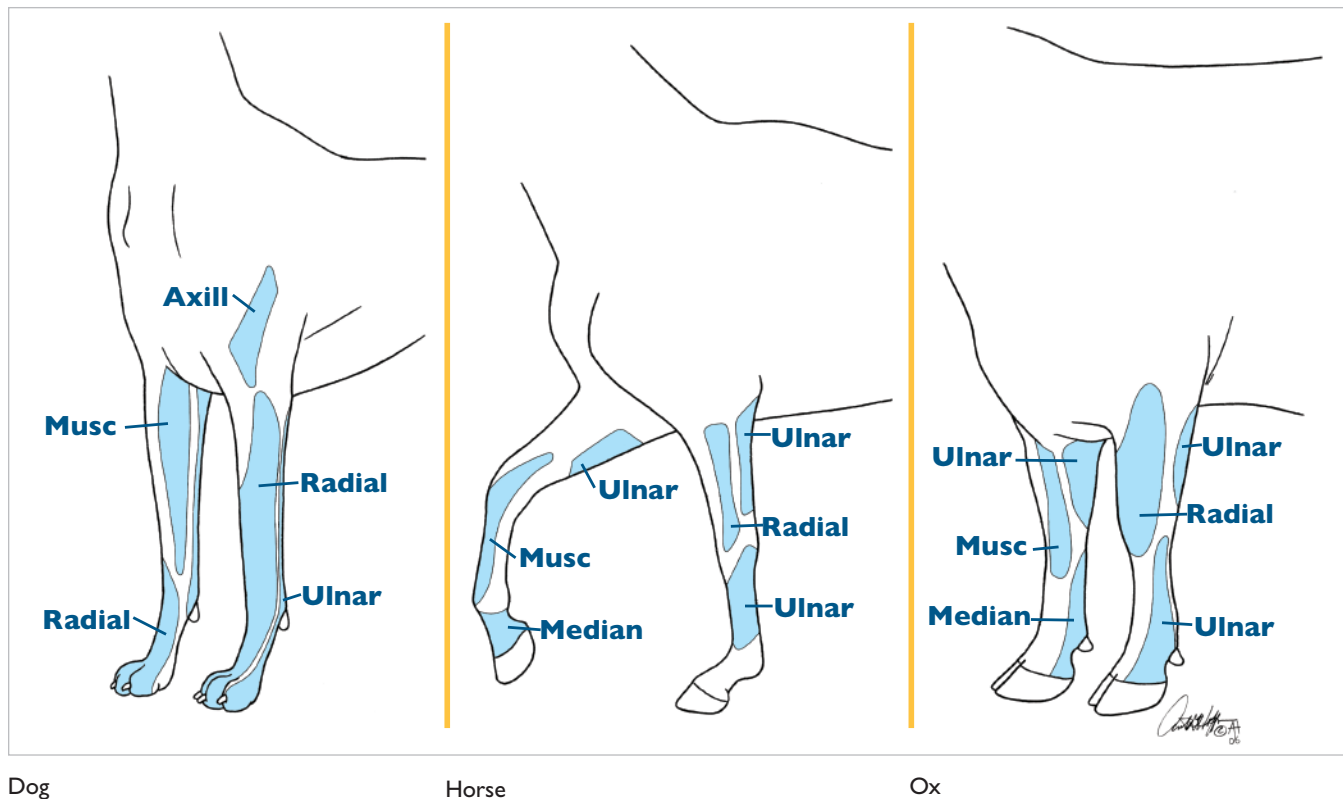
Figure 1. The major thoracic limb autonomous zones. (*Axill* = axillary nerve; *Musc* = musculocutaneous nerve)

Illustration by Anton G. Hoffmann

muscle in the horse and other species.^{28,31} Damage to the axillary nerve causes minimal gait disturbances. Two cutaneous branches supply the cranio-lateral skin over the brachium and proximal antebrachium; a small autonomous zone is present in the dog over the lateral aspect of the brachium.³²

In the horse, the **radial nerve** follows the caudal border of the brachial artery and then travels distally between the heads of the triceps muscle. As it courses along the humerus, the nerve follows the brachialis groove and advances cranio-laterally, giving small branches to the triceps muscles.^{1,3,28,29,33} Just proximal to the elbow, it splits into superficial and deep branches.^{1,3,28,29,33} The superficial branch provides the lateral cutaneous antebrachial nerve, which supplies the distal cranio-lateral portion of the antebrachium.³³ The lateral cutaneous antebrachial nerve does not continue past the carpus in the horse as it does in other species.^{3,29,33} The deep branch provides motor innervation to the carpal and digital extensor muscles.^{3,28,29,33}

The course of the radial nerve in the ox and dog is fairly similar to that in the horse, as is the motor innervation.^{3,28,29,33,34} In the ox, the superficial branch receives

fibers from the musculocutaneous nerve.¹ The superficial branch continues distal to the carpus and divides into two dorsal common digital nerves (II and III).¹ Dorsal common digital nerve II supplies the abaxial surface of digit III.¹ Dorsal common nerve III furnishes sensory supply to the dorsal axial surfaces of digits III and IV.¹ The dorsum of the manus is supplied through cutaneous innervation by radial nerve branches in the dog and the ox.³² This area, including digits II and III and the axial portion of IV, is an easily identifiable autonomous zone in the dog.³²

Because the radial nerve innervates extensors of the elbow, carpus, and digits, injuries involving the motor neurons or associated projections can cause significant functional impairment. High radial nerve paralysis, which results from disruption of the nerve proximal to branches that distribute to the triceps brachii muscle, results in total inability to support weight on the affected limb.³⁵⁻³⁷ Injuries distal to the tricipital branches result in low radial paralysis, which is characterized by inability to support weight at the carpus or digit.^{35,36} Animals with low radial paralysis walk on the dorsum of the carpus or

digit while supporting the limb appropriately at the level of the elbow.³⁵ They may compensate by swinging the limb forward when walking to avoid scuffing.³⁶

While it is conjoined with the musculocutaneous nerve, the **median nerve** follows the cranial border of the brachial artery in the horse and ox; as it travels distally, it traverses the vessel to lie on the caudal margin. This nerve can be palpated as it runs over the medial collateral ligament of the elbow and can be blocked at this point, generally 5 cm distal to the elbow, proximal to the origin of the extensor carpi radialis.^{30,38-42} Portions of the deep digital flexor and flexor carpi radialis are supplied by the median nerve in the horse, ox, and dog. The medial palmar nerve and lateral palmar nerve are the two major branches of the median nerve in the horse.

The medial palmar nerve of the horse lies in a groove between the interosseus and flexor tendons and can be blocked at the proximal end of the splint bone or just

blocked at two sites: deep at the level of the base of the splint bone, or where they emerge distally from beneath the distal ends of the splint bones.³⁹⁻⁴² It is controversial whether fibers from the palmar metacarpal nerves continue distal to the coronet.^{1,45} The lateral palmar digital nerve can be anesthetized in a fashion similar to that used for the medial palmar digital nerve.

In the ox, the median nerve follows the median artery through the carpal canal before dividing into medial and lateral branches. The medial branch yields two palmar axial digital nerves that supply the palmar surface of digit III. The lateral branch continues as palmar axial digital nerve IV, which supplies the axial surface of digit IV, and a communicating branch to the palmar branch of the ulnar nerve. In the dog, the cutaneous area of the median nerve in the paw, which covers the palmar surface of digits II, III, and IV, is completely overlapped by the cutaneous branches of the palmar branch of the ulnar nerve.

Selective injury of the radial nerve causes the most significant gait abnormalities in all species.

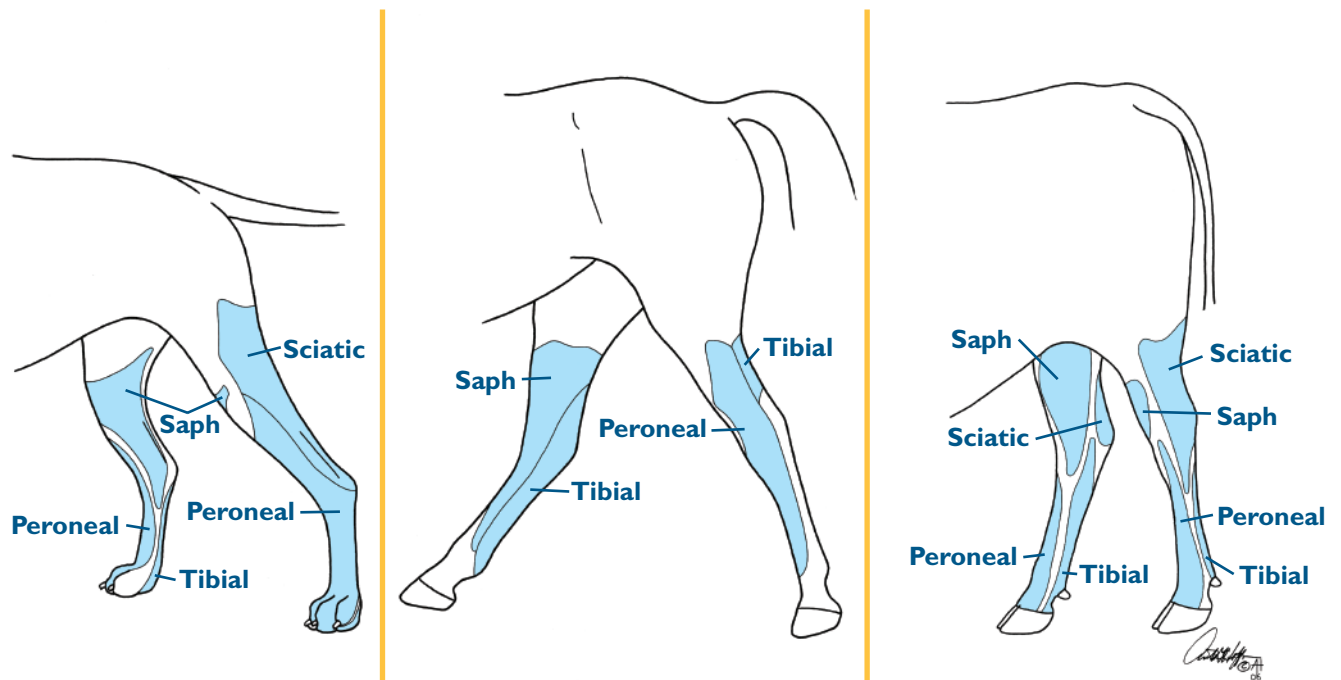
proximal to the fetlock.³⁹⁻⁴² In the mid-metacarpus, a communicating branch from the medial palmar nerve runs distally over the flexor tendons to join the lateral palmar nerve. The medial palmar nerve then divides into a medial palmar digital nerve and a dorsal branch. The medial palmar digital nerve can be palpated and blocked along the abaxial aspect of the sesamoid bone.³⁹⁻⁴² The medial palmar digital nerve can also be anesthetized at the level of the foot, either where it emerges just distal and deep to the ligament of the ergot or where it courses beneath the collateral cartilage of the third phalanx.³⁹⁻⁴² The dorsal branch supplies general somatic afferents to the dorsomedial aspect of the digit and cornium of the hoof.^{31,43} A small autonomous zone is present in this area in the horse.⁴⁴

The lateral palmar nerve of the horse joins the palmar branch of the ulnar nerve at the carpus and can be blocked at the level of the proximal end of the splint bone.³⁹⁻⁴² It receives the communicating branch from the medial palmar nerve near the distal end of the metacarpus. The deep branch of the lateral palmar nerve arises just distal to the carpus and splits into medial and lateral palmar metacarpal nerves that innervate the splint bones, deep metacarpal structures (e.g., the interosseous muscle), and portions of the fetlock joint. The medial and lateral palmar metacarpal nerves can be

In the horse and ox, the **ulnar nerve** follows the caudal border of the brachial artery as it travels distally in the brachium. A caudal cutaneous antebrachial nerve branches from the ulnar nerve proximal to the elbow to provide general somatic afferents to the skin over the caudolateral antebrachium; in the horse and dog, an autonomous zone for this nerve is located on the caudal antebrachium.⁴⁴ The remainder of the ulnar nerve passes over the medial epicondyle of the humerus and innervates carpal and digital flexor muscles. Distal to the efferent branches to these muscles, the ulnar nerve is largely sensory. In the horse, this nerve can be blocked 10 cm proximal to the accessory carpal bone between the flexor carpi ulnaris and the ulnaris lateralis muscles, before it branches into dorsal and palmar divisions.³⁸⁻⁴² The dorsal branch of the ulnar nerve can be palpated and blocked along the accessory carpal bone as it travels distally to innervate skin over the lateral metacarpus in the horse and ox.⁴⁶ An autonomous zone for the dorsal ulnar branch in the horse exists over the dorsolateral metacarpus.⁴⁴

Innervation to the Pelvic Limb

Horses, oxen, and dogs all have a lumbosacral plexus that receives ventral rami of spinal nerves from the caudal lumbar and sacral spinal cord segments. Numerous

Figure 2. The major pelvic limb autonomous and cutaneous zones. (*Saph* = saphenous branch of the femoral nerve)

Dog; autonomous zones.

Horse; cutaneous zones.

Ox; autonomous zones.

texts, including *Nomina Anatomica Veterinaria*,⁴⁷ and clinicians divide the lumbosacral plexus into a lumbar plexus and a sacral plexus. These plexuses contribute to multiple peripheral nerves, including the femoral (lumbar plexus), obturator (lumbar plexus), and sciatic (ischiatric; sacral plexus) nerves.

The **femoral nerve** originates within the psoas major muscle and travels caudally in all three species. It continues through the iliopsoas muscle and exits into the pelvic limb at the level of the femoral triangle. The femoral nerve directly supplies the iliopsoas and quadriceps femoris muscles in the horse, ox, and dog. A saphenous branch arises from the femoral nerve close to its exit point from the iliopsoas and innervates the sartorius muscle. It then courses with the femoral artery distally, providing general somatic afferents to the skin over the medial crus and, in the horse and ox, the dorsomedial metatarsus and fetlock joint (Figure 2).⁴⁸ In the dog, the sensory supply to the skin of the medial pelvic limb is more extensive, covering a region from the craniomedial thigh to the foot.^{49,50} Animals with femoral nerve paralysis cannot support the affected limb due to lack of

extensor tone.^{35,51} In calves, femoral nerve palsy is often secondary to stretching and trauma resulting from dystocia.⁵²

The **obturator nerve** of the horse, ox, and dog is formed within the caudal portion of the iliopsoas muscle. After coursing in the pelvic canal alongside the medial aspect of the ilium, it exits via the obturator foramen and provides general somatic efferent fibers to the external obturator, pectineus, gracilis, and adductor muscles. It has no cutaneous branches. In the ox, this nerve is particularly vulnerable to compression secondary to parturition. Affected animals cannot adduct the pelvic limbs, which frequently splay out on slick surfaces.^{35,53} Animals that are nonambulatory due to calving paralysis probably have concurrent involvement of the sciatic nerve.^{53,54}

The **sciatic nerve** emerges from the pelvis via the major ischiatic foramen (horse and ox) or ischiatic notch (dog). It passes caudodistally over the hip joint and between the laterally positioned biceps femoris and the medially positioned adductor, semitendinosus, and semimembranosus muscles, providing motor innervation to

the internal obturator, gemelli, quadratus femoris, and all of the caudal thigh muscles. Just proximal to the stifle, the nerve splits into common peroneal and tibial nerve branches.⁵⁵ Sensory branches, including the lateral cutaneous sural and distal caudal cutaneous sural nerves, supply the skin of the lateral crus and caudal crus, respectively.⁴⁹ Sciatic nerve palsy results in hyperflexion at the tarsus with knuckling of the distal pelvic limb.³⁵ Animals with isolated peroneal neuropathy exhibit knuckling of the distal pelvic limb with limited flexion at the tarsus.³⁵ Tibial neuropathy leads to hyperflexion of the tarsus without knuckling.³⁵

After splitting from the sciatic nerve, the **peroneal nerve** of the horse courses laterally under the tendon of the biceps femoris muscle at the origin of the long digital extensor.^{39,41} Distal to this point, the nerve divides into deep and superficial branches that run in a groove between the long and lateral digital extensor muscles.

The lumbosacral plexus is derived from ventral rami of lumbar and sacral spinal cord segments.

For diagnostic purposes, these branches can both be blocked approximately 10 cm proximal to the tibiotarsal articulation and cranial to the septum between the long and lateral digital extensors.^{39,41,42} The peroneal nerve can also be blocked as it emerges from under the biceps femoris muscle and crosses over the lateral side of the head of the fibula, providing analgesia to the dorsal portion of the limb distal to the hock.³⁰ The superficial branch of the peroneal nerve supplies the lateral digital extensor and skin surrounding the lateral tarsus and metatarsus.⁴⁸ The deep branch of the peroneal nerve of the horse dives between the lateral digital extensor and the long digital extensor, providing branches to these muscles as well as to the cranial tibial and peroneus tertius muscles.⁵⁶ As the deep branch continues distally, it becomes a purely sensory nerve that splits into medial and lateral branches over the hock. These metatarsal nerves run between the long digital extensor tendon and splint bones. Both supply sensation to the fetlock and hock joints as well as to the overlying skin. The extent to which they provide sensory innervation to the most distal portion of the pelvic limb and corium of the hoof is controversial.⁵⁶ Perineural anesthesia of both medial and lateral dorsal metatarsal nerves is necessary to completely desensitize structures in the distal limb.

The peroneal nerve of the ox has a very similar course

to that of the horse. However, the superficial branch has three distinct divisions: a medial branch that supplies digit III, a middle branch that supplies the axial portions of digits III and IV, and a lateral branch that innervates the abaxial surface of digit IV.³ As in the horse, the deep peroneal nerve supplies the muscles of the cranial crus and then runs in a groove in the dorsal metatarsus. It sends branches that communicate with the middle branch of the superficial nerve to innervate the axial portions of the claws.³

Like the horse and the ox, the dog has superficial and deep branches of the peroneal nerve. The superficial peroneal nerve and its divisions innervate cutaneous surfaces along the distal two-thirds of the crus and the hind paw as well as the lateral digital extensor and peroneus brevis. The deep branch and its rami innervate a small area on the dorsomedial pes as well as the remaining muscles in the peroneal distribution. The peroneal

nerve can be palpated just caudal to the fibular head in the dog and is often blocked at this point.

The **tibial nerve** runs between the two heads of the gastrocnemius muscle and crosses the stifle on the surface of the popliteus.¹ The tibial nerve provides general somatic efferents to digital flexors and tarsal extensors in all species discussed. Just proximal to the tarsus, it splits into medial and lateral plantar nerves. In the horse, the tibial nerve can be blocked before its division, approximately 10 cm above the point of the hock, where it is palpable between the tendon of the gastrocnemius and the deep flexor tendon.^{39,41,42} In the ox, the tibial nerve can be palpated as it courses along the cranial aspect of the calcanean tendon.^{1,3} The tibial nerve of the dog can be palpated and blocked in the caudal crus, where it runs parallel and cranial to the calcanean tendon.

In the horse, the medial plantar nerve supplies general somatic afferents to the medial aspect of the tarsus and metatarsus in an arrangement similar to that of the medial palmar nerve.^{3,29} Just distal to the tarsus, the lateral plantar nerve detaches a deep branch that supplies the interosseus muscle and then divides into medial and lateral plantar metatarsal nerves. The architecture is similar to the thoracic limb digital innervation.^{3,29} In the ox, the lateral plantar nerve supplies the abaxial plantar portion of the lateral digit. The medial plantar nerve innervates

the entire plantar medial digit and the axial surface of the lateral digit. In the dog, the tibial nerve divides into medial plantar and larger lateral plantar nerves proximal to the tarsocrural joint; the general pattern of subsequent branching is very similar to that of the horse and ox.

In the horse, perineural anesthesia of the hindlimb below the level of the hock is conducted similarly to that in the forelimb below the carpus. The medial and lateral plantar, plantar metatarsal, and plantar digital nerves are blocked at the same sites as the corresponding nerves in the front limb. There is no corresponding block to the lateral palmar metacarpal block in the forelimb, which desensitizes the head of the suspensory ligament.^{39–42}

SPECIES-SPECIFIC REFLEXES IN THE HORSE

The cervicoauricular reflex, local cervical reflex, and slap test have been used exclusively in the horse to help localize lesions in the cervical spinal cord and brainstem. Although the reliability of these tests has been questioned by some authors,^{57–59} their frequent use in the clinical setting necessitates brief discussion of their neuroanatomic basis and value.

The cervicoauricular reflex can be elicited by tapping the area between the crest and the jugular groove cranial to the C3–C4 articulation.⁶⁰ The ipsilateral eye is shielded with one hand to avoid stimulating the visual system.⁶⁰ In a normal horse, after the appropriate region is tapped while the ears are focused cranially, the ipsilateral ear will turn caudally.⁶⁰ The proposed neuroanatomic basis for this reflex is that cutaneous afferents arising from C1 through C3 spinal cord segments transmit signals ipsilaterally through cervical spinal cord and medulla white matter projections. The ipsilateral facial nucleus is ultimately stimulated, resulting in the caudally directed ear movement. Lesions in the cervical spinal cord or medulla can cause absence of the cervicoauricular reflex.

The local cervical reflex—ipsilateral turning of the head and neck—occurs after the area between the crest and the jugular groove caudal to the C3–C4 articulation is tapped. The tap stimulates afferent projections originating from the caudal cervical spinal cord that are believed to interact with cervical alpha motor neurons.⁶⁰ Diseases that compromise the caudal cervical spinal cord may interrupt the local cervical reflex.^{60,61}

The slap test can be used to detect cervical spinal cord, medulla, or recurrent laryngeal nerve lesions. The horse is gently slapped with a hand just caudal to the withers while it is exhaling.⁶² Afferent projections from the slapped area enter the spinal cord via thoracic nerves T1 through T7 and send signals to dorsal horn interneurons.^{62,63} These interneurons have projections that ascend the contralateral lateral funiculus and interact with efferent-arm motor neurons in the medulla. The efferent arm of the reflex originates within alpha motor neurons of the nucleus ambiguus and reaches the dorsal and lateral cricoarytenoid muscles via the vagus and recurrent laryngeal nerves.^{62,63} The normal response is quick adduction of the contralateral arytenoid cartilage, which can be seen via endoscopy or palpated.⁶³ The value of the slap reflex in the diagnosis of laryngeal paresis and cervical spinal cord and medulla lesions has been questioned.^{57,58,62,64}

CONCLUSION

A basic knowledge of vertebral column and peripheral nerve anatomy is important in the practice of veterinary medicine. While species-specific differences are numerous and, in some cases, of critical importance, general architecture is similar among quadrupeds.

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ARTICLE #1 CE TEST



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1. The dens is

- a. absent in the horse.
- b. an embryonic fusion of the centrum of the proatlans and centrum I of the axis.
- c. wider in companion animals than large domestic species.
- d. held in place by transverse and intercapital ligaments.

2. Which statement is not true regarding the intervertebral disk?

- a. Disk herniation is a common cause of cervical spinal cord disease in the horse.
- b. The nucleus pulposus of the ox is similar to that of the dog.
- c. The nucleus pulposus of the horse is composed of a fibrocartilagenous matrix.
- d. Intervertebral disk disease in the ox is infrequently reported.

3. Which statement is true concerning vertebral column biomechanics?

- a. The atlanto-occipital joint permits lateral movement of the head.
- b. The atlantoaxial joint is responsible for 73% of lateral bending movement in the equine spine.
- c. The T2–T16 region of the vertebral column permits minimal dorsoventral movement.
- d. The L6–S1 joint permits minimal dorsoventral flexion and extension.

4. Which statement is false regarding the suprascapular nerve?

- a. It innervates the supraspinatus and infraspinatus muscles.
- b. In the horse, it is not well protected by the acromion and thus is susceptible to injury.
- c. Supraspinatus/infraspinatus contracture of the dog is not related to suprascapular nerve injury.
- d. A cutaneous zone exists for the suprascapular nerve.

5. Which sign is most consistent with high radial nerve paralysis?

- a. appropriate support of the limb at the elbow with compensatory swinging of the limb forward
- b. inability to support weight on the affected limb
- c. atrophy of digital flexors
- d. atrophy of the biceps brachii

6. The medial palmar nerve in the horse can be blocked by injecting local anesthetic

- a. where the nerve can be palpated running over the medial collateral ligament.
- b. where the nerve runs beneath the collateral cartilage of the third phalanx.
- c. at the level of the head of the splint bone or just proximal to the fetlock.
- d. 10 cm proximal to the accessory carpal bone, between the flexor carpi ulnaris and ulnaris lateralis muscles.

7. Lesions within the obturator nerve typically lead to

- a. inability to support weight in the pelvic limb.
- b. inability to adduct the pelvic limb.

- c. knuckling on the dorsum of the pelvic limb hoof or paw.
- d. extension of the pelvic limb.

8. Before splitting into peroneal and tibial branches, the sciatic nerve provides sensation to the

- a. corium of the hoof.
- b. medial crus.
- c. inguinal area.
- d. caudal and medial crus.

9. The tibial nerve provides

- a. special visceral afferents to the foot.
- b. general somatic efferents to digital flexors.
- c. general somatic efferents to digital extensors.
- d. general somatic afferents to the dorsum of the hoof or paw.

10. Which statement is true regarding the slap test?

- a. The horse should adduct the ipsilateral laryngeal fold in response to a slap over the saddle region.
- b. After the appropriate stimulus is delivered, the ipsilateral ear will turn caudally.
- c. It can be used to assist in detecting medulla, cervical spinal cord, or laryngeal lesions.
- d. It is extremely accurate for detecting laryngeal paresis.