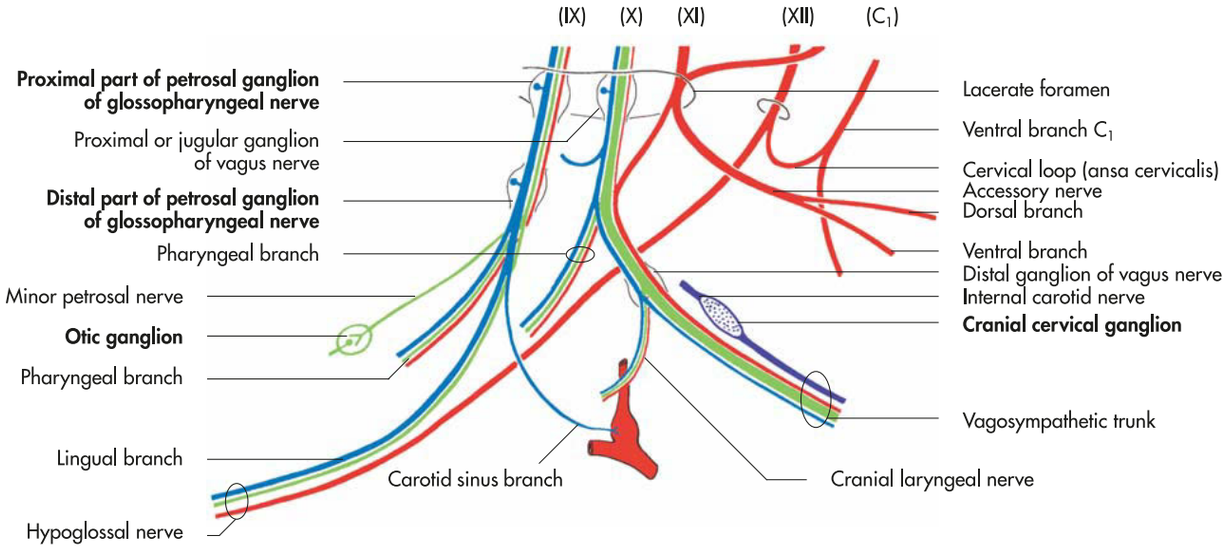

Fig. 15.58 Schematic illustration of the original parts of the vagus group (glossopharyngeal, vagus and accessory nerves) and the hypoglossal nerve, including major ganglia (blue = sensory, red = motor, green = parasympathetic fibres); fig. based on data from Budras and Röck, 1997.

of the nucleus ambiguus of the medulla oblongata and are joined by additional motor fibres from the accessory nerve. The **cell bodies** of the **pseudounipolar sensory neurons** are located in the **proximal ganglion of the vagus nerve** (formerly called jugular ganglion). Their receptors are located in the viscera, and their afferent fibres extend to sensory nuclei in the medulla oblongata.

The **parasympathetic preganglionic cell bodies** are located in the **parasympathetic nucleus of the vagus**, which lies immediately caudal to that of the glossopharyngeal nerve in the **medulla oblongata**. The long preganglionic parasympathetic fibres of this nucleus terminate in the intramural ganglia of the thoracic and abdominal viscera.

The parasympathetic branches of the head synapse in the **distal ganglion** (formerly called ganglion nodosum), which is located at the detachment of the cranial laryngeal nerve (▶ Fig. 15.58).

The vagus nerve emerges on the ventrolateral aspect of the medulla oblongata between the glossopharyngeal and the accessory nerves with which it passes through the jugular foramen. The proximal ganglion of the vagus lies within the **jugular foramen** (▶ Fig. 15.58).

The vagus nerve detaches a small **meningeal branch** (ramus meningeus) and the auricular branch close to the jugular foramen. The **auricular** joins a branch of the facial nerve to innervate the skin on the inside of the external ear. It is the only branch of the vagus that innervates the skin. It is hypothesised that this branch plays a major role in auricular acupuncture.

The next branch to arise is the strong **pharyngeal branch** (▶ Fig. 15.58), which joins the glossopharyngeal nerve in the formation of the **pharyngeal plexus**. This plexus forms a fine network with numerous dispersed groups of nervous cells on the surface of the muscles and in the tela submucosa of the pharynx. These vagus fibres provide sensory innervation to the mucosa of the epiglottis, trachea and oesophagus. Branches for the constrictors of the pharynx and the root of the tongue arise from the pharyngeal plexus.

The **cranial laryngeal nerve** arises from the vagus at the **distal ganglion** and marks the end of the cranial portion of the vagus nerve (▶ Fig. 15.58). It passes to the larynx, where it divides into an **external** and an **internal ramus**. The external branch innervates the caudal pharyngeal constrictors, while the internal branch is sensory to the larynx. Before bifurcating, the cranial laryngeal nerve detaches the depressor branch that runs either alone or together with the **vagosympathetic trunk** to the **cardiac plexus**, where its action is to slow the heart rate.

The vagus nerve receives **sympathetic fibres** from the **cranial cervical ganglion**. The distal ganglion of the vagus nerve is visible macroscopically in the dog, cat and pig, while in the horse, ox and sheep it consists of several dispersed cell bodies and requires microscopic identification. In the goat both discrete and diffuse ganglia occur in different individuals.

The **cervical part** of the vagus nerve begins after the detachment of the cranial laryngeal nerve. It continues along the neck, dorsolateral to the common carotid artery, enclosed in a common fascial sheath with the sympathetic trunk, constituting the **vagosympathetic trunk**. At the thoracic inlet, the vagus separates from the sympathetic trunk proximal to the **middle cervical ganglion** (▶ Fig. 15.58).

The **thoracic portion** of the vagus nerve continues ventral to the subclavian artery to enter the mediastinum, where it detaches cardiac branches that pass to the cardiac plexus, together with sympathetic fibres from the middle cervical ganglion and the stellate ganglion.

The large **caudal (recurrent) laryngeal nerve** is detached within the thorax (▶ Fig. 15.59). The **right caudal laryngeal nerve**

arises at the level of the **arterial costocervical trunk**. It turns around the **right subclavian artery** and ascends along the trachea to end at the larynx. The **left vagus** gives rise to the **left caudal (recurrent) nerve** at the level of **Botallo's ligament**. It arches around the aorta, where it comes in close contact with the **tracheobronchial lymph nodes**. It continues cranially along the trachea to the larynx, medial to the common carotid artery. Its axons are one of the longest found in the body.

The **two caudal laryngeal nerves** are **motor** to all muscles of the larynx except the **cricothyroid muscle** and sensory to the mucosa of the caudal part of the larynx. They detach cardiac branches shortly after their origin and small branches to the trachea and oesophageus along their cervical passage. Paralysis of the left caudal laryngeal muscle leads to a condition, known as **"roaring"** in the horse.

The vagal trunk continues to the root of the lung, where it divides into **dorsal** and **ventral branches** which unite with their counterparts from the opposite side of the oesophagus to form the **dorsal** and **ventral vagal trunks**, respectively. The dorsal and ventral branches give off bronchial branches.

The dorsal and ventral vagal trunks pass through the oesophageal opening of the diaphragm and continue as the **abdominal vagus nerve**. Upon reaching the abdominal cavity, it spreads out to join the sympathetic fibres in the formation of a neural plexus responsible for the innervation of the visceral organs (▶ Fig. 15.83).

Accessory nerve (XI) (nervus accessorius)

The accessory nerve is also **part of the vagus group**. At its origin it consists of **motor fibres** only, but receives **sympathetic fibres** from the **cranial cervical ganglion**. It is formed by two roots (▶ Fig. 15.50, ▶ Fig. 15.57 and ▶ Fig. 15.58; ▶ Table 15.1). The fibres of the cranial root take their origin in the **caudal part of the nucleus ambiguus** of the medulla oblongata and leave the accessory nerve to join the vagus nerve.

The fibres of the spinal root have their cell bodies in the **nucleus of the accessory nerve** which is located in the cervical part of the spinal cord. These leave the spinal cord on the lateral aspect and combine in a trunk that runs along the spinal cord to enter the cranial cavity through the foramen magnum. The accessory nerve exits from the skull with the glossopharyngeal nerve and the vagus, through the jugular foramen. It divides in **ventral** and **dorsal branches** ventral to the wing of the atlas. The dorsal branch passes caudodorsally between the brachiocephalic and the splenius muscles to innervate the covering brachiocephalic (except the cleidobrachial muscle), the omotransverse and the trapezius muscles. The ventral branch innervates the sternocephalic muscle.

Hypoglossal nerve (XII) (nervus hypoglossus)

The fibres of the hypoglossal nerve originate in the **hypoglossal nucleus** of the **caudal medulla**. They emerge lateral to the pyramids and pass through the dura mater. Their combined trunk leaves the cranial cavity through the hypoglossal canal (▶ Fig. 15.57 and ▶ Fig. 15.58; ▶ Table 15.1).

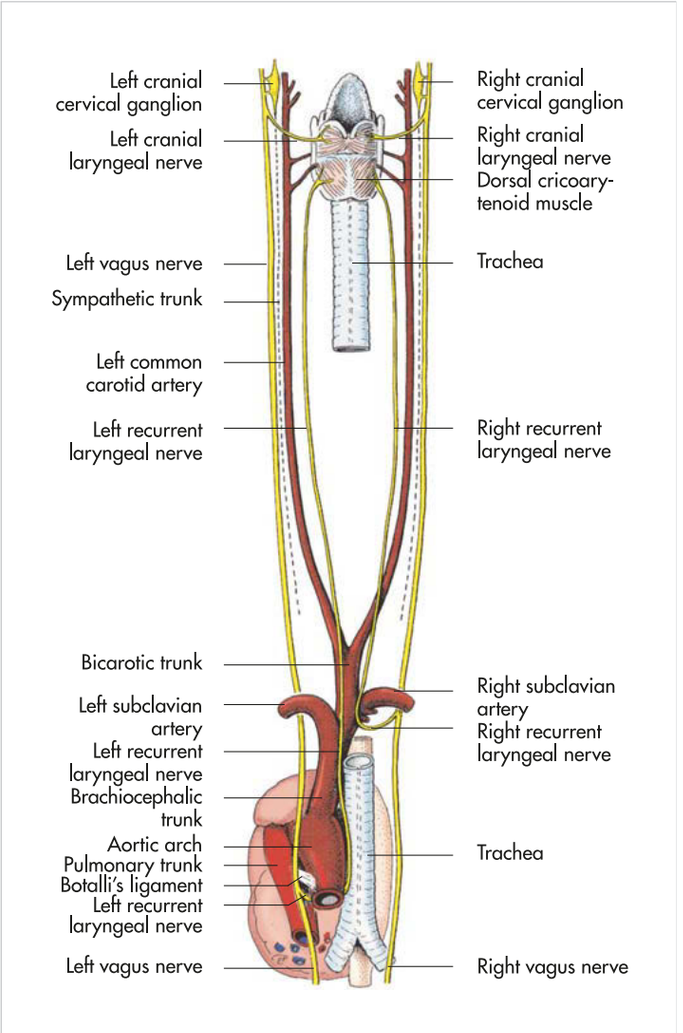

Fig. 15.59 Schematic illustration of the caudal (recurrent) laryngeal nerves of the horse; fig. based on data from Grau, 1974.

It passes rostrally between the vagus and accessory nerve to reach the tongue, where it divides into **deep** and **superficial branches**. It innervates both extrinsic and intrinsic muscles of the tongue.

In the horse, it passes through the medial compartment of the guttural pouch, in a common fold with the glossopharyngeal muscle. It crosses the internal carotid artery and runs parallel with the linguofacial trunk to the root of the tongue.

Clinical note

Infectious diseases or **idiopathic lesions** of the guttural pouch can lead to damage of this nerve and are characterised by **paralysis of the tongue**.

Table 15.1 Summary of the areas of innervation of the cranial nerves.

Nerve	Innervation		
	Motor	Sensory	Parasympathetic
Olfactory nerve (I)	–	Sense of smell	–
Optic nerve (II)	–	Sight	–
Oculomotor nerve (III)	Superficial levator muscle of eyelid and all the muscles of the eyeball apart from the dorsal oblique muscle of the eyeball and lateral straight muscle of eyeball	–	Ciliary muscle and pupillary sphincter muscle
Trochlear nerve (IV)	Dorsal oblique muscle of the eyeball	–	–
Trigeminal nerve (V):			
• **Ophthalmic nerve (V_1):** ◦ Lacrimal nerve ◦ Frontal nerve ◦ Nasociliary nerve	–	Eyeball, conjunctiva, skin in the eye region, olfactory mucosa, parts of the frontal sinus	By the facial nerve for the lacrimal gland
• **Maxillary nerve (V_2):**			
◦ Zygomatic nerve	–	Skin of the temporal and parietal region, lower eyelid	–
◦ Pterygopalatine nerve: – Caudal nasal nerve – Major palatine nerve – Minor palatine nerve	–	Mucosa of the nasal cavity, maxillary cavity, hard and soft palate	Fibres from the facial nerve for the lacrimal gland
◦ Infraorbital nerve	–	Teeth of the upper jaw, skin of the nose and upper lip	–
• **Mandibular nerve (V_3):**			
◦ Masticator nerve	Masseter muscle, temporal muscle,	–	–
◦ Medial and lateral pterygoideus nerve	Lateral and medial pterygoid muscle, tensor tympani muscle	–	–
◦ Buccal nerve	–	Buccal mucosa	Fibres from the glossopharyngeal nerve for the buccal glands, parotid gland
◦ Auriculotemporal nerve	–	Skin in the facial region	–
◦ Inferior alveolar nerve	Mylohyoid muscle and rostral part of the digastric muscle	Teeth in the lower jaw, lower lip	–
◦ Lingual nerve	–	First two-thirds of the lingual mucosa	Fibres from the facial nerve (chorda tympani) for the sublingual glands and mandibular gland
Abducent nerve (VI)	Lateral straight muscle of the eyeball, lateral quarter of the retractor muscle of the eyeball	–	–

Table 15.1 continued

Nerve	Innervation		
	Motor	Sensory	Parasympathetic
Facial nerve (VII):			
• Stapedius nerve	Stapedius muscle	–	–
• Caudal auricular nerve	Muscles for the pinna of the ear	Skin of the pinna of the ear	–
• Auriculopalpebral nerve	Muscles for the eyelids	–	–
• Cervical branch	Muscles for the skin on the neck	–	–
• Digastric branch	Caudal part of the digastric muscle	–	–
• Buccal branches	Facial muscles (mimic)	–	–
• Intermediate part (chorda tympani and major petrosal nerve)	–	Lingual mucosa	Lacrimal gland, glands of nasal and palate mucosa, sublingual gland and mandibular gland
Vestibulocochlear nerve (VIII)	–	Balance and hearing	–
Glossopharyngeal nerve (IX):			
• Pharyngeal branch	Caudal stylopharyngeal muscle, pharynx	Carotid body (glomus caroticum)	Parotid gland and buccal glands
• Lingual branch	Levator muscle and tensor muscle of soft palate	Caudal third of the tongue	–
Vagus nerve (X):			
• **Cranial part:**			
◦ Auricular branch	–	Skin inside of the pinna of the ear	–
◦ Cranial laryngeal branch	Cricothyroid muscle, larynx	–	–
◦ Depressor nerve	–	–	Cardiac plexus
• **Cervical part** connected to the sympathetic trunk			
• **Thoracic part:** ◦ Right caudal laryngeal nerve around the right costocervical trunk, left caudal laryngeal nerve around the aorta ◦ Dorsal vagal trunk ◦ Ventral vagal trunk	All laryngeal muscles apart from the cricothyroid muscle	–	Organs in the pectoral cavity
• **Abdominal part**	–	–	Organs in the abdominal cavity
Accessory nerve (XI):			
• Dorsal branch	Brachiocephalic muscle, trapezius muscle, omotransverse muscle	–	–
• Ventral branch	Sternocephalic muscle, cleidomastoid muscle, cleido-occipital muscle	–	–
Hypoglossal nerve (XII)	Lingual musculature	–	–

Sensible = conducting information about all types of stimuli from the peripheral (PNS) to the central nervous system (CNS), sensory = innervation of the senses (smell, sight, sound, touch, taste and balance).
The sympathetic innervation of several cranial organs is achieved via the cranial cervical ganglion.

15.2.3 Spinal nerves (nervi spinales)

The number of spinal nerve pairs in each section of the vertebral column corresponds to the number of vertebrae with the exception of the cervical spine and the tail. The first cervical nerve passes through the **lateral vertebral foramen of the atlas**, while the succeeding cervical nerves exit in front of the corresponding vertebra, and the last cervical nerve exits between the seventh cervical vertebra and the first thoracic vertebra, hence there are eight cervical spinal nerves for seven cervical vertebrae. In the coccygeal region, there are fewer nerves than vertebrae.

Each spinal nerve originates from the **spinal cord** with a **dorsal** and a **ventral root**. The two roots unite within the vertebral canal to form the spinal nerve. Close to the union of the two roots the dorsal root carries the spindle-shaped **spinal ganglion** which consists of the cell bodies of afferent, **pseudounipolar neurons** (▶ Fig. 15.60).

The **dorsal root** is composed of **afferent fibres**, while the **ventral root** is composed of **efferent motor** and **autonomous fibres**. The resulting mixed spinal nerve exits through the intervertebral foramen and divides almost at once into dorsal and ventral branches.

The **dorsal branch** (▶ Fig. 15.60) further divides into a **medial branch** for the innervation of the muscles of the back, that are located dorsal to the transverse vertebral processes and a **lateral branch** for the skin of the back. Cutaneous segments, which are innervated by a particular spinal nerve, are designated dermatomes. The **autonomous component** of their innervation is responsible for so-called **Head's zones**, where certain inner organs are projected onto the skin. The dermatomes of the more caudal spinal nerves extend further ventrally, while the extent of the cranial ones is restricted to the more dorsal parts of the body wall.

The **larger ventral branch** (▶ Fig. 15.60) innervates the muscles ventral to the transverse processes and the remaining skin, including the limbs. It usually divides into **two primary branches**, the first one arising in the middle of the abdomen and the second close to the linea alba. The ventral branches of the last three cervical vertebrae and the first two thoracic nerves form the **brachial plexus** that gives rise to the nerves of the forelimb. The last three lumbar nerves and the first two sacral nerves form the **lumbosacral plexus** of the hindlimb.

Cervical nerves (nervi cervicales)

The dorsal and the ventral branches of the cervical nerves communicate with each other to form the dorsal and ventral cervical plexus, respectively (▶ Fig. 15.60).

The **ventral branch of the first cervical nerve** joins the hypoglossal nerve in the **cervical loop** (ansa cervicalis), from which branches arise for the innervation of the long muscles of the hyoid apparatus: the sternohyoid, the sternothyroid and the omohyoid muscles.

The **ventral branch of the second cervical nerve** detaches the great auricular nerve (n. auricularis magnus), which joins the caudal auricular branch of the facial nerve in the innervation of the caudal part of the external ear.

The **ventral roots of the fifth** (cat: fourth) to **seventh cervical nerves** form the **phrenic nerve**, which runs caudally within the mediastinum to innervate the diaphragm.

The **supraclavicular branches** also arise from ventral branches and innervate the skin over the shoulder joint.

Brachial plexus (plexus brachialis) and nerves of the thoracic limb

The brachial plexus is usually formed by the ventral branches of the **sixth, seventh** and **eight cervical** and the **first** and **second thoracic spinal nerves**. It gives origin to the nerves that innervate the muscles and skin of the thoracic limb (▶ Fig. 15.68), parts of the shoulder girdle musculature and the lateral wall of the thorax and abdomen (▶ Fig. 15.61; ▶ Table 15.3 and ▶ Table 15.2).

Exceptions are the brachiocephalic, the omotransverse, the rhomboid, and the trapezius muscles and the skin over the upper shoulder region. These structures are supplied by the dorsal and ventral branches of the cervical and thoracic spinal nerves.

The **branches of the brachial plexus** are usually **mixed**, since the cerebrospinal fibres are joined by autonomous fibres from the stellate ganglion.

The plexus is located **cranial to the first rib** between the long muscle of the neck and the scaleni muscles. The roots of the plexus reach the medial aspect of the shoulder by passing between the middle and ventral portions of the scalenus. In carnivores the roots pass ventral to the middle scalene muscle. Several branches of the plexus have very restricted local distributions on the wall of the thorax and are of no clinical importance. These nerves will only be described briefly (▶ Fig. 15.61; ▶ Table 15.2):

- long thoracic nerve (n. thoracicus longus),
- thoracodorsal nerve (n. thoracodorsalis),
- lateral thoracic nerve (n. thoracicus lateralis),
- cranial and caudal pectoral nerves (nn. pectorales craniales et caudales) and
- subscapular nerves (nn. subscapulares).

Table 15.2 Summary of the innervation areas of the brachial plexus nerves supplying the lateral side of the thorax.

Nerve	Motor	Sensory
Cranial pectoral nerve	Superficial pectoral muscle, subclavian muscle	–
Caudal pectoral nerves	Deep pectoral muscle	–
Long thoracic nerve	Thoracic part of the ventral serrate muscle	–
Thoracodorsal nerve	Broadest muscle of back	–
Lateral thoracic nerve	Cutaneous muscle	Skin lateral on the thorax and covering the triceps muscle of the forelimb
Intercostobrachial nerve	Cutaneous muscle	Skin lateral on the thorax and covering the triceps muscle of the forelimb

Comment: the nerves of the brachial plexus contain motor, sensory and vegetative fibres.

König/Liebich, Veterinary Anatomy of Domestic Animals (ISBN 9783132429338), © 2020 Georg Thieme Verlag KG

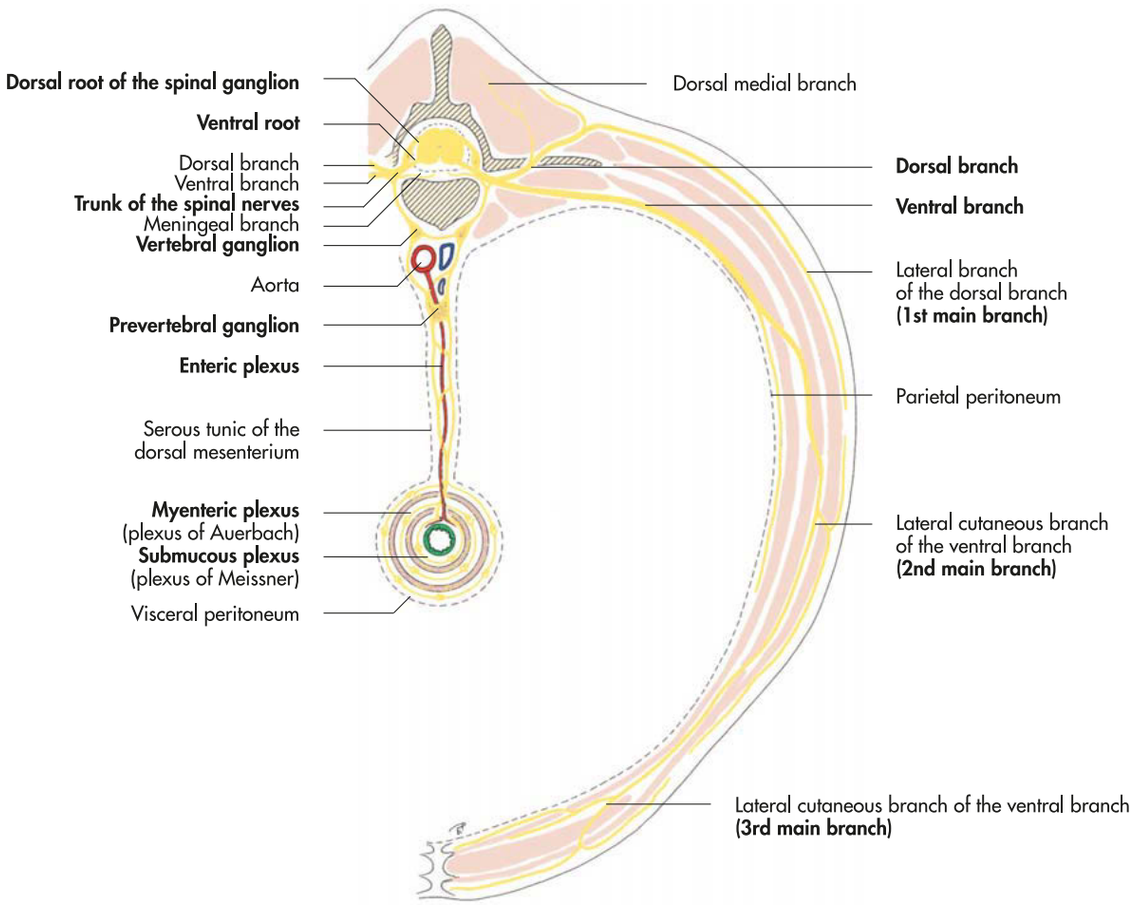

Fig. 15.60 Spinal nerve of the horse (schematic); fig. based on data from Grau, 1974.

The **long thoracic nerve** passes caudally on the lateral surface of the thoracic part of the ventral serrate muscle, which it innervates. The cervical portion of this muscle is supplied by cervical spinal nerves.

The **thoracodorsal nerve** arises from the last cervical spinal nerve, runs caudally, crosses the major teres muscle and branches out on the medial surface of the broadest muscle of the back, which it innervates.

The **lateral thoracic nerve** arises from caudal parts of the plexus (C8 and Th1) and passes along the broadest muscle of the back to innervate the abdominal part of the cutaneous muscle. Some of its branches unite with adjacent intercostal nerves to form the intercostobrachial nerve, which innervates the skin caudal to the triceps and over the ventral thorax and abdomen. Sensory fibres are contributed by the intercostal nerves.

The **cranial** and **caudal pectoral nerves** arise from the cranial part of the plexus and innervate the pectoral muscles. The cranial pectoral nerves innervate the superficial pectoral muscle and in ungulates the subclavian muscle. The caudal pectoral nerves pass caudoventrally to the deep pectoral muscle.

The **subscapular nerves** arise either as individual nerves or as a plexus from the cranial part of the brachial plexus. They innervate the cranial and middle part of the subscapular muscle.

Table 15.3 Composition of the most important nerves of the brachial plexus; table based on data from Habel, 1978.

Nerve	Ventral branch of the segmental nerves			
	C_6	C_7	C_8	Th_1
Suprascapular nerve	×	×	–	–
Musculocutaneous nerve	×	×	–	–
Axillary nerve	–	×	×	–
Radial nerve	–	×	×	×
Median nerve	–	–	×	×
Ulnar nerve	–	–	×	×

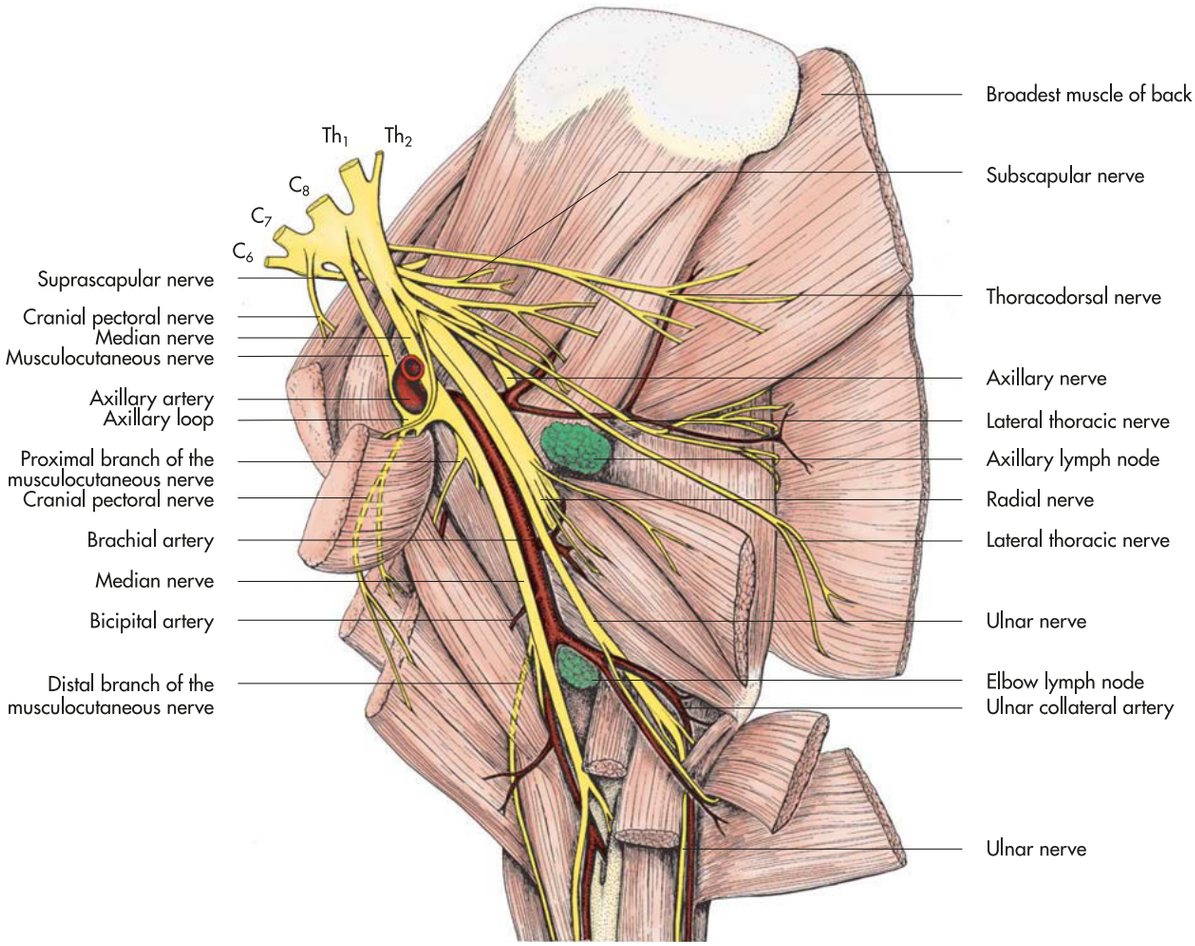

Fig. 15.61 Brachial plexus of the right thoracic limb of the horse (schematic, medial aspect).

The following **three nerves** have a relatively limited distribution, but are of considerable functional importance (▶ Fig. 15.61 and ▶ Fig. 15.65; ▶ Table 15.3 and ▶ Table 15.4):

- suprascapular nerve (n. suprascapularis),
- musculocutaneous nerve (n. musculocutaneus) and
- axillary nerve (n. axillaris).

Suprascapular nerve (nervus suprascapularis)

The suprascapular nerve passes between the subscapular and the suprascapular muscles to reach the cranial margin of the neck of the scapula, around which it winds to the lateral aspect of the bone, where it innervates the supraspinatus and infraspinatus muscles. Because of its close relationship to the bone, it is vulnerable to traumatic damage.

Clinical note

Paralysis of the suprascapular nerve usually results in atrophy of the muscles it innervates. In the standing animal, the shoulder is abducted and this becomes more pronounced during locomotion **("shoulder slip")**. The condition occurs most commonly in horses, in which it is clinically known as **"sweeney"**. It is usually caused by trauma, when the nerve is stretched against the scapula by over-abduction of the limb or violent retraction.

Musculocutaneous nerve (nervus musculocutaneus)

The musculocutaneous nerve arises caudal to the suprascapular nerve from the brachial plexus. It runs parallel to the median nerve, with which it joins in ungulates to form a **loop around the axillary artery** (**ansa axillaris**). In the proximal part of the humerus, it branches to form the proximal muscular branch, which passes cranially between the humerus and the coracobrachial muscle to innervate the latter and the biceps muscle. The musculocutaneous nerve divides again in the distal third of the upper

Fig. 15.62 Left forelimb of a cat, showing the radial nerve (lateral aspect).

arm to form the median nerve, which innervates the brachial muscle and the skin on the medial aspect of the antebrachium.

Clinical note

Lesions of the musculocutaneous nerve are uncommon but would paralyse the main flexors of the elbow. However, this could be compensated for by the radial nerve, which also contributes to the innervation of the brachial muscle. **Loss of sensation of the skin** on the medial aspect of the antebrachium will aid in the diagnosis of musculocutaneous nerve damage.

Axillary nerve (nervus axillaris)

The axillary nerve passes to the lateral aspect of the limb caudal to the shoulder joint. On the medial side, it innervates the teres major muscle and the caudal third of the subscapular muscle. It also innervates the capsular and teres minor muscles. It branches to innervate the deltoid muscle and gives off a branch to the cleidobrachial muscle. Its cutaneous branch reaches a subcutaneous position on the ventral border of the deltoid muscle and innervates the skin on the cranial aspect of the arm and antebrachium (▶ Fig. 15.61, ▶ Fig. 15.64 and ▶ Fig. 15.65).

The remaining **three nerves of the thoracic limb** extend from the brachial plexus all the way to the apex of the limb (▶ Fig. 15.61 and ▶ Fig. 15.65; ▶ Table 15.3 and ▶ Table 15.5):

- radial nerve (n. radialis),
- median nerve (n. medianus) and
- ulnar nerve (n. ulnaris).

Radial nerve (nervus radialis)

The radial nerve receives most of its fibres from the eighth cervical nerve. It is the **largest nerve** of the brachial plexus and has the **widest distribution**. It innervates all extensor muscles of the thoracic limb except those of the shoulder joint. It innervates the skin over the lateral aspect of the limb, extending from the antebrachium to the apex of the limb in all domestic mammals other than the horse, where it ends distal to the carpus (▶ Fig. 15.61, ▶ Fig. 15.62, ▶ Fig. 15.64 and ▶ Fig. 15.65).

The **radial nerve** runs distally, caudal and parallel to the brachial artery, before passing between the long and medial heads of the triceps muscle to follow the spiral groove of the humerus to the craniolateral aspect of the limb. On its course, it innervates branches to the extensor muscles of the elbow joint (triceps of the forelimb, anconeus, tensor of the antebrachial fascia). In the distal third of the humerus, it detaches its cutaneous branch (ramus cutaneus antebrachii) to the skin of the antebrachium.

Clinical note

Clinical signs of radial nerve paralysis depend on the **site of injury**. The more proximal the damage, the more severe the syndrome and the more grave the prognosis. **Avulsion of the brachial plexus**, seen in animals after car accidents, results in numerous neurological deficits, which rarely resolve. Damage to the radial nerve **proximal to the middle of the arm** usually results in paralysis of the extensors of the elbow, paralysis of the carpal and digital extensors and anaesthesia of the skin territory. The affected animal cannot fix its elbow joint, thus displaying a non-weightbearing lameness with dragging of the toes. Injury to the radial nerve in the **distal part of the radius** results in paralysis of the carpal and digital extensors (radial carpi extensor, ulnar carpi extensor, common digital extensor), and the affected animal knuckles over and tries to stand on the dorsal aspect of the toe.

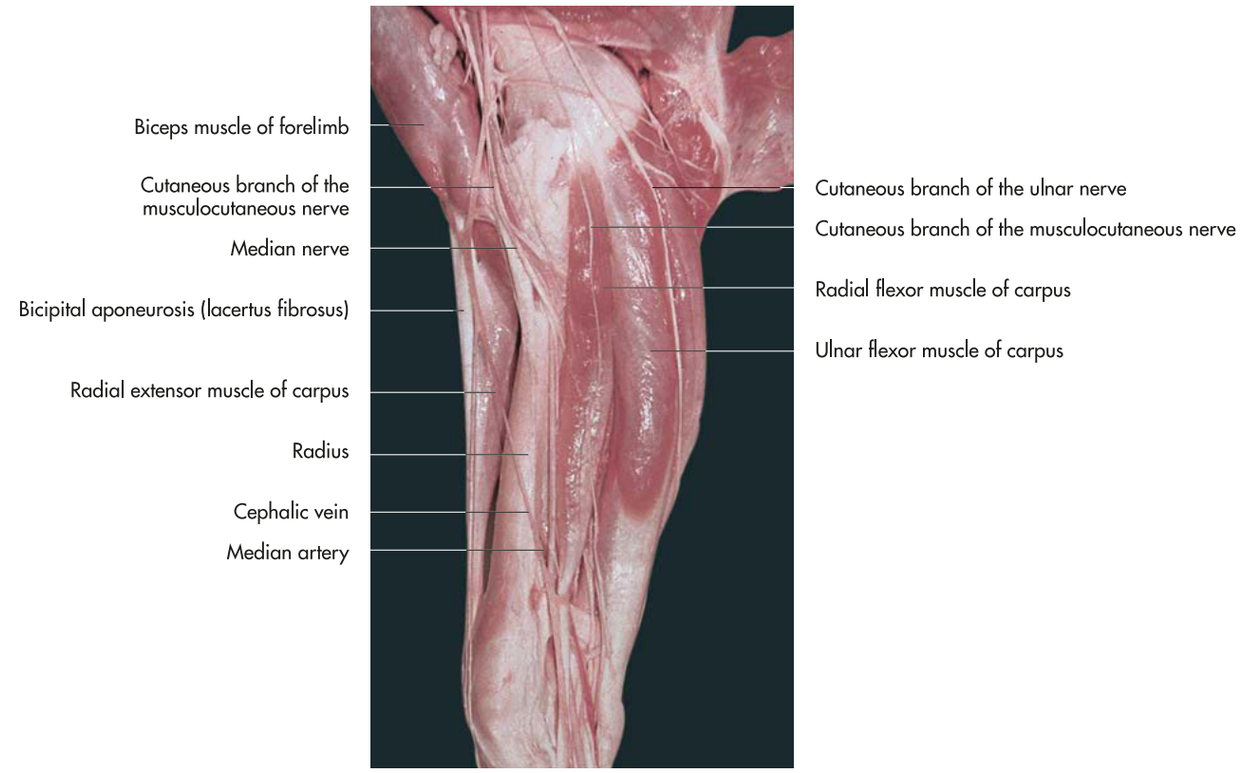

Fig. 15.63 Cutaneous branches of the right antebrachium of a horse (medial aspect). (source: courtesy of Dr. R. Macher, Vienna)

Median nerve (nervus medianus)

After its origin from the brachial plexus, the median nerve runs down the medial surface of the antebrachium. It combines with the musculocutaneous nerve to form a **loop around the axillary artery** (▶ Fig. 15.61). At the cranial aspect of the elbow joint, the median nerve passes laterally under the round pronator muscle to innervate the large caudal group of flexor muscles of the antebrachium. In the cat, it passes through the supracondylar foramen. It innervates the radial flexor muscle and the deep and superficial digital flexor muscles. Its distribution overlaps with that of the ulnar nerve. In the distal part of the antebrachium it divides into two or more branches, which descend through the carpal canal to innervate most of the structures on the palmar aspect of the distal limb (▶ Fig. 15.68).

Ulnar nerve (nervus ulnaris)

The ulnar nerve runs distally on the medial aspect of the antebrachium in close relation to the median nerve and caudal to the brachial artery. It passes caudally at the level of the elbow joint, running under the ulnar head of the ulnar flexor muscle to the ulnar groove on the caudal aspect of the antebrachium (▶ Fig. 15.61, ▶ Fig. 15.65 and ▶ Fig. 15.66).

Within the antebrachium, it detaches the caudal antebrachial cutaneous nerve to the skin on its caudal aspect. In the proximal part of the antebrachium, it branches to innervate the ulnar flexor muscle and the deep and superficial digital flexor muscles.

A **dorsal branch** arises proximal to the accessory carpal bone and passes dorsally to innervate the skin on the lateral surface of the distal limb. The narrow continuation of the ulnar nerve passes through the carpal canal and innervates muscles, skin and deeper structures of the digit. The distribution within the foot is closely related to that of the median nerve, with which it partly combines (▶ Fig. 15.66).

Table 15.4 Summary of the innervation areas of the brachial plexus nerves, supplying the proximal muscles of the forelimb.

Nerve	Motor	Sensory
Suprascapular nerve	Supraspinatus muscle, infraspinatus muscle	–
Axillary nerve	Flexors of the shoulder joint: • Deltoid muscle • Major teres muscle • Minor teres muscle • Cleidobrachial muscle	Skin on the front surface of the antebrachium
Subscapular nerves	Subscapular muscle	–
Musculocutaneous nerve	Coracobrachial muscle, biceps muscle of forelimb, brachial muscle of forelimb (in part)	Skin medial of the antebrachium

Comment: the nerves of the brachial plexus contain motor, sensory and vegetative fibres.

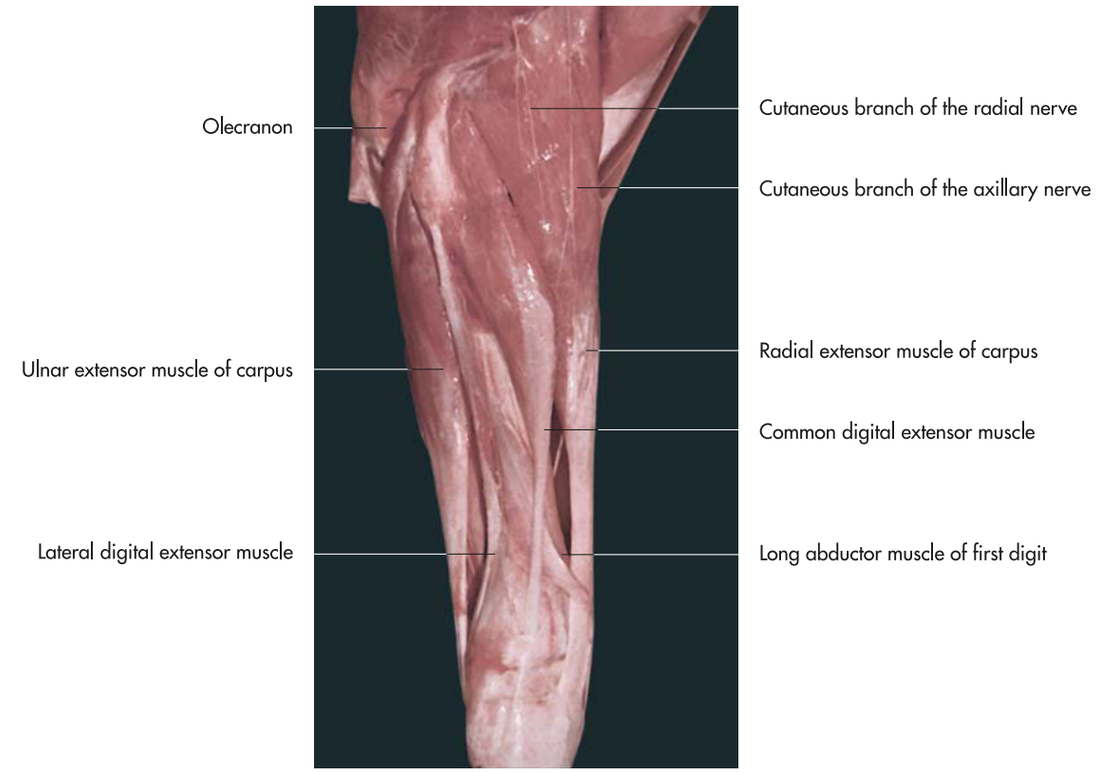

Fig. 15.64 Cutaneous branches of the right antebrachium of a horse (lateral aspect). (source: courtesy of Dr. R. Macher, Vienna)

Innervation of the distal limb

With the exception of the horse, each digit is supplied by **four nerves**, two dorsal and two palmar digital, see Chapter 20 "Topographical-clinical anatomy" (p. 685). The axial and abaxial dorsal digital nerves are terminal branches of the superficial branch of the radial nerve, with the exception of the dorsal digital nerves of the most lateral digit, which are branches of the ulnar nerve. The palmar digital nerves of the first, second and third digits arise from the median nerve, while those for the fourth and fifth digit to arise from the ulnar nerve (▶ Table 15.6).

Innervation of the distal limb of the horse

Most of the structures distal of the carpus are supplied by the **medial** and **lateral palmar nerves**, both of which are branches of the **median nerve**, and the **dorsal** and **palmar branches** of the **ulnar nerve**. The median nerve divides into medial and lateral nerves proximal to the carpus (▶ Fig. 15.65, ▶ Fig. 15.66 and ▶ Fig. 15.67). The lateral palmar nerve detaches a deep branch to the suspensory ligament at the level of the carpus.

Table 15.5 Summary of the innervation areas of the brachial plexus nerves, supplying the tip of the forelimb.

Nerve	Motor	Sensory
Radial nerve	All extensors of the forelimb except the shoulder joint muscles: • Triceps muscle of the forelimb • Anconeus muscle • Tensor muscle of antebrachial fascia • Brachial muscle of the forelimb (in part) • Radial extensor muscle of the carpus • Common digital extensor muscle • Lateral digital extensor muscle • Ulnar extensor muscle of the carpus (flexor) • Long abductor muscle of first digit • Brachioradial muscle • Supinator muscle	Skin lateral on the brachium and antebrachium
Median nerve	Radial flexor muscle, round pronator muscle, pronator quadratus muscle, deep digital flexor muscle (in part), superficial digital flexor muscle (in part)	Skin palmar on the metacarpus and the digits (with the ulnar nerve)
Ulnar nerve	Ulnar flexor muscle of the carpus, deep digital flexor muscle (in part), superficial digital flexor muscle, interosseous muscles	Skin caudal on the antebrachium, dorsolateral on the metacarpus and the digit (in part)

Comment: the nerves of the brachial plexus contain motor, sensory and vegetative fibres.

The **palmar branches** lie palmar to the metacarpal bone between the suspensory ligament and the digital flexor tendons. In the mid-metacarpal region the medial palmar nerve detaches a communicating branch that crosses over the superficial digital flexor tendon, where it is usually palpable, to join the lateral palmar nerve.

Table 15.6 Innervation of the joints of the forelimb.

Joint	Nerve
Shoulder joint	Axillary nerve, suprascapular nerve
Elbow joint and carpal joint	Median nerve, ulnar nerve
Fetlock joint and further digital joints	Palmar nerves, digital nerves

Just proximal to the metacarpophalangeal joint, the palmar nerves become the **medial** and **lateral digital nerves**, which pass distally, caudal to the like-named artery over the abaxial aspect of the proximal sesamoid bones. Both nerves detach **dorsal branches** at the level of the proximal and middle phalanges. Variations in their distribution pattern are common.

Clinical note

Local anaesthesia of these nerves plays a major role in the diagnosis of lameness. The nerves are sequentially blocked at different levels from distal to proximal to determine the location of the lesion.

Ventral branches of the thoracic nerves

The first two ventral branches of the thoracic spinal nerves contribute to the brachial plexus (▶ Fig. 15.65). Generally, the thoracic ventral branches form the intercostal nerves, which pass ventrally on the caudal aspect of the corresponding rib. The intercostal nerves innervate the intercostal muscles, the transversus thoracis muscle and the rectus thoracis muscle. The last five to ten ventral thoracic branches innervate the abdominal muscles. The ventral branch of the last thoracic nerve is referred to as the costoabdominal nerve. The ventral branches also detach branches to the mammary glands.

Lumbar nerves (nervi lumbales)

The number of lumbar spinal nerve pairs corresponds to the number of lumbar vertebrae: six in the horse, pig and ruminants and seven in the dog and cat. Similar to the other spinal nerves, they divide into **dorsal** and **ventral branches** shortly after their passage through the intervertebral foramen.

Each dorsal branch typically divides into **medial** and **lateral branches**. The medial branches innervate the muscles of the back dorsal to the spine, and the lateral branches arborize in the skin over the lumbar and rump region (▶ Fig. 15.69). The branches that innervate the rump are termed the **cranial clunial nerves** (nn. clunium craniales).

The **ventral branches** of the **lumbar spinal nerves** interconnect to form the **lumbar plexus**. Some authors describe the lumbar plexus as being formed by the ventral branches of all lumbar spinal nerves. However, the first three ventral lumbar branches exchange relatively few fibres and are described as individual nerves. The remaining ventral lumbar branches form the **lumbar plexus proper** (plexus lumbalis), which unites with the first and second sacral nerves in the **lumbosacral plexus** (plexus lumbosacralis) (▶ Fig. 15.70 and ▶ Fig. 15.71; ▶ Table 15.7 and ▶ Table 15.8).

Clinical note

The **ventral branches** of the **lumbar spinal nerves** are of considerable clinical importance, since they are often anaesthetised locally to facilitate abdominal and pelvic surgery. These nerves can be identified for injection by palpating the ends of the transverse processes and anaesthetising the nerve where it runs between the transverse and the internal oblique abdominal muscles.

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Table 15.7 Composition of the most important nerves of the hindlimb; table based on data from Habel, 1978.

Nerve	Ventral branches of the segmental nerves of the dog and cat				
	L_4	L_5	L_6	L_7	S_1
Femoral nerve	×	×	×	–	–
Obturator nerve	×	×	×	–	–
Fibular nerve	–	–	×	×	–
Tibial nerve	–	–	–	×	×
Nerve	**Ventral branches of the segmental nerves of the ox and horse**				
	L_4	L_5	L_6	S_1	S_2
Femoral nerve	×	×	×	–	–
Obturator nerve	×	×	×	–	–
Fibular nerve	–	–	×	×	–
Tibial nerve	–	–	–	×	×

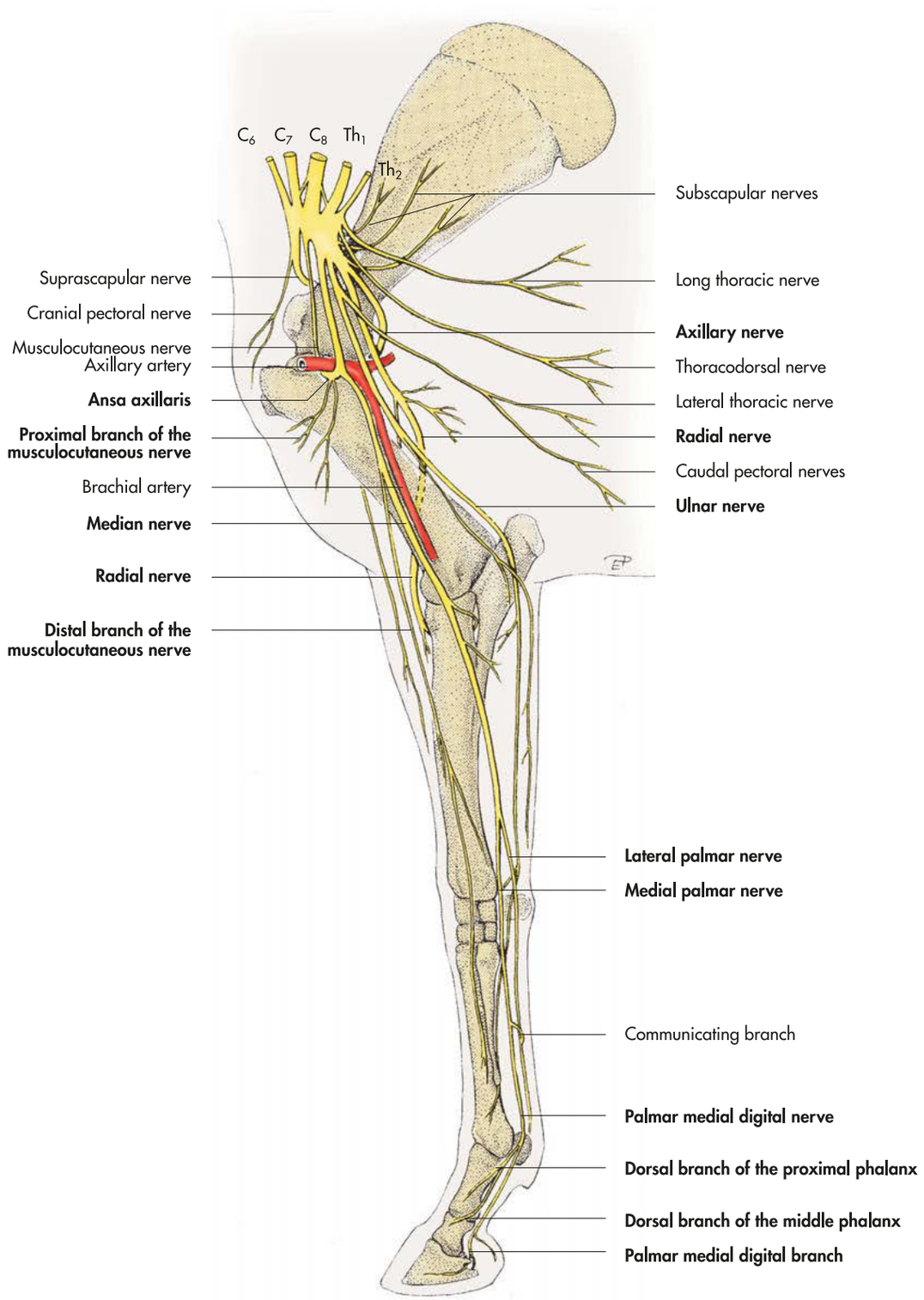


Fig. 15.65 Brachial plexus and its branches of the right thoracic limb of the horse (schematic, medial aspect); fig. based on data from Ellenberger and Baum, 1943.

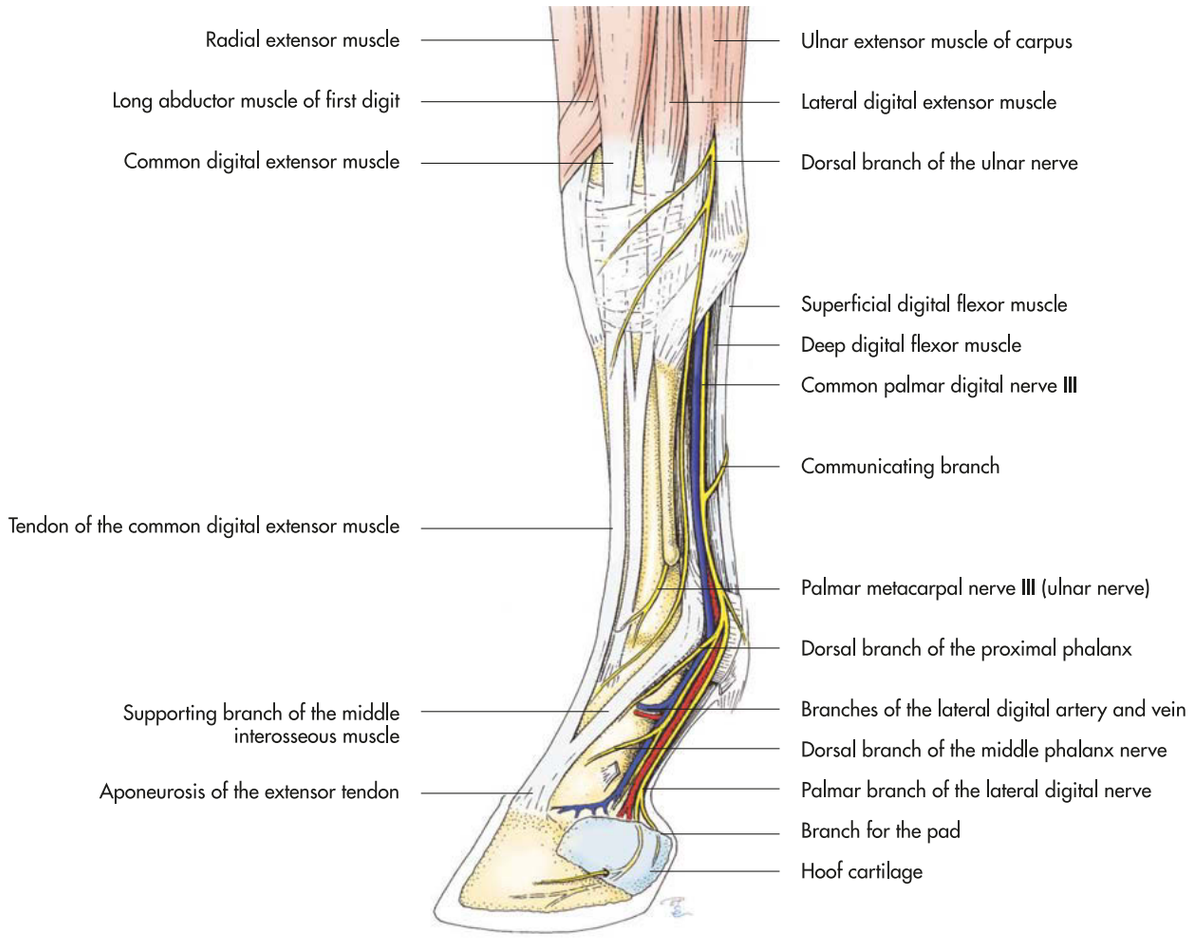


Fig. 15.66 Nerves of the left forefoot of the horse (schematic, lateral aspect).

The following individual nerves arise **from the lumbar plexus** (▶ Fig. 15.70; ▶ Table 15.7 and ▶ Table 15.8):

- iliohypogastric nerve (n. iliohypogastricus),
- ilioinguinal nerve (n. ilioinguinalis),
- genitofemoral nerve (n. genitofemoralis),
- lateral cutaneous femoral nerve (n. cutaneus femoris lateralis),
- femoral nerve (n. femoralis) and
- obturator nerve (n. obturatorius).

Iliohypogastric nerve (nervus iliohypogastricus)

The iliohypogastric nerve represents the primary ventral branch of the **first lumbar nerve** (▶ Fig. 15.70 and ▶ Fig. 15.71). It extends to a retroperitoneal position between the tip of the transverse processes of the first two lumbar vertebrae. In the cat and the dog, in which there are seven lumbar vertebrae, the first two ventral branches are known as the cranial and caudal iliohypogastric nerves.

Ventral to the transverse processes, the iliohypogastric nerve divides into lateral and medial branches. The **medial branch** passes to the inguinal region. The **lateral branch** passes between the abdominal muscles, which it innervates, and detaches two branches to the skin: the lateral cutaneous branch, which innervates a narrow band of skin caudal to the ribs, and the medial cutaneous branch, which innervates the skin over the ventral abdomen, the inguinal mammary glands and the medial side of the thigh, where it combines with the ilioinguinal nerve.

Ilioinguinal nerve (nervus ilioinguinalis)

The ilioinguinal nerve is the primary ventral branch of the **second (third in carnivores) lumbar spinal nerve** (▶ Fig. 15.70 and ▶ Fig. 15.71). Its branching pattern is similar to that of the iliohypogastric nerve. Its lateral cutaneous branch innervates a territory caudal to that of the iliohypogastric nerve, with which it overlaps.

Genitofemoral nerve (nervus genitofemoralis)

The genitofemoral nerve arises from the **third** and **fourth ventral lumbar branches**, the root of the third being larger than that of the fourth (▶ Fig. 15.70 and ▶ Fig. 15.71). It runs caudally between the inner lumbar muscles and reaches the inner inguinal ring together with the external iliac artery. Before leaving the abdomen, it detaches a branch to the internal oblique abdominal muscle. It passes through the inguinal canal with the external pudendal artery and vein.

It innervates the skin over the medial aspect of the thigh. It sends branches to the inguinal mammary glands and in the female cat and dog to the skin surrounding the vulva. It also con-

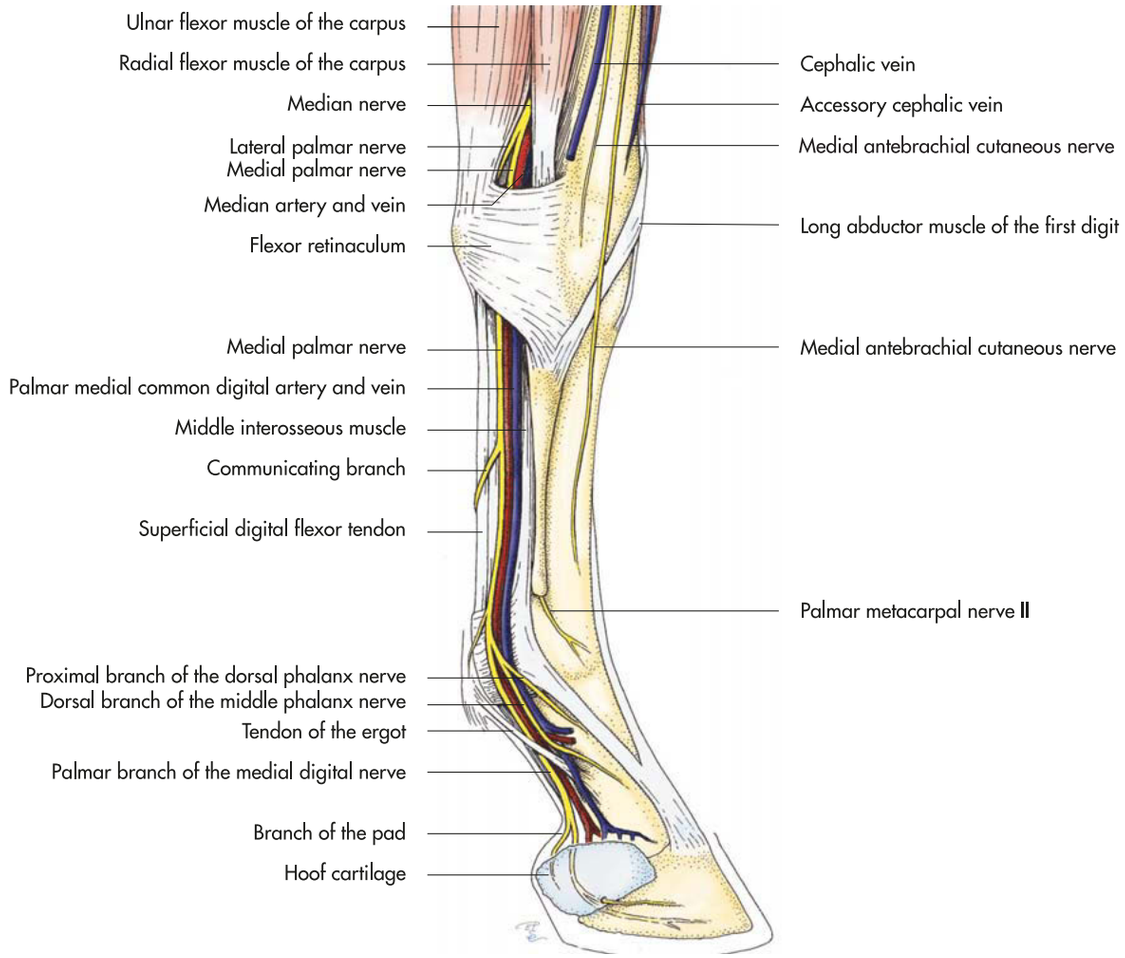


Fig. 15.67 Nerves of the left forefoot of the horse (schematic, medial aspect).

veys autonomic fibres that regulate milk flow during suckling. In the male, it innervates the prepuce and the scrotum.

Lateral cutaneous femoral nerve (nervus cutaneus femoris lateralis)

The lateral cutaneous femoral nerve is formed primarily by the ventral branch of the **fourth lumbar nerve** (▶ Fig. 15.71). It detaches branches to the inner lumbar muscles and accompanies the caudal branch of the deep circumflex iliac artery through the abdominal wall. It innervates the skin over the lateral aspect of the distal thigh and the stifle joint.

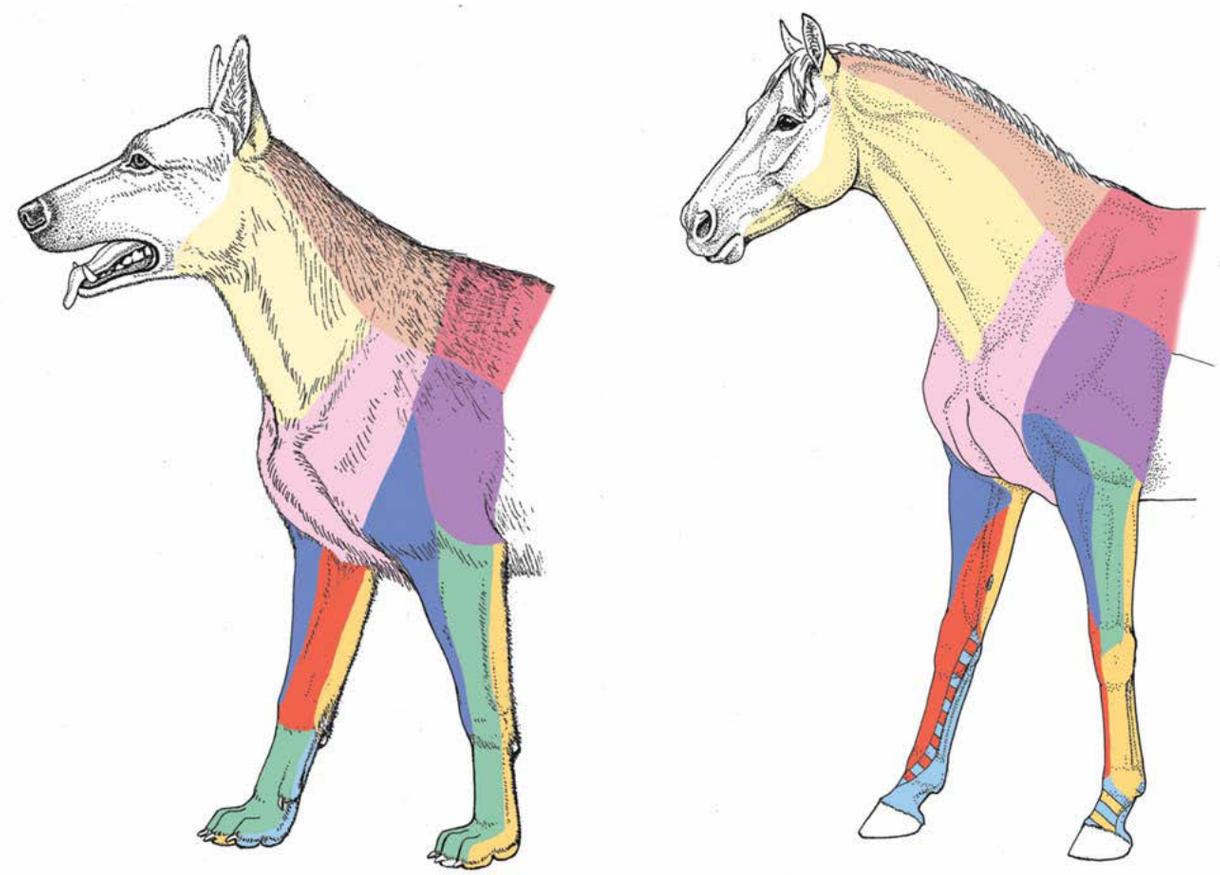
Femoral nerve (nervus femoralis)

The femoral nerve is a very large nerve which detaches branches to the inner lumbar muscles in its proximal portion (▶ Fig. 15.71). It continues caudally along the iliopsoas and greater psoas muscles and branches to form the saphenous nerve, which enters the femoral canal. The femoral nerve innervates all four heads of the quadriceps muscle. It passes adjacent to the pecten of the os pubis, where it is prone to mechanical damage. Over-extension of the quadriceps muscles, e.g. during recovery from anaesthesia or pelvic fractures, are the most common causes of femoral nerve injuries. Damage to this nerve leads to paralysis of the quadriceps, which prevents fixation of the stifle joint and renders the whole limb incapable of supporting weight.

The **saphenous nerve** (n. saphenus) forms muscular branches which innervate the sartorius, pectineal and gracilis muscles (▶ Fig. 15.71 and ▶ Fig. 15.74). It passes through the femoral canal cranial to the femoral artery. In the middle of the thigh, it reaches a subcutaneous position. At the level of the stifle, a small branch accompanies the descending genicular vessels to the stifle joint. The saphenous nerve continues distally, parallel to the like-named artery and the medial saphenous vein to innervate the skin over the medial aspect of the leg, extending from the thigh to the tarsus.

Obturator nerve (nervus obturatorius)

The obturator nerve (▶ Fig. 15.71) follows the medial aspect of the shaft of the ilium to reach the obturator foramen, through which it leaves the pelvis. It provides innervation to the adductor muscles of the pelvic limb. This group comprises the pectineal, gracilis and external obturator muscles. Because of its close relationship to bone, the obturator nerve is prone to injuries. Pelvic fractures and compression of the nerve during calving are most common causes.



Dorsal branches of cervical nerves
Ventral branches of cervical nerves
Drosal branches of thoracal nerves
Supraclavicular nerves
Axillary nerve
Intercostobrachial nerve
Radial nerve
Musculocutaneous nerve
Ulnar nerve
Median nerve

Fig. 15.68 Zones of the cutaneous innervation of the neck and thoracic limbs of the dog and the horse.