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# The Normal Anatomy of the Neck

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## Introduction

The neck is a common derived characteristic of land vertebrates, not shared by their aquatic ancestors. In fish, the thoracic fin girdle, the precursor of the scapula, coracoid and clavicle, is frequently fused to the caudal aspect of the skull. In contrast, as vertebrates emerged on to the dry land, the forelimb separated from the head and the intervening vertebrae specialised to form a relatively mobile region – the neck – to allow the head to be freely steered in many directions.

With the exception of the tail, the neck remains the most mobile region of the spinal column in modern-day horses. It permits a wide range of sagittal plane flexion and extension to allow alternating periods of grazing and predator surveillance, as well as frontal plane flexion to allow the horizon to be scanned, and rotational movement to allow nuisance insects to be flicked off. Among domestic animals the equine neck is relatively long and the head relatively heavy, and so the neck has become strong, muscular and massive. This is enhanced by the fact that regular, forceful movements of this region must also occur to maintain balance when horses are running [1]. However, the length and flexible nature of the neck may also cause problems in the passage of foals through the birth canal.

In this chapter I will briefly review the anatomy of bones, joints, ligaments and muscles of the equine neck. The 'locomotor component' of the neck is a common site of pathology, and the diverse forms of neck disease reflect the sometimes complex and conflicting regional variations and functional constraints so evident in this region [2].

Unlike the abdomen and thorax, there is no coelomic cavity in the neck, yet its ventral part is taken up by a relatively small 'visceral compartment', containing the larynx, trachea, oesophagus and many important vessels, nerves and endocrine glands. However, I will not review these structures, as they do not represent an extension of the equine 'back' in the same way that the more dorsal locomotor region does.

## Cervical Vertebrae 3–7

Almost all mammals, including the horse, possess seven cervical vertebrae, C1 to C7 (Figure 1.1). While C1 and C2 are extremely modified for their particular functions, C3 to C7 are more homogenous in structure. C3, C4 and C5 in particular are usually thought of as the 'typical' cervical vertebrae (Figure 1.2).

Vertebrae C3–C7 consist of an approximately cylindrical body or **centrum**, a structure present in all jawed vertebrates to resist longitudinal compression of the spinal column. The centra of the equine neck are the longest in the body, but become progressively smaller caudally. Those of C3–C7 possess a distinctively convex cranial surface, the **head**, and a correspondingly concave caudal

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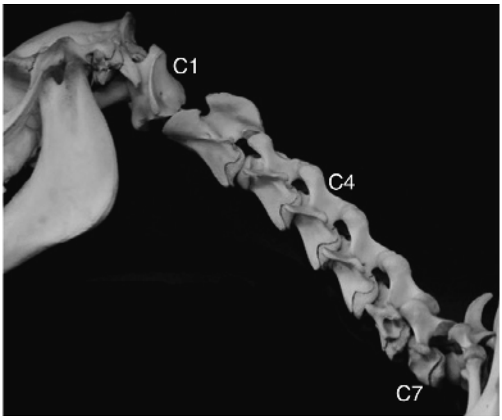


**Figure 1.1** Lateral view of an articulated osteological preparation of the neck of a young horse.

surface, the **fossa**. Thus the intervertebral joints, which are far more mobile than in the trunk, may be thought of functionally as ball-and-socket joints, although their constituent parts are very structurally different from those of synovial ball-and-socket joints.

Dorsal to the centrum is the **neural arch**, formed from bilateral bony **laminae**, which surrounds and protects the spinal cord and its associated structures. The **vertebral canal** formed by successive arches is relatively wide in the neck, especially cranially, to allow the spinal cord, which is wide in this region, to flex freely. The vertebrae C3–C7 each develop from three primary centres of ossification – one in the centrum and one in each of the two laminae. Formation of cervical neural arches, which are either statically or dynamically stenotic, is thought to be a cause of equine cervical 'wobbler syndrome' [3].

The centrum and arch are adorned with a variety of bony processes for the attachment of ligaments and muscles, and which often develop as secondary centres of ossification. These vertebral processes are a feature evolved by land vertebrates to permit complex movements in three dimensions and resist torsional forces.

a) The single dorsal midline **spinous process** is distinctively short in equine C3–C5.
b) In contrast, all equine cervical vertebrae bear a characteristically large **ventral crest**, often with a pronounced **caudal tubercle**.
c) The bilateral **transverse processes** are large but squat, and thought to incorporate vestigial ribs, sometimes yielding the name 'costotransverse processes'. In C3–6, the processes are bifid and slanted, with a cranial **ventral tubercle** and caudal **dorsal tubercle**. The transverse processes of C1–6 are perforated by a large **transverse foramen**, which conveys the vertebral artery and vein.
d) Lateral to the neural arch lie the large, irregular **articular processes**, with their smooth ovoid articular surfaces. The caudal facets are directed ventrolaterally, and the complementary cranial facets dorsomedially. Ventral to the caudal process lies a notch for passage of the laterally coursing spinal nerve.

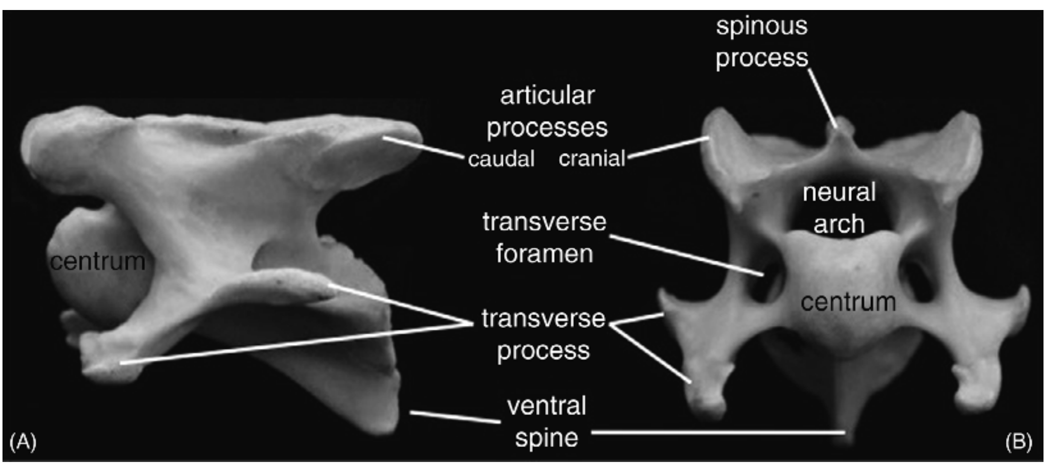


**Figure 1.2** (A) Lateral view of equine C4 vertebra and (B) cranial view of C5.

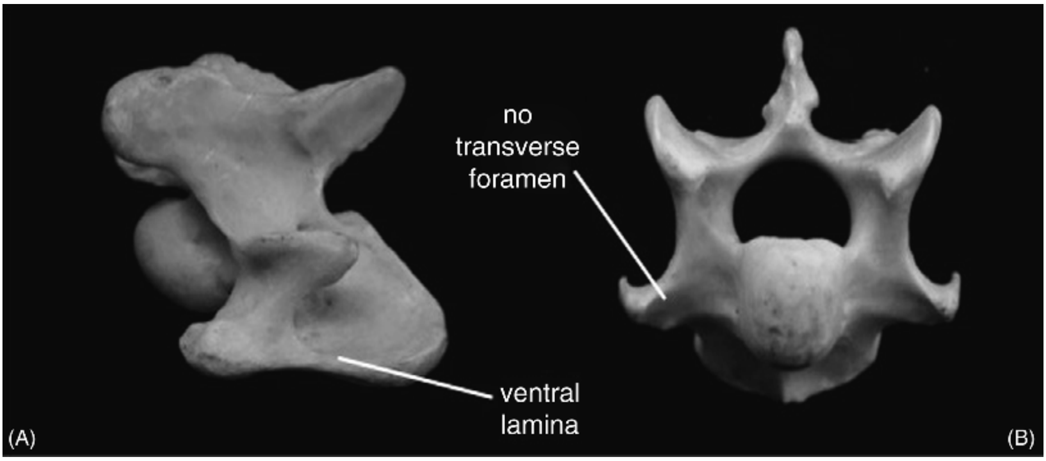


**Figure 1.3** (A) Lateral view of equine C6 vertebra and (B) cranial view of C7.

The sixth cervical vertebra (Figure 1.3) differs from its cranial neighbours in that it bears pronounced paired bony sheets, the **ventral laminae**, which act as a site of attachment and force redirection of muscles, especially longus colli. In the horse these laminae are elaborated into **cranial and caudal tubercles**. C6 also possesses a longer spinous process than C3, 4 and 5 – a reflection of a gradual transition to a more 'thoracic' morphology.

This trend continues in C7 (Figure 1.3), which has an even longer spinous process, non-bifid transverse processes, and no transverse foramen – the vertebral arteries arise too far cranially to pass through C7. However, C7 does possess a caudal notch for the passage of a spinal nerve, but it should be emphasised that the nomenclature of the spinal nerves in inconsistent. Unlike the rest of the body, cervical spinal nerves emerge *cranial* to the vertebra of the same number, and the nerves emerging caudal to vertebra C7 are named C8, even though there is no corresponding C8 vertebra. Finally, the centra of C7 caudally bear unconvincing **costal facets** for the articulation of the cranial extremities of the capitula of the first ribs [4].

## Atlas and Axis, C1 and C2

The anatomy of the caudal part of the axis, C2 (Figure 1.4), is similar to that of the more caudal cervical vertebrae – with centrum and neural arch formed from the same three centres of ossification, as well as the spinous process, ventral crest and tubercle, caudal articular facets and dorsal tubercle of the transverse process. However, the cranial part of the bone is markedly aberrant to allow the unique rotational, trochoid, 'head-shaking' movement of the atlanto-axial joint. Its unusual shape results from the incorporation of embryonic elements of C1.

A fourth primary centre of ossification, actually the annexed centrum of C1, forms the **dens** ('tooth') or **odontoid process** of C2. This cranially directed process is attached ventrally to the main centrum of C2 by a base formed from a further, secondary centre, which represents the cranial epiphysis of C2. The dens articulates closely with the ventral part of C1, and thus is smooth on its ventral surface, but is roughened dorsally with a midline gutter to allow attachment of stabilising ligaments. The smooth articular region of the dens is continuous with the large bilateral saddle-shaped **cranial articular surfaces**, which slide across reciprocal surfaces on C1 to allow rotation of the joint. These surfaces also develop from their own secondary ossification centres.

The axis contains a relatively large amount of trabecular bone compared to the other cervical vertebrae, and is also characterised by a large spinous process. Equine C2 is also distinctive in possessing bilateral foramina for the passage of the second pair of spinal nerves,

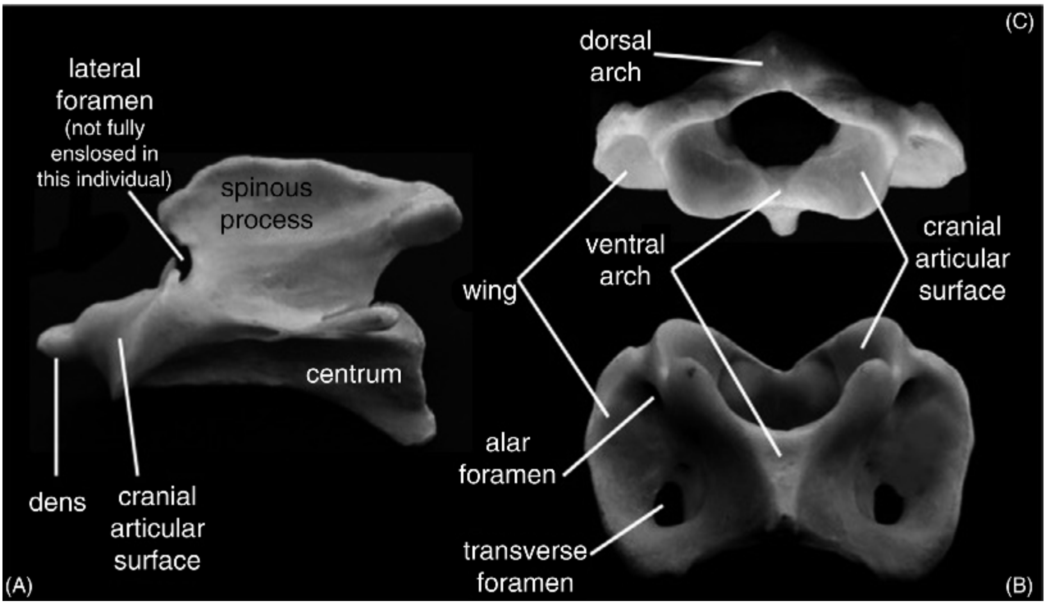


**Figure 1.4** (A) Lateral view of equine C2 vertebra, and (B) ventral and (C) cranial views of C1.

which do not emerge between adjacent vertebrae, as all the more caudal spinal nerves do. In some texts these are called 'intervertebral foramina', which seems illogical, so the name **lateral foramina** is perhaps preferable.

The atlas, C1 (Figure 1.4), is the most bizarre of all the vertebrae, due to it performing specialised movements with both the skull (sagittal plane flexion and extension/'nodding'/'yes' movement) and the axis (rotation about the long axis of the spine/'shaking head'/'no' movement).

The atlas has no centrum and no neural spine, but is instead constituted by one large hollow cylinder formed by **dorsal and ventral arches** of bone. The dorsal arch is equivalent to the neural arches of other vertebrae, but the thicker ventral arch is a unique structure probably derived from paired cranial epiphyseal developmental elements. The absence of a centrum means that, unlike C2, C1 contains an unusually low proportion of trabecular bone. The caudal part of the dorsal, internal surface of the ventral arch is the smooth **fovea dentis**, which articulates with the dens of the axis, whereas the more cranial 'floor' of the atlas is much rougher.

The equine atlas is relatively large compared to that of humans, but small compared to that of dogs. Attached laterally to the arches are the irregular **lateral masses**, which support the **caudal articular surfaces** as well as the wide, ovoid and profoundly concave **cranial articular surfaces**. Also attached laterally are the large modified transverse processes termed **wings** or **alae**. The wings, distinctively concave ventrally in the horse, form the attachment of several of the long and short muscles of the cranial neck, and also contain transverse foramina similar to those in C2–C6. The alar notches present on the cranial edge of the wings of the atlas in some species are entirely enclosed into **alar foramina** in the horse, and mark the tortuous course of the vertebral arteries [5,6]. A further, slightly medial foramen permits the entry of the artery into the vertebral canal as well as the exit of spinal nerve C1 and, as with the equivalent 'non-intervertebral' route taken by nerve C2 through the bony laminae of the axis, this is best termed the **lateral foramen**.

## Joints of the Neck

The articulations between C2, 3, 4, 5, 6 and 7 are similar to those found in the trunk region. Once labelled with the somewhat confusing name 'amphiarthroses', these intervertebral joints are best considered as compound joints each comprising two completely different forms of articulation.

First, the adjacent centra are bonded together by a single **intercentral joint**, a unique form of symphysis more often called an **intervertebral disc**. Each disc is interposed between two centra and contains two parts. An outer ring, the **annulus fibrosus**, consists of multiple layers of interwoven fibrous tissue with alternating diagonally oriented collagenous fibres that resist torsion and extension of the spine. The annulus becomes less fibrous centrally. Encircled by the annulus is the **nucleus pulposus**, an unusual admixture of fibrous tissue, gel-like matrix, and swollen cells derived evolutionarily and developmentally from the notochord. Indeed, small foveae in the centra often hint at the fact that the notochord once passed all along the body, piercing through longitudinal foramina in every centrum. However, the nucleus still retains its ancestral function, which is to resist compression. Disc disease may be rare in horses, although the age-related degeneration of their intervertebral discs has been little studied [7].

The second type of intervertebral articulation is formed by the bilateral **interneural joints (also known as articular process joints, or APJs)**, synovial diarthroses between the facets on the articular processes that lie lateral to the neural arch. These joints are more mobile in the neck than in the trunk, although their joint capsules are strong and fibrous.

The C1–C2 **atlanto-axial joint** is, as mentioned previously, an unusual trochoid or pivot joint. The dens and cranial articular surfaces of C2 articulate with caudal articular surfaces and fovea dentis of C1 by means of what is, in horses, a large single synovial joint capsule – there is no disc. The congruence of the articular surfaces is poor, and the centre of rotation is maintained just above the axis of the dens by a series of ligaments, discussed later.

The C1–skull **atlanto-occipital joint** is a specialised sagittal-plane ginglymus or hinge joint. The paired convex **occipital condyles** of the bilateral exoccipital skull bones form a good fit with the large concave cranial articular facets of the atlas, allowing rotation about a transverse axis – again, there is no disc. In all horses their joint initially consists of paired bilateral synovial spaces, although these may form a ventral interconnection in later life in some individuals [6]. Genetic congenital malformation of this joint has been reported in Arab foals [8].

## Ligaments of the Neck

The equine neck ligaments represent a modification, sometimes dramatic, of the ligaments present more caudally in the spine. This is due to not only the greater mobility in the region but also the constraints of supporting the large head.

The 'yellow', interlamellar or **interarcuate ligaments**, or ligamenta flava, are sheets of elastic tissue that span the space between adjacent vertebral neural arches. They contact the epidural space medially, the neck musculature laterally, blend with nearby synovial capsules, and each contain a gap via which spinal nerves may exit the vertebral canal. In the equine neck they are unusually extensive and flexible to allow movement.

The **dorsal longitudinal ligament** runs along the dorsal surface of the centra of all the cervical vertebrae, and thus along the 'floor' of the vertebral canal. It is narrower over the body of each centrum and then fans out to a wide attachment on the dorsal edge of each intervertebral disc. Notably, the **ventral longitudinal ligament** does not extend into the cervical region in the horse.

The **interspinous ligaments** are elastic in the equine neck to permit movement, but their small size reflects the diminutive nature of the spinous processes in this species. Intertransverse ligaments are not clearly apparent in the equine neck.

The **supraspinous ligament** is greatly elaborated in the equine neck into the extensive, strong, elastic **nuchal ligament** (Figure 1.5). The function of this ligament is to support the weight of the massive head and neck, and

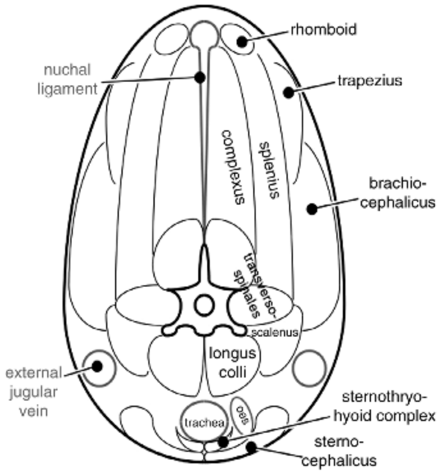


**Figure 1.5** Schematic midcervical transverse section of the equine neck, showing position of muscles.

to store elastic potential energy when the head is lowered to the ground to graze, so that energy may then be retrieved to lift it. The ligament is elaborated into two parts. The **funicular part** is a strong cord connecting the withers to the nuchal region of the skull, laterally compressed at its cranial end. The funicular part is equivalent to the nuchal ligament of the dog, although in that species it terminates on the axis. The nuchal ligament is actually constituted by paired bilateral components, and through much of the length of the funicular part these are separated by an almost invisible midline fibrous seam. Cranially, there may be a slight divergence of the two sides of the ligament. The **lamellar part**, which has no equivalent in the carnivores, consists of fibres radiating from the withers and funicular part to the spinous processes of C2–C7. Some consider there to be two subdivisions of the lamellar part: a thinner caudal division inserting on C7, C6 and C5, and a thicker cranial division inserting on C4, C3 and C2. The lamellar part does not constitute a complete sheet filling the space between the funicular part and the neck vertebrae, but leaves spaces, as well as areas where the ligaments may potentially abrade the spinous processes. At these points, there are often **bursae** interposed between bone and ligament. The most constant are those overlying C1 (**atlantal bursa**), vertebra T2 (**supraspinous bursa**), but less constant ones may also be found dorsal to C2 (**axial bursa**) and C3. These bursae may occasionally be sites of inflammation [9].

The specialised function of the C1–C2 or atlanto-axial joint has led to the development of an unusual array of ligaments. The elastic **dorsal atlanto-axial ligament** from the spinous process of C2 to the dorsal tuberosity of C1 may be seen as a localised adjunct to the nuchal ligament, whereas the more fibrous **ventral atlanto-axial ligament** presumably prevents extension of the joint. The transverse, alar and apical ligaments, which bind the dens to the atlas in the dog, are almost absent in the horse, and instead a thick **odontoid ligament**, a continuation of the dorsal longitudinal ligament, radiates cranially from the dens to attach on the cranial roughened area of the floor of the vertebral canal of the atlas. Finally, the atlanto-axial joint is also spanned by the strong **membrane tectoria**, a fibrous sheet running from the region of the dens to the internal surface of the axis, as well as the ventral rim of the foramen magnum of the skull itself.

The C1-skull or atlanto-occipital joint is also specialised. Its main ligamentar support is from the strong paired **lateral atlanto-occipital ligaments**, which pass from the wings of the atlas to the adjacent paramastoid surface of the skull. In addition the joint is enclosed by the thin **ventral atlanto-occipital membrane** and the stronger **dorsal atlanto-occipital membrane**, which contains thick fibrous strands in a cruciate arrangement [6]. Clinical access may be gained to the underlying cisterna magna of the subarachnoid space by passing a needle through this latter membrane and the underlying meninges [10].

## Muscles of the Neck

Most of the mass of the neck is made up of muscles that act to move the head and neck, the hyoid apparatus, the forelimbs or a combination of these structures. These muscles may be divided into two groups – the larger dorsal **epaxial muscles**, which act to extend the spine in the sagittal plane or flex it in the frontal plane if contracted asymmetrically, and the smaller ventral **hypaxial muscles**, which usually act to flex the spine sagittally [11]. A schematic midlevel cross-section of the neck muscles is given in Figure 1.5.

Some of the more dorsally and laterally positioned muscles probably act on the forelimb more than on the neck and head, but are mentioned here because of their origins in that region. These include the cranial portions of the **trapezii** and **rhomboids,** which insert on the scapula, the **brachiocephalicus,** which inserts primarily on the humerus, and the fibrous **serratus ventralis,** which slings the weight of the body on the forelimbs. The epaxial spinal muscles become larger and elaborated in the cervical region and take up most of the upper half of the horse's neck. The **transversospinalis** group continues into the neck as the complexus and multifidus muscles, as do the complex interleavings of the **longissimus** group, reaching as far as the skull. **Splenius** is also present in the horse, originating on vertebrae T3–T5 and inserting on the transverse processes of C1, C3, C4 and C5 and the caudal aspect of the skull. There are also short, specialised muscles in the cranial neck. The extensors are **obliquus capitis cranialis** (ventral wing of atlas to caudal skull), **rectus capitis dorsalis major** (spinous process of axis to caudal skull) and **rectus capitis dorsalis minor** (dorsal atlas to caudal skull), while **obliquus capitis caudalis** (spinous process of axis to caudal skull) is well aligned to act as a rotator. This profusion of smaller muscles attached to the atlas and axis explain why these vertebrae bear such expansive bony processes.

Some of the far-ventral hypaxial muscles do not warrant much mention in a book about the 'back'. These include the **sternocephalicus**, **omohyoideus** and the **sternothyrohyoid complex**. However, there are specific, although relatively small, spinal flexors in this region. One prime neck flexor is **longus colli,** which passes from the ventral surfaces of T1–T6 to the ventral tubercles of all the cervical vertebrae, running ventral to a bursa at T1 and the ventral laminae of C6. Another is **scalenus**, which originates on the first rib and inserts on the transverse processes of C1–C7. There is also the **rectus capitis ventralis major**, from the transverse processes of T3–T5 to the ventral skull, the **rectus capitis ventralis major** from the ventral atlas to the ventral skull, and the more laterally positioned but similarly short **rectus capitis lateralis** [12].

It is unclear to what extent these muscles are sites of pathology, especially as many of them are not amenable to direct clinical examination.

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