Anatomy of the Cervical Spine

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Michele D'Arienzo, Giovanni Peri,
Biagio Valentino, Antonella Conti,
Antonio D'Arienzo, and Daniele Peri

The vertebral column, or spine, consisting of a coordinated series of 33–34 vertebrae separated from each other by intervertebral disks, is divided in five segments or sections: cervical, dorsal, lumbar, sacral and coccygeal [1–7].

The cervical section is made up of 7 vertebrae, the thoracic section of 12 vertebrae the lumbar section of 5 vertebrae, the sacral of 5 vertebrae which are fused together and the coccygeal section is made up of 4–5 vertebrae.

Functionally, vertebrae form a single structure designed to maintain the upright posture and balance against the gravity, to allow the locomotion and every other kinetic movement in relation to forces applied and to resistance.

This is because the two basic requirements of the spine are rigidity, for the static efficiency and protection of spinal cord and spinal nerves, and flexibility for the kinematics of spine.

Spine consists of physiological curves, cervical and lumbar lordosis, thoracic and sacral kyphosis, which greatly increase the resistance to the stress of axial compressions compared to a rectilinear column (up to ten times).

The cervical section, "cervical vertebrae C1-C7", whose length varies from 15 to 16 cm in women and from 18 to 19 cm in men which 1/4 is represented by the thickness of the intervertebral disks, presents a lordodic mobile anteriorly convex curvature of about 36° that varies according to modifications of the other spinal curves and it's more accentuated in elderly.

The cervical segment supports the head allowing at the same time large freedom of movement and it also protects the upper section of spinal cord, vertebral arteries and cervical and brachial plexa.

Cervical vertebrae, according to their peculiarities, can be grouped in:

- Superior group made up by C1-C2 vertebrae
- Inferior group made up by C3-C7 vertebrae

So in the cervical spine a superior section and an inferior section can be recognized.

Superior Cervical Spine

C1 is also known as atlas and C2 as axis and they have different peculiarity from the other vertebrae.

Atlas is ring-like shaped and it's made of an anterior arch which have a median tubercle and

M. D'Arienzo, MD (✉) • A. Conti • A. D'Arienzo
Orthopaedics Department, University of Palermo, Palermo, Italy
e-mail: michele.darienzo@unipa.it

G. Peri • B. Valentino
Anatomy Department, University of Palermo, Palermo, Italy

D. Peri
Biomedical Engineering Department, University of Palermo, Palermo, Italy

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an anterior convex facet; It's also made of a posterior arch which consists of a median tubercle too and to lateral masses. It has no body and no spinous process.

Both of lateral masses presents a concave superior articular facet which articulates with occipital condyles and a flat inferior articular facet which articulates with the axis.

Medially, the lateral masses present a little rafe in which the atlas transverse ligament inserts and divides in two halves the vertebral foramen: one anterior half for the tooth ad a posterior half for the spinal cord.

Axis is the second cervical vertebra whose structure is similar to the other cervical vertebrae. The most distinctive characteristic is this strong conic process, called odontoid process or tooth which is placed vertically on the superior surface of the vertebral body presenting two articular facets, an anterior one and a posterior one.

This process, with its anterior articular facet, articulates with the articular facet of the anterior arch of the atlas and, with its posterior articular facet, with the atlas transverse ligament. Vertebral foramen is smaller than in the other vertebrae and it's triangular.

Inferior Cervical Spine

Inferior cervical spine is made up of five vertebrae (C3-C7) which have different morphogenetic characteristics that are similar to each other.

They consist of a smaller articular body developed in transversal direction. The body has also two faces, superior and inferior, and also has at the lateral extremities two rafes directed superiorly called spinosus processes.

Two pedicles are directed backward and transverse processes are located anteriorly. Each of these processes consists of two roots, an anterior one and a posterior one which are linked by a bony lamina.

On the base of the two transverse processes there is a hole, the transverse foramen. The transverse channel is made of all the transverse foramina and it's crossed by the vertebral vessels and by the vertebral nerve.

Articular processes, superior and inferior, are located posteriorly to the pedicles and articulate with the upper and lower vertebra. Superior articular process ends with an articular facet facing backward while the inferior one with an articular facet facing forward.

Spinous processes are short and bifid with the exception of the 7th cervical vertebra which it' called prominent whose spinous process is long and not bifid and palpable on the base of the neck and it's an important landmark if you are looking for upper and lower vertebrae. The 7th vertebra has also a smaller transverse foramen through which only the vein ad the transverse process passe.

Sixth cervical vertebra is characterized for the anterior tubercle of the transverse process which is more developed and prominent (Chassaignac tubercle): landmark for the common carotid (ligature), for the inferior tiroid artery and for the vertebral artery (Figs. 1.1, 1.2, and 1.3).

Cervical Spine Joints

Joints between vertebrae are made for making spine mobile.

Vertebrae which make up the different part of the spine have joints that allow to the different parts of spine different movements.

Two sections of cervical spine, "superior cervical spine", which includes occipital bone, atlas and axis and the "inferior cervical spine" which extendes from the inferior edge of the axis to the superior edge of the first thoracic vertebra, have different joints that functionally complete each others allowing movements like rotation, inclination, flexion, extension of the head.

The occipito-atlas joints realize flexion-extension movements on sagittal plane and inclination on frontal plane. They involve occipital bone condyles and the concave articular facets located on lateral masses of the atlas. These joints, defined condylartrosis, have two axis of movement and two grades of freedom. This joint is made of two bones and a fibrous capsule, covered

Figs. 1.1, 1.2, and 1.3 Sixth cervical vertebra is characterized for the anterior tubercle of the transverse process which is more developed and prominent (Chassaignac tubercle): landmark for the common carotid (ligature), for the inferior tiroid artery and for the vertebral artery

by a synovial membrane, which insert in the boundary of the occipital condyles and on the border of the superior articular facet of the atlas. The articular capsule medially is thin and lateral is thicker and it is enforced by the anterior atlas-occipital membrane which extends from the posterior edge of the foramen magnum to the superior edge of the posterior arch of the atlas.

The anterior atlas-occipital membrane has a fibrous band where origins the anterior longitudinal ligament and the posterior occipital membrane is crossed by the first cervical nerve and by the vertebral artery.

Between the occipital condyle and the atlas the first pair of spinal nerves emerge and they will form the cervical plexus.

This joint alone realizes almost the 50 % of the flexion and extension of the head involving for the rest the whole cervical section.

The atlas-axis joint is a diartrosis with no inter vertebral disk between C1 and C2. It's formed by the atlas, axis lateral joints atlas-axis medial joint and atlas-odontoid.

The lateral atlas-axis joint is a diartrosis of artrodia type and it's made by the inferior articular facets of the lateral masses which are slightly concave and by the superior articolar facets of the axis which are slightly convesse. The articular capsule is inserted on the lateral edges of the articular cartilagines and it's enforced anteriorly by the anterior longitudinal ligament and posteriorly by the yellow ligaments and postero medially by the accessorius ligament which arises from the posterior section of the body of the axis and insert on the posterior face of the lateral masses of the atlas.

The medial atal-axis joint is a pivot joint between the posterior facet of the anterior arch of the atlas covered by articular cartilage ad the articular facet of the odontoid covered also by articular cartilage.

The joint is stabilized posteriorly by a fibrous lamina, the "transverse ligament" which surrounds the tooth.

And extendes between the two lateral masses of the atlas realizing in this way a osteo-fibrous ring made anteriorly by the anterior arch of the atlas and posteriorly by the transverse ligament.

From the medial section of the ligament start some fibers that go up to insert on the basilar part of the occipital bone, superior longitudinal ligament, and down on the posterior face of the axis, inferior longitudinal ligament (Fig. 1.4) [9, 10]

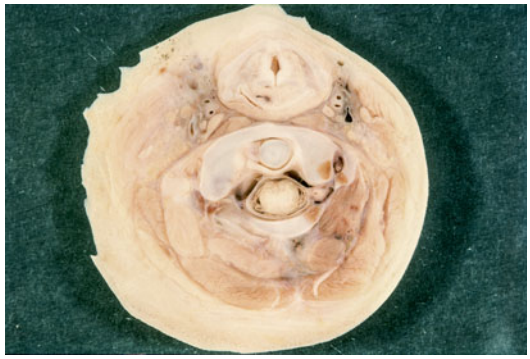


Fig. 1.4 From the medial section of the ligament start some fibers that go up to insert on the basilar part of the occipital bone, superior longitudinal ligament, and down on the posterior face of the axis, inferior longitudinal ligament

The articulation of the "inferior cervical spine" are artrodial joints and between the vertebral bodies intervertebral disks are present.

This section is specialized in flexion -extension movements and lateral flexion: lateral flexion is made by c3-c5 joint while flexion-extension by the C4-C6.

In the inferior cervical spine the joints have common features to the whole spine except sacrum. There are inter-somatic junctions between vertebral bodies esured by the presence of the intervertebral disk and the zigoapofisary joints between the superior articular processes of a vertebra and the inferior articular processes of the lower vertebra. The intersomatic joints are sinartrosis of sinfisys type which are made between the surface of the body of a vertebra and the inferior one of the body of the upper vertebra covered by ialine cartilage.

The shape of the disks is like the one of the vertebral bodies whose is in between and contribute on the flexion-extension movement and lateral flexion of this section and to form the cervical lordosis so the diskes are thicker anteriorly. Discs and vertebral bodies are united and stabilized by the anterior and posterior longitudinal ligaments.

The anterior longitudinal ligament is a fibrous tape which arises from the occipital bone and from th body of the axis and running in the inside of the vertebral channel, it inserts on the posterior surface of the vertebral bodies.

The intervertebral disk is made by a central part called nucleus polposus and by a peripheral part called annulus fibrous. Nucleus polposus is made by a deformable and incompressible gel made by mucopolysaccharides and water. Hydrophilic properties of proteoglycans depend on quantity and quality of mucopolysaccharides.

Idrophily of nucleus polposus determines vertebral resistance to mechanical loading whilst fibro-cartilaginous ring which it's made by anular fibres, allows flexion movements.

These structural features of disk are very important especially following spinal trauma because herniae of nucleus polposus into the specus vertebralis may happen with compression of nerve roots.

Zigoapofisary joints are artrodiae that allow movements of slipping between superior and inferior vertebral processes of two close vertebrae. Superior articular processes, covered by ialine cartilage, run up and backward whilst inferior one run down and forward and are covered by a thin articular capsule that ends on the edge of articular cartilage.

We distinguish:

Intrinsic Muscles of the *Cervical Spine*, *in which muscles have their attachment only* on the vertebrae:

- Interspinous muscles
- Intertrasversarii cervici muscles
- Multifidus muscle
- Short and long rotator muscles
- Semispinalis Capitis muscle
- Spinalis cervicis muscle
- Longissimus Cervicis muscle
- Longus cervicis muscle
- Inferior obliquus cervicis muscle

Extrinsic muscles, in which muscles have their insertion both in cervical spine and in other skeletal segments:

- Spinalis capitis muscle
- Semispinalis capitis muscle
- Longissimus capitis muscle
- Iliocostalis muscle
- Rectus capitis major and minor muscles

- Obliquus capitis superior muscle
- Rectus capitis anterior and lateral muscle
- Levator scapulae muscle
- Splenius capitis and cervicis muscles
- Serratus posterior superior muscle
- Rhomboideus minor muscle
- Trapezius muscle

Neck proprii muscles (excluding cervical spine):

- Suprahyoid muscles: digastric, stylohyoid, mylohyoid and geniohyoid
- **Infrahyoid muscles**: **omohyoid**, **sternocleidohyoid**, **sternothyroid and sternohyoid muscles**
- Sternocleidomastoid muscle
- Platysma muscle

Muscles in the head and neck realize movements of the head and the neck: flexion, extension, lateral deviation and rotation,

Different positions and features of insertion make these muscles can arrange different movements. Another job it's maintain, with the thoracic muscles, the standing of the head and neck.

Vessel Architeture

Artery Network

The neck blood supply is ensured by external carotid and by subclavian arteries [8].

Esternal carotid artery gives:

Occipital artery which surrounds the external edge of the mastoid process sliding under sternocleido-mastoideus muscle, longissimus capitis, latissimus capitis, splenius muscle and semispinalis muscle to end on occipital mucle; during walk borders on hypogloxal nerve which passes laterally and with accessorius nerve which stays medially.

Superior thyroid artery

Subclavian artery gives: vertebral arteries are originally located between scalenus anterior and longus colli then goes back and goes in to foramen trasversarius of the sixth cervical vertebra, then into transverse channel and arises from the hole of transverse process of atlas making a medially concave curve, then surrounds the lateral mass making a second curve anteriorly concave, then goes into the posterior occipito-atlas membrane, dura madre, arachnoids and finally crossing great occipital foramen reaches the cranium. The second curve is located in a triangle delimited from rectus capitis posterior and from obliquus capitis superior and inferior. At its origin artery comes close with inferior thyroid artery and with nerve and vessel of the neck which crossed it anteriorly. It' s also important that the artery comes close to spinal nerves at the beginning of intervertebral holes. In fact osteoarthritis of uncinate processes can compromise normal functions of both artery and nerve. During its course vertebral artery is divided in vertebra-medullary artery and posterior meningeus artery. Thyroid cervical trunk: we talk about one of its collateral branch: arteria cervicalis ascendent that come close with anterior scalenum and frenic nerve; from this artery muscular branches and vertebral-medullar branches arise; artery ends by third cervical vertebra. Costo-cervical trunk: we talk about one of its collateral branch: i.e. arteria cervicalis profunda. This artery goes between transverse process of 7th cervical vertebra and the neck of first rib to end in deep muscles of nape. Transverse artery of the neck is the outermost of the subclavia collaterals. It aries from the interscalenic portion and contributes with its branches to supply muscles of neck and nape ant supply the trunks of brachial plexus as well (Fig. 1.6).

Venous Network

Vnous network of neck is made superficially by anterior giugular veins system, posterior giugular veins system and external giugular veins system and deeply by venous trunks tireolinguofacialis of internal giugular veins and subclaviae veins.

Linfatic Network

Linfatic network is made up by a superficial linfatic network that receives afferents from superficial cervical lymph nodes and of a deep system that receives afferents from deep cervical lymph nodes.

Both superficial and deep system go to jugular trunk that on the right side ends in the junction of the internal jugular and subclavian veins, called the venous angle. On the left side it joins the thoracic duct.

Innervation

Innervation of cervical spine is pertinence of cervical plexus.

Cervical plexus is made up by the anasthomosys of ventral branches of the first four cervical nerves and by an anasthomotyc branch of fifth one that form some arches: the atlantoid arch, the axial and the cervical arches.

Plexus is located deeply and it's close to transverse process of cervical spine; it's near to the vessels and nerves in the neck laterally and to the deep lymphatic nodes of latero-cervical chain anteriorly, medially with glossopharingeus, vagus, accessorius, hypoglossal and with superior and medium cervical ganglia.

From cervical plexus arise:

Superficial branches that made up the superficial plexus; we talk about small occipital nerve that arises from C2-C3 and innerves the skin of the lateral portion of the occipital region.

Deep muscular branches that make up deep cervical plexus. We talk about discendent cervical nerve (C1-C2-C3) which is very close with the discendent branch of and f hypoglossal frenic nerve which is very close to the scalenus nerve. This is the place to find the frenic nerve to perform surgery.

Nerves of nape are represented by posterior branches of eight cervical nerves.

The first cervical branch, called suboccipital nerve is only a motor nerve. This nerve divides itself from the spinal trunk by the atlas reef for vertebral artery, then goes into the occiput triangle delimited by posterior magnus rectus capitis and obliquus superior and inferior capitis.

It also contributes to form cervical plexus with an anasthomotic branch which sends to C2: in the triangle this nerve is close to with one of vertebral artery branches.

The second branch arises from the second cervical trunk, posteriorly to the atlas-axis joint. This nerve, once reached the inferior edge of great obliquus muscle, divides in two branches, one more lateral and thinner, the other one ticker and more medial which distribute to muscles that are close to them. The medial branch, going up, ends in a gap between semispinal muscle and trapezium muscle. After going over the nucal line of insertion of the trapezium, become subcuticular and by the name of great occipital nerve (arnold's) is exclusively sensitive and ends in the skin of the occipital region, place that can hurt (nevralgia).

The 3rd branch arises from the 3d cervical trunk, right after it emerges from the coniugation hole, contributing with its branches to the innervations of nucal muscles.

The branches from 4th to 8th thinner than the others arise from the trunk by the exit from the coniugation hole. Then give a lateral motor branch and a medial mixed.

The medial branch of the 4th, after giving muscolar branches, goes up, goes into the splenium muscle and trapezium and as 3rd occipital nerve exclusively sensitive ends to the skin of the nape.

Nerve branches coming from the brachial plexus contribute also to innervate this region. The brachial plexus is made up by the last four cervical nerves, one anhastomotic branch of the 4th cervical nerve and an anastomotic nerve of the first thoracic nerve.

An important contribution to the innervations of the neck is given by some cranial nerves: by hypoglossal nerve which forms an anastomosys with the discontent cervical nerve. From this anastomosys branches for subdeltoidei muscles and accessories nerve arise.

This nerve during its walk seems to be in touch with the early cervical nerves, expecially with the first one.

This nerve, after arising from the jugular hole divides in an inner branch, which is in touch with the vagus nerve, and in an external branch that walking in oblique direction go down laterally backward. After it reaches the posterior face of the sternocleidomastoideus muscle it innerves

this one and continuing its walk in the upper clavicular region reaches the anterior edge of the trapezium where it ends.

Topographic Organization

Structural components of the neck are covered by a system of fasciae: the medial and deep superficial cervical fascia. These fasciae, being in touch with the structures they meet during their walk, contribute to form connectival spaces of the neck in which they receive the faringo-laringo.tracheal channel and the vascular space with nerve and vessels of the neck (carotid, internal jugular and vagus).

Fasciae of neck as they are disposed on different planes, allow to locate a succession of planes with particular for any region of the neck features.

In the antero- lateral region, beneath the cutaneous and subcuticular plane, two muscle fasciae planes and one muscle-bone plane can be found. The first one is made by the sternocleidomastoideus muscle and over-ioideum muscles surrounded by superficial fascia.

The second one is made up of omoioideum muscle and interioideum muscles covered by medial cervical fascia.

Muscle-bony plane is made up of prevertebral muscles: longus colli, rectus capitis anterior and rectus capitis lateralis and of scalene muscles covered by deep cervical fascia.

In posterior region of the nape, under skin and subcutaneus plane, four muscle-fascial planes and an osteo-fibrous plane can be found: the first one is made up by trapezium muscle covered by superficial cervical fascia, the second one is made up by spleni and levetor scapulae muscles and by superior fascia of rhomboid muscle and posterior dentatus; the third one is made up by three muscles which are orientated in longitudinal direction: longus colli in lateral position, longus capitis in intermedial position and semispinalis capitis muscle located medially. The fourth plane is made up by rectus posteriori and rectus oblique of the head and by cervical spine intrinseci muscles and finally the 5th plane is made up by the flake of the occipital bone and by the cervical spine with its junctions. This plane is in connection with the cervical part of the orthosympathetic system laterally near to the deep cervical fascia made by the sympathetic branches of cervical superior, medium and inferior ganglia. The cervical superior ganglius corresponds to the second cervical vertebra; the medium ganglius, which can be missing sometimes, corresponds to the 5th and 6th cervical vertebra, the inferior cervical ganglius, called star-shaped, corresponds to the 7th cervical vertebra and to the first thoracic vertebra.

From all these ganglia nerves which made visceral plexa of the neck arise:

The cervical superior ganglius correspone to the transverse processes of the second and third cervical vertebra, laterally to the faringe, anteriorly to the longus capitis muscle and posteriorly to the vessels and nerves of the neck.

The medium cervical ganglius and the star-shaped ganglius contribute to the built of the ansa of Vieussens around the subclavia (Figs. 1.4 and 1.5).

Vertebral channel

Across the osteo-fibrous plane the neural space that contain the spinal cord and its cover membrane can be reached.

One of the ways to access the vertebral channel is the laminectomy. Across this the neural space delimitated by osteofibrous walls can be reached.

From the inside to the outside we can see:

The epidural space which is closed cranially from the fusion of the dura madre with the periostium which surrounds the occipital hole, and caudally from the sacral-coccygeal ligaments that close the sacral iatus.

In the epidural space the roots of the spinal nerves with vessels and epidural nerves run. The epidural adipose tissue spreads around the dural sac and accumulates on lateral and posterior parts where the epidural space is wider.

Dura mater is a very strong fibrous membrane that extends like a cilindric sac from the occipital hole to the second sacral vertebra where it ends in the dural cone which continues in the filum terminalis that inserts on the coccyx.

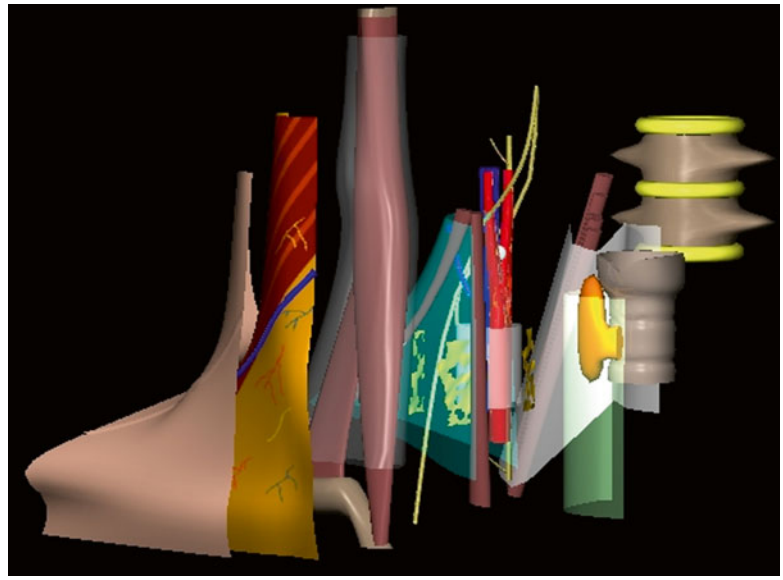


Fig. 1.5 From the skin, progression of the anatomical structures around cervical spine

Arachnoid is a thin membrane that it's modeled on the inner face of the dural sac and it's separate from that by a tiny virtual space (subdural space). Arachnoid delimitates on the inside the subarachnoid space which is the space between the aracnoid and the pia mater and it's extendend for all the length of the spinal cord.

Sub aracnoide space is filled with an amount of fibrous filaments where vessels run each others. This space contains cerebrospinal fluid and it's crossed by the roots of the spinal nerves which are separate from the denticolar ligaments.

Pia mater is a very thin fibrous membrane that covers the spinal cord: from there the denticular ligaments and the anterior and posterior septa arise. Pia mater is close with the epinervium of the spinal nerves and it's rich of blood vessels, linfatic vessels and sentitive nerve terminations which also arises from sensitive corpuscles.

The spinal cord is divided in neuromeres that correspond to the origin of a couple of spinal nerves roots that made the spinal nerve which is covered by dura mater, run into the intervertebral hole.

Spinal cord peripherally is made up by fascia of mielinic nerve fibers which are organized in anterior, lateral and posterior cords that are delimitated by the median, anterior and posterior split and by the lateral, anterior and posterior grooves.

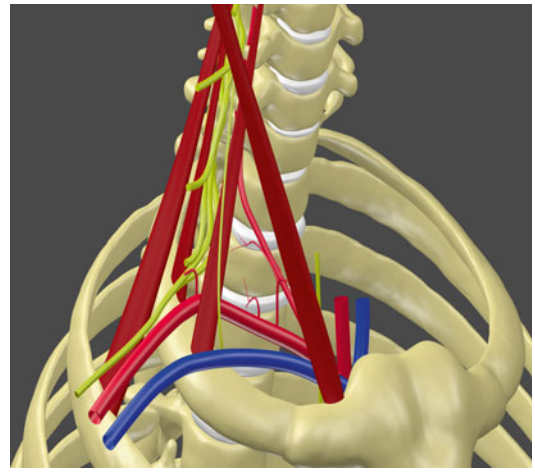
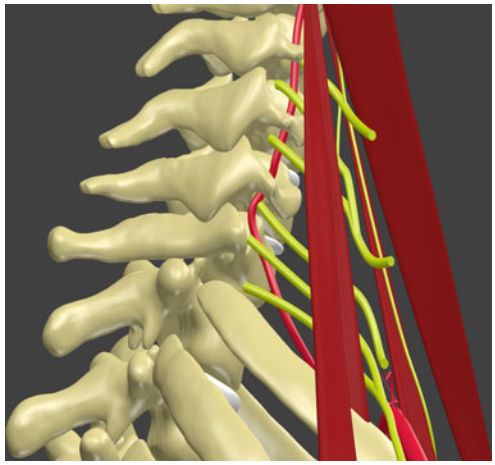
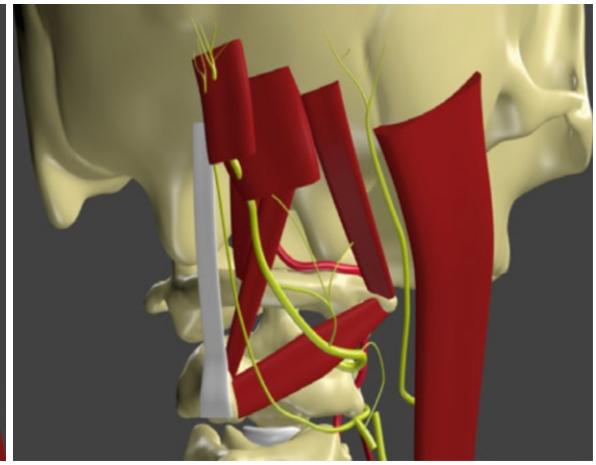


Fig. 1.6 Transverse artery of the neck is the outermost of the subclavia collaterals. It aries from the interscalenic portion and contributes with its branches to supply muscles of neck and nape ant supply the trunks of brachial plexus as well

Centrally the spinal cord presents the neural component organized in two symmetric lateral masses that are linked centrally by the grey commissure which is crossed by the central channel or ependymal channel.

Two lateral masses present an anterior territory that contains motor neurons and a posterior nerve that contain sensitive nerves.





Figs. 1.7 and 1.8 Brachial plexus, subclavia artery and dorsal scapular arteries

In the thoracic-lumbar section there is a lateral protrusion that contains neurons of the simphatethic system.

Cervical cord in C4-T1 presents a conic bump flat in anterior-posterior direction in which is located the brachial plexus. In this place the anterior corn is larger than the other on top and the posterior horn is thinner that the one on top of it (Figs. 1.3 and 1.4) [9, 10].

Dissection Anatomy

When you make a dissection or perform surgery on the muscle-fascial planes of the neck, you must pay attention, when skin and underlying plane are prepared, to the third occipital nerve, to the great occipital and to the occipital artery that appear on the top of the trapezium muscle: when you arrive on the second and the third plane in the space between the trapezium and splenium you must be careful to the small occipital nerve which it's located laterally to the splenium muscle and to the third occipital nerve which it's located laterally to the nucal ligament. In this space the great occipital nerve and the occipital artery can easily seen between the splenium capitis muscle and semispinalis capitis.

When the underlining plane is prepared attention must be payed to the vertebral artery, the suboccipital nerve and the dorsal root of the second cervical nerve with its ganglium, another space that must be attentioned is that one located between the trapezium and the elevator of the scapula where the vascular pedicle and the accessories nerve run.

Finally, when scalenic muscles are prepared attention must be payd to the trunks of brachial plexus, subclavia artery and dorsal scapular arteries (Figs. 1.6, 1.7 and 1.8).

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