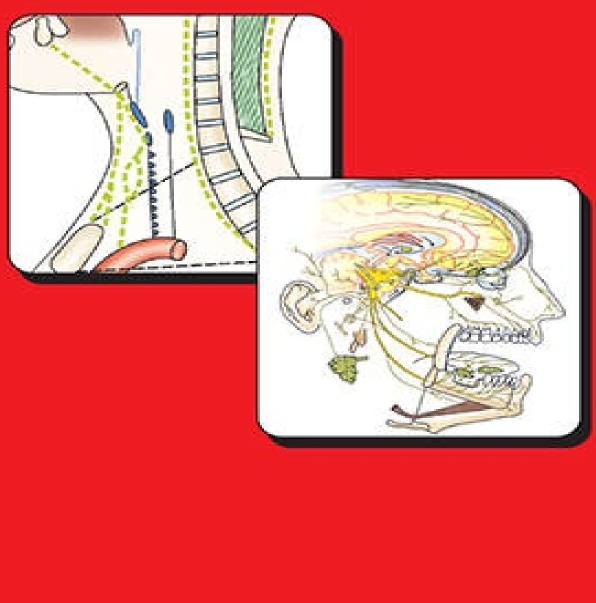
Companion Pocketbook
for quick review

B D Chaurasia's

HUMAN ANATOMY

Head and Neck, Brain

Volume 3



Krishna Garg

CBS Publishers & Distributors Pvt Ltd

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HUMAN ANATOMY

Head and Neck, Brain

Volume 3

Companion Pocketbook volumes

Volume 1
Upper Limb and Thorax

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Volume 3
Head and Neck, Brain

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Volume 3

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Preface

BD Chaurasia's Human Anatomy has been doing well for a few decades. The three volumes have steadily been enlarging to accommodate gross anatomy, histology, embryology and detailed clinical anatomy. Numerous colour line diagrams support the text of gross, surface and clinical anatomy. Because of its size, it is difficult for the students to revise the volumes prior to their class tests and examinations. This gave us the idea of bringing out a pocketbook based on each volume, giving only "must know" of anatomy. Each pocketbook is almost one-third the size of the main volume containing exclusively the essential components.

The pocketbook is no replacement for the main volume. It is just a complementary book for quick last minute revision of the "volatile anatomy". The illustrations given in the pocketbook are aimed at helping the students review the topics easily as well as retaining and reproducing the information clearly in their examinations. Dissection, clinicoanatomical problems, multiple choice questions, mnemonics, CD containing videos of soft parts and hard parts and questions-answers have not been included in the pocketbook. Knowledge of anatomy and its clinical aspects are provided with equal intensity in the pocketbook. Pocketbook is chiefly meant for first professional undergraduate students. It could be a further help to the students during their clinical postings as they can comfortably keep it in their apron pockets.

Section I of this volume contains the foramina of skull bones with their contents. Scalp, face, lacrimal apparatus, and deep cervical fascia with its extensions are described briefly. The boundaries and contents of posterior triangle of neck, suboccipital triangle and anterior triangle of neck are enumerated. Contents of vertebral canal and cranial cavity including cavernous sinus are mentioned. The three salivary glands, thyroid, and the parathyroid glands are briefly described. Muscles in the orbit, muscles of mastication of palate, pharynx, larynx and tongue are tabulated. Various viscera of the neck like mouth, pharynx, the tonsil, palate, nasal cavity, larynx, tongue, ear and eye are described. **Appendix 1** contains sympathetic trunk and four parasympathetic ganglia. Arteries of head and neck are shown in tabulated form. Clinical terms are given.

Section II of this volume contains a brief introduction of brain and tables of folds of dura mater and ascending and descending tracts of spinal cord. All the cranial nerves have been put in one chapter including their clinical anatomy as these are of importance throughout the clinical period. Various sections of components of brainstem are given. Cerebellum and ventricles are described briefly. Cerebrum with its sulci and gyri, functional areas, diencephalon, internal capsule are tabulated with their clinical importance. Blood supply of spinal cord and brain is mentioned. **Appendix 2** comprises nuclear components of cranial nerves, arteries of brain and clinical terms.

I am highly obliged to Prof Ved Prakash, Prof Mohini Kaul, Prof Indira Bahl, Prof NA Faruqi, Prof SN Kazi, Prof Suvira Gupta, Dr Kiran Vasudeva, Dr PS Mittal, Dr Neeraj Master, Dr Azmi Mohsin, Ms Surbhi Garg and other colleagues for sharing their wealth of knowledge and experience.

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About the Book

B D Chaurasia's Human Anatomy has been serving the interests of medical students as the most popular textbook because of the simplicity of its text, lucidity of expression, clarity of discussion and remarkably vivid detailing in the illustrations, making human anatomy most comprehensible to learn. The three volumes have steadily been enlarging to accommodate gross anatomy, histology, embryology and detailed clinical anatomy. Numerous colour line diagrams support the text of gross, surface and clinical anatomy. Because of the size, it is difficult for the students to revise the volumes prior to their class tests and examinations.

The COMPANION POCKETBOOKs on the volumes have been designed and brought out giving only the essential components highlighting "must know" of anatomy. Content of each pocketbook is almost one-third the size of the main volume, meant mainly for quick last minute revision of the "volatile anatomy". The illustrations are aimed at helping the students review the topics easily as well as retaining and reproducing the information clearly in their examinations. Clinical aspects are induded with equal intensity. Mainly meant for first professional undergraduate students, they could also use these for quick reference during their clinical postings.

HIGHLIGHTS OF VOLUME 3

Section I contains the foramina of skull bones with their contents. Scalp, face, lacrimal apparatus, and deep cervical fascia with its extensions are described briefly. Boundaries and

contents of posterior triangle of neck, suboccipital triangle and anterior triangle of neck are enumerated. Contents of vertebral canal and cranial cavity including cavernous sinus are mentioned. The three salivary glands, thyroid, and the parathyroid glands are briefly described. Muscles in the orbit, muscles of mastication of palate, pharynx, larynx and tongue are tabulated. Various viscera of the neck like mouth, pharynx, the tonsil, palate, nasal cavity, larynx, tongue, ear and eye are described. **Appendix 1** contains sympathetic trunk and four parasympathetic ganglia. Arteries of head and neck are shown in tabulated form. Clinical terms are also given.

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Dr Garg Is the editor of *BD Chaurasia's Human Anatomy* 5 edn (Volumes 1-3), *BD Chaurasia's Human Anatomy for Dental Students* 2 edn, *B D Chaurasia's Handbook of General Anatomy*, and *B D Chaurasia's Human Embryology*, is the coauthor of *Textbook of Histology*, *Textbook of Neuroanatomy*, and *Anatomy and Physiology for Nurses*; and has produced CDs containing videos on osteology and soft parts including frequently asked questions, accompanying the *BDC's Human Anatomy* volumes and *Human Anatomy for Denial Students* 2 edn.

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1. Osteology of Head and Neck

Bones of the Skull

The skull consists of the 28 bones which are named as follows.

The calvaria or brain case is composed of 14 bones including 3 paired ear ossicles.

Paired		Unpaired
1. Parietal		1. Frontal
2. Temporal		2. Occipital
3. Malleus	Described in Chapter 18	3. Sphenoid
4. Incus		4. Ethmoid
5. Stapes		

The *facial skeleton* is composed of 14 bones.

Paired	Unpaired
1. Maxilla	1. Mandible
2. Zygomatic	2. Vomer
3. Nasal	
4. Lacrimal	
5. Palatine	
6. Inferior nasal concha.	

Skull Joints

The joints in the skull are mostly sutures, a few primary cartilaginous joints and three pairs of synovial joints. Two pairs of synovial joints are present between the ossicles of middle ear. One pair is the largest temporomandibular joint. This mobile joint permits us to speak, eat, drink and laugh.

Sutures are:

Plane — intemasal suture

Serrate — interparietal suture

Denticulate — lambdoid suture

Squamous — parietotemporal suture

Anatomical Position of Skull

The skull can be placed in proper orientation by considering any one of the two planes.

1. Reid's base line is a horizontal line obtained by joining the infraorbital margin to the centre of external acoustic meatus, i.e. auricular point.
2. The Frankfurt's horizontal plane of orientation is obtained by joining the infraorbital margin to the upper margin of the external acoustic meatus (Fig. 1.1).

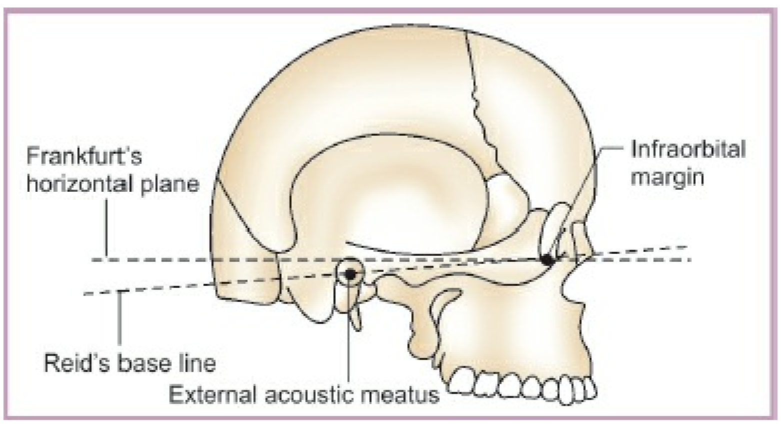


Fig. 1.1: Anatomical position of skull.

Peculiarities of Skull Bones

1. Base of skull ossifies in cartilage while the skull cap ossifies in membrane.
2. At birth, skull comprises one table only. By 4 years or so, two tables are formed. Between the two tables are diploe containing red bone marrow forming RBC, granular series of WBC and platelets. Four diploic veins drain formed blood cells into neighbouring veins.

3. At birth, the 4 angles of parietal bone have membranous gaps or fontanelles. These allow overlapping of bones during vaginal delivery, if required. These also allow skull bones to increase in size after birth, for housing the delicate brain.
4. Some skull bones have air cells in them and are called pneumatic bones, e.g. frontal, maxilla. These give resonance to voice. These may get infected resulting in sinusitis.
5. Skull bones are united mostly by sutures.
6. Skull has foramina for “emissary veins” which connect intracranial venous sinuses with extracranial veins. These try to relieve raised intracranial pressure. Infection may reach through the emissary veins into cranial venous sinuses.
7. Petrous temporal is the densest bone of the body. It lodges internal ear, middle ear including three ossicles, i.e. malleus, incus and stapes. Ossicles are *bones within the bone* and are hilly formed at birth.
8. Skull lodges brain, meninges, CSF, glands like hypophysis cerebri and pineal, venous sinuses, teeth, special senses like retina of eyeball, taste buds of tongue, olfactory epithelium, cochlear and vestibular nerve endings.

MANDIBLE

Foramina and Relations to Nerves and Vessels

1. The mental foramen transmits the *mental nerve and vessels* (Fig. 1.2).
2. The *inferior alveolar nerve and vessels* enter the *mandibular canal through the mandibular foramen,* and run forwards within the canal.
3. The mylohyoid nerve and vessels lie in the mylohyoid groove.

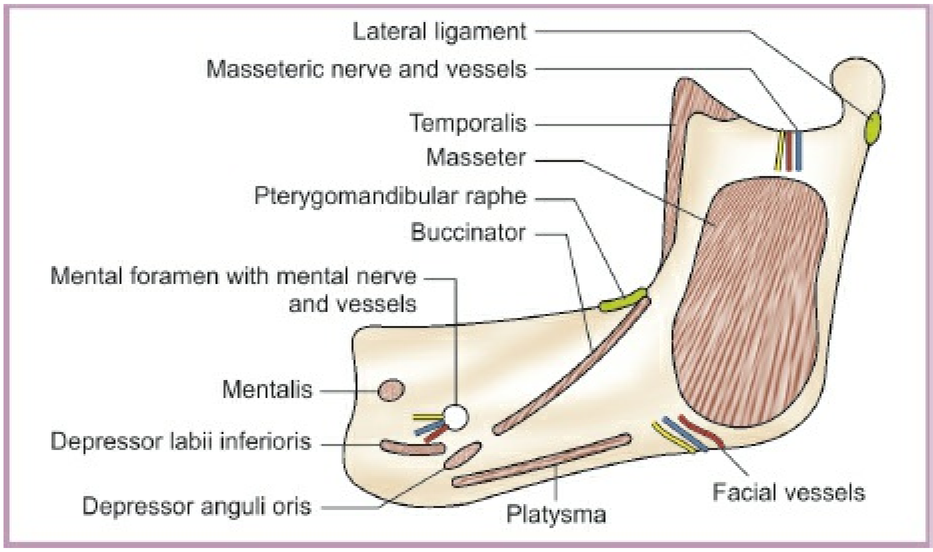


Fig. 1.2: Outer surface of the left half of the mandible.

4. The *lingual nerve* is related to the medial surface of the ramus in front of the mylohyoid groove (Fig. 1.3).
5. The area above and behind the mandibular foramen is related to the *inferior alveolar nerve and vessels* and to the *maxillary artery*.
6. The *masseteric nerve and vessels* pass through the mandibular notch (Fig. 1.2).
7. The *auriculotemporal nerve* and *superficial temporal artery* are related to the medial side of the neck of mandible (Fig. 1.3).

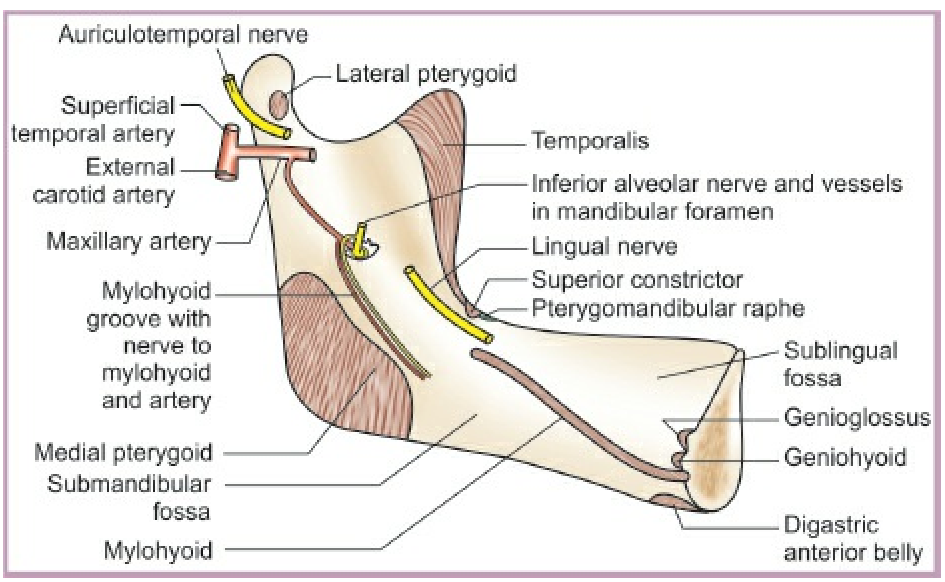


Fig. 1.3: Inner surface of the left half of the mandible.

3. Facial artery is palpable on the lower border of mandible at anteroinferior angle of masseter.

Ossification: The mandible is the *second bone, next to the clavicle, to ossify* in the body. Its greater part ossifies *in membrane.* The parts ossifying in *cartilage* include the *incisive part* below the incisor teeth, the *coronoid and condyloid processes,* and the *upper half of the ramus* above the level of the mandibular foramen.

Each half of the mandible ossifies from only one *centre* which appears at about the *6th week* of intrauterine life in the mesenchymal *sheath of Meckel s cartilage* near the future mental foramen. Meckel’s cartilage is the skeletal element of *first pharyngeal arch.*

At birth the mandible consists of two halves connected at the *symphysis menti* by fibrous tissue. Bony union takes place during the first year of life.

Structures Related to Mandible

Salivary glands: Parotid, submandibular and sublingual

Lymph nodes: Parotid, submandibular and submental.

Arteries: Maxillary, superficial temporal, masseteric, inferior alveolar, mylohyoid, mental and facial.

Nerves: Lingual, auriculotemporal, masseteric, inferior alveolar, mylohyoid and mental.

Muscles of mastication: Insertions of temporalis, masseter, medial pterygoid and lateral pterygoid.

Ligaments: Lateral ligament of temporomandibular joint, stylomandibular ligament, sphenomandibular and pterygomandibular raphe.

CERVICAL VERTEBRAE

Identification

The cervical vertebrae are identified by the presence of foramina transversaria.

There are seven cervical vertebrae, out of which the third to sixth are typical, while the first, second and seventh are atypical.

FIRST CERVICAL VERTEBRA

It is called the *atlas*. It can be identified by the following features:

- It is ring-shaped. It has neither a body nor a spine.
- The atlas has a short anterior arch, a long posterior arch, right and left lateral masses, and transverse processes.
- The *anterior arch* is marked by a median *anterior tubercle* on its anterior aspect. Its posterior surface bears an *oval facet* which articulates with the *dens* (Fig. 1.4).
- The *posterior arch* forms about two-fifths of the ring and is much longer than the anterior arch. Its posterior surface is marked by a median posterior tubercle. The upper surface of the arch is marked behind the lateral mass by a *groove*.

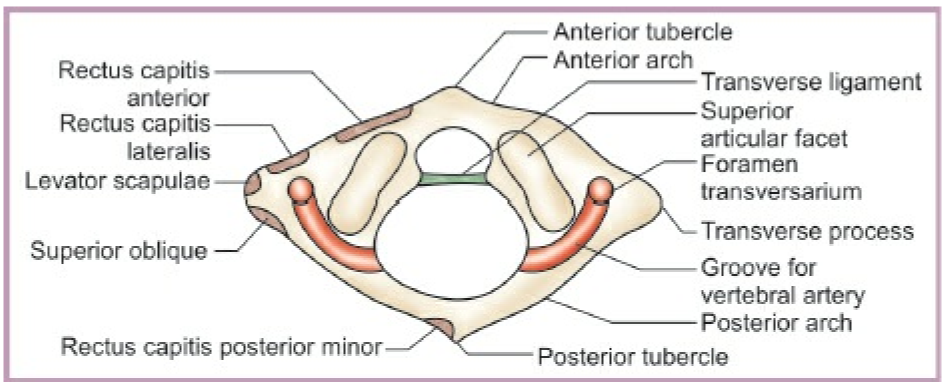


Fig. 1.4: Atlas vertebra seen from above.

SECOND CERVICAL VERTEBRA

This is called the *axis*. It is identified by the presence of the dens or odontoid process which is a strong, tooth-like process projecting upwards from the body. The dens is usually believed to represent the centrum or body of the atlas which has fused with the centrum of the axis (Fig. 1.5).

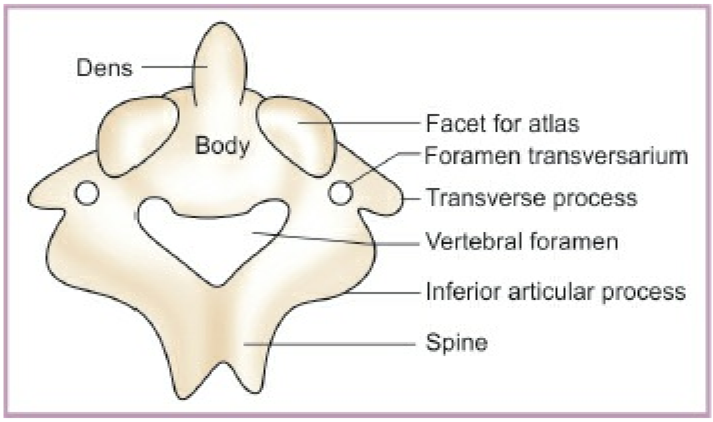


Fig. 1.5: Axis vertebra, posterosuperior view.

Body and Dens

1. The *superior surface* of the body is fused with the dens, and is encroached upon on each side by the superior articular facets. The dens articulates anteriorly with the anterior arch of the atlas, and posteriorly with the transverse ligament of the atlas.
2. The *inferior surface* has a prominent anterior margin which projects downwards.
3. The *anterior surface* presents a median ridge on each side of which there are hollowed out impressions.

SEVENTH CERVICAL VERTEBRA

It is also known as the *vertebra prominens* because of its long spinous process, the tip of which can be felt through the skin at the lower end of the nuchal furrow.

Its spine is thick, long and nearly horizontal. It is not bifid, but ends in a tubercle.

The transverse processes are comparatively large in size, the posterior root is larger than the anterior. The anterior tubercle is absent. The foramen transversarium is relatively small.

Foramina of Skull bones — see Table 1.1

Table 1.1: Foramina of skull bones and their contents

Foramina/apertures	Contents
Anterior cranial fossa	
Groove for superior sagittal sinus	Superior sagittal sinus
Foramen caecum	Emissary vein to superior sagittal si nus from upper part of nose
Anterior ethmoidal foramen	Anterior ethmoidal nerve and vessel s
Foramina of cribriform plate	Olfactory nerve rootlets
Posterior ethmoidal foramen	Posterior ethmoidal vessels
Middle cranial fossa	
Optic canal	Optic nerve and ophthalmic artery
Superior orbital fissure	Lateral part, middle part, medial par t
Lateral part	Lacrimal and frontal nerves, branch es of ophthalmic nerve; trochlear ne rve; superior ophthalmic vein; meni ngeal branch of lacrimal artery.; ana stomotic branch of middle meninge al artery. which anastomoses with r ecurrent branch of lacrimal artery.
Middle part	Upper and lower divisions of oculo motor nerve (CN III), nasociliary ne rve, abducent nerve (CN VI)
Medial part	Inferior ophthalmic vein; sympathet ic nerve from plexus around internal carotid artery.
Foramen rotundum	Maxillary nerve (CN V2)
Foramen ovale	Mandibular nerve (CN V3); accesso ry meningeal artery; lesser petrosal nerve; emissary vein connecting cav ernous sinus with pterygoid plexus (MALE)

Foramen spinosum	Middle meningeal artery and vein, meningeal branch of mandibular nerve (CN V3)
Sphenoidal emissary foramen	Emissary vein connecting cavernous sinus with pterygoid plexus of veins
Foramen lacerum	(During life, the foramen Is filled with cartilage) No significant structure passes through it; internal carotid artery and nerve plexus pass across its superior end; nerve to pterygoid canal pass through its anterior wall; occasionally meningeal branch of ascending pharyngeal artery and emissary vein from cavernous sinus pass from lower part.
Carotid canal	Internal carotid artery and nerve plexus (sympathetic)
Groove for lesser petrosal nerve	Lesser petrosal nerve
Groove for greater petrosal nerve	Greater petrosal nerve
Posterior cranial fossa	
Foramen magnum	Lowest part of medulla oblongata and meninges; vertebral arteries; spinal roots of CN XI; anterior and posterior spinal arteries; apical ligament; vertical band of cruciate ligament and membrane tectoria.
Jugular foramen	CN IX; X; XI; inferior petrosal and sigmoid sinuses; meningeal branches of ascending pharyngeal and occipital arteries.
Hypoglossal canal/anterior condylar	CN XII

canal	
Internal acoustic meatus	CN VII; VIII and labyrinthine vesse ls
External opening of vestibular aque duct	Endolymphatic duct
Posterior condylar canal	Emissary vein connecting sigmoid s inus with the suboccipital venous pl exus
Mastoid foramen	Mastoid emissary vein and meninge al branch of occipital artery
Other formlna	
External acoustic meatus	Air waves
External nasal foramen	External nasal nerve
Greater palatine foramen	Greater palatine vessels; anterior pal atine nerve
Incisive canal	Greater palatine vessels; terminal pa rt of nasopalatine nerve
Inferior orbital fissure	Zygomatic nerve; orbital branches o f pterygopalatine ganglion; infraorbi tal nerve and vessels
lnfraorbital foramen	lnfraorbital nerve and vessels
Lesser palatine foramen	Middle and posterior palatine nerve s
Mandibular foramen/canal	Inferior alveolar nerve and vessels
Mandibular notch	Masseteric nerve and vessels
Mastoid canaliculus	Auricular branch of vagus nerve
Mental foramen	Mental nerve and vessels
Mental foramen	Pharyngeal branch from pterygopal atine ganglion; pharyngeal branch o f maxillary artery
Parietal foramen	Emissary vein from scalp to superio

	r sagittal sinus
Petrotympanic fissure	Chorda tympanic nerve and anterior tympanic artery.
Pterygoid canal	Nerve to pterygoid canal and vessel s
Pterygomaxillary fissure	Maxillary nerve
Pterygopalatine fossa	Pterygopalatine ganglion
Stylomastoid foramen	Facial nerve; stylomastoid branch o f posterior auricular artery.
Supraorbital foramen	Supraorbital nerve and vessels
Tympanic canaliculus	Tympanic branch of glossopharyng eal nerve
Tympanomastoid fissure	Auricular branch of vagus nerve
Vomerovaginal canal	Branch of pharyngeal nerve and ves sels
Zygomatic foramen	Zygomatic nerve
Zygomaticofacial foramen	Zygomaticofacial nerve
Zygomaticotemporal foramen	Zygomaticotemporal nerve

CLINICAL ANATOMY

(a) Fontanelles are sites of growth of skull, permitting growth of brain.

(b) If fontanelles fuse early, brain growth is stunted; such children are less intelligent.

(c) If anterior fontanelle is bulging, there is raised intracranial pressure, if anterior fontanelle is depressed, it shows decreased intracranial pressure, mostly due to dehydration. Bones override at the fontanelle helping to decrease size of head during vaginal delivery. Caput succedaneum is soft tissue swelling on any part of skull due to rupture of capillaries. Skull becomes normal within one weak.

- The *nasal bone is one of the most commonly fractured bones of the face.* Mandible and parietal eminence are the next bones to be fractured.
- *Pterion* is the thin part of skull. In roadside accidents, the anterior division of middle meningeal artery may be ruptured, leading to clot formation between the skull bone and dura mater or extradural haemorrhage. The clot compresses the motor area of brain, leading to paralysis of the opposite side. The clot must be sucked out at the earliest by trephining. The head must be protected by a helmet.
- Fracture of the anterior cranial fossa may cause bleeding and discharge of cerebrospinal fluid through the nose. It may also cause a condition called *black eye* which is produced by see page of blood into the eyelid.
- Fracture of the middle cranial fossa produces:
  (a) Bleeding and discharge of CSF through the ear.
  (b) Bleeding through the nose or mouth may occur due to involvement of the sphenoid bone.
  (c) The seventh and eighth cranial nerves may be damaged if the fracture also passes through the internal acoustic meatus. If a semicircular canal is damaged, vertigo may occur.
- The middle cranial fossa is most commonly fractured. The fracture line usually follows a definite course. It begins at the parietal tuber which is usually the site of injury and passes through the parietal bone, the squamous temporal, and the petrous temporal bones usually involving the tegmen tympani, and frequently involving the internal acoustic meatus and the foramen ovale.
- Fracture of the posterior cranial fossa causes bruising over the mastoid region extending down over the sternocleidomastoid muscle.
- The mandible is commonly fractured at the canine socket where it is weak. Involvement of the inferior alveolar nerve in the callus may cause neuralgic pain, which may be referred to the areas of distribution of the buccal and auriculotemporal nerves. If the nerve is paralysed, the areas supplied by these nerves become insensitive.
- The next common fracture of the mandible occurs at the angle and

neck of mandible.

- Carcinoma of maxillary sinus arises from mucosal lining. Thin wall of the sinus may allow extension of the growth upwards into the orbit pushing the eyeball medially into the nasal cavity, forwards on the cheek, or backwards into the infratemporal fossa. Extraction of molar teeth may damage the floor of the sinus.
- In a suspected case of murder, fracture of the hyoid bone strongly indicates throttling or strangulation.
- Since the thoracic vertebrae have the enlarged costal element in the form of the ribs, the costal element of seventh cervical vertebra may get enlarged to form a cervical rib.
- A cervical rib is an additional rib arising from the C7 vertebra and usually gets attached to the 1 st rib near the insertion of scalenus anterior. If the rib is more than 5 cm long, it usually displaces the brachial plexus and the subclavian artery upwards.

  The symptoms are tingling pain along the inner border of the forearm and hand including weakness and even paralysis of the muscles of the palm.
- The intervertebral foramina of the cervical vertebrae, lie anterior to the joints between the articular processes. Arthritic changes in these joints, if occur, cause tiny projections or osteophytes. These osteophytes may press on the anteriorly placed cervical spinal nerves in the foramina causing pain along the course and distribution of these nerves.
- The joints in the lateral parts of adjacent bodies of cervical vertebrae are called Luschka’s joints. The osteophytes commonly occur in these joints. The cervical nerve roots lying posterolateral to these joints may get pressed causing pain along their distribution.
- The vertebral artery coursing through the foramen transversarium lies lateral to these joints. The osteophytes of Luschka joints may cause distortion of the vertebral artery leading to vertebrobasilar insufficiency. This may cause vertigo, dizziness, etc.
- Prolapse of the intervertebral disc occurs at the junction of different curvatures. So the common site is lower cervical and upper lumbar vertebral region. In the cervical region, the disc involved is above or below 6th cervical vertebra. The nerve roots affected are C6 and C7.

There is pain and numbness along the lateral side of forearm and hand. There may be wasting of muscles of thenar eminence.

- During judicial hanging, the odontoid process usually breaks to hit upon the vital centers in the medulla oblongata.
- Atlas may fuse with the occipital bone. This is called *occipitalization of atlas* and this may at times compress the spinal cord which requires surgical decompression.
- The pharyngeal and retropharyngeal inflammations may cause decalcification of atlas vertebra. This may lead to loosening of the attachments of transverse ligament which may eventually yield, causing *sudden death* from *dislocation of dens.*
- Fractures of skull may be depressed, linear and basilar.

2. Scalp, Temple and Face

SCALP AND SUPERFICIAL TEMPORAL REGION

Extent of Scalp

Anteriorly, supraorbital margins; posteriorly, external occipital protuberance and superior nuchal lines; and on each side, the superior temporal lines.

Structure

Conventionally, the superficial temporal region is studied with the scalp, and the following description, therefore, will cover both the regions.

The scalp is made up of five layers:

1. Skin,
2. Superficial fascia,
3. Deep fascia in the form of the epicranial aponeurosis or galea aponeurotica with the occipitofrontalis muscle,
4. Loose areolar tissue, and
5. Pericranium.

Superficial Temporal Region

It is the area between the superior temporal line and the zygomatic arch. This area contains the following 6 layers:

1. Skin,
2. Superficial fascia,
3. Thin extension of epicranial aponeurosis which gives origin to extrinsic muscles of the auricle,
4. Temporal fascia,

5. Temporalis muscle, and
6. Pericranium.

Arterial Supply of Scalp and Superficial Temporal Region

In front of the auricle, the scalp is supplied from before backwards by the: (i) *supratrochlear*,; (ii) *supraorbital*,; and (iii) superficial temporal arteries (Fig. 2.1). The first two are branches of the ophthalmic artery which in turn is a branch of the internal carotid artery. The superficial temporal is a branch of the external carotid artery.

Behind the auricle, the scalp is supplied from before backwards by the (iv) *posterior auricular*, and (v) *occipital* arteries, both of which are branches of the external carotid artery.

Thus, the scalp has a *rich blood supply* derived from both the internal and the external carotid arteries, the two systems anastomosing over the temple.

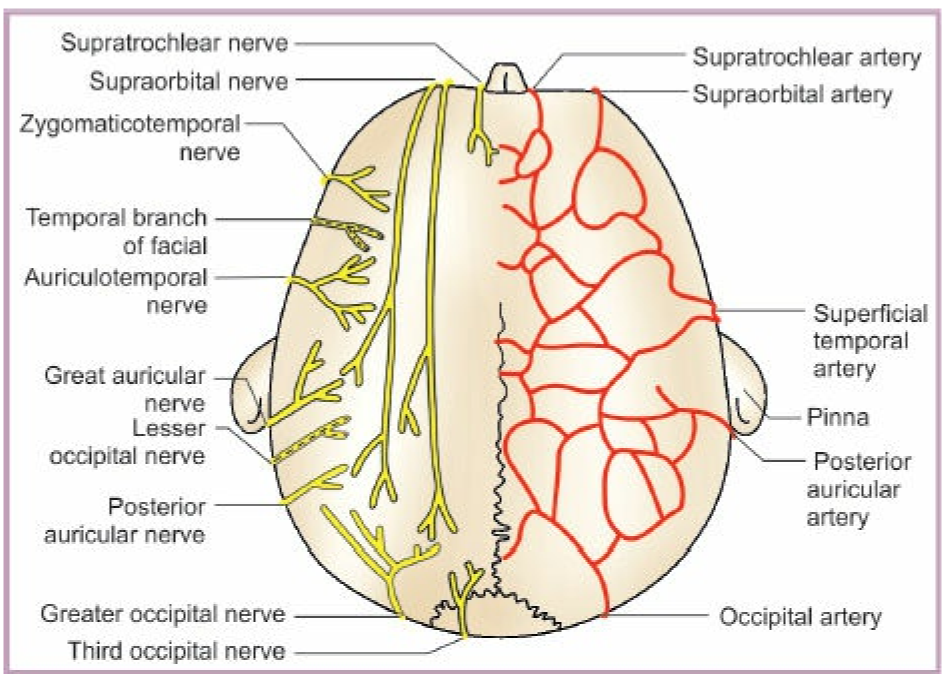


Fig. 2.1: Arterial and nerve supply of scalp and superficial temporal region.

Nerve Supply

The scalp and temple are supplied by ten nerves on each side. Out of these five nerves (four sensory and one motor) enter the scalp in front of the auricle. The remaining five nerves (again four sensory and one motor) enter the scalp behind the auricle (Fig. 2.1 and Table 2.1).

FACE

Muscles Around the Mouth

1. Orbicularis oris
2. Levator labii superioris alaeque nasi
3. Zygomaticus major
4. Levator labii superioris
5. Levator anguli oris (Fig. 2.2)
6. Zygomaticus minor
7. Depressor anguli oris
8. Depressor labii inferioris
9. Mentalis
10. Risorius
11. Buccinator

Table 2.1: Nerves of the scalp and superficial temporal region

In front of auricle	Behind the auricle
Sensory nerves	*Sensory nerves*
1. Supratrochlear, branch of the frontal (ophthalmic division of trigeminal nerve)	1. Posterior division of great auricular nerve (C2, C3) from cervical plexus
2. Supraorbital, branch of frontal (ophthalmic division of trigeminal nerve)	2. Lesser occipital nerve (C2), from cervical plexus
3. Zygomaticotemporal, branch of zygomatic nerve (maxillary divi	3. Greater occipital nerve (C2, dorsal ramus)

sion of trigeminal nerve)	
4. Auriculotemporal branch of mandibular division of trigeminal nerve	4. Third occipital nerve (C3, dorsal ramus)
Motor nerve Temporal branch of facial nerve	*Motor nerve* Posterior auricular branch of facial nerve

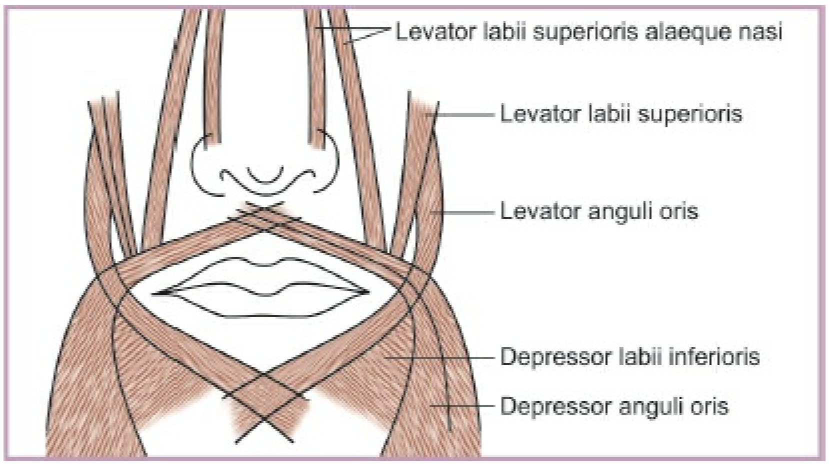


Fig. 2.2: Some of the facial muscles.

Muscles of the Face: Important Functional Groups

See Table 2.2.

Table 2.2: Functional groups of facial muscles

Opening	Sphincter	Dilators
A. Palpebral fissure	Orbicularis oculi	1. Levator palpebrae superioris 2. Frontalis part of occipitofrontalis
B. Oral fissure	Orbicularis oris	All the muscles around the mouth, except the orbicularis oris the sphi

		ncter, and the mentalis which does not mingle with orbicularis oris (see above)
C. Nostrils	Compressor naris	1. Dilator naris 2. Depressor septi 3. Medialslipoflevator labii superioris alaeque nasi

The occipitofrontalis muscle is mentioned with the scalp. Details of the other muscles are given in Table 2.3.

A few of the *common facial expressions* and the muscles producing them are given below.

1. *Smiling and laughing:* Zygomaticus major.
2. *Sadness:* Levator labii superioris and levator anguli oris.
3. *Grief:* Depressor anguli oris.
4. *Anger:* Dilator naris and depressor septi.
5. *Frowning:* Corrugator supercilii and procerus..
6. *Horror, terror and fright:* Platysma.
7. *Surprise:* Frontalis.
8. *Doubt:* Mentalis
9. *Grinning:* Risorius
10. *Contempt:* Zygomaticus minor.
11. *Closing the mouth:* Orbicularis oris.
12. *Whistling:* Buccinator, and orbicularis oris.

Sensory Nerve Supply of the Face

See Table 2.4.

LACRIMAL APPARATUS

The structures concerned with secretion and drainage of the lacrimal or tear fluid constitute the lacrimal apparatus. It is made up of the following parts:

1. Lacrimal gland and its ducts.
2. Conjunctival sac.
3. Lacrimal puncta and lacrimal canaliculi.
4. Lacrimal sac.
5. Nasolacrimal duct.

Table 2.3: The facial muscles

Muscle	Origin	Insertion	Action
1. Corrugator supercilii	Medial end of superciliary arch	Skin of mid-eyebrow	Vertical lines in forehead: frowning
2. Orbicularis oculi			
(a) Orbital part, on and around the orbital margin	Medial part of medial palpebral ligament and adjoining bone	Concentric rings return to the point of origin	Closes lids tightly; wrinkling; Protects eye from bright light
(b) Palpebral part, in the lids	Lateral part of medial palpebral ligament	Lateral palpebral raphe	Closes lids gently; blinking
(c) Lacrimal part, lateral and deep to the lacrimal sac	Lacrimal fascia and lacrimal bone	Upper and lower eyelids	Dilates lacrimal sac; directs lacrimal puncta into lacus lacrimalis; supports the lower lid
3. Orbicularis oris			
(a) Intrinsic part, deep stratum, very thin sheet	Superior incisivus, from maxilla; inferior incisivus, from mandible	Angle of mouth	Closes and purses the mouth; numerous extrinsic muscles make it most versatile for various types of grimaces
(b) Extrinsic part, two strata, formed by converging muscles.	Thickest middle stratum, derived from buccinator; thick superficial stratum, derived from elevators and depressors of lips and their angles	Lips and the angle of the mouth	
4. Buccinator, the muscle of the cheek	1. Upper fibres, from maxilla opposite molar teeth 2. Lower fibres, from mandible, opposite molar teeth 3. Middle fibres, from pterygo-mandibular raphe	1. Upper fibres, straight to the upper lip 2. Lower fibres, straight to the lower lip 3. Middle fibres decussate before passing to the lips	Flattens cheek against gums and teeth; prevents accumulation of food in the vestibule. This is the whistling muscle
5. Platysma	Upper parts of pectoral and deltoid fasciae Fibres run upwards and medially	Anterior fibres, to the base of the mandible; posterior fibres to the skin of the lower face and lip, and may be continuous with the risorius	Releases pressure of skin on the subjacent veins; depresses mandible; pulls the angle of the mouth downwards as in horror or surprise

Table 2.4: Cutaneous nerves of the face

Source	Cutaneous nerve	Area of distribution
A. Ophthalmic divisio	1. Supratrochlear ner	1. Upper eyelid and f

	n of trigeminal nerve	ve 2. Supraorbital nerve 3. Supraorbital nerve 4. lnfratrochlear 5. External nasal	orehead 2. Upper eyelid, frontal air sinus, scalp 3. Lateral part of upper eyelid 4. Medial parts of both eyelids 5. Lower part of dorsum and tip of nose
B.	Maxillary division of trigeminal nerve	1. lnfraorbital nerve 2. Zygomaticofacial nerve 3. Zygomaticotemporal nerve	1. Lower eyelid, side of nose and upper lip 2. Upper part of cheek. 3. Anterior part of temporal region
C.	Mandibular division of trigeminal nerve	1. Auriculotemporal nerve 2. Buccal nerve 3. Mental nerve	1. Upper 2/3rd of lateral side of auricle, temporal region 2. Skin of lower part of cheek 3. Skin over chin
D.	Cervical plexus	1. Anterior division of great auricular nerve (C2, C3) 2. Upper division of transvese (anterior) cutaneous nerve of neck (C2, C3)	1. Skin over angle of the jaw and over the parotid gland 2. Lower margin of the lower jaw

Lacrimal Gland

It is a *serous gland* situated chiefly in the lacrimal fossa on the anterolateral part of the roof of the bony orbit and partly on the upper eyelid. Small *accessory lacrimal glands* are found in the conjunctival fomices.

The secretomotor fibres run as follows: Lacrimatory nucleus → nervus inteπnedius → geniculate ganglion → greater petrosal nerve → nerve of pterygoid canal → pterygopalatine ganglion → relay → zygomatic nerve → zygomaticotemporal → lacrimal nerve → lacrimal gland.

The lacrimal fluid secreted by the lacrimal gland flows into the conjunctival sac where it lubricates the front of the eye and the deep surface of the lids. Periodic blinking helps to spread the fluid over the eye. Most of the fluid evaporates. The rest is drained by the lacrimal canaliculi. When excessive, it overflows as *tears.*

Conjunctival Sac

The conjunctiva lining the deep surfaces of the eyelids is called palpebral conjunctiva and that lining the front of the eyeball is bulbar conjunctiva. The potential space between the palpebral and bulbar parts is the *conjunctival sac.* The lines along which the palpebral conjunctiva of the upper and lower eyelids is reflected on to the eyeball are called the superior and inferior *conjunctival fomices.*

The *palpebral conjunctiva* is thick, opaque, highly vascular, and adherent to the tarsal plate. The *bulbar conjunctiva* covers the sclera. It is thin, transparent, and loosely attached to the eyeball. Over the cornea, it is represented by the anterior epithelium of the cornea.

Lacrimal Puncta and Canaliculi

Each lacrimal canaliculus begins at the *lacrimalpunctum,* and is 10 mm long. It has a vertical part which is 2 mm long and a horizontal part which is 8 mm long. There is a dilated ampulla at the bend. Both canaliculi open close to each other in the lateral wall of the lacrimal sac behind the medial palpebral ligament.

Lacrimal Sac

It is membranous sac 12 mm long and 5 mm wide, situated in the lacrimal groove behind the medial palpebral ligament. Its upper end is blind. The lower end is continuous with the nasolacrimal duct.

The sac is related anteriorly to the medial palpebral ligament and to the orbicularis oculi. Medially, the lacrimal groove separates it from the nose. Laterally, it is related to the lacrimal fascia and the lacrimal part of the orbicularis oculi.

Inflammation of the lacrimal sac is called *dacrocystitis*.

Nasolacrimal Duct

It is a membranous passage 18 mm long. It begins at the lower end of the lacrimal sac, runs downwards, backwards and laterally, and opens into the inferior meatus of the nose. A fold of mucous membrane called the *valve of Hasner* forms an imperfect valve at the lower end of the duct.

DEVELOPMENT OF FACE

Five processes of face, one frontonasal, two maxillary and two mandibular processes form the face. Frontonasal process forms the forehead, the nasal septum, philtrum of upper lip and premaxilla bearing upper four incisor teeth.

Maxillary process forms whole of upper lip except the philtrum and most of the hard and soft palate except the part formed by the premaxilla. Mandibular process forms the whole lower lip.

Cord of ectoderm gets buried at the junction of frontonasal and maxillary processes. Canalisation of ectodermal cord of cells gives rise to nasolacrimal duct.

CLINICAL ANATOMY

- Because of the abundance of sebaceous glands, the scalp is a common site for sebaceous cysts.
- Since the blood supply of scalp and superficial temporal region is very rich; avulsed portions need not be cut away. They can be replaced in position and stitched: they usually take up and heal well.
- Wounds of the scalp bleed profusely because the vessels are prevented from retracting by the fibrous fascia. Bleeding can be arrested by applying pressure against the bone.
- Because of the density of fascia, subcutaneous haemorrhages are never

extensive, and the inflammations in this layer cause little swelling but much pain.

- The layer of loose areolar tissue is known as the *dangerous area of the scalp* because the emissary veins, which open here may transmit infection from the scalp to the cranial venous sinuses.
- Collection of blood in the layer of loose connective tissue causes generalised swelling of the scalp. The blood may extend anteriorly into the root of the nose and into the eyelids, causing *black eye*. The posterior limit of such haemorrhage is not seen. If bleeding is due to local injury, the posterior limit of haemorrhage is seen.
- Wounds of the scalp do not gape unless the epicranial aponeurosis is divided transversely.
- Because the pericranium is adherent to sutures, collections of fluid deep to the pericranium known as cephalhaematoma take the shape of the bone concerned.
- The facial nerve is examined by testing the following facial muscles.

  (a) *Frontalis:* Ask the patient to look upwards without moving his head, and look for the normal horizontal wrinkles of the forehead.

  (b) *Dilators of mouth:* Showing the teeth.

  (c) *Orbicularis oculi:* Tight closure of the eyes.

  (d) *Buccinator:* Puffing the mouth and then blowing forcibly as in whistling.
- *Platysma:* Forcible pulling of the angles of the mouth downwards and backwards forming prominent vertical folds of skin on the side of the neck. The platysma contracts along with the risorius.
- In intranuclear lesions of the facial nerve, known as Bell's palsy, the whole of the face of the same side gets paralysed. The face becomes asymmetrical and is drawn up to the normal side. The affected side is motionless. Wrinkles disappear from the forehead. The eye cannot be closed. Any attempt to smile draws the mouth to the normal side. During mastication, food accumulates between the teeth and the cheek. Articulation of labials is impaired.
- In supranuclear lesions of the facial nerve; usually a part of hemiplegia, only the lower part of the opposite side of face is paralysed. The upper

part with the frontalis and orbicularis oculi escapes due to its bilateral representation in the cerebral cortex.

- The sensory distribution of the trigeminal nerve explains why headache is a uniformly common symptom in involvements of the nose (common cold, boils), the paranasal air sinuses (sinusitis), infections and inflammations of teeth and gums, refractive errors of the eyes, and infection of the meninges as in meningitis.
- Trigeminal neuralgia may involve one or more of the three divisions of the trigeminal nerve. It causes attacks of very severe burning and scalding pain along the distribution of the affected nerve. Pain is relieved either: (a) by injecting 90% alcohol into the affected division of the trigeminal ganglion, or (b) by sectioning the affected nerve, the main sensory root, or the spinal tract of the trigeminal nerve which is situated superficially in the medulla. The procedure is called *medullary tractotomy*.
- The facial veins and its deep connecting veins are devoid of valves, making an uninterrupted passage of blood to cavernous sinus. Squeezing the pustules or pimples in the area of the upper lip or side of nose or even the cheeks may cause infection which may be carried to the cavernous sinus leading to its thrombosis. So the cheek area may also be included as the dangerous area.
- The Muller's muscle or involuntary part of levator palpebrae superioris is supplied by sympathetic fibres from the superior cervical ganglion. Paralysis of this muscle leads to partial ptosis in *Homer s syndrome*.
- The palpebral conjunctiva is examined for anaemia and for conjunctivitis; the bulbar conjunctiva for jaundice.
- Foreign bodies are often lodged in a groove situated 2 mm from the edge of each eyelid.
- Chalazion is inflammation of a tarsal gland, causing a localized swelling pointing inwards.
- Ectropion is due to eversion of the lower lacrimal punctum. It usually occurs in old age due to laxity of skin.

- Conjunctivitis is one of the commonest diseases of the eye. It may be caused by infection or by allergy.

- Trachoma is a contagious granular conjunctivitis caused by the trachoma virus. It is regarded as the commonest cause of blindness.
- Stye or hordeolum is a suppurative inflammation of one of the glands of Zeis. The gland is swollen, hard and painful, and the whole of the lid is oedematous. The pus points near the base of one of the cilia.
- Blepharitis is inflammation of the eyelids, specially of the lid margin.
- The ducts of lacrimal gland open through its palpebral part into the conjunctival sac. Because of this arrangement, the removal of palpebral part necessitates the removal of the orbital part as well.
- Excessive secretion of lacrimal fluid, i.e. tears is mostly due to emotional reasons. The tears not only flow on the cheeks but also flow out through the nasal cavity, due to stimulation of pterygopalatine ganglion.
- Excessive secretion of the lacrimal fluid overflowing on the cheeks is called *Epiphora*. Epiphora may result due to obstruction in the lacrimal fluid pathway, either at the level of punctum or canaliculi or nasolacrimal duct.

3. Side of the Neck

DEEP CERVICAL FASCIA (Fascia Colli)

The deep fascia of the neck is condensed to form the following layers: (1) Investing layer (Fig. 3.1) (2) Pretracheal layer, (3) Prevertebral layer, (4) Carotid sheath, (5) Buccopharyngeal fascia, (6) Pharyngobasilar fascia.

INVESTING LAYER

This layer surrounds the neck like a collar. It is attached superiorly to base of mandible, mastoid process, external occipital protrubance; inferiorly to manubrium stemi, clavicle, acromion and spine of scapula; anteriorly to symphysis menti and hyoid; posteriorly to ligamentum nuchal and spine of 7th cervical vertebra.

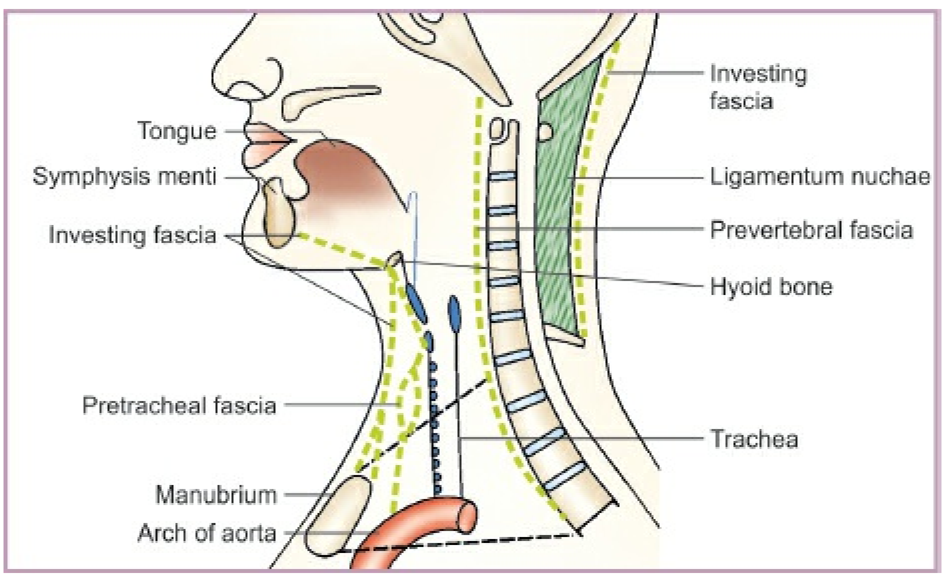


Fig. 3.1: Vertical extent of the first three layers of the deep cervical fascia. Continuity between the tissue space of the neck and the mediastinum can be

seen

Other Features

1. The investing layer of deep cervical fascia *splits* to enclose:
   (a) *Muscles*: Trapezius and sternocleidomastoid
   (b) *Salivary glands*: Parotid and submandibular
   (c) *Spaces*: Suprasternal and supraclavicular
2. It also forms *pulleys* to bind the tendons of the digastric and omohyoid muscles.

The *suprasternal space* contains:

(a) The sternal heads of the right and left sternocleidomastoid muscles, (b) The jugular venous arch, (c) The interclavicular ligament

The *supraclavicular space* is traversed by:

(a) The external jugular vein, (b) The supraclavicular nerves, and (c) Cutaneous vessels, including lymphatics.

PRETRACHEAL FASCIA

The importance of this fascia is that it encloses and suspends the thyroid gland and forms its false capsule.

Other Features

The posterior layer of the thyroid capsule is thick. On either side, it forms a ***suspensory ligament*** for the thyroid gland known as ***ligament of Berry.***

PREVERTEBRAL FASCIA

It lies in front of the prevertebral muscles, and forms the floor of the posterior triangle of the neck.

Other Features

1. The cervical and brachial plexuses lie behind the prevertebral fascia. The fascia is pierced by the four cutaneous branches of the cervical plexus.

2. As the trunks of the brachial plexus, and the subclavian artery, pass laterally through the interval between the scalenus anterior and the scalenus medius, they carry with them a covering of the prevertebral fascia known as the ***axillary sheath*** which extends into the axilla. The subclavian and axillary veins lie outside the sheath and as a result they can dilate during increased venous return from the limb.

CAROTID SHEATH

It is a condensation of the fibroareolar tissue around the main vessels of the neck. There are the common and internal carotid arteries, internal jugular vein and the vagus nerve. It is thin over the vein (Fig. 3.2a and b).

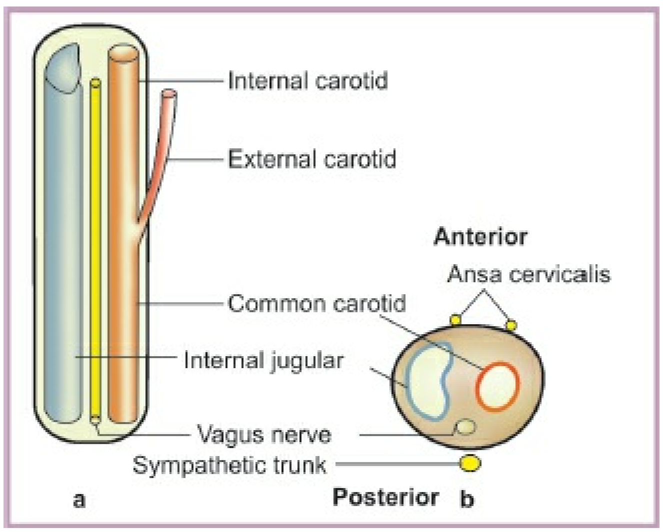


Fig. 3.2: Right carotid sheath with its contents, (a) Surface view, (b) Sectional view. The ansa cervicalis is embedded in the anterior wall of the sheath, whereas the sympathetic chain lies posterior to the sheath.

BUCCOPHARYNGEAL FASCIA

This fascia covers the superior constrictor muscle externally and extends on to the superficial aspect of the buccinator muscle.

PHARYNGOBASILAR FASCIA

This fascia is especially thickened between the upper border of superior constrictor muscle and the base of the skull. It lies deep to the pharyngeal muscles.

POSTERIOR TRIANGLE

The posterior triangle is a space on the side of the neck situated behind the sternocleidomastoid muscle.

Boundaries

Anterior: Posterior border of sternocleidomastoid (Fig. 3.3)

Posterior: Anterior border of trapezius

Inferior or base: Middle one-third of clavicle

Apex: Lies on the superior nuchal line where the trapezius and sternocleidomastoid meet

Roof

The roof is formed by the investing layer of deep cervical fascia

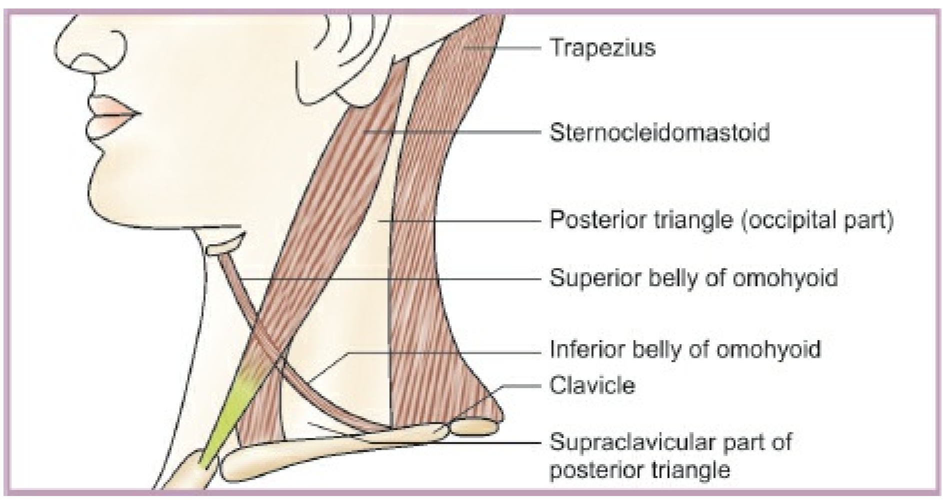


Fig. 3.3: Boundaries of the posterior triangle. Note that the inferior belly of the omohyoid divides the triangle into upper or occipital and lower or supraclavicular parts.

Floor

The floor of the posterior triangle is formed by the prevertebral layer of deep cervical fascia, covering the following muscles:

(a) Splenius capitis

(b) Levator scapulae

(c) Scalenus medius (Fig. 3.4)

Division of the Posterior Triangle

It is subdivided by the inferior belly of omohyoid into:

(a) A larger upper part, called the ***occipital triangle***

(b) A smaller lower part, called the ***supraclavicular*** or the ***subclavian triangle*** (Fig. 3.4)

Contents of the Posterior Triangle

These are enumerated in Table 3.1.

STERNOCLEIDOMASTOID MUSCLE

(Sternomastoid)

The sternocleidomastoid and trapezius are large superficial muscles of the neck. Both of them are supplied by the spinal root of the accessory nerve. The trapezius, because of its main action on the shoulder girdle, is considered with the upper limb. The sternocleidomastoid is described below.

Origin

1. The ***sternal head*** is tendinous and arises from the superolateral part of the front of the manubrium stemi (Fig. 3.4).

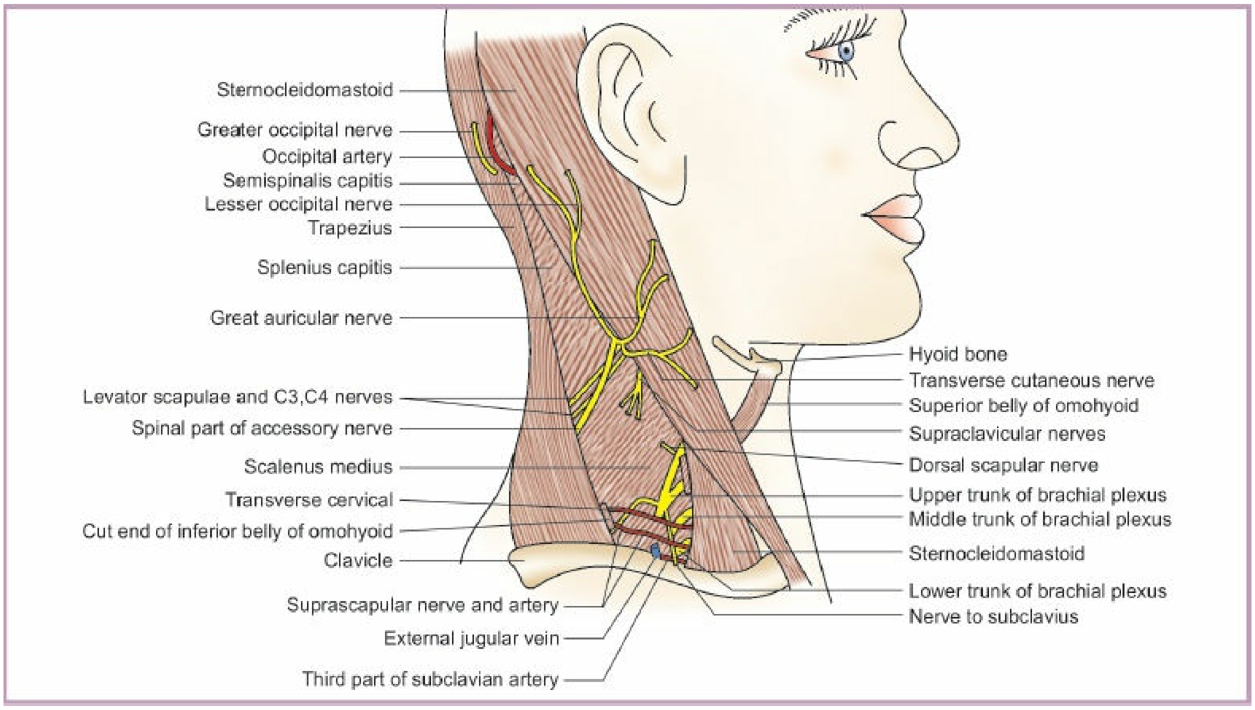


Fig. 3.4: The posterior triangle of neck.

Table 3.1: Contents of the posterior triangle (Fig. 3.4)

Contents	Occipital triangle	Subclavian triangle
A. Nerves	1. Spinal accessory nerve 2. Four cutaneous branches of cervical plexus: (a) Lesser occipital (C2) (b) Great auricular (C2, C3) (c) Anterior cutaneous nerve of neck (C2, C3) (d) Supraclavicular	1. Three trunks of brachial plexus 2. Nerve to serratus anterior (long thoracic, C5, C6, C7) 3. Nerve to subclavius (C5, C6) 4. Suprascapular nerve (C5, C6)

	nerves (C3, C4) 3. Muscular branches: (a) Two small branches to the levator scapulae (C3, C4) (b) Two small branches to the trapezius (C3, C4) (c) Nerve to rhomboideus (proprioceptive) (C5) 4. C5, C6 roots of the brachial plexus	
B. Vessels	1. Transverse cervical artery and vein 2. Occipital artery	1. Third part of subclavian artery and subclavian vein 2. Suprascapular artery and vein 3. Commencement of transverse cervical artery and termination of the corresponding vein 4. Lower part of external jugular vein
C. Lymph nodes	Along the posterior border of the sternocleidomastoid, more in the lower part-the supraclavicular nodes and a few	A few members of the supraclavicular chain

	at the upper angle-the occipital nodes

2. The ***clavicular head*** is musculotendinous and arises from the medial one-third of the superior surface of the clavicle. It passes deep to the sternal head, and the two heads blend below the middle of the neck. Between the two heads, there is a small triangular depression of the lesser supraclavicular fossa, overlying the internal jugular vein.

Insertion

It is inserted:

(a) By a thick tendon into the lateral surface of ***mastoid process,*** from its tip to superior border.

(b) By a thin aponeurosis into the lateral half of the ***superior nuchal line*** of the occipital bone.

Nerve Supply

(i) The spinal accessory nerve provides the motor supply. It passes through the muscle, (ii) branches from the ventral rami of C2 are proprioceptive.

Blood Supply

Arterial supply—one branch each from superior thyroid artery and suprascapular artery and, two branches from the occipital artery supply the big muscle. Veins follow the arteries.

Actions

A. When one muscle contracts:

(a) It turns the chin to the opposite side.

(b) It can also tilt the head towards the shoulder of same side.

B. When both muscles contract together:

(a) They draw the head forwards, as in eating and in lifting the head from a pillow.

(b) With the longus colli, they flex the neck against resistance.

(c) It also helps in forced inspiration.

CLINICAL ANATOMY

Cervical Fascia

- Parotid swellings are very painful due to the unyielding nature of parotid fascia.
- While excising the submandibular salivary gland, the external carotid artery should be secured before dividing it, otherwise it may retract through the stylomandibular ligament and cause serious bleeding.
- The thyroid gland and all thyroid swellings move with deglutition because the thyroid is attached to the larynx by the suspensory ligaments of Berry.
- Fascia of supraclavicular space is pierced by external jugular vein to drain into subclavian vein.
- Neck infections behind the prevertebral fascia arise usually from tuberculosis of the cervical vertebrae or cervical caries. Pus produced as a result may extend in various directions. It may pass forwards forming a chronic retropharyngeal abscess which may form a bulging in the posterior wall of the pharynx, in the median plane. The pus may extend laterally through the axillary sheath and point in the posterior triangle, or in the lateral wall of the axilla. It may extend downwards into the superior mediastinum, where its descent is limited by fusion of the prevertebral fascia to the fourth thoracic vertebra.
- Neck infections in front of the prevertebral fascia in the retropharyngeal space usually arise from suppuration, i.e. formation of pus in the retropharyngeal lymph nodes. The pus forms an acute retropharyngeal abscess which bulges forwards in the paramedian position due to fusion of the buccopharyngeal fascia to the prevertebral fascia in the median plane. The infection may extend down through the superior mediastinum into the posterior mediastinum.
- Neck infections in front of the pretracheal facia may bulge in the suprasternal area or extend down into the anterior mediastinum.
- Division of the external jugular vein in the supraclavicular space may

cause air embolism and consequent death because the cut ends of the vein are prevented from retraction and closure by the fascia, attached firmly to the wall of the vein.

- The most common swelling in the posterior triangle is due to enlargement of the supraclavicular lymph nodes. While doing biopsy of the lymph node, one must be careftd in preserving the accessory nerve which may get entangled amongst enlarged lymph nodes.
- Supraclavicular lymph nodes are commonly enlarged in tuberculosis, Hodgkin's disease, and in malignant growths of the breast, arm or chest.
- Torticollis or wry neck is a deformity in which the head is bent to one side and the chin points to the other side. This is a result of spasm or contracture of the muscles supplied by the spinal accessory nerve, these being the sternocleidomastoid and trapezius. Although there are many varieties of torticollis depending on the causes, the common types are:
  (a) Rheumatic torticollis due to exposure to cold or draught
  (b) Reflex torticollis due to inflamed or suppurating cervical lymph nodes which irritate the spinal accessory nerve
  (c) Congenital torticollis due to birth injury
  (d) Spasmodic torticollis due to central irritation
- Block dissection of the neck for malignant diseases is the removal of cervical lymph nodes along with other structures involved in the growth. This procedure does not endanger those nerves of the posterior triangle which lie deep to the prevertebral fascia, i.e. the brachial and cervical plexuses and their muscular branches.
- A cervical rib may compress the the second part of subclavian artery. In these cases, blood supply to upper limb reaches via anastomoses around the scapula.
- Dysphagia caused by compression of the oesophagus by an abnormal subclavian artery is called ***dysphagia lusoria.***
- In Blalock's operation for Fallot's tetralogy, the right subclavian artery is anastomosed end to side to short circuit the pulmonary stenosis.
- Elective arterial surgery of the common carotid artery is done for aneurysms, AV fistulae or arteriosclerotic occlusions. It is better to

expose the common carotid artery in its upper part where it is superficial. While ligating the artery, care should be taken not to include the vagus nerve or the sympathetic chain.

- Second part of the subclavian artery may get pressed by the scalenus anterior muscle, resulting in decreased blood supply to the upper limb. If the muscle is divided, the effects are abolished.
- External jugular vein is clinically important. The distension of this vein is visible in raised venous pressure due to congestive heart failure. The height of the column above the clavicle provides a rough guide to the increase in the venous pressure. This is called ***jugular venous pressure.***

Potential Spaces in Neck

These spaces get prominent only if they get infected.

- ***Pretracheal space:*** Surrounds the trachea, extends to lie behind pretracheal fascia and in front of anterior wall of oesophagus. Infection spreads by perforating the anterior wall of oesophagus or from retrovisceral space.
- ***Retrovisceral space:*** Lies between posterior wall of oesophagus and prevertebral fascia. It extends into superior mediastinum and fuses with the connective tissue behind oesophagus at T4 level.
- ***Prevertebral space:*** Lies between prevertebral fascia and the vertebral column. Infection spreads from retrovisceral space. Inferiorly, infection extends into posterior mediastinum. Inferolaterally, tubercular infection may spread into axilla along axillary sheath.

4. Back of the Neck

SUBOCCIPITAL TRIANGLE

The suboccipital triangle is a muscular space situated deep in the suboccipital region.

Boundaries

Superomedially

Rectus capitis posterior major muscle supplemented by the rectus capitis posterior minor (Fig. 4.1).

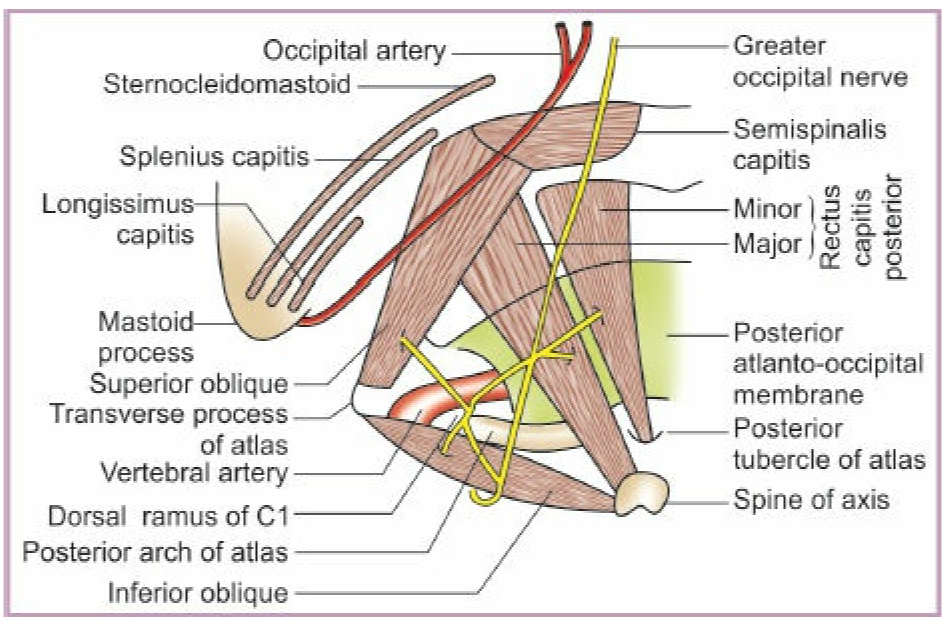


Fig. 4.1: Left suboccipital triangle; boundaries, floor and contents.

Superoloterally

Superior oblique muscle

Interiorly

Inferior obliαue muscle

Roof

Medially

Dense fibrous tissue covered by the semispinalis capitis

Laterally

Longissimus capitis and occasionally the splenius capitis

Floor

1. Posterior arch of atlas
2. Posterior atlanto-occipital membrane

Contents

1. Third part of vertebral artery
2. Dorsal ramus of nerve C1—suboccipital nerve
3. Suboccipital plexus of veins

CLINICAL ANATOMY

- Neck rigidity, seen in cases with meningitis, is due to spasm of the extensor muscles. This is caused by irritation of the nerve roots during their passage through the subarachnoid space which is infected. Passive flexion of neck and straight leg raising test cause pain as the nerves are stretched.
- Cisternal puncture is done when lumbar puncture fails. The patient either sits up or lies down in the left lateral position. A needle is introduced in the midline just above the spine of the axis vertebra, and is passed forwards and upwards, parallel to an imaginary line joining the external auditory meatus with the nasion. As the needle pierces the posterior atlanto-occipital membrane at a depth of about 4 to 5 cm in adults, the resistance is suddenly lost and the tip of the needle enters the cistema magna. In this procedure, there is danger of injury to the

medulla which lies 2.5 cm anterior to the posterior atlanto-occipital membrane. Such injury is fatal.

- Neurosurgeons approach the posterior cranial fossa through this region.

5. Contents of Vertebral Canal

CONTENTS

The vertebral canal contains the following structures from without inwards (Fig. 5.1).

1. Epidural or extradural space
2. Thick dura mater or pachymeninx
3. Subdural capillary space
4. Delicate arachnoid mater
5. Wide subarachnoid space containing cerebrospinal fluid (CSF)
6. Firm pia mater. The arachnoid and pia together form the leptomeninges
7. Spinal cord or spinal medulla and the cauda equina

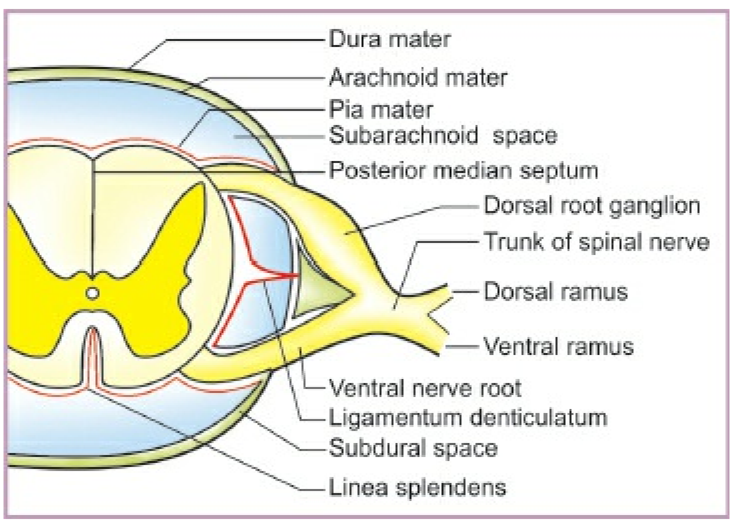


Fig. 5.1: Schematic transverse section showing the spinal meninges.

Spinal Nerves

The spinal cord gives rise to thirty-one pairs of *spinal nerves:* eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal. Each nerve is attached to the cord by two roots, ventral motor and dorsal sensory. Each dorsal nerve root bears a ganglion. The ***ventral and dorsal nerve roots*** unite in the intervertebral foramen to form the ***nerve trunk*** soon divides into ventral and dorsal ***rami*** (Fig. 5.2).

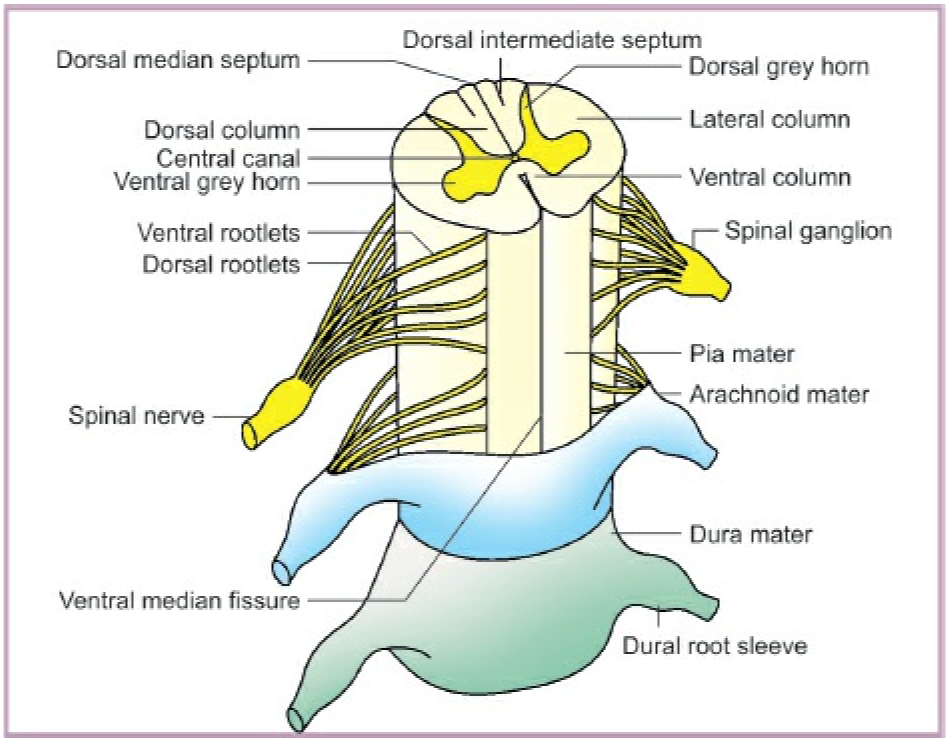


Fig. 5.2: Formation of spinal nerve.

The uppermost nerve roots pass horizontally from the spinal cord to reach the intervertebral foramina. Lower down they have to pass with increasing obliquity, as the spinal cord is much shorter than the vertebral column. Below the termination of the spinal cord at the level of first lumbar vertebra, the obliquity becomes much more marked.

Below the lower end of the spinal cord, the roots form a bundle known as the ***cauda equina*** because of its resemblance to the tail of a horse.

CLINICAL ANATOMY

Leptomeninges

- Inflammation due to infection of leptomeninges-pia mater and arachnoid mater is known as meningitis. This is commonly tubercular or pyogenic. It is characterized by fever, marked headache, neck rigidity, often accompanied by delirium and convulsions, and a changed biochemistry of CSF. CSF pressure is raised, its proteins and cell content are increased, and sugars and chloride are selectively diminished.

Vertebral Canal

- Compression of the spinal cord by a tumour gives rise to paraplegia or quadriplegia, depending on the level of compression.
- Spinal tumours may arise from dura mater (meningioma), glial cells (glioma), nerve roots (neurofibroma), ependyma (ependymoma), and other tissues. Apart from compression of the spinal cord, the tumour causes obstruction of the subarachnoid space so that pressure of CSF is low below the level of lesion. ***(From's syndrome***) is seen. There is yellowish discolouration of CSF below the level of obstruction. CSF reveals high level ofproteinbutthe cell content is normal ***Queckenstedis test*** does not show a sudden rise and a sudden fall of CSF pressure by coughing or by brief pressure over the jugular veins. Spinal block can be confirmed either by myelography CT scan or MRI scan.
- Compression of the cauda equina gives rise to flaccid paraplegia, saddle anaesthesia and sphincter disturbances. This is called the ***cauda equina syndrome.***
- Compression of roots of spinal nerves may be caused by prolapse of an intervertebral disc, by osteophytes (formed in osteoarthritis), by a cervical rib, or by an extramedullary tumour. Such compression results in shooting pain along the distribution of the nerve.
- ***Lumbarpuncture in adult:*** Patient is lying on side with maximally flexed spine. A line is taken between highest points of iliac spine at L4 level. Skin locally anaesthetized, and lumbar puncture needle with trocar inserted carefully between L3 and L4 spines. Needle courses through skin, fat, supraspinous and interspinous ligaments, ligamentum

flava, epidural space, dura, arachnoid, subarachnoid space to release CSF.

- ***Lumbar puncture in infant, children:*** During 2nd month of life, spinal cord usually reaches L3 level. Lumbar puncture needle is introduced in flexed spine between L4 and L5.
- ***Cisternal puncture:*** This procedure is rather difficult and dangerous. Cerebellomedullary cistern is approached through posterior atlanto-occipital membrane.
- ***Lumbar epidural:*** The epidural space is the space between vertebral canal and dura mater. The epidural space is deeper in the midline. The procedure is same as lumbar puncture, the needle should reach only in the epidural space and not deep to it in the dura mater. Epidural space is utilized for giving anaesthesia or analgesia.
- ***Caudal epidural:*** The needle is passed through sacral hiatus, which lies equidistant from the right and left posterior superior iliac spines. The needle passes through posterior sacrococcygeal ligament and enters the sacral canal. Then the hub of needle is lowered so that it passes along sacral canal. This space lies below S2.

6. Cranial Cavity

CEREBRAL DURA MATER

The dura mater is the outermost, thickest and toughest membrane covering the brain (dura=hard).

There are two layers of dura:

(a) An outer or *endosteal layer* which serves as an internal periosteum or endosteum or endocranium for the skull bones.

(b) An inner or *meningeal layer* which surrounds the brain. The meningeal layer is continuous with the spinal dura mater.

The two layers are fused to each other at all places, except where the cranial venous sinuses are enclosed between them.

Endosteal Layer or Endocranium

The endocranium is continuous

(a) With the periosteum lining the outside of the skull or pericranium through the sutures and foramina

(b) With the periosteal lining of the orbit through the superior orbital fissure

Meningeal Layer

At places, the meningeal layer of dura mater is folded on itself to form partitions which divide the cranial cavity into compartments which lodge different parts of the brain. The folds are the

A. Falx cerebri

B. Tentorium cerebelli

C. Falx cerebelli

D. Diphragma sellae

CAVERNOUS SINUSES

Each cavernous sinus is a large venous space situated in the middle cranial fossa, on either side of the body of the sphenoid bone. Its interior is divided into a number of spaces or caverns by trabeculae. The trabeculae are much less conspicuous in the living than in the dead (Fig. 6.1).

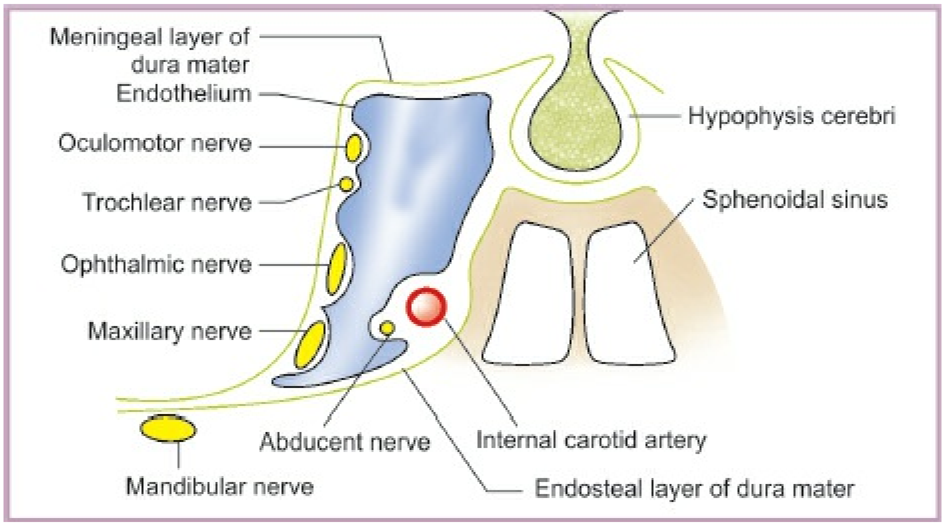


Fig. 6.1: Coronal section through the middle cranial fossa showing the relations of the cavernous sinus.

The floor of the sinus is formed by the endosteal dura mater. The lateral wall, roof and medial walls are formed by the meningeal dura mater.

Anteriorly, the sinus extends up to the medial end of the superior orbital fissure and ***posteriorly,*** up to the apex of the petrous temporal bone. It is about 2 cm long, and 1 cm wide.

Relations

Structures in the lateral wall of the sinus, from above downwards

(a) ***Oculomotor nerve.*** In the anterior part of the sinus, it divides into superior and inferior divisions which leave the sinus by passing through the superior orbital fissure.

(b) ***Trochlear nerve.*** In the anterior part of the sinus, it crosses superficial to the oculomotor nerve, and enters the orbit through the superior orbital fissure.

(c) ***Ophthalmic nerve.*** In the anterior part of the sinus, it divides into the lacrimal, frontal and nasociliary nerves.

Tributaries or Incoming Channels

From the orbit

(a) The superior ophthalmic vein

(b) A branch of the inferior ophthalmic vein or sometimes the vein itself.

(c) The central vein of the retina may drain either into the superior ophthalmic vein or into the cavernous sinus.

From the brain

(a) Superficial middle cerebral vein

(b) Inferior cerebral veins from the temporal lobe

From the meninges

(a) Sphenoparietal sinus

(b) The frontal trunk of the middle meningeal vein may drain either into the pterygoid plexus through the foramen ovale or into the sphenoparietal or cavernous sinus.

Draining Channels or Communications

The cavernous sinus drains

(a) Into the transverse sinus through the superior petrosal sinus

(b) Into the internal jugular vein through the inferior petrosal sinus and through a plexus around the internal carotid artery

(c) Into the pterygoid plexus of veins through the emissary veins passing through the foramen ovale, the foramen lacerum and the emissary sphenoidal foramen

(d) Into the facial vein through the superior ophthalmic vein

(e) The right and left cavernous sinuses communicate with each other through the anterior and posterior intercavernous sinuses and through the basilar plexus of veins

HYPOPHYSIS CEREBRI (Pituitary Gland)

The hypophysis cerebri is a small endocrine gland situated in relation to the base of the brain.

SUBDIVISIONS/PARTS AND DEVELOPMENT

The gland has two main parts: ***Adenohypophysis*** and ***neurohypophysis*** which differ from each other embryologically, morphologically and functionally. The adenohypophysis develops as an upward growth called the Rathke's pouch from the ectodermal roof of the stomodeum. The neurohypophysis develops as a downward growth from the floor of the diencephalon, and is connected to the hypothalamus by neural pathways.

Adenohypophysis

(a) Anterior lobe or pars anterior, pars distalis, or pars glandularis
(b) Intermediate lobe or pars intermedia
(c) Tuberal lobe or pars tuberalis

Neurohypophysis

(a) Posterior lobe or neural lobe, pars posterior
(b) Infundibular stem
(c) Median eminence

Arterial Supply

The hypophysis cerebri is supplied by the following branches of the internal carotid artery

1. One superior hypophyseal artery on each side
2. One inferior hypophyseal artery on each side

TRIGEMINAL GANGLION

This is the ***sensory ganglion*** of the fifth cranial nerve. It is homologous with the dorsal nerve root ganglia of spinal nerves. All such ganglia are made up of pseudounipolar nerve cells, with a 'T'-shaped arrangement of their process; one process arises from the cell body which then divides into a central and a peripheral process.

The ganglion is crescentic or semilunar in shape, with its convexity directed anterolaterally. The three divisions of the trigeminal nerve emerge from this convexity. The posterior concavity of the ganglion receives the sensory root of the nerve (Fig. 6.2).

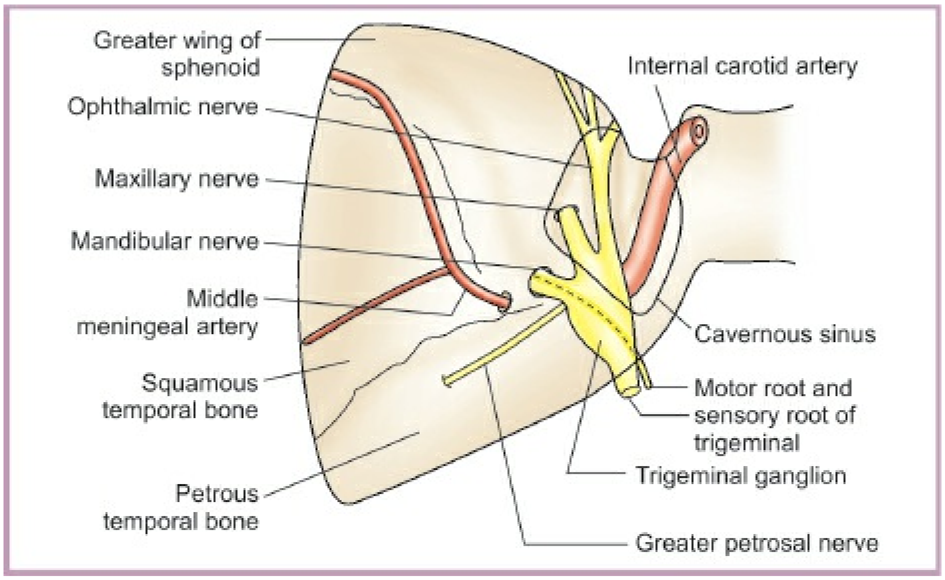


Fig. 6.2: Parts of the hypophysis cerebri as seen in a sagittal section.

CLINICAL ANATOMY

- ***Pain sensitive intracranial structures*** are
  (a) The large cranial venous sinuses and their tributaries from the surface of the brain
  (b) Dural arteries
  (c) The dural floor of the anterior and posterior cranial fossae
  (d) Arteries at the base of the brain
- ***Headache*** may be caused by
  (a) Dilatation of intracranial arteries

(b) Dilatation of extracranial arteries

(c) Traction or distension of intracranial pain sensitive structures

(d) Infection and inflammation of intracranial and extracranial structures supplied by the sensory cranial and cervical nerves

- ***Extradural and subdural haemorrhages*** are both common. An extradural haemorrhage can be distinguished from a subdural haemorrhage because of the following differences.

  (a) The extradural haemorrhage is arterial due to injury to middle meningeal artery, whereas subdural haemorrhage is venous in nature

  (b) Symptoms of cerebral compression are late in extradural haemorrhage

  (c) In an extradural haemorrhage, paralysis first appears in the face and then spreads to the lower parts of the body. In a subdural haemorrhage, the progress of paralysis is haphazard.

  (d) In an extradural haemorrhage, there is no blood in the CSF; while it is a common feature of subdural haemorrhage.

- ***Thrombosis of the cavernous sinus*** may be caused by sepsis in the dangerous area of the face, in nasal cavities, and in paranasal air sinuses. This gives rise to the following symptoms.

  A. ***Nervous symptoms***

  (a) Severe pain in the eye and forehead in the area of distribution of ophthalmic nerve

  (b) Involvement of the third, fourth and sixth cranial nerves resulting in paralysis of the muscles supplied

  B. ***Venous symptoms:*** Marked oedema of eyelids, cornea and root of the nose, with exophthalmos due to congestion of the orbital veins.

- A communication between the cavernous sinus and the internal carotid artery may be produced by head injury. When this happens the eyeball protrudes and pulsates with each heart beat. It is called the ***pulsating exophthalmos.***

- ***Thrombosis of the superior sagittal sinus*** may be caused by spread of infection from the nose, scalp and diploe. This gives rise to:

(a) A considerable rise in intracranial tension due to defective absorption of CSF.

(b) Delirium and sometimes convulsions due to congestion of the superior cerebral veins.

(c) Paraplegia of the upper motor neuron type due to bilateral involvement of the paracentral lobules of cerebrum where the lower limbs and perineum are represented.

- ***Thrombosis of the sigmoid sinus*** is always secondary to infection in the middle ear or otitis media, or in the mastoid process called mastoiditis.
- During operations on the mastoid process, one should be careful about the sigmoid sinus, so that it is not exposed.
- Spread of infection or thrombosis from the sigmoid and transverse sinuses to the superior sagittal sinus may cause impaired CSF drainage into the latter and may, therefore, lead to the development of hydrocephalus. Such a hydrocephalus associated with sinus thrombosis following ear infection is known as ***otitic hydrocephalus.***
- Pituitary tumours give rise to two main categories of symptoms:

A. ***General symptoms*** due to pressure over surrounding structures:

(a) The sella turcica is enlarged in size.

(b) Pressure over the central part of optic chiasma causes bitemporal hemianopia or bitemporal upper quadrantic hemianopia.

(c) Pressure over the hypothalamus may cause one of the hypothalamic syndromes like obesity of Frolich’s syndrome in cases with Rathke’s pouch tumours.

(d) A large tumour may press upon the third ventricle, causing a rise in intracranial pressure.

B. ***Specific symptoms*** depending on the cell type of the tumour.

(a) Acidophil or eosinophil adenoma causes acromegaly in adults and gigantism in younger patients.

(b) Basophil adenoma causes Cushing’s syndrome.

(c) Chromophobe adenoma causes effects of hypopituitarism.

(d) Posterior lobe damage causes diabetes insipidus, although the lesion in these cases usually lies in the hypothalamus.

- Intractable facial pain due to trigeminal neuralgia or carcinomatosis may be abolished by injecting alcohol into the ganglion. Sometimes cutting of the sensory root is necessary.
- Congenital cutaneous naevi on the face (port-wine stain) map out accurately the areas supplied by one or more divisions of the V cranial nerve.
- The middle meningeal artery is of great surgical importance because it can be tom in head injuries resulting in ***extradural haemorrhage. The frontal*** or ***anterior branch*** is commonly involved. The haematoma presses on the motor area, giving rise to hemiplegia of the opposite side. The anterior division can be approached surgically by making a hole in the skull over the pterion, 4 cm above the midpoint of the zygomatic arch.
- Rarely, the parietal or posterior branch is implicated, causing contralateral deafness. In this case, the hole is made at a point 4 cm above and 4 cm behind the external acoustic meatus.

7. Contents of the Orbit

EXTRAOCULAR MUSCLES

The extraocular muscles are as follows.

Voluntary Muscles

1. Four recti
   (a) Superior rectus
   (b) Inferior rectus
   (c) Medial rectus
   (d) Lateral rectus
2. Two oblique
   (a) Superior oblique
   (b) Inferior oblique
3. The levator palpebrae superioris elevates the upper eyelid

Voluntary Muscles

Origin

1. The four recti arise from a *common annular tendon* or *tendinous ring*. This ring is attached to the orbital surface of the apex of the orbit. It encloses the optic canal and the middle part of the superior orbital fissure (Fig. 7.1).
2. The superior oblique arises from the body of the sphenoid, superomedial to the optic canal.
3. The inferior oblique arises from the orbital surface of the maxilla, lateral to the lacrimal groove.

Insertion

1. The recti are inserted into the sclera: a little posterior to the limbus. The average distances of the insertions from the cornea are: superior 7.7 mm; inferior 6.5 mm; medial 5.5 mm; lateral 6.9 mm (Fig. 7.2).
2. The tendon of the superior oblique passes through a fibrocartilaginous pulley attached to the trochlear fossa of the frontal bone. The tendon then passes laterally, downwards and backward below the superior rectus. It is inserted into the sclera behind the equator of the eyeball, between the superior rectus and the lateral rectus.

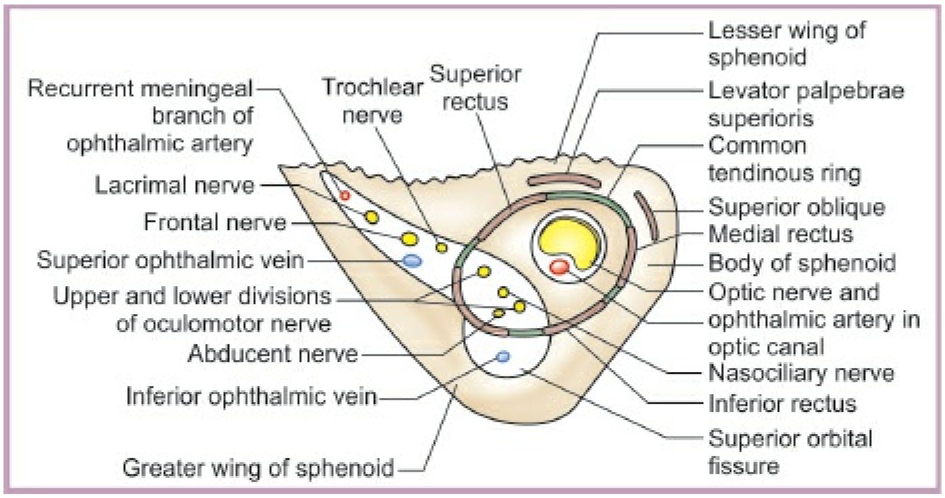


Fig. 7.1: Apical part of the orbit showing the origins of the extraocular muscles, the common tendinous ring and the structures passing through superior orbital fissure.

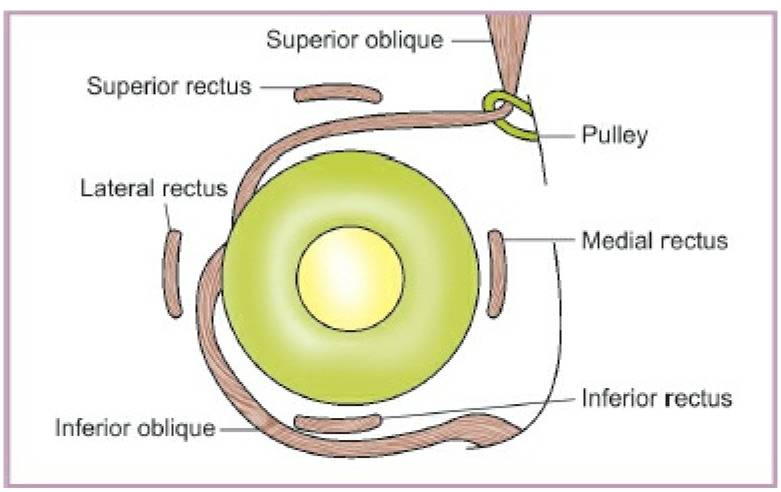


Fig. 7.2: Scheme to show the insertion of the oblique muscles of the eyeball.

3. The inferior oblique is inserted close to the superior oblique a little below and posterior to the latter.
4. The flat tendon of the levator splits into a superior or voluntary and an inferior or involuntary lamellae. The superior lamella of the levator is inserted into the anterior surface of the superior tarsus, and into the skin of the upper eyelid. The inferior lamella (smooth part) is inserted into the upper margin of the superior tarsus and into superior conjunctival fomix.

Table 7.1: Actions of individual muscles

Muscle	In primary position (looking at infinite)	Abducted eye	Adducted eye
1. Superior oblique	Depression Abduction Intortion	Only intortion	Only depression and intorsion (position of test)
2. Inferior oblique	Elevation Abduction Extortion	Only extortion	Only elevation and extorsion (position of test)
3. Inferior rectus	Depression Adduction Extortion	Only depression (position of test)	Only extortion
4. Superior rectus	Elevation Adduction Intortion	Only elevation (position of test)	Only intortion
5. Medial rectus	Only adduction	—	—
6. Lateral rectus	Only abduction	—	—

Nerve Supply

1. The superior oblique is supplied by the IV cranial or trochlear nerve (SO4).
2. The lateral rectus is supplied by the VI cranial or abducent nerve (LR6).
3. The remaining five extraocular muscles; superior, inferior and medial recti; inferior oblique and part of levator palpebrae superioris are all supplied by the III cranial or oculomotor nerve.

CLINICAL ANATOMY

- Weakness or paralysis of a muscle causes squint or strabismus, which may be concomitant or paralytic. Concomitant squint is congenital; there is no limitation of movement, and no diplopia.

  In paralytic squint, movements are limited, diplopia and vertigo are present, head is turned in the direction of the function of paralysed muscle, and there is a false orientation of the field of vision.
- Nystagmus is characterized by involuntary, rhythmical oscillatory movements of the eyes. This is due to incoordination of the ocular muscles. It may be either vestibular or cerebellar, or even congenital.
- The anterior ciliary arteries arise from the muscular branches of ophthalmic artery. The muscular arteries are important in this respect.
- The central artery of retina is the only arterial supply to most of the nervous layer, the retina of the eye. If this artery is blocked, there is sudden blindness.
- The anastomoses between tributaries of facial vein and ophthalmic veins may result in spread of infection from the orbital and nasal regions to the cavernous sinus leading to its thrombosis.
- Optic neuritis is characterized by pain in and behind the eye on ocular movements and on pressure. The papilloedema is less but loss of vision is more. When the optic disc is normal as seen by an ophthalmoscopy the same condition is called ***retrobulbar neuritis.***

  The common causes are demyelinating diseases of the central nervous system, any septic focus in the teeth or paranasal sinuses, meningitis, encephalitis, syphilis, and even vitamin B deficiency.
- Optic nerve has no neurilemma sheath, and has no power of regeneration. It is a tract and not a nerve.
- Optic atrophy may be caused by a variety of diseases. It may be primary or secondary.
- ***Surgical spaces in the orbit:*** These are of importance as most orbital pathologies tend to remain in the space in which they are formed. Therefore, their knowledge helps the surgeon in choosing the most direct surgical approach. Each orbit is divisible into four surgical spaces.

  (a) The subperiosteal space. This is a potential space between the bone and the periosteum.

(b) The peripheral space. It is bounded peripherally by the periorbita and internally by the four recti with thin intermuscular septa. For peribulbar anaesthesia, injection is made in this space.

(c) The central space. It is also called retrobulbar space. It is bounded anteriorly by the Tenon capsule lining back of the eyeball and peripherally by the four recti muscles and their intermuscular septa in the anterior part. In the posterior part, it becomes continuous with the peripheral space. Retrobulbar injections are made in this space.

(d) Tenon space. It is a potential space around the eyeball between the sclera and Tenon capsule.

8. Anterior Triangle of the Neck

ANTERIOR TRIANGLE OF NECK

The boundaries of the triangle are

The anterior median plane of the neck medially; sternocleidomastoid laterally; base of the mandible and a line joining the angle of the mandible to the mastoid process, superiorly.

SUBDIVISIONS

The anterior triangle of each side is subdivided (by the digastric muscle and the superior belly of the omohyoid into

(a) Submental—only half. Contains submental lymph nodes.

(b) Digastric

(c) Carotid

(d) Muscular triangles.

Digastric Triangle

Boundaries: The boundaries of the digastric triangle are as follows.

Anteroinferiorly: Anterior belly of digastric.

Posteroínferiorly: Posterior belly of digastric and the stylohyoid.

Contents

Anterior Part of the Triangle

1. *Structures superficial to mylohyoid* are

   (a) Superficial part of the submandibular salivary gland. The facial vein and the submandibular lymph nodes are superficial to it and the facial artery is deep to it.

(b) Submental artery

(c) Mylohyoid nerve and vessels.

2. *Structures superficial to the hyoglossus* seen without disturbing the mylohyoid and the submandibular gland are

   (a) The submandibular salivary gland.

   (b) The intermediate tendon of the digastric and the stylohyoid.

Carotid Triangle

Boundaries

Anterosuperiorly: Posterior belly of the digastric muscle; and the stylohyoid (Fig. 8.1).

Anteroinferiorly: Superior belly of the omohyoid.

Posteriorly: Anterior border of the sternocleidomastoid muscle.

Contents

Arteries

1. The common carotid artery with the carotid sinus and the carotid body at its termination;
2. Internal carotid artery; and
3. The external carotid artery with its superior thyroid, lingual, facial, ascending pharyngeal and occipital branches (Fig. 8.1 and Table A1.3).

Veins

1. The internal jugular vein (Fig. 8.1).
2. The common facial vein draining into the internal jugular vein.
3. A pharyngeal vein which usually ends in the internal jugular vein.
4. The lingual vein which usually terminates in the internal jugular vein.

Nerves

1. The vagus running vertically downwards.

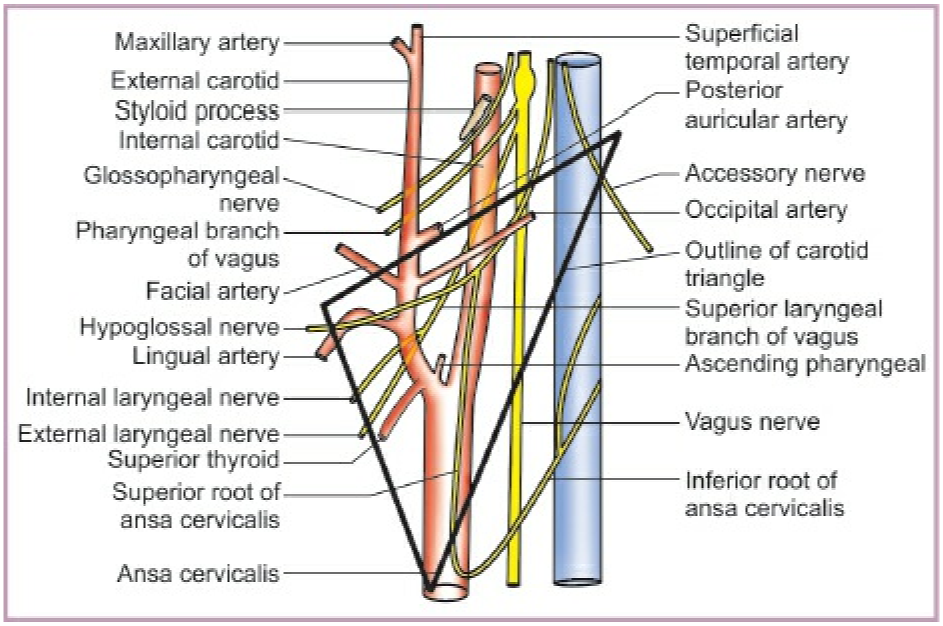


Fig. 8.1: The ninth, tenth, eleventh and twelfth cranial nerves and their branches related to the carotid arteries and to the internal jugular vein, in and around the carotid triangle.

2. The superior laryngeal branch of the vagus, dividing into the external and internal laryngeal nerves.
3. The spinal accessory nerve running backwards over the internal jugular vein.
4. The hypoglossal nerve running forwards over the external and internal carotid arteries. The hypoglossal nerve gives off the upper root of the ansa cervicalis or descendens hypoglossi, and another branch to the thyrohyoid.
5. Sympathetic chain runs vertically downwards posterior to the carotid sheath.

Carotid sheath with its contents.

Lymph nodes: The deep cervical lymph nodes are situated along the internal jugular vein, and include the jugulodigastric node below the posterior belly of the digastric and the jugulo-omohyoid node above the inferior belly of the omohyoid.

Muscular Triangle

Boundaries

Anteriorly: Anterior median line of the neck from the hyoid bone to the sternum.

Posterosuperiorly: Superior belly of the omohyoid muscle.

Posteroinferiorly: Anterior border of the sternocleidomastoid muscle.

Contents

The infrahyoid muscles are the chief contents of the triangle. These muscles may also be regarded arbitrarily as forming the floor of the triangle.

The ***infrahyoid muscles*** are

1. Sternohyoid
2. Sternothyroid (Table 8.1)
3. Thyrohyoid
4. Omohyoid

CLINICAL ANATOMY

- The common anterior midline swellings of the neck are as follows.
  - (a) Enlarged submental lymph nodes and sublingual dermoid in the submental region
  - (b) Thyroglossal cyst and inflamed subhyoid bursa just below the hyoid bone
  - (c) Goitre, carcinoma of larynx and enlarged lymph nodes in the suprasternal region
- Tracheostomy is an operation in which the trachea is opened and a tube inserted into it to facilitate breathing. It is most commonly done in the retrothyroid region after retracting the isthmus of the thyroid gland. A suprathyroid tracheostomy is liable to stricture, and an infrathyroid one is difficult due to the depth of the trachea and is also dangerous because numerous vessels lie anterior to the trachea here.
- Cut throat wounds are most commonly situated just above or just below the hyoid bone. The main vessels of the neck usually escape injury because they are pushed backwards to a deeper plane during

voluntary extension of the neck.

- Skin incisions to be made parallel to natural creases or Langer's lines.
- Ludwig’s angina is the cellulitis of the floor of the mouth. The infection spreads above the mylohyoid forcing the tongue upwards. Mylohyoid is pushed downwards. There is swelling within the mouth as well as below the chin.
- The carotid sinus is richly supplied by nerves. In some persons, the sinus may be hypersensitive. In such persons, sudden rotation of the head may cause slowing of heart. This condition is called as “carotid sinus syndrome”.
- The supraventricular tachycardia may be controlled by carotid sinus massage, due to inhibitory effects of vagus nerve on the heart.

Table 8.1: Infrahyoid muscles

Muscle	Proximal attachment	Distal attachment	Nerve supply	Actions
1. **Sternohyoid**	(a) Posterior surface of manubrium sterni (b) Adjoining parts of the clavicle and the posterior sternoclavicular ligament	Medial part of lower border of hyoid bone	Ansa cervicalis C1, C2, C3	Depresses the hyoid bone following its elevation during swallowing and during vocal movements
2. **Sternothyroid** It lies deep to the sternohyoid	(a) Posterior surface of manubrium sterni (b) Adjoining part of first costal cartilage	Oblique line on the lamina of the thyroid cartilage	Ansa cervicalis C1, C2, C3	Depresses the larynx after it has been elevated in swallowing and in vocal movements
3. **Thyrohyoid** It lies deep to the sternohyoid	Oblique line of thyroid cartilage	Lower border of the body and the greater cornua of the hyoid bone	C1 through hypoglossal nerve	(a) Depresses the hyoid bone (b) Elevates the larynx when the hyoid is fixed by the suprahyoid muscles
4. **Omohyoid** It has an inferior belly, a common tendon and a superior belly. It arises by the inferior belly, and is inserted through the superior belly	(a) Upper border of scapula near the suprascapular notch (b) Adjoining part of supra-scapular ligament	Lower border of body of hyoid bone lateral to the sternohyoid. The central tendon lies on the internal jugular vein at the level of the cricoid cartilage and is bound to the clavicle by a fascial pulley	Superior belly by the superior root of the ansa cervicalis, and inferior belly by ansa cervicalis	Depresses the hyoid bone following its elevation during swallowing or in vocal movements

9. Parotid Region

PAROTID GLAND

(*Para* = around; *otic* = ear)

The parotid is the largest of the salivary glands. It weighs about 15 g. It is situated below the external acoustic meatus, between the ramus of the mandible and the sternocleidomastoid.

External Features

The gland resembles a three-sided pyramid. The apex of the pyramid is directed downwards. The gland has four surfaces

1. Superior (base of the pyramid)
2. Superficial (Fig. 9.1)
3. Anteromedial
4. Posteromedial (Fig. 9.2).

The surfaces are separated by three borders

1. Anterior
2. Posterior
3. Medial

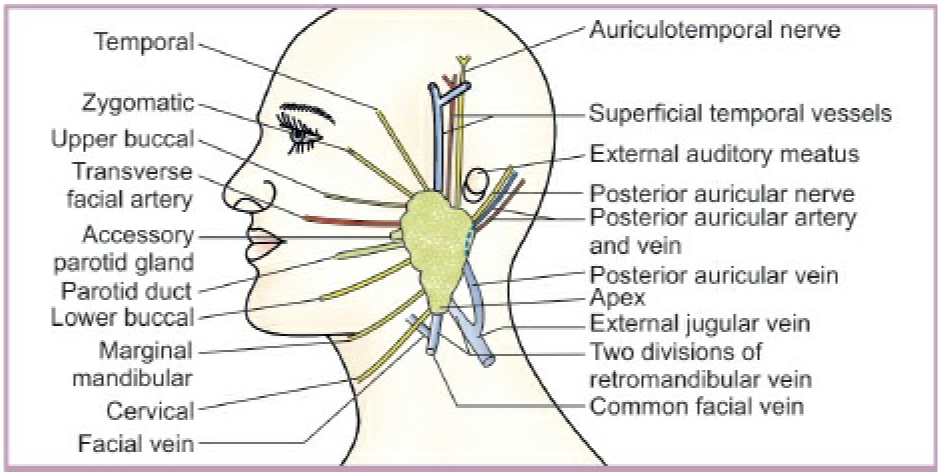


Fig. 9.1: Structures emerging at the periphery of the parotid gland.

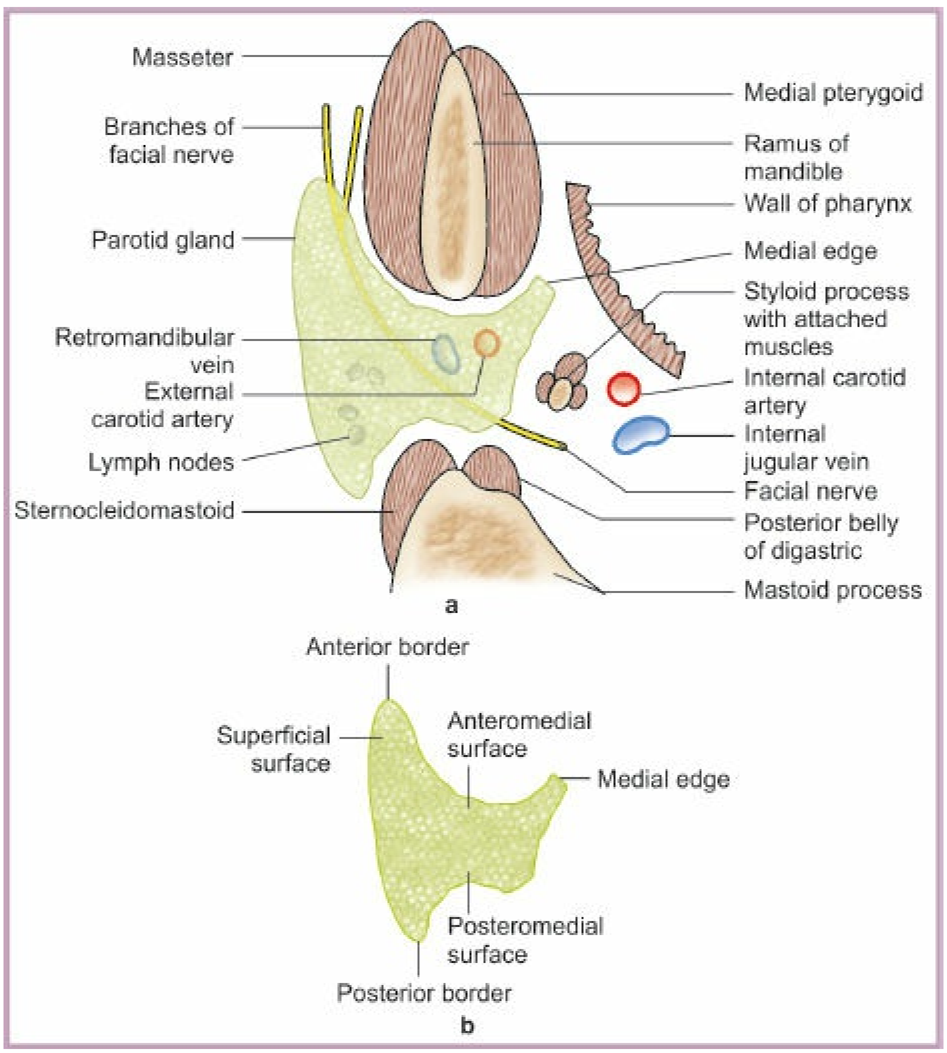


Fig. 9.2: (a) Horizontal section through the parotid gland showing its

relations and the structures passing through it. (b) Gross features of parotid gland.

Relations

The ***apex*** (Fig. 9.1) overlaps the posterior belly of the digastric and the adjoining part of the carotid triangle. The cervical branch of the facial nerve and the two divisions of the retromandibular vein emerge through it.

Surfaces

The ***superior surface*** or base forms the upper end of the gland which is small and concave. It is related to

(a) The cartilaginous part of the external acoustic meatus

(b) The posterior surface of the temporomandibular joint

(c) The superficial temporal vessels

(d) The auriculotemporal nerve

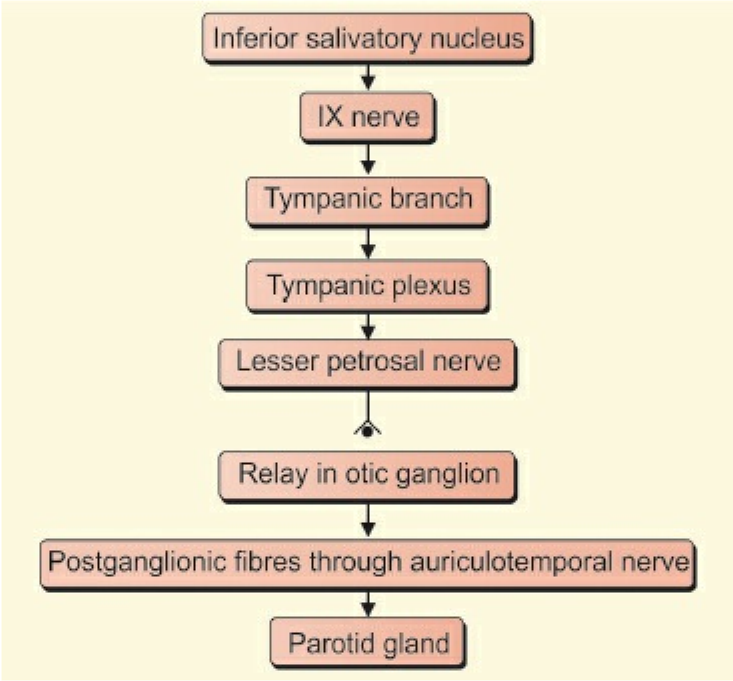
The ***superficial surface*** is the largest of the four surfaces. It is covered with (a) Skin, (b) Superficial fascia

The ***anteromedial surface*** is grooved by the posterior border of the ramus of the mandible

The ***posteromedial surface***: The styloid process, with structures attached to it. The external carotid artery enters the gland through this surface

Structures within the gland: External carotid artery, retromandibular vein, Facial nerve, and Lymph nodes (Fig. 9.2)

Nerve supply: The secretomotor nerve supply is traced in Flow chart 9.1.



Flow chart 9.1: Tracing nerve supply of parotid gland.

CLINICAL ANATOMY

- ***Parotid swellings*** are very painful due to the unyielding nature of the parotid fascia.
- ***Mumps*** is an infectious disease of the salivary glands (usually the parotid) caused by a specific virus.
- Viral parotitis or mumps characteristically does not suppurate. Its complications are orchitis and pancreatitis.
- A ***parotid abscess*** may be caused by spread of infection from the opening of parotid duct in the mouth cavity.
- A parotid abscess is best drained by horizontal incisions known as Hilton's method to prevent injury to branches of facial nerve.
- Dining surgical removal of the parotid gland or parotidectomy, the facial nerve is preserved by removing the gland in two parts, superficial and deep separately. The plane of cleavage is defined by tracing the nerve from behind forwards.
- ***Mixed parotid tumour*** is a slow growing lobulated, painless tumour

without any involvement of the facial nerve. Malignant change of such a tumour is indicated by pain, rapid growth, fixity with hardness, involvement of the facial nerve, and enlargement of cervical lymph nodes.

- The parotid calculi may get formed within the parotid gland or in its ***Stenson's duct.*** These can be located by injecting a radiopaque dye through its opening in the vestibule of the mouth. The procedure is called 'Sialogram'. The duct can be examined by a spatula or bidigital examination.
- Parotidectomy is the removal of the parotid gland. After this operation, at times, there may be regeneration of the secretomotor fibres in the auriculotemporal nerve which join the great auricular nerve. This causes stimulation of the sweat glands and hyperaemia in the area of its distribution, thus producing redness and sweating in the area of skin supplied by the nerve. This clinical entity is called ***Frey syndrome.*** Whenever such a person chews there is increased sweating in the region supplied by auriculotemporal nerve. So it is also called ' auriculotemporal syndrome '. Areas supplied by this nerve are external auditory meatus, lateral surface of tympanic membrane and skin of temporal region.

10. Temporal and Infratemporal Regions

Boundaries of Temporal Fossa

Anterior: Zygomatic and frontal bones

Posterior: Inferior temporal line and supramastoid crest

Superior: Superior temporal line

Inferior: Zygomatic arch

Floor: Parts of frontal, parietal, temporal and greater wing of sphenoid. Temporalis muscle is attached to the floor and inferior temporal line.

Contents

(i) Temporalis muscle
(ii) Middle temporal artery (branch of superficial temporal artery)
(iii) Zygomaticotemporal nerve and artery
(iv) Deep temporal nerve
(v) Deep temporal artery

INFRATEMPORAL FOSSA

It is an irregular space below zygomatic arch

Boundaries

Anterior: Posterior surface of body of maxilla

Roof: Infratemporal surface of greater wing of sphenoid

Medial: Lateral pterygoid plate and pyramidal process of palatine bone

Lateral: Ramus of mandible

Contents

- Lateral pterygoid muscle

- Medial pterygoid muscle
- Mandibular nerve with its branches
- Maxillary nerve with posterior superior alveolar nerve
- Chorda tympani, branch of VII nerve
- 1st and 2nd parts of maxillary artery with their branches

PTERYGOPALATINE FOSSA

Pterygopalatine fossa lies in the depth of pterygomaxillary fissure

Boundaries

Anterior: Posterior surface of maxilla

Posterior: Pterygoid process and greater wing of sphenoid

Medial: Perpendicular plate of palatine bone

Floor: Union of anterior and posterior walls

Contents

- Maxillary nerve and its branches
- Pterygopalatine ganglion with its branches
- Third part of maxillary artery and its branches

MUSCLES OF MASTICATION

These are given in Tables 10.1 and 10.2.

MAXILLARY ARTERY

Course and Relations

For descriptive purposes, the maxillary artery is divided into three parts (Fig. 10.1).

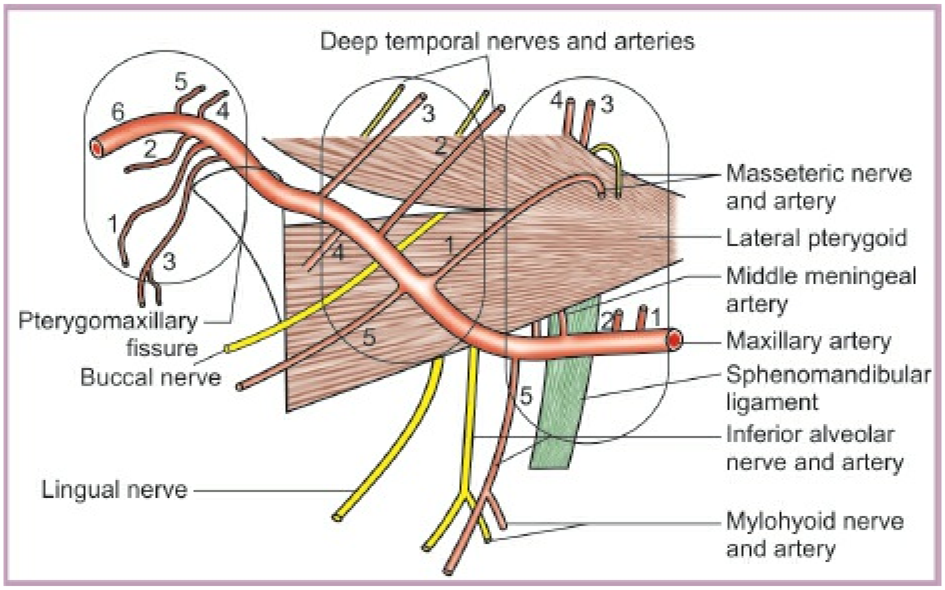


Fig. 10.1: Some relations of the lateral pterygoid muscle and branches of maxillary artery.

1. The ***first (mandibular) part*** runs horizontally forwards, first between the neck of the mandible and the sphenomandibular ligament, below the auriculotemporal nerve, and then along the lower border of the lateral pterygoid.

Table 10.1: Muscles of mastication

Muscle	Origin	Fibres
Masseter quadrilateral, covers la teral surface of ramus of mandible, has two la yers	(a) *Supetficial layer* (la rgest): from anterio r 2/3rd of lower bor der of zygomatic ar ch and adjoining zy gomatic process of maxilla (b) *Deep layer:* from d eep surface of zygo matic arch	(a) Superficial fibres p ass downwards and backwards at 45° (b) Deep fibres pass ve rtically downwards
Temporalis Fan-shaped, fills the te	(a) Temporal fossa, ex cluding zygomatic	Anterior fibres run vert ically, middle obliquel

mporal fossa	bone (b) Temporal fascia	y and posterior horizon tally. All converge and pass through the gap d eep to zygomatic arch
Lateral pterygoid Short, conical, has upp er and lower heads	(a) *Upper head* (small) : from infratempora l surface and crest of greater wing of s phenoid bone (b) *Lower head* (larger): from lateral surfa ce of lateral pteryg oid plate. Origin is medial to insertion	Fibres run backwards a nd laterally and conver ge for insertion
Medial pterygoid Quadrilateral, has a sm all superficial and a lar ge deep head	(a) *Supetficial head* (s mall slip): from tub erosity of maxilla a nd adjoining bone (b) *Deep head* (quite la rge): from medial s urface of lateral pte rygoid plate and ad joining process of palatine bone	Fibres run downwards, backwards and laterall y

Table 10.2: Muscles of mastication

Muscle	Insertion	Nerve supply	Action
Masseter	(a) Superficial layer: into lower part of lateral surface of ramus of mandible (b) Deep layer: into rest of the ramus of the mandible	Masseteric nerve, a branch of anterior division of mandibular nerve	Elevates mandible to close the mouth to bite
Temporalis	(a) Margins and deep surface of coronoid process. (b) Anterior border of ramus of mandible	Two deep temporal branches from anterior division of mandibular nerve	(a) Elevates mandible (b) Helps in side to side grinding movement (c) Posterior fibres retract lower jaw
Lateral pterygoid	(a) Pterygoid fovea on the anterior surface of neck of mandible (b) Anterior margin of articular disc and capsule of temporomandibular joint. Insertion is posterolateral and at a slightly higher level than origin	A branch from anterior division of mandibular nerve	(a) Depress mandible to open mouth, with suprahyoid muscle (b) Protrudes mandible (c) Right lateral and medial pterygoids push the chin towards left side.
Medial pterygoid	Roughened area on the medial surface of angle and adjoining ramus of mandible, below and behind the mandibular foramen and mylohyoid groove	Nerve to medial pterygoid, branch of the main trunk of mandibular nerve	(a) Elevates mandible (b) Helps protrude mandible (c) Right lateral and medial pterygoids push the chin towards left side.

2. The ***second (pterygoid) part*** runs upwards and forwards superficial to the lower head of the lateral pterygoid.
3. The ***third (pterygopalatine) part*** passes between the two heads of the lateral pterygoid and through the pterygomaxillary fissure, to enter the pterygopalatine fossa.

Branches of the Maxillary Artery

These are given in Table 10.3.

TEMPOROMANDIBULAR JOINT

This is a synovial joint of the condylar variety.

Articular Surfaces

The upper articular surface is formed by the following parts of the temporal bone:

(a) Articular tubercle
(b) Anterior part of mandibular fossa

The inferior articular surface is formed by the head of the mandible

The articular surfaces are covered with ***fibrocartilage.*** The joint cavity is divided into upper and lower parts by an intra-articular disc.

Ligaments

The ligaments are the fibrous capsule, the lateral ligament, the sphenomandibular ligament, and the stylomandibular ligament.

1. The fibrous capsule is attached above to the articular tubercle, the circumference of the mandibular fossa and the squamotympanic fissure, and below to the neck of the mandible
2. The lateral or temporomandibular ligament
3. The sphenomandibular ligament
4. The stylomandibular ligament

Articular Disc

The ***articular disc*** (Fig. 10.2) is an oval fibrous plate that divides the joint into an upper and a lower compartments. The upper compartment permits ***gliding*** movements, and the lower, ***rotatory*** as well as ***gliding*** movements. The disc has a concavoconvex superior surface, and a concave inferior surface.

Relations of Temporomandibular Joint

Lateral

(a) Skin and fasciae
(b) Parotid gland
(c) Temporal branches of the facial nerve

Table 10.3: Branches of maxillary artery (Fig. 10.1)

Branches	Foramina transmitting	Distribution
A. Of first part		
1. Deep auricular	Foramen in the floor (cartilage or bone) of external acoustic meatus	Skin of external acoustic meatus, and outer surface of tympanic membrane

2. Anterior tympanic	Petrotympanic fissure	Inner surface of tympanic membrane
3. Middle meningeal	Foramen spinosum	Supplies more of bone and less of meninges; also 5th and 7th nerves, middle ear and tensor tympani
4. Accessory meningeal	Foramen ovale	Main distribution is extracranial to pterygoids
5. Inferior alveolar	Mandibular foramen	Lower teeth and mylohyoid muscle
B. Of second part		
1. Masseteric	–	Masseter
2. Deep temporal	–	Temporalis
3. Deep temporal	–	Temporalis
4. Pterygoid	–	Lateral and medial pterygoids
5. Buccal	–	Skin of the cheek
C. Of third part		
1. Posterior superior alveolar	Alveolar canals in body of maxilla	Upper molar and premolar teeth and gums; maxillary sinus
2. Infraorbital	Inferior orbital fissure	Lower orbital muscles; lacrimal sac; maxillary sinus; upper incisor and canine teeth

3. Greater palatine	Greater palatine canal	Soft palate; tonsil; palatine glands and mucosa of upper gums
4. Pharyngeal	Pharyngeal (palatovaginal) canal	Roof of nose and pharynx; auditory tube; sphenoidal sinus
5. Artery of pterygoid canal	Pterygoid canal	Auditory tube; upper pharynx; and middle ear
6. Sphenopalatine (terminal part)	Sphenopalatine foramen	Lateral and medial walls of nose and various air sinuses

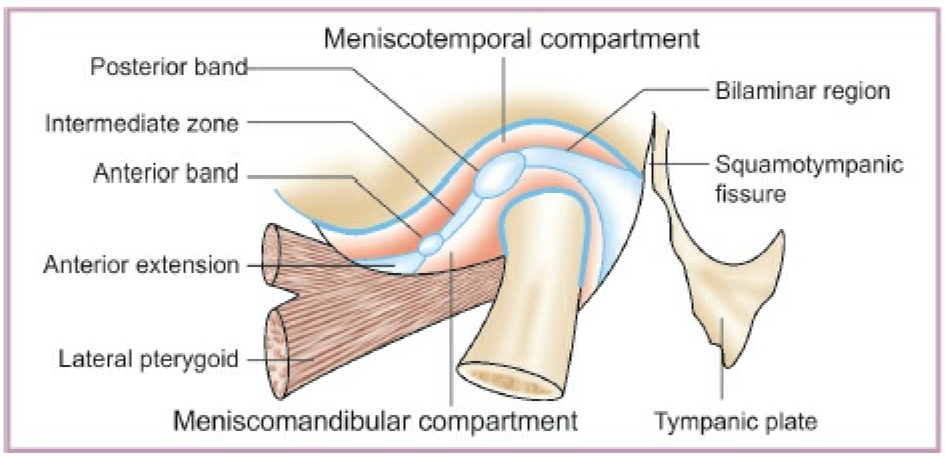


Fig. 10.2: Subdivision and attachment of the articular disc of the temporomandibular joint.

Medial

(a) The tympanic plate separates the joint from the internal carotid artery.
(b) Spine of the sphenoid, with upper end of the sphenomandibular ligament attached to it.
(c) Auriculotemporal and chorda tympani nerves.
(d) Middle meningeal artery

Anterior

(a) Lateral pterygoid

(b) Masseteric nerve and artery

Posterior

(a) The parotid gland separates the joint from the external auditory meatus.

(b) Superficial temporal vessels

(c) Auriculotemporal nerve

Superior

(a) Middle cranial fossa

(b) Middle meningeal vessels

Inferior

Maxillary artery and vein.

Blood Supply

Branches from superficial temporal and maxillary arteries. Veins follow the arteries.

Nerve Supply

Auriculotemporal nerve and masseteric nerve.

Muscles Producing Movements

↓ ***Depression*** is brought about mainly by the lateral pterygoid. The digastric, geniohyoid and mylohyoid muscles help when the mouth is opened wide or against resistance.

↑ ***Elevation*** is brought about by the masseter, the anterior vertical, middle oblique fibres of temporalis, and the medial pterygoid muscles of both sides. These are antigravity muscles.

← ***Protrusion*** is done by the lateral and medial pterygoids.

→ ***Retraction*** is produced by the posterior horizontal fibres of the temporalis.

Lateral or side to side movements, e.g. turning the chin to left side produced by right lateral pterygoid and right medial pterygoid and vice versa.

MANDIBULAR NERVE

This is the largest of the three divisions of the trigeminal nerve. It has both sensory and motor fibres. It is the nerve of the first branchial arch and supplies all structures derived from the mandibular or first branchial arch. Otic and submandibular ganglia are associated with this nerve.

Course and Relations

Mandibular nerve begins in the middle cranial fossa through a large sensory root and a small motor root. The sensory root arises from the lateral part of the trigeminal ganglion, and leaves the cranial cavity through the foramen ovale.

Branches

From the main trunk

(a) Meningeal branch

(b) Nerve to the medial pterygoid

From the anterior trunk

(a) A sensory branch, the buccal nerve

(b) Motor branches, the masseteric and deep temporal nerves and the nerve to the lateral pterygoid

From the posterior trunk

(a) Auriculotemporal

(b) Lingual (Table 10.4)

(c) Inferior alveolar nerves.

OTIC GANGLION

It is a peripheral parasympathetic ganglion which relays secretomotor fibres to the parotid gland. Topographically, it is intimately related to the mandibular nerve, but functionally it is a part of the glossopharyngeal nerve.

Table 10.4: Branches of the mandibular nerve (CN V3)

Muscular	Sensory	Others
Temporalis and masset	Meningeal	Taste

er	Auriculotemporal	
Medial and lateral pter ygoids	Inferior alveolar	Secretory
Tensor veli palatini an d tensor tympani	Lingual	Articular
Mylohyoid and digastri c (anterior belly)	Buccal	

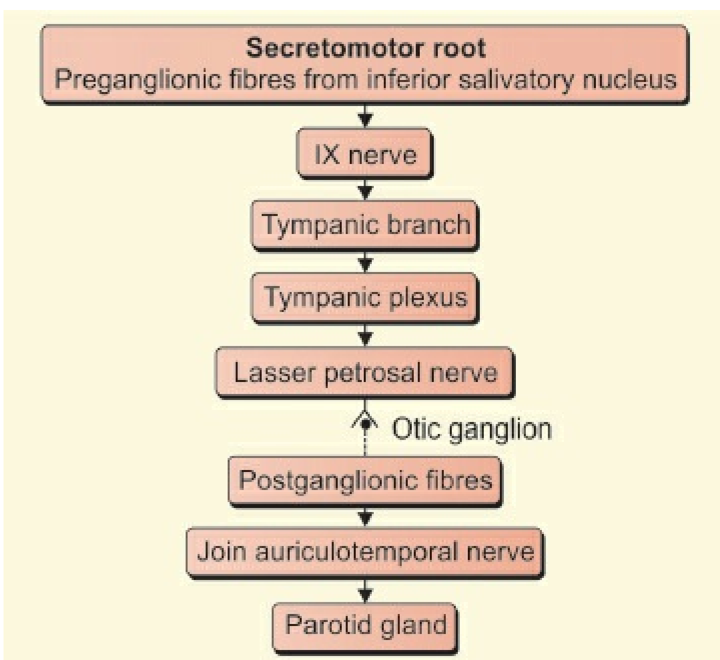
Size and Situation

It is 2 to 3 mm in size, and is situated in the infratemporal fossa, just below the foramen ovale. It lies medial to the mandibular nerve, and lateral to the tensor veli palatini. It surrounds the origin of the nerve to the medial pterygoid.

Connections and Branches

The ***parasympathetic root*** is formed by the lesser petrosal nerve. Its origin and course is shown in Flow chart 10.1.

The ***sympathetic root*** is derived from the plexus on the middle meningeal artery.



Flow chart 10.1: Secretomotor fibres for parotid gland

Sensory root is from auriculotemporal nerve.

Motor root is from nerve to medial pterygoid. It ***does not*** relay in the ganglion. It divides into two branches to supply tensor veli palatini and tensor tympani muscles.

CLINICAL ANATOMY

- ***Dislocation of mandible:*** During excessive opening of the mouth, the head of the mandible of one or both sides may slip anteriorly into the infratemporal fossa, as a result of which there is inability to close the mouth. Reduction is done by depressing the jaw with the thumbs placed on the last molar teeth, and at the same time elevating the chin.
- Derangement of the articular disc may result from any injury, like overclosure or malocclusion. This gives rise to clicking and pain during movements of the jaw.
- In operations on the temporomandibular joint, the VII nerve and auriculotemporal nerve, branch of mandibular division of V should be preserved with care.
- The motor part of the mandibular nerve is tested clinically by asking the patient to clench her/his teeth and then feeling for the contracting masseter and temporalis muscles on the two sides. If one masseter is paralysed, the jaw deviates to the paralysed side, on opening the mouth by the action of the normal lateral pterygoid of the opposite side. The activity of the pterygoid muscles is tested by asking the patient to move the chin from side to side.
- ***Referred pain:*** In cases with cancer of the tongue, pain radiates to the ear and to the temporal fossa, over the distribution of the auriculotemporal nerve as both lingual and auriculotemporal are branches of mandibular nerve. Sometimes the lingual nerve is divided to relieve intractable pain of this kind. This may be done where the nerve lies in contact with the mandible below and behind the last molar tooth, covered only by mucous membrane.
- ***Mandibular neuralgia:*** Trigeminal neuralgia of the mandibular

division is often difficult to treat. In such cases, the sensory root of the nerve may be divided behind the ganglion, and this is now the operation of choice when pain is confined to the distribution of the maxillary and mandibular nerves. During division, the ophthalmic fibres that lie in the superomedial part of the root are spared, to preserve the corneal reflex thus avoiding damage to the cornea.

- Lingual nerve lies in contact with mandible, medial to the third molar tooth. In extraction of malplaced ‘wisdom’ tooth, care must be taken not to injure the lingual nerve.
- Since the mandibular nerve innervates a portion of the external ear and the lower teeth, the pain of lower teeth may be referred to the ear.
- A lesion at the foramen ovale leads to paraesthesias along the mandible, tongue, temporal region and paralysis of the muscles of mastication. This also leads to loss of jaw-jerk reflex.
- The mandibular nerve supplies both the efferent and afferent loops of the jaw-jerk reflex, as it is a mixed nerve. Tapping the chin causes contraction of the pterygoid muscles.
- In extraction of mandibular teeth, inferior alveolar nerve needs to be anaesthetised. The drug is given into the nerve before it enters the mandibular canal.
- ***Inferior alveolar nerve:*** Inferior alveolar nerve as it travels the mandibular canal can be damaged by the fracture of the mandible. This injury can be assessed by testing sensation over the chin.
- During extraction of the 3rd molar, the buccal nerve may also get involved by the local anaesthetic agent causing temporary numbness of the cheek.
- ***Lingual nerve damage:*** During improper extraction of the 3rd molar tooth, or fracture of angle of the mandible, the lingual nerve may get damaged in the floor of the mouth. This results in loss of all sensations from anterior two-thirds of the tongue.
- ***Referred pain in the ear:*** Inflammation of any branch of mandibular nerve may cause referred pain in the ear. If there is cotton wool in ear, look in the mouth for oral or tongue disease/cancer.

11. Submandibular Region

SUPRAHYOID MUSCLES

The suprahyoid muscles are the digastric, the stylohyoid, the mylohyoid and the geniohyoid. The muscles are in following layers as follows.

First layer formed by digastric and stylohyoid

Second layer formed by mylohyoid

Third layer formed by geniohyoid and hyoglossus

Fourth layer formed by genioglossus

The muscles are described in Tables 11.1 and 11.2

Relations of Hyoglossus

Superficial

Styloglossus, lingual nerve, submandibular ganglion, deep part of the submandibular gland, submandibular duct, hypoglossal nerve and veins accompanying it.

Deep

(a) Inferior longitudinal muscle of the tongue
(b) Genioglossus
(c) Middle constrictor of the pharynx
(d) Glossopharyngeal nerve
(e) Stylohyoid ligament
(f) Lingual artery

Structures passing deep to posterior border of hyoglossus, from above downwards

(a) Glossopharyngeal nerve
(b) Stylohyoid ligament
(c) Lingual artery (Fig. 11.1)

SUBMANDIBULAR SALIVARY GLAND

Superficial Part

This part of the gland fills the digastric triangle. It extends upwards deep to the mandible up to the mylohyoid line. It has

(a) Inferior surace

Table 11.1: Suprahyoid muscles

Muscle	Origin	Fibres
1. **Digastric** (DG) has two bellies united b y an intermediate t endon	(a) Anterior belly (DG A): from digastric f ossa of mandible (b) Posterior belly (DG P): from mastoid n otch of temporal bo ne	(a) Anterior belly runs downwards and ba ckwards (b) Posterior belly runs downwards and for wards
2. **Stylohyoid** (SH). S mall muscle, lies o n upper border of DGP	Posterior surface of sty loid process	Tendon is perforated b y DGP tendon
3. **Mylohyoid** (MH). Flat, triangular mus cle; two mylohyoid s form floor of mou th cavity, deep to D GA	Mylohyoid line of man dible	Fibres run medially an d slightly downwards
4. **Geniohyoid** (GH).	Inferior mental spine (	Runs backwards and d

Short and narrow muscle; lies above medial part of MH	genial tubercle)	ownwards
5. **Hyoglossus**. lt is a muscle of tongue. l t forms important l andmark in this reg ion	Whole length of greate r cornua and lateral par t of body of hyoid bon e	Fibres run upwards an d forwards

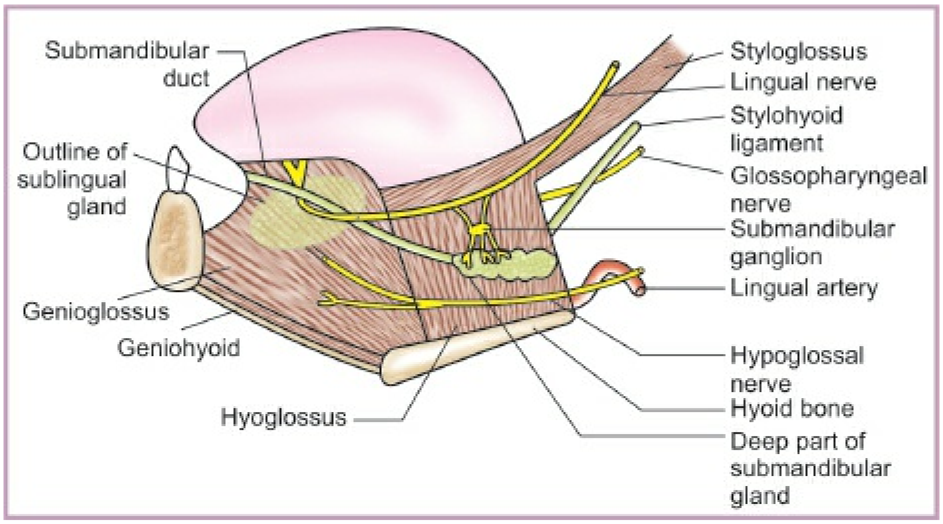


Fig. 11.1: Submandibular region showing the superficial and deep relations of the hyoglossus and genioglossus muscles.

Table 11.2: Suprahyoid muscles

Muscle	Insertion	Nerve supply	Action
1. Digastric (DG)	Both heads meet at the intermediate tendon which perforates SH and is held by a fibrous pulley to the hyoid bone	(a) Anterior belly by nerve to mylohyoid (b) Facial nerve supplies posterior belly	(a) Depresses mandible when mouth is opened widely or against resistance; it is secondary to lateral pterygoid (b) Elevates hyoid bone
2. Stylohyoid (SH).	Junction of body and greater cornua of hyoid bone	Facial nerve	(a) Pulls hyoid bone upwards and backwards (b) With other hyoid muscles, it fixes the hyoid bone
3. Mylohyoid (MH).	(a) Posterior fibres: body of hyoid bone (b) Middle and anterior fibres; median raphe, between mandible and hyoid bone	Nerve to mylohyoid	(a) Elevates floor of mouth in first stage of deglutition (b) Helps in depression of mandible, and elevation of hyoid bone
4. Geniohyoid (GH).	Anterior surface of body of hyoid bone	C1 through hypoglossal nerve	(a) Elevates hyoid bone (b) May depress mandible when hyoid is fixed
5. Hyoglossus.	Side of tongue between styloglossus and inferior longitudinal muscle of tongue	Hypoglossal (XII) nerve	Depresses tongue, makes dorsum convex, retracts the protruded tongue

(b) Lateral surface

(c) Medial surface

The gland is partially enclosed between two layers of deep cervical fascia. The superficial layer of fascia covers the inferior surface of the gland and is attached to the base of the mandible. The deep layer covers the medial surface of the gland and is attached to the mylohyoid line of the mandible.

Deep Part

This part is small in size. It lies deep to the mylohyoid, and superficial to the hyoglossus and the styloglossus. Posteriorly, it is continuous with the superficial part round the posterior border of the mylohyoid. Anteriorly, it extends up to the posterior end of the sublingual gland.

Submandibular Duct

It is thin walled, and is about 5 cm long. It opens on the floor of the mouth, on the summit of the sublingual papilla, at the side of the frenulum of the tongue.

Nerve Supply

It is supplied by branches from the submandibular ganglion. These branches convey

(a) Secretomotor fibres

(b) Sensory fibres from the lingual nerve

(c) Vasomotor sympathetic fibres from the plexus on the facial artery

SUBLINGUAL SALIVARY GLAND

This is smallest of the three salivary glands. It is almond-shaped and weighs about 3 to 4 g. It lies above the mylohyoid, below the mucosa of the floor of the mouth, medial to the sublingual fossa of the mandible and lateral to the genioglossus.

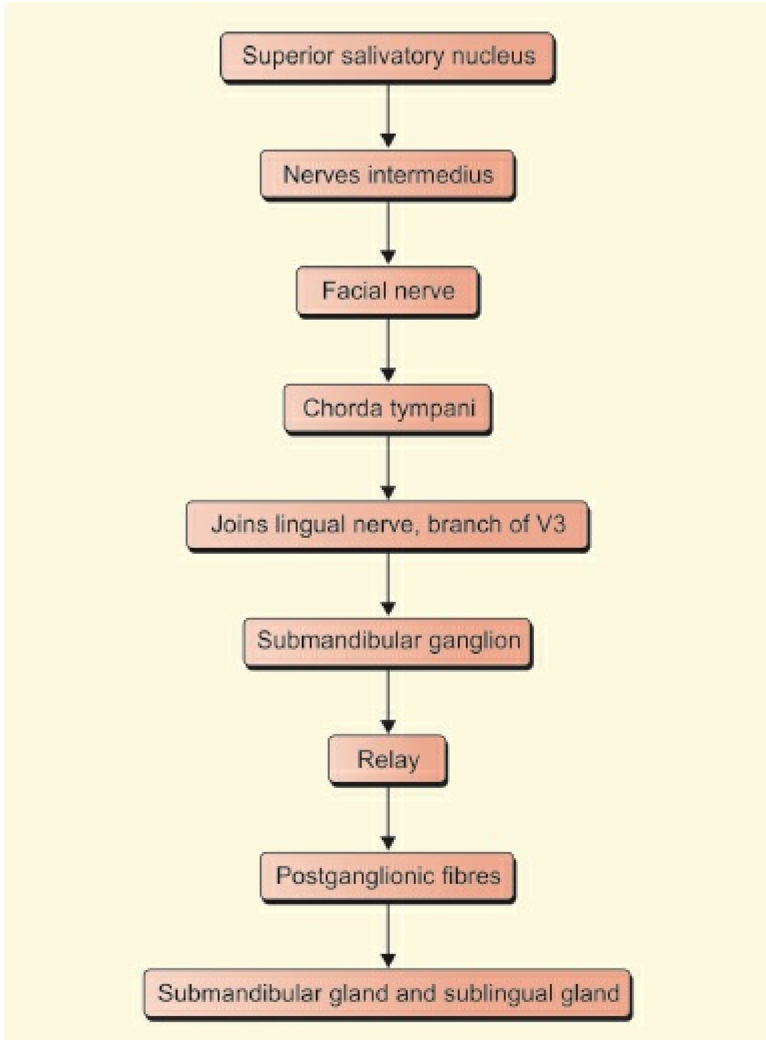
About 15 ducts emerge from the gland. Most of them open directly into the floor of the mouth on the summit of the sublingual fold.

The gland receives its blood supply from the lingual and submental arteries. The nerve supply is similar to that of the submandibular gland.

SUBMANDIBULAR GANGLION

This is a parasympathetic peripheral ganglion. It is a relay station for secretomotor fibres to the submandibular and sublingual salivary glands. Topographically, it is related to the lingual nerve, but functionally, it is connected to the chorda tympani branch of the facial nerve (Flow chart 11.1).

Flow chart 11.1: Secretomotor fibres to the glands.



CLINICAL ANATOMY

- Excision of the submandibular gland for calculus or tumour is done by an incision below the angle of the jaw. Since the marginal mandibular branch of the facial nerve passes posteroinferior to the angle of the jaw before crossing it, the incision must be placed more than 4 cm below the angle to preserve the nerve.

  The nerve also passes across the lymph nodes of submandibular region. One should be careful of the nerve while doing biopsy of lymph node.
- The chorda tympani supplying secretomotor fibres to submandibular and sublingual salivary glands lies medial to the spine of sphenoid.

The auriculotemporal nerve supplying secretomotor fibres to the parotid gland is related to lateral aspect of spine of sphenoid. Injury to spine may involve both these nerves with loss of secretion from all three salivary glands.

- Submandibular lymph nodes lie both within and outside the submandibular salivary gland. The gland is to be removed if lymph nodes are affected in any disease especially carcinoma of tongue.
- Mylohyoid muscle divides the gland into superficial and deep parts. Lymph nodes lie around and within the gland. Cancer of the tongue or of the gland may metastasise into the mandible also.
- The duct of submandibular gland may get impacted by a small stone, which can be demonstrated on radiographs.
- Secretion of submandibular gland is more viscous, so there are more chances of the gland getting calculi or small stones.
- Submandibular gland can be manually palpated by putting one finger within the mouth and one finger outside, in relation to the position of the gland. The enlarged lymph nodes lying on the surface of the gland and within its substance can also be palpated.

12. Deep Structures in the Neck

THYROID GLAND

The thyroid (shield like) is an endocrine gland, situated in the lower part of the front and sides of the neck. It regulates the basal metabolic rate, stimulates somatic and psychic growth, and plays an important role in calcium metabolism.

The gland consists of right and left *lobes* that are joined to each other by the *isthmus*.

Situation and Extent

(a) The gland lies against vertebrae C5, C6, C7 and Tl, embracing the upper part of the trachea.

(b) Each lobe extends from the middle of thyroid cartilage to the fourth or fifth tracheal ring.

Capsules of Thyroid

1. The *true capsule* is the peripheral condensation of the connective tissue of the gland.
2. The *false capsule* is derived from the pretracheal layer of the deep cervical fascia. It is thin along the posterior border of the lobes, but thick on the inner surface of the gland where it forms a suspensory ligament (of Berry), which connects the lobe to the cricoid cartilage.

A dense capillary plexus is present deep to the true capsule. To avoid haemorrhage during operations, the thyroid is removed along with the true capsule.

Relations

The lobes are conical in shape having

(a) An apex
(b) A base
(c) Three surfaces: Lateral, medial and posterolateral.
(d) Two borders: Anterior and posterior.

The ***lateral*** or ***superficial surface*** is convex, and is covered by

(a) The sternohyoid
(b) The superior belly of the omohyoid
(c) The sternothyroid
(d) The anterior border of the sternocleidomastoid (Fig. 12.1).

The ***medial surface*** is related to

(a) Two tubes, trachea and oesophagus
(b) Two muscles, inferior constrictor and cricothyroid
(c) Two nerves, external laryngeal and recurrent laryngeal.

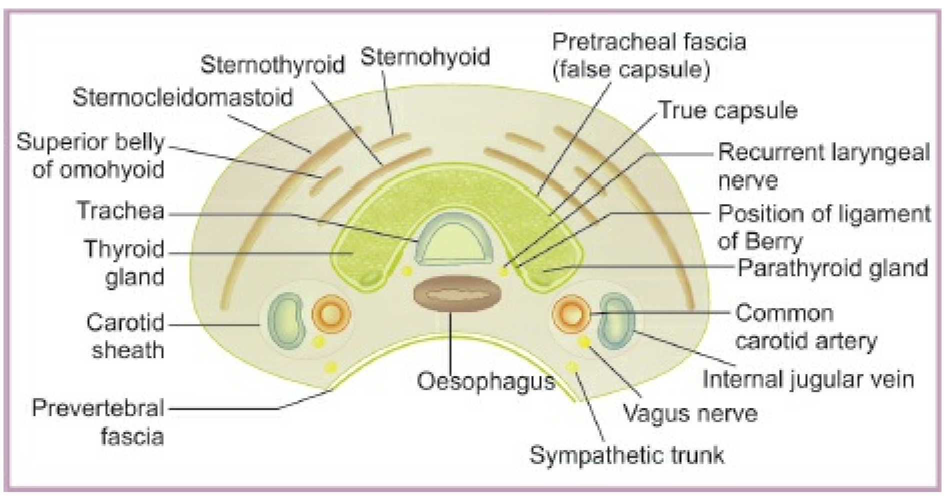


Fig. 12.1: Transverse section through the anterior part of the neck at the level of the isthmus of the thyroid gland.

The ***posterolateral*** or ***posterior surface*** is related to the carotid sheath and overlaps the common carotid artery (Fig. 12.1).

The ***anterior border*** is thin and is related to the anterior branch of superior thyroid artery.

The ***posterior border*** is thick and rounded and separates the medial and posterior surfaces. It is related to

(a) Inferior thyroid artery

(b) Anastomoses between the superior and inferior thyroid arteries

(c) Parathyroid glands

(d) Thoracic duct only on the left side.

The isthmus connects the lower parts of the two lobes. It has:

(a) Two surfaces, anterior and posterior.

(b) Two borders, superior and inferior.

The ***anterior surface*** is covered by

(a) The right and left sternothyroid and sternohyoid muscles.

(b) The anterior jugular veins.

(c) Fascia and skin (Fig. 12.1).

The ***posterior surface*** is related to the second to fourth tracheal rings.

The ***upper border*** is related to the anastomosis between the right and left superior thyroid arteries.

Lower border. Inferior thyroid veins leave the gland at this border.

Arterial Supply

The thyroid gland is supplied by the superior and inferior thyroid arteries.

The ***superior thyroid artery*** is the first anterior branch of the external carotid artery. It runs downwards and forwards in intimate relation to the external laryngeal nerve. After giving branches to adjacent structures, it pierces the pretracheal fascia to reach the upper pole of the lobe where the nerve deviates medially and the artery divides into anterior and posterior branches.

The ***anterior branch*** descends on the anterior border of the lobe and continues along the upper border of the isthmus to anastomose with its fellow of the opposite side.

The ***posterior branch*** descends on the posterior border of the lobe and anastomoses with the ascending branch of inferior thyroid artery.

The ***inferior thyroid artery*** is a branch of thyro-cervical trunk (which arises from the subclavian artery).

It runs first upwards, then medially, and finally downwards to reach the lower pole of the gland. During its course, it passes behind the carotid sheath and the middle cervical sympathetic ganglion; and in front of the vertebral vessels; and gives off branches to adjacent structures (Fig. 12.2).

Its terminal part is intimately related to the recurrent laryngeal nerve, while its proximal part is away from the nerve.

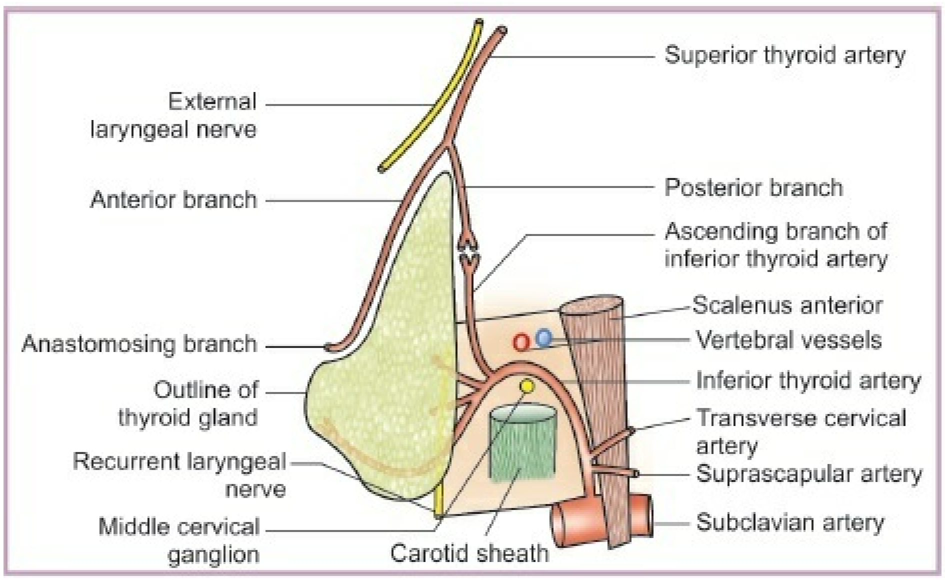


Fig. 12.2: Arterial supply of the thyroid gland (lateral view).

The artery divides into 4 to 5 glandular branches which pierce the fascia separately to reach the lower part of the gland. One ***ascending branch*** anastomoses with the posterior branch of the superior thyroid artery, and supplies the parathyroid glands.

Venous Drainage

The thyroid is drained by the superior, middle and inferior thyroid veins.

Development

The thyroid develops from a ***median endodermal thyroid diverticulum*** which grows down in front of the neck from the floor of the primitive pharynx, just caudal to the tuberculum impar.

The lower end of the diverticulum enlarges to form the gland. The rest of the diverticulum remains narrow and is known as the ***thyroglossal duct.***

PARATHYROID GLANDS

These are two pairs (superior and inferior) of small endocrine glands, that usually lie on the posterior border of the thyroid gland, within the false capsule. The ***superior parathyroids*** are also referred to as ***parathyroid IV*** because they develop from the endoderm of the ***fourth pharyngeal pouch.*** The ***inferior parathyroids,*** similarly, are also called ***parathyroid III because*** they develop from the ***third pouch.***

Position

The anastomotic artery between the superior and inferior thyroid arteries is usually a good guide to the glands because they usually lie close to it.

THYMUS

Each lobe develops from the endoderm of the third pharyngeal pouch. It lies on the pericardium, the great vessels of the superior mediastinum, and the trachea.

Functions

1. The thymus controls lymphopoiesis.
2. It controls development of the peripheral lymphoid tissues of the body during the neonatal period.
3. The cortical lymphocytes of the thymus act as immunologically competent but uncommitted cells, i.e. they can react to any unfamiliar, new antigen.

LYMPH NODES OF HEAD AND NECK

The peripheral nodes are arranged in two circles, superficial and deep.

The ***superficial circle of cervical lymph nodes*** is made up of the following groups.

1. Submental (Fig. 12.3)
2. Submandibular
3. Buccal and mandibular (facial)
4. Preauricular (parotid)
5. Postauricular (mastoid)
6. Occipital
7. Anterior cervical
8. Superficial cervical nodes.

The ***deep (inner) circle of cervical lymph nodes*** includes the following:

1. Prelaryngeal and pretracheal
2. Paratracheal
3. Retropharyngeal nodes
4. Waldeyer's ring comprises lingual, palatine, tubal and nasopharyngeal tonsils.

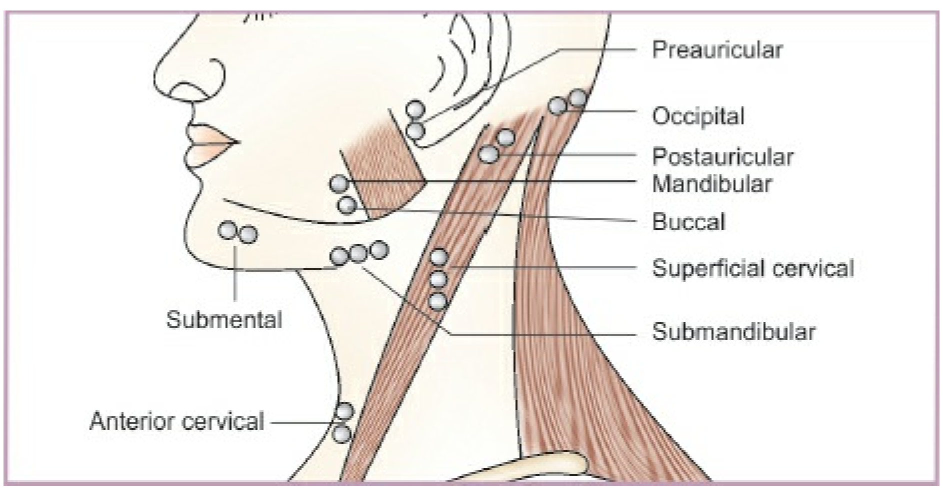


Fig. 12.3: Superficial lymph nodes of the neck.

Main Lymph Trunks at the Root of the Neck

1. The ***thoracic duct*** is the largest lymph trunk of the body. It begins in the abdomen from the upper end of the cistema chyli, traverses the thorax, and ends on the left side of the root of the neck by opening into the angle of junction between the left internal jugular vein and the left subclavian

vein. Before its termination, it forms an arch at the level of the transverse process of vertebra C7 rising 3 to 4 cm above the clavicle. It receives left ***jugular trunk*** which drains left half of the head and neck. The left ***subclavian trunk*** draining the left upper limb. The left ***bronchomediastinal trunk*** drains the lung, left half of the mediastinum and parts of the anterior walls of the thorax and abdomen.

2. On the right side, the subclavian, jugular and bronchomediastinal trunks may unite to form the ***right lymph trunk*** which ends at junction of right subclavian and right internal jugular veins.

SCALENE MUSCLES

These muscles are described in Table 12.1.

STYLOID APPARATUS

The styloid process with its attached structures is called the styloid apparatus. The structures attached to the process are three muscles and two ligaments. The muscles are the stylohyoid (VII), styloglossus (XII) and stylopharyngeus (IX) and ligaments are the stylohyoid and stylomandibular.

CLINICAL ANATOMY

- Any swelling of the thyroid gland (goitre) should be palpated from behind.
- Removal of the thyroid (thyroidectomy) with true capsule may be necessary in hyperthyroidism.
- In subtotal thyroidectomy, the posterior parts of both lobes are left behind. This avoids the risk of simultaneous removal of the parathyroids and also ofpostoperative myxoedema (caused by deficiency of thyroid hormones).
- During thyroidectomy, the superior thyroid artery is ligated near the gland to save the external laryngeal nerve; and the inferior thyroid artery is ligated away from the gland to save the recurrent laryngeal nerve.

- Hypothyroidism causes cretinism in infants and myxoedema in adults.
- Benign tumours of the gland may displace and even compress neighboring structures, like the carotid sheath, the trachea, etc. Malignant growths tend to invade and erode neighbouring structures. Pressure symptoms and nerve involvements are common in carcinoma of the glands.
- Tumours of the parathyroid glands lead to excessive secretion of parathormone (hyperparathyroidism). This leads to increased removal of calcium from bone making them weak and liable to fracture. Calcium levels in blood increase (hypercalcaemia) and increased urinary excretion of calcium can lead to the formation of stones in the urinary tract.
- Hypoparathyroidism may occur spontaneously or from accidental removal of the glands during thyroidectomy. This results in hypocalcaemia leading to increased neuromuscular irritability causing muscular spasm and convulsions (tetany).
- Parathyroid glands are tough glands and will continue to function if these are transplanted from an excised thyroid gland into the sternocleidomastoid muscle.
- Involution of the thymus is enhanced by hypertrophy of the adrenal cortex, injection of cortisone or of androgenic hormone. The involution is delayed by castration and adrenalectomy.
- Thymic hyperplasia or tumours are often associated with myasthenia gravis, characterized by excessive fatiguability of voluntary muscles. The precise role of the thymus in this disease is uncertain; it may influence, directly or indirectly, the transmission at the neuromuscular junction.
- Thymic tumours may press on the trachea, oesophagus, and the large veins of the neck, causing hoarseness, cough, dysphagia and cyanosis.
- The third part of the subclavian artery can be effectively compressed against the first rib after depressing the shoulder. The pressure is applied downwards, backwards, and medially in the angle between the sternocleidomastoid and the clavicle.
- A cervical rib may compress the subclavian artery, diminishing the radial pulse.

- An aneurysm may form in the third part of the subclavian artery. Its pressure on the brachial plexus causes pain, weakness, and numbness in the upper limb.
- The right subclavian artery may arise from the descending thoracic aorta. In that case, it passes posterior to the oesophagus which may be compressed and the condition is known as (dysphagia lusoria).
- Obstruction to the subclavian artery proximal to the origin of vertebral artery may lead to "stealing of blood from the brain through the opposite vertebral artery. This may provide necessary blood to the affected side. The nervous symptoms incurred are called 'subclavian steal syndrome".
- The common carotid artery can be compressed against the carotid tubercle, i.e. the anterior tubercle of the transverse process of vertebra C6 which lies at the level of the cricoid cartilage.
- Deep to the lesser supraclavicular fossa, the internal jugular vein is easily accessible for recording of venous pulse tracings. The vein can be cannulated by direct puncture in the interval between sternal and clavicular heads of sternocleidomastoid muscle.
- In congestive cardiac failure or any other disease where venous pressure is raised, the internal jugular vein is markedly dilated and engorged.
- The deep cervical lymph nodes lie on the internal jugular vein. These nodes often become adherent to the vein in malignancy or in tuberculosis. Therefore, during operation on such patients the vein is also resected. These are examined from behind.
- The head and neck are supplied by sympathetic nerves arising from the upper four thoracic segments of the spinal cord. Most of these preganglionic fibres pass through the stellate ganglion to relay in the superior cervical ganglion.
- Injury to cervical sympathetic trunk produces ***Homer s syndrome.*** It is characterized by:

  (a) Ptosis—drooping of the upper eyelid.

  (b) Miosis—constriction of the pupil.

  (c) Anhydrosis—loss of sweating on that side of the face.

(d) Enophthalmos—retraction of the eyeball.

(e) Loss of the ciliospinal reflex—pinching the skin on the nape of the neck does not produce dilatation of the pupil (which normally takes place).

- Homer's syndrome can also be caused by a lesion within the central nervous system anywhere at or above the first thoracic segment of the spinal cord involving sympathetic fibres.
- The accessory phrenic nerve is commonly a branch from the nerve to the subclavius. It lies lateral to the phrenic nerve and descends behind, or sometimes in front of the subclavian vein. It joins the main nerve usually near the first rib, but occasionally the union may even be below the root of the lung.
- The trachea may be compressed by pathological enlargements of the thyroid, the thymus, lymph nodes and the aortic arch. This causes dyspnoea, irritative cough, and often a husky voice.
- Tracheostomy is an emergency operation done in cases of laryngeal obstruction (foreign body, diphtheria, carcinoma, etc.). It is commonly done in the retrothyroid region after retracting the isthmus of the thyroid gland.
- Superficial cervical, supraclavicular and lymph nodes of anterior triangle can easily be palpated.
- Chronic infection of the palatine tonsil causes enlargement of jugulodigastric lymph nodes which adhere to the internal jugular vein.
- Painful enlargement of the submandibular lymph nodes is common because infections in tongue, mouth and cheek are quite common. These nodes may be affected by tubercular bacteria.
- Spinal root of accessory nerve may get entangled in the enlarged lymph nodes situated in the posterior triangle of neck. While taking biopsy of the lymph node, one must be careful not to injure the accessory nerve lest trapezius gets damaged.
- Oesophagus has four natural constrictions. While passing any instrument, one must be careful at these sites.
- The left supraclavicular nodes are called Virchow's lymph nodes. Cancer from stomach and testis may metastasize into these lymph

nodes, which may become palpable.

Table 12.1: The scalene muscles

Muscle	Origin from	Insertion into	Nerve supply	Actions
1. Scalenus anterior	Anterior tubercles of transverse processes of cervical vertebrae, 3, 4, 5 and 6	Scalene tubercle and adjoining ridge on the superior surface of the first rib (between subclavian artery and vein)	Ventral rami of nerves C4–C6	(a) Anterolateral flexion of cervical spine (b) Rotates cervical spine to opposite side (c) Elevates the first rib during inspiration (d) Stabilizes the neck along with other muscles
2. Scalenus medius	(a) Posterior tubercles of transverse processes of cervical vertebrae 3, 4, 5, 6, 7 (b) Transverse process of axis and sometimes also of the atlas vertebra	Superior surface of the first rib behind the groove for the subclavian artery	Ventral rami of nerves C3-C8	(a) Lateral flexion of the cervical spine (b) Elevation of first rib (c) Stabilizes neck along with other muscles
3. Scalenus posterior	Posterior tubercles of transverse processes of cervical vertebrae, 4, 5, 6	Outer surface of the second rib behind the tubercle for the serratus anterior	Ventral rami of nerves C6-C8	(a) Lateral flexion of cervical spine (b) Elevation of the second rib (c) Stabilizes neck along with other muscles

13. Prevertebral Region

PREVERTEBRAL MUSCLES (Anterior vertebral muscles)

The four prevertebral or anterior vertebral muscles are the longus colli (cervicis), the longus capitis, the rectus capitis anterior and the rectus capitis lateralis. These are weak flexors of the head and neck. They extend from the base of the skull to the superior mediastinum. They partially cover the anterior aspect of the vertebral column. They are covered anteriorly by the thick prevertebral fascia. The muscles are described in Table 13.1.

VERTEBRAL ARTERY

See Appendix 1

Development of Vertebral Artery

Different parts of vertebral artery develop in the following ways.

First part: From a branch of dorsal division of 7th cervical intersegmental artery

Second part: From postcostal anastomosis

Third part: From spinal branch of the first cervical intersegmental artery

Fourth part: From preneural branch of first cervical intersegmental artery

Special Joints Between the Atlas, the Axis and the Occipital Bone

1. The atlanto-occipital and the atlantoaxial joints are designed to permit

free movements of the head on the neck (vertebral column).

2. The axis vertebra and the occipital bone are connected together by very strong ligaments. Between these two bones, the atlas is held like a washer. The axis of movement between the atlas and skull is transverse, permitting flexion and extension (nodding), whereas the axis of movement between the axis and the atlas is vertical, permitting rotation of the head (Fig. 13.1).

Table 13.1: The prevertebral muscles

Muscle	Origin from	Insertion into	Nerve supply	Actions
1. Longus colli (cervicis). This muscle extends from the atlas to the third thoracic vertebra. It has upper and lower oblique parts and a middle vertical part	(a) The upper oblique part is from the anterior tubercles of the transverse processes of cervical vertebrae 3, 4, 5 (b) Lower oblique part is from bodies of upper 2–3 thoracic vertebrae (c) Middle vertical part is from bodies of upper 3 thoracic and lower 3 cervical vertebrae	(a) Upper oblique part is into the anterior tubercle of the atlas (b) Lower oblique part is into the anterior tubercles of the transverse processes of 5th and 6th cervical vertebrae (c) Middle vertical part is into bodies of 2,3,4 cervical vertebrae	Ventral rami of nerves C3-C8	(a) Flexes the neck (b) Oblique parts flex the neck laterally (c) Lower oblique part rotates the neck to the opposite side
2. Longus capitis. It overlaps the longus colli. It is thick above and narrow below	Anterior tubercles of transverse processes of cervical 3-6 vertebrae	Inferior surface of basilar part of occipital bone	Ventral rami of nerves C1-C3	Flexes the head
3. Rectus capitis anterior. This is a very short and flat muscle. It lies deep to the longus capitis	Anterior surface of lateral mass of atlas in front of the occipital condyle	Basilar part of the occipital bone	Ventral ramus of nerve C1	Flexes the head
4. Rectus capitis lateralis. This is a short, flat muscle	Upper surface of transverse process of atlas	Inferior surface of jugular process of the occipital bone	Ventral rami of nerves C1, C2	Flexes the head laterally

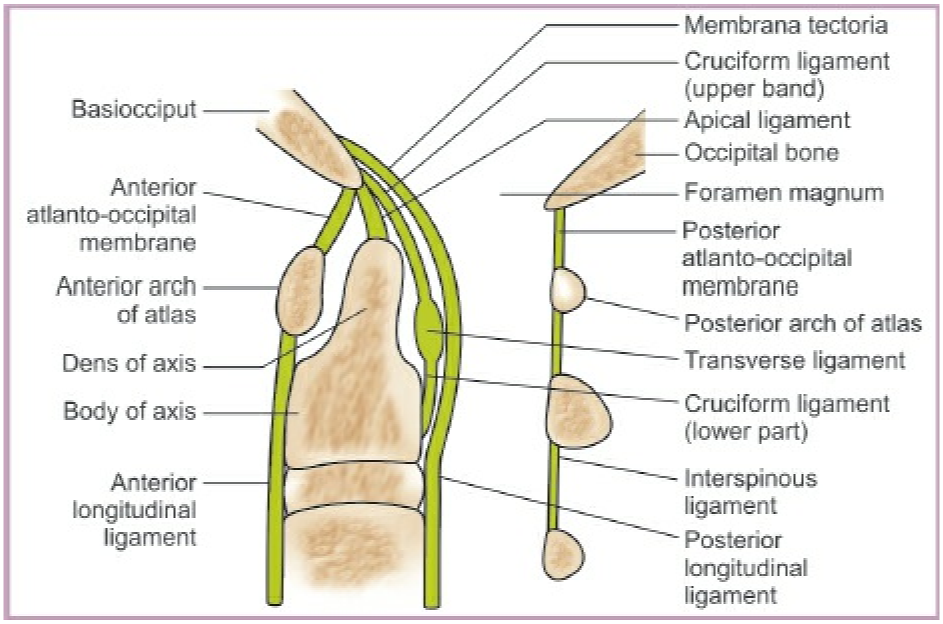


Fig. 13.1: Median section through the foramen magnum and upper two cervical vertebrae showing the ligaments in this region.

Ligaments

1. The ***fibrous capsule (capsular ligament)*** surrounds the joint. It is thick posterolaterally and thin anteromedially.
2. The ***anterior atlanto-occipital membrane*** extends from the anterior margin of the foramen magnum above, to the upper border of the anterior arch of the atlas below (Fig. 13.1).
3. The ***posterior atlanto-occipital membrane*** extends from the posterior margin of the foramen magnum above, to the upper border of the posterior arch of the atlas below.

Atlantoaxial Joints

Types and articular surfaces

These joints comprise

1. A pair of lateral atlantoaxial joints between the inferior facets of the atlas and the superior facets of the axis. These are plane joints.
2. A median atlantoaxial joint between the dens (odontoid process) and the anterior arch and transverse ligament of the atlas. It is a pivot joint. The joint has two separate synovial cavities, anterior and posterior.

Ligaments

The lateral atlantoaxial joints are supported by

(a) A capsular ligament all around

(b) The lateral part of the anterior longitudinal ligament

(c) The ligamentum flavum

The median atlantoaxial joint is strengthened by the following:

(a) The anterior smaller part of the joint between the anterior arch of the atlas and the dens is surrounded by a loose capsular ligament.

(b) The posterior larger part of the joint between the dens and transverse ligament (often called a bursa) is often continuous with one of the atlanto-occipital joints. Its main support is the transverse ligament which forms a part of the cruciform ligament of the atlas (Fig. 13.1).

The ***transverse ligament*** is attached on each side to the medial surface of the lateral mass of the atlas. In the median plane, its fibres are prolonged upwards to the basiocciput and downwards to the body of the axis, thus forming the ***cruciform ligament of the atlas vertebra.*** The transverse ligament embraces the narrow neck of the dens, and prevents its dislocation.

Movements

Movements at all three joints are rotatory and take place around a vertical axis. The dens forms a pivot around which the atlas rotates (carrying the skull with it). The movement is limited by the alar ligaments.

Ligaments Connecting the Axis with the Occipital Bone

1. The membrana tectoria is an upward continuation of the posterior longitudinal ligament
2. Cruciate ligament (see transverse ligament)
3. The apical ligament of the dens
4. The ***alar ligament***

CLINICAL ANATOMY

- Death in execution by hanging is due to dislocation of the dens following rupture of the transverse ligament of the dens, which then crushes the spinal cord and medulla. However, hanging can also cause fracture through the axis, or separation of the axis from the third cervical vertebra.

- ***Cervical spondylosis.*** Injury or degenerative changes of old age may rupture the thin lateral parts of the annulus fibrosus (of the intervertebral disc) resulting in prolapse of the nucleus pulposus. This is known as disc prolapse or spondylosis and may be lateral or median. Although it is commonest in the lumbar region, it may occur in the lower cervical region. This causes shooting pain along the distribution of the cervical nerve pressed. A direct posterior prolapse may compress the spinal cord.
- Cervical vertebrae may be fractured or, dislocated by a fall on the head with acute flexion of the neck. In the cervical region, the vertebrae can dislocate without any fracture of the articular processes due to their horizontal position.
- Pithing of frog takes place when the cruciate ligament of median atlantoaxial joint ruptures, crushing the vital centres in medulla oblongata, resulting in immediate death. This occurs injudicial hanging as well.
- The degenerative changes or spondylitis may occur in the cervical spine, leading to narrowed intervertebral foramen, causing pressure on the spinal nerves.

14. Mouth and Pharynx

Oral Cavity

The oral or mouth cavity is divided into an outer, smaller portion, the vestibule, and an inner larger part, the oral cavity proper.

Vestibule

1. The vestibule of the mouth is a narrow space *bounded* externally by the lips and cheeks, and internally, by the teeth and gums.
2. The *parotid duct* opens on the inner surface of the cheek (vestibule) opposite the crown of the upper second molar tooth.

Lips

Each lip is *composed* of

(a) Skin

(b) Superficial fascia

(c) The orbicularis oris muscle

(d) The submucosa, containing mucous labial glands and blood vessels

(e) Mucous membrane

Cheeks (Buccae)

Each cheek is *composed of*

(a) Skin

(b) Superficial fascia containing some facial muscles, the parotid duct, mucous molar glands, vessels and nerves

(c) The buccinator covered by buccopharyngeal fascia and pierced by the parotid duct

(d) Submucosa, with mucous buccal glands

(e) Mucous membrane

Teeth

In man, the teeth are replaced only once *(díphyodont)* in contrast with non-mammalian vertebrates where teeth are constantly replaced throughout life *(polyphyodoni)*. The teeth of the first set (dentition) are known as *milk*, or *deciduous teeth*, and the second set, as *permanent teeth*.

Parts of a Tooth

Each tooth has three parts:

1. A ***crown,*** projecting above or below the gum.
2. A ***neck,*** between the crown and root and surrounded by the gum (Fig. 14.1).
3. A ***root,*** embedded in the jaw beneath the gum.

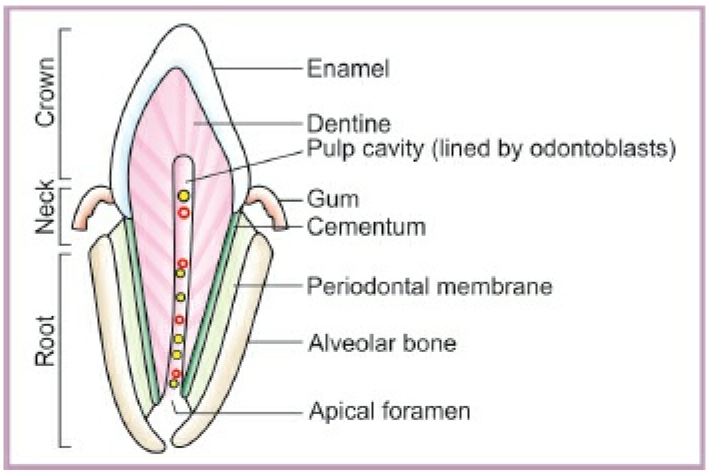


Fig. 14.1: Parts of a tooth.

Structure

Structurally, each tooth is composed of

1. The pulp in the centre
2. The dentine surrounding the pulp
3. The enamel covering the projecting part of dentine, or crown.
4. The cementum surrounding the embedded part of the dentine.
5. The periodontal membrane.

Eruption of Teeth

The approximate ages of eruption are given in Table 14.1.

Nerve Supply of Teeth

The upper teeth are supplied by the posterior superior alveolar, middle superior alveolar, and the anterior superior alveolar nerves (maxillary nerve). The lower teeth are supplied by the inferior alveolar nerve (mandibular nerve) (Fig. 14.2).

Development of Teeth

Teeth are formed in relation to alveolar process. The epithelium thickens to form dental lamina. The cells of dental lamina proliferate at various sites to form enamel organ, which grows into underlying mesenchyme and acquires a cup-shaped appearance, occupied by the mesenchyme. This mesenchyme is of neural crest origin and is called dental papilla. The dental papilla together with enamel organ is known as tooth germ. This stage is called “cap stage”. The cells of enamel organ adjacent to dental papilla cells get columnar and are known as ameloblasts.

The mesenchymal cells now arrange themselves along the ameloblasts and are called odontoblasts. The two cell layers are separated by a basement membrane. The rest of the mesenchymal cells form the “pulp of the tooth”. This is the “bell stage”.

Table 14.1: Usual time of eruption of teeth and time of shedding of dec iduous teeth

Tooth	Eruption time	Shedding time
Deciduous		
Medial incisor	6-8 months	6-7 years
Lateral incisor	8-10 months	7-8 years
First molar	12-16 months	8-9 years
Canine	16-20 months	10-12 years
Second molar	20-24 months	10-12 years
Permanent		

First molar	6-7 years
Medial incisor	7-8 years
Lateral incisor	8-9 years
First premolar	10-11 years
Second premolar	11-12 years
Canine	12-13 years
Second molar	13-14 years
Third molar	17-25 years

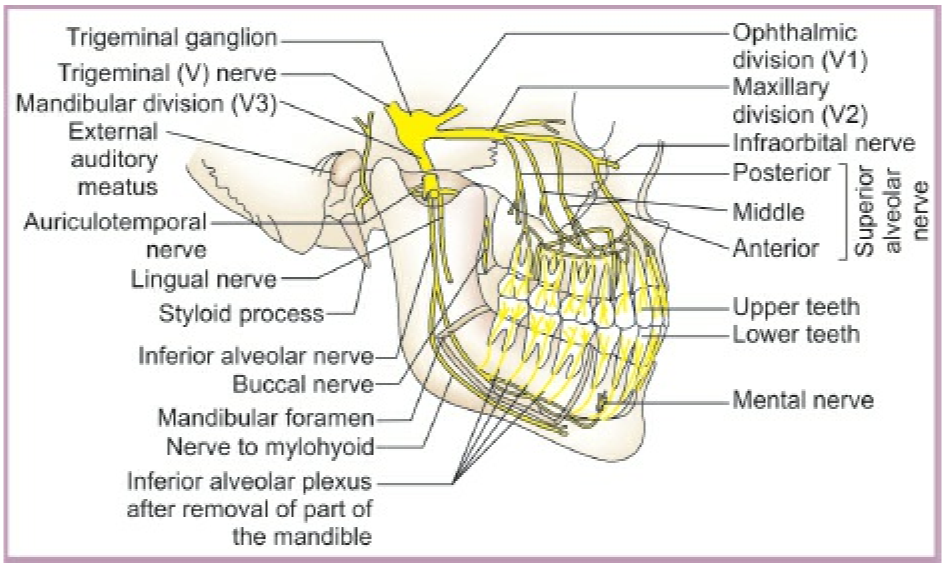


Fig. 14.2: Nerve supply of teeth.

Now ameloblasts lay enamel on the outer aspect, while odontoblasts lay dentine on the inner aspect. Later ameloblasts disappear while odontoblasts remain.

The root of the tooth is formed by laying down of layers of dentine, narrowing the pulp space to a canal for the passage of nerve and blood vessels only. The dentine in the root is covered by mesenchymal cells which differentiate into cementoblasts for laying down the cementum. Outside this is the periodontal ligament connecting root to the socket in the bone.

HARD PALATE

It is a partition between the nasal and oral cavities. Its anterior two-thirds are formed by the palatine processes of the maxillae; and its posterior one-third by the horizontal plates of the palatine bones.

The ***anterolateral margins*** of the palate are continuous with the alveolar arches and gums

The ***posterior margin*** gives attachment to the soft palate

The ***superior surface*** forms the floor of the nose

The ***inferior surface*** forms the roof of the oral cavity

Vessels and Nerves

Arteries: Greater palatine branch of maxillary artery

Veins: Drain into the pterygoid plexus of veins

Nerves: Greater palatine and nasopalatine branches of the pterygopalatine ganglion suspended by the maxillary nerve

Lymphatics: The lymphatics drain mostly to the upper deep cervical nodes and partly to the retropharyngeal nodes.

SOFT PALATE

It is a movable, muscular fold, suspended from the posterior border of the hard palate. It separates the nasopharynx from the oropharynx, and is often looked upon as traffic controller at the crossroads between the food and air passages. The soft palate has two surfaces, anterior and posterior; and two borders, superior and inferior.

Muscles of the Soft Palate

They are as follows

1. Tensor palati (tensor veli palatini) (Fig. 14.3)
2. Levator palati (levator veli palatini)
3. Musculus uvulae

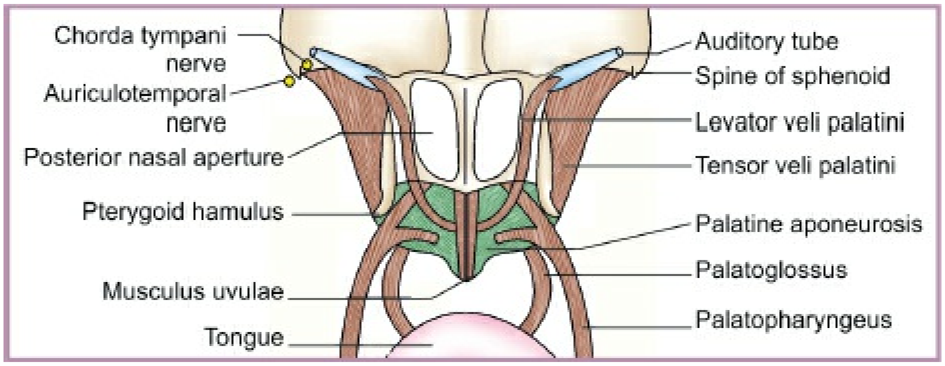


Fig. 14.3: Muscles of the soft palate.

4. Palatoglossus
5. Palatopharyngeus

   Details of the muscles are given in Table 14.2

Nerve Supply

1. Motor nerves. All muscles of the soft palate except the tensor veli palatini are supplied by the pharyngeal plexus. The fibres of this plexus are derived from the cranial part of the accessory nerve through the vagus. The tensor veli palatini is supplied by the mandibular nerve.
2. General sensory nerves are derived from
   (a) The middle and posterior lesser palatine nerves, which are branches of the maxillary nerve through the pterygopalatine ganglion.
   (b) The glossopharyngeal nerve.
3. Special sensory or gustatory nerves carrying taste sensations from the oral surface are contained in the lesser palatine nerves. The fibres travel through the greater petrosal nerve to the geniculate ganglion of the facial nerve and from there to the nucleus of the solitary tract.
4. Secretomotor nerves are also contained in the lesser palatine nerves. They are derived from the superior salivatory nucleus and travel through the greater petrosal nerve.

PHARYNX

The pharynx is a wide muscular tube, situated behind the nose, the mouth and the larynx. Clinically, it is a part of the upper respiratory passages where infections are common. The upper region of the pharynx (nasopharynx) transmits only air, the lower region (below the inlet of the larynx), only food (laryngopharynx) but the middle region is a common passage for both air and food (oropharynx) (Fig. 14.4).

Table 14.2: Muscles of the soft palate

Muscle	Origin	Insertion	Actions
1. **Tensor veli palatini** This is a thin, triangular muscle	Lateral side of auditory tube and adjoining part of the base of the skull (greater wing and scaphoid fossa of sphenoid bone)	Muscle converges to form a delicate tendon which winds round the pterygoid hamulus and flattens out to form the palatine aponeurosis attached to posterior border of hard palate and inferior surface of palate behind the palatine crest	Tightens the soft palate, chiefly the anterior part and opens the auditory tube to equalize air pressure between the middle ear and the nasopharynx
2. **Levator veli palatini** This is a cylindrical muscle that lies deep to the tensor veli palatini	Inferior aspect of auditory tube and adjoining part of inferior surface of petrous temporal bone	Muscle enters the pharynx by passing over the upper concave margin of the superior constrictor, runs downwards and medially and spreads out in the soft palate. It is inserted into the upper surface of the palatine aponeurosis	Elevates soft palate and closes the pharyngeal isthmus and opens the auditory tube, like the tensor veli palatini
3. **Musculus uvulae:** This is a longitudinal strip placed on each side of the median plane	Posterior nasal spine Palatine aponeurosis	Mucous membrane of uvula	Pulls up the uvula
4. **Palatoglossus**	Oral surface of palatine aponeurosis	Descends in the palatoglossal arch, to the side of the tongue at the junction of its oral and pharyngeal parts	It approximates the palatoglossal arches, and thus closes the oropharyngeal isthmus
5. **Palatopharyngeus** It consists of two fasciculi that are separated by the levator veli palatini	Anterior fasciculus from posterior border of hard palate and posterior fasciculus from the palatine aponeurosis	Descends in the palatopharyngeal arch to form of longitudinal muscle coat of pharynx. It is inserted into posterior border of the lamina of the thyroid cartilage	Pulls up the wall of the pharynx and shortens it during swallowing

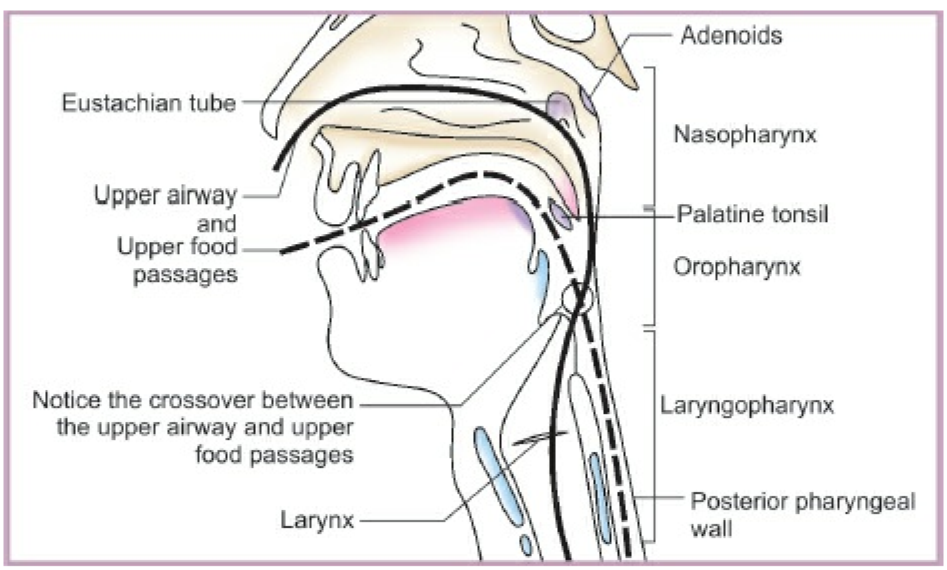


Fig. 14.4: The three regions of the pharynx.

Parts of the Pharynx

The cavity of the pharynx is divided into

(a) The nasal part, nasopharynx

(b) The oral part, oropharynx

(c) The laryngeal part, laryngopharynx

These are tabulated in Table 14.3.

Palatine Tonsil (The Tonsil)

Features

The palatine tonsil occupies the tonsillar sinus or fossa between the palatoglossal and palatopharyngeal arches. It can be seen through the mouth. The tonsil is almond-shaped. It has two surfaces medial and lateral; two borders, anterior and posterior and two poles, upper and lower.

The ***medial surface*** is covered by stratified squamous epithelium continuous with that of the mouth. This surface has 12 to 15 crypts. The largest of these is called the ***intratonsillar cleft.***

The ***lateral surface*** is covered by a sheet of fascia which forms the capsule of the tonsil.

The bed of the tonsil is formed from within outwards by:

(a) The pharyngobasilar fascia.

(b) The superior constrictor and palatopharyngeus muscles.

(c) The buccopharyngeal fascia.

(d) In the lower part, the styloglossus.

(e) The glossopharyngeal nerve.

Table 14.3: Comparison between nasopharynx, oropharynx and laryngopharynx

Particulars	Nasopharynx	Oropharynx	Laryngopharynx
(a) Situation	Behind nose	Behind oral cavity.	Behind larynx.
(b) Extent	Base of skull (body of sphenoid) to soft palate	Soft palate to upper border of epiglottis	Upper border of epiglottis to lower border of cricoid cartilage
(c) Communications	Anteriorly with nose. (Fig. 14.4)	I. Anteriorly with oral cavity, II. Above with nasopharynx III. Below with laryngopharynx	Inferiorly with oesophagus
(d) Nerve supply	Pharyngeal branches of pterygopalatine ganglion	IX and X nerves	IX and X nerves
(e) Relations: (i) Anterior	Posterior nasal aperture	Oral cavity	I. Inlet of larynx, II. Posterior surface of cricoid III. Arytenoid cartilage
(ii) Posterior	Body of sphenoid bone	Body of second and third cervical vertebrae	Fourth and fifth cervical vertebrae
(iii) Lateral wall	Opening of auditory tube	Tonsillar fossa containing palatine tonsils	Piriform fossa
(f) Lining epithelium	Ciliated columnar epithelium	Stratified squamous nonkeratinised epithelium	Stratified squamous nonkerati-nised epithelium
(g) Function	Passage for air (Respiratory function)	Passage for air and food	Passage for food

The ***anterior border*** is related to the palatoglossal arch with its muscle. The ***posterior border*** is related to the palatopharyngeal arch with its muscle. The ***upper pole*** is related to the soft palate, and the ***lower pole,*** to the tongue (Fig. 14.5).

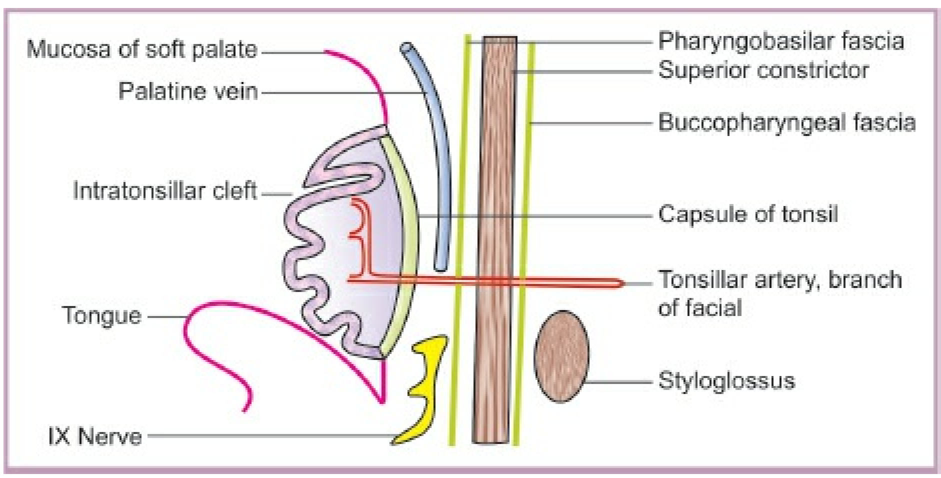


Fig. 14.5: Vertical section through the left tonsil, showing its deep relations.

Arterial Supply of Tonsil

1. Main source: Tonsillar branch of facial artery
2. Additional sources

(a) Ascending palatine branch of facial artery

(b) Dorsal lingual branches of the lingual artery

(c) Ascending pharyngeal branch of the external carotid artery

(d) The greater palatine branch of the maxillary artery

Venous Drainage

One or more veins leave the lower part of deep surface of the tonsil, pierce the superior constrictor, and join the palatine, pharyngeal, or facial veins.

Structure of Pharynx

The wall of the pharynx is composed of the following five layers from within outwards.

1. ***Mucosa***
2. ***Submucosa***
3. ***Pharyngobasilar fascia*** or pharyngeal aponeurosis. This is a fibrous sheet internal to the pharyngeal muscles.
4. The ***muscular coat*** consists of an outer circular layer made up of the three constrictors, and an inner longitudinal layer made up of the stylo-pharyngeus, the salpingopharyngeus and the palatopharyngeus muscles.
5. The ***buccopharyngealfascia*** covers the outer surface of the constrictors of the pharynx.

Details of Origin of Constrictors

1. The ***superior constrictor*** takes origin from the following (from above downwards)

   (a) Pterygoid hamulus

   (b) Pterygomandibular raphe

   (c) Medial surface of the mandible at the posterior end of the mylohyoid line, i.e. near the lower attachment of the pterygomandibular raphe

   (d) Side of posterior part of tongue

2. The ***middle constrictor*** takes origin from

   (a) The lower part of the stylohyoid ligament

(b) Lesser cornua of hyoid bone

(c) Upper border of the greater cornua of the hyoid bone.

3. The ***inferior constrictor*** consists of two parts. One part the ***thyro-pharyngeus*** arises from the thyroid cartilage. The other part the ***crico-pharyngeus*** arises from the cricoid cartilage.

Insertion of Constrictors of Pharynx

All the constrictors of the pharynx are inserted into a median raphe on the posterior wall of the pharynx. The upper end of the raphe reaches the base of the skull where it is attached to the pharyngeal tubercle on the basilar part of the occipital bone.

Longitudinal Muscle Coat of the Pharynx

The pharynx has three muscles that run longitudinally. The ***stylopharyngeus*** arises from the styloid process. The fibres of the ***palatopharyngeus*** descend from the sides of the palate and run longitudinally on the inner aspect of the constrictors (Fig. 14.6). The ***salpingopharyngeus*** descends from the auditory tube to merge with palatopharyngeus.

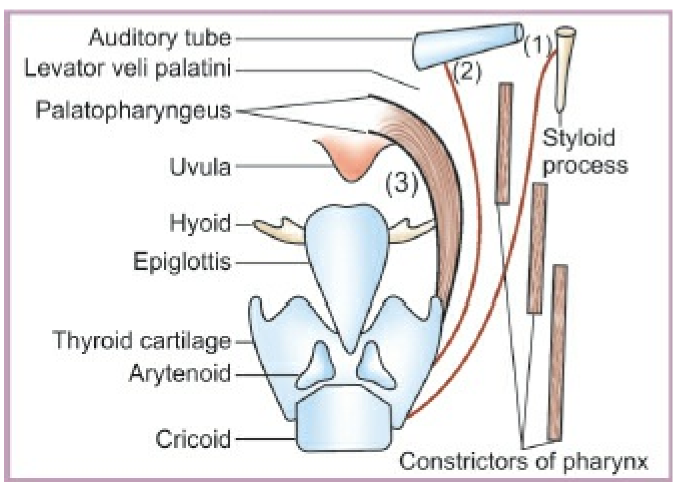


Fig. 14.6: Longitudinal muscles of pharynx: 1. Stylopharyngeus, 2. Salpingopharyngeus, 3. Palatopharyngeus.

Gaps Between Pharyngeal Muscles and Structures Related to them

1. The ***large gap between the upper concave border of the superior constrictor and the base of the skull*** is semilunar and is known as the

sinus of Morgagni. It is closed by the upper strong part of the pharyngobasilar fascia. The structures passing through this gap are:

(a) The auditory tube

(b) The levator veli palatini muscle

(c) The ascending palatine artery.

2. The structures passing through the ***gap between the superior and middle constrictors*** are the stylopharyngeus and the glossopharyngeal nerve.
3. The internal laryngeal nerve and the superior laryngeal vessels pierce the thyrohyoid membrane in the ***gap between the middle and inferior constrictors.***
4. The recurrent laryngeal nerve and the inferior laryngeal vessels pass through the ***gap between the lower border of the inferior constrictor and the oesophagus.***

Nerve Supply

The pharynx is supplied by the pharyngeal plexus of nerves which lies chiefly on the middle constrictor. The plexus is formed by:

1. The pharyngeal branch of the vagus carrying fibres of the cranial accessory nerve
2. The pharyngeal branches of the glossopharyngeal nerve
3. The pharyngeal branches of the superior cervical sympathetic ganglion.

Auditory Tube

It is also known as the pharyngotympanic tube or the Eustachian tube.

The auditory tube is a trumpet-shaped channel which connects the middle ear cavity with the nasopharynx. It is about 4 cm long, and is directed downwards, forwards and medially. It forms an angle of 45 degrees with the sagittal plane and 30 degrees with the horizontal plane. The tube is divided into bony and cartilaginous parts.

Bony Part

The bony part forms the posterior and lateral one-third of the tube. It is 12 mm long.

Cartilaginous Part

The cartilaginous part forms the anterior and medial two-thirds of the tube. It is 25 mm long, and lies in the sulcus tubae, a groove between the greater wing of the sphenoid and the apex of the petrous temporal.

Function

The tube provides a communication of the middle ear cavity with the exterior, thus ensuring equal air pressure on both sides of the tympanic membrane.

The tube is usually closed. It opens during swallowing, yawning and sneezing, by the actions of the tensor and levator veli palatini muscles.

CLINICAL ANATOMY

- The papilla of the parotid duct in the vestibule of the mouth provides access to the parotid duct for the injection of the radiopaque dye to locate calculi in the duct system or the gland.
- Koplik's spots are seen as white pin point spots around the opening of the parotid duct in measles. These are diagnostic of the disease.
- Acute glossitis of the tongue causes extreme swelling of the tongue due to the presence of loose connective tissue and rich network of lymph vessels.
- The genioglossus is the only muscle of the tongue which protrudes it forwards. It is used for testing the integrity of hypoglossal nerve. If hypoglossal nerve of the right side is paralysed, the tongue on protrusion will deviate to the right side.
- Paralysis of the soft palate in lesions of the vagus nerve produces:

  (a) Nasal regurgitation of liquids

  (b) Nasal twang in voice

  (c) Flattening of the palatal arch

  (d) Deviation of uvula to normal side.
- Ludwig's angina is the cellulitis of the floor of the mouth. The tongue is forced upwards leading to swelling both below the chin and within the mouth. The disease is usually caused due to a carious molar tooth.

- Being the hardest and chemically the most stable tissues in the body, the teeth are selectively preserved after death and may be fossilized. Because of this, the teeth are very helpful in medicolegal practice for identification of otherwise unrecognizable dead bodies. The teeth also provide by far the best data to study evolutionary changes and the relationship between ontogeny and phylogeny.
- In scurvy (caused by deficiency of vitamin C), the gums are swollen and spongy, and bleed on touch. In gingivitis, the edges of the gums are red and bleed easily.
- Improper oral hygiene may cause gingivitis and suppuration with pocket formation between the teeth and gums. This results in a chronic pus discharge at the margin of the gums. The condition is known as pyorrhoea alveolaris (chronic periodontitis). Pyorrhoea is common cause of foul breath for which the patient hardly ever consults a dentist because the condition is painless.
- Decalcification of enamel and dentine with consequent softening and gradual destruction of the tooth is known as dental caries. A carious tooth is tender and mastication painful.
- Infection of apex of root (apical abscess) occurs only when the pulp is dead. The condition can be recognized in a good radiograph.
- Irregular dentition is common in rickets and the upper permanent incisors may be notched, the notching corresponds to a small segment of a large circle. In congenital syphilis, also the same teeth are notched, but the notching corresponds to a large segment of a small circle (Hutchinson’s teeth).
- The third molar teeth also called ***wisdom teeth*** usually erupt between 18 and 20 years. These may not erupt normally due to less space and may get impacted causing enormous pain.
- Time of eruption of the teeth helps in assessing the age of the person.
- The upper canine teeth are called as the “eye teeth” as these have long roots which reach up to the medial angle of the eye. Infection of these roots may spread in the facial vein and even lead to thrombosis of the cavernous sinus.
- The upper teeth need separate injections of the anaesthetic on both the buccal and palatal surfaces of the maxillary process just distal to the

tooth·The thin layer of bone permits rapid diffusion of the drug up to the tooth.

- Cleft palate is a congenital defect caused by non-fusion of the right and left palatal processes. It may be of different degrees. In the least severe type, the defect is confined to the soft palate. In the most severe cases, the cleft in the palate is continuous with harelip.
- Hypertrophy or enlargement of the pharyngeal tonsil or adenoids may obstruct the posterior nasal aperture and may interfere with nasal respiration and speech leading to mouth breathing. These tonsils usually regress by puberty.
- Hypertrophy of the tubal tonsil may occlude the auditory or pharyngotympanic tube leading to middle ear problems.
- The tonsils are large in children. They retrogress after puberty.
- The tonsils are frequently sites of infection, specially in children. Infection may spread to surrounding tissue forming a peritonsillar abscess.
- Enlarged and infected tonsils often require surgical removal. The operation is called ***tonsillectomy.*** A knowledge of the relationship of the tonsil is of importance to the surgeon.
- Tonsillectomy is usually done by the guillotine method. Haemorrhage after tonsillectomy is checked by removal of clot from the raw tonsillar bed. This is to be compared with the method for checking postpartum haemorrhage from the uterus. These are the only two organs in the body where bleeding is checked by removal of clots. In other parts of the body, clot formation is encouraged.
- Tonsillitis may cause referred pain in the ear as glossopharyngeal nerve supplies both these areas.
- Suppuration in the peritonsillar area is called ***quinsy.*** A peritonsillar abscess is drained by making an incision in the most prominent point of the abscess.
- Tonsils are often sites of a septic focus. Such a focus can lead to serious disease like pulmonary tuberculosis, meningitis, etc. and is often the cause of general ill health.
- Difficulty in swallowing is known as dysphagia.

- Infections may pass from the throat to the middle ear through the auditory tube. This is more common in children because the tube is shorter, wider and straighter in them.
- Inflammation of the auditory tube (Eustachian catarrh) is often secondary to an attack of common cold, or of sore throat. This causes pain in the ear which is aggravated by swallowing, due to blockage of the tube. Pain is relieved by instillation of decongestant drops in the nose, which help to open the ostium. The ostium is commonly blocked in children by enlargement of the tubal tonsil.

15. Nose and Paranasal Sinuses

NOSE

The nose performs two functions. It is a respiratory passage. It is also the organ of smell. The receptors for smell are placed in the upper one-third of the nasal cavity. This part is lined by olfactory mucosa. The rest of the nasal cavity is lined by respiratory mucosa. The respiratory mucosa is highly vascular and warms the inspired air.

Nasal Cavity

The nasal cavity extends from the external nares or nostrils to the posterior nasal apertures, and is subdivided into right and left halves by the nasal septum. Each half has a roof, a floor, and medial and lateral walls. Each half measures about 5 cm in height, 5-7 cm in length, and 1.5 cm in width near the floor. The width near the roof is only 1-2 mm.

Nasal Septum

The *nasal septum* is median osseocartilaginous partition between the two halves of the nasal cavity. On each side, it is covered by mucous membrane and forms the medial wall of both nasal cavities.

The *bony part* is formed almost entirely by

1. The vomer, and
2. The perpendicular plate of ethmoid

The *cartilaginous part* is formed by

1. The septal cartilage, and
2. The septal processes of the inferior nasal cartilages.

The *cuticular part* or lower end is formed by fibro-fatty tissue covered by skin. The lower margin of the septum is called the *columella*.

Arterial Supply

Anterosuperiorpart is supplied by the anterior ethmoidal artery (Fig. 15.1).

Posteroinferior part is supplied by the sphenopalatine artery.

Anteroinferior part by the superior labial branch of facial artery.

Posterosuperior part by the greater palatine artery branch of 3rd part of maxillary artery.

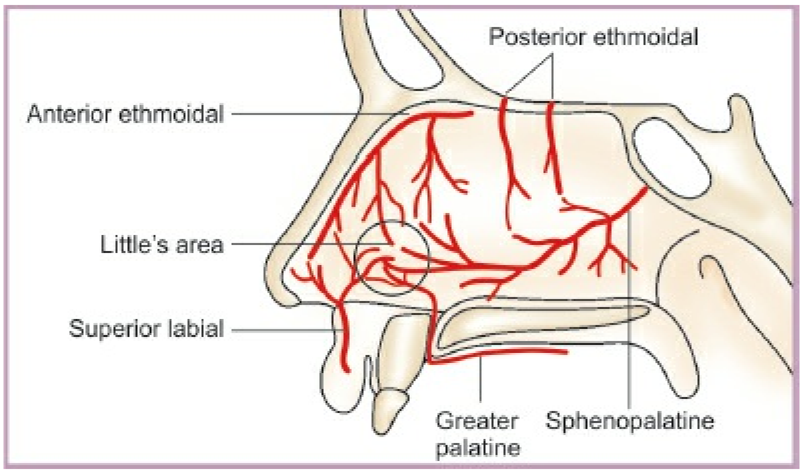


Fig. 15.1: Arterial supply of nasal septum.

The anteroinferior part or vestibule of the septum contains anastomoses between the septal ramus of the superior labial branch of the facial artery, branch of sphenopalatine artery, and of anterior ethmoidal artery. These form a large capillary network called the ***Kiesselbach s plexus.*** This is a common site of bleeding from the nose or epistaxis, and is known as ***Little s area.***

Nerve Supply

[. ***General sensory nerves,*** arising from trigeminal nerve, are distributed to whole of the septum (Fig. 15.2).

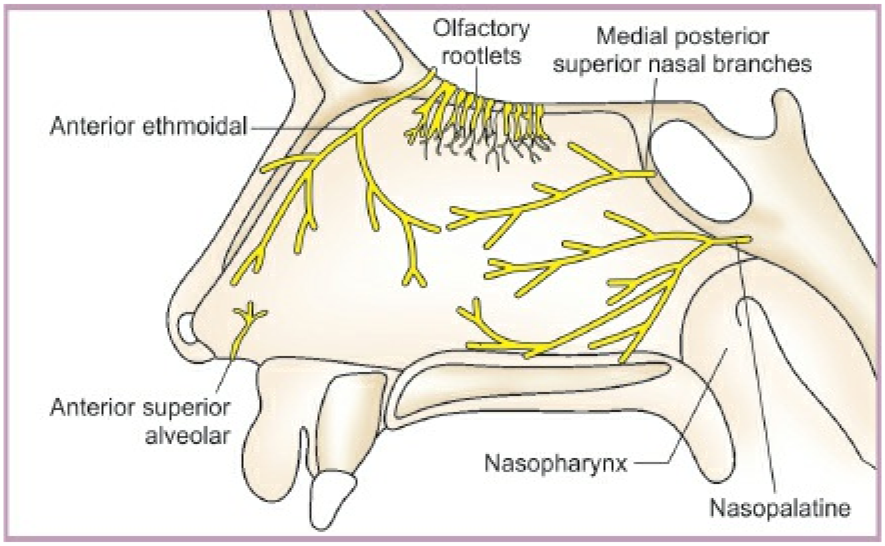


Fig. 15.2: Nerve supply of nasal septum.

1. The anterosuperior part of the septum is supplied by the internal nasal branches of the anterior ethmoidal nerve.
2. Its anteroinferior part is supplied by anterior superior alveolar nerve.
3. The posterosuperior part is supplied by the medial posterior superior nasal branches of the pterygopalatine ganglion
4. The posteroinferior part is supplied by the nasopalatine branch of the pterygopalatine ganglion.

II. ***Special sensory nerves*** or ***olfactory*** nerves are confined to the upper part or olfactory area.

Conchae and Meatuses

The ***nasal conchae*** are curved bony projections directed downwards and medially. The following three conchae are usually found:

1. The ***inferior concha*** is an independent bone.
2. The ***middle concha*** is a projection from the medial surface of ethmoidal labyrinth.
3. The ***superior concha*** is also a projection from the medial surface of the ethmoidal labyrinth. This is the smallest concha situated just above the posterior part of the middle concha.

The ***meatuses of the nose*** are passages beneath the overhanging conchae.

Each meatus communicates freely with the nasal cavity proper.

1. The ***inferior meatus*** lies underneath the inferior concha, and is the largest of the three meatuses. The nasolacrimal duct opens into it at the junction of its anterior one-third and posterior two-thirds. The opening is guarded by the lacrimal fold, or Hasner's valve.
2. The ***middle meatus*** lies underneath the middle concha. It presents the following features:
   (a) The ***ethmoidal bulla,*** is a rounded elevation produced by the underlying middle ethmoidal sinuses.
   (b) The ***hiatus semilunaris,*** is a deep semicircular sulcus below the bulla.
   (c) The ***infundibulum*** is a short passage at the anterior end of the hiatus.
   (d) The ***opening of frontal air sinus*** is seen in the anterior part of hiatus semilunaris.
   (e) The ***opening of maxillary air sinus*** is located in posterior part of the hiatus semilunaris. It is often represented by two openings.
   (f) The ***opening of the middle ethmoidal air sinus*** is present at the upper margin of the bulla.
3. The ***superior meatus*** lies below the superior concha. This is the shortest and shallowest of the three meatuses. It receives the openings of the posterior ethmoidal air sinuses.

The sphenoethmoidal recess is a triangular fossa just above the superior concha. It receives the opening of the sphenoidal air sinus.

Arterial Supply of Lateral Wall

1. The ***anterosuperior quadrant*** is supplied by the anterior ethmoidal artery assisted by the posterior ethmoidal arteries.
2. The ***anteroinferior quadrant,*** is supplied by branches from the facial and greater palatine arteries.
3. The***posterosuperior quadrant,*** is supplied by the sphenopalatine artery.
4. The ***posteroinferior quadrant*** is supplied by branches from greater palatine artery which pierce the perpendicular plate of palatine bone.

Nerve Supply

I. ***General sensory nerves*** derived from the branches of trigeminal nerve are distributed to whole of the lateral wall:

   1. ***Anterosuperior quadrant*** is supplied by the anterior ethmoidal nerve branch of ophthalmic nerve.
   2. ***Anteroinferior quadrant*** is supplied by the anterior superior alveolar nerve, branch of infraorbital, continuation of maxillary nerve.
   3. ***Posterosuperior quadrant*** is supplied by the lateral posterior superior nasal branches from the pterygopalatine ganglion suspended by the maxillary nerve.
   4. ***Posteroinferior quadrant*** is supplied by the anterior or greater palatine branch from the pterygopalatine ganglion suspended by the maxillary nerve.

II. ***Special sensory nerves*** or ***olfactory*** nerves are distributed to the upper part of the lateral wall just below the cribriform plate of the ethmoid up to the superior concha.

Frontal Sinus

Features

1. The frontal sinus lies in the frontal bone deep to the superciliary arch.
2. It ***opens*** into the middle meatus of nose at the anterior end of the hiatus semilunaris.
3. ***Arterial supply:*** Supraorbital artery.

   Nerve supply: Supraorbital nerve.

Maxillary Sinus

Features

1. The maxillary sinus lies in the body of the maxilla, and is the largest of all the paranasal sinuses.
2. It ***opens*** into the middle meatus of the nose in the lower part of the hiatus semilunaris.
3. Its ***roof is*** formed by the floor of orbit, and is traversed by the infraorbital nerve. The floor is formed by the alveolar process of maxilla, and lies

about 1 cm below the level of floor of the nose.

4. The maxillary sinus is the first paranasal sinus to ***develop.***
5. ***Arterial supply:*** Facial, infraorbital and greater palatine arteries. ***Venous drainage*** into the facial vein and the pterygoid plexus of veins. ***Lymphatic drainage*** into the submandibular nodes.

Nerve supply: Infraorbital, and anterior, middle and posterior superior alveolar nerves.

Sphenoidal Sinus

Features

1. The right and left sphenoidal sinuses lie within the body of sphenoid bone. Each sinus opens into the sphenoethmoidal recess of corresponding half of the nasal cavity.
2. Each sinus is related superiorly to the optic chiasma and the hypophysis cerebri; and laterally to the internal carotid artery and the cavernous sinus.
3. ***Arterial supply:*** Posterior ethmoidal and internal carotid arteries.

Ethmoidal Sinuses

Features

Ethmoidal sinuses are numerous small inter-communicating spaces which lie within the labyrinth of the ethmoid bone.

The ***anterior ethmoidal sinus*** is made up of 1 to 11 air cells, opens into the anterior part of the hiatus semilunaris of the nose. It is supplied by the anterior ethmoidal nerve and vessels.

The ***middle ethmoidal sinus*** consisting of 1 to 7 air cells open into the middle meatus of the nose. It is supplied by the anterior ethmoidal nerve.

The ***posterior ethmoidal sinus*** consisting of 1 to 7 air cells open into the superior meatus of the nose. It is supplied by the posterior ethmoidal nerve.

PTERYGOPALATINE FOSSA

This is small pyramidal space situated deeply, below the apex of the orbit.

Boundaries

Anterior: Superomedial part of the posterior surface of the maxilla.

Posterior: Root of the pterygoid process and adjoining part of the anterior surface of the greater wing of the sphenoid.

Medial: Upper part of the perpendicular plate of the palatine bone. The orbital and sphenoidal processes of the bone also take part.

Lateral: The fossa opens into the infratemporal fossa through the pterygomaxillary fissure.

Superior: Undersurface of the body of sphenoid.

Inferior: Closed by the pyramidal process of the palatine bone in the angle between the maxilla and the pterygoid process.

Communications

Anteriorly: With the orbit through the medial end of the inferior orbital fissure.

Posteriorly with the

(a) Middle cranial fossa through the foramen rotundum.

(b) Foramen lacerum through the pterygoid canal.

(c) Pharynx through the palatinovaginal canal.

Medially: With the nose through sphenopalatine foramen.

Laterally: With the infratemporal fossa through the pterygomaxillary fissure.

Inferiorly: With the oral cavity through the greater and lesser palatine canals.

Contents

1. Third part of the maxillary artery and its branches which bear the same names as the branches of the pterygopalatine ganglia and accompany all of them.
2. Maxillary nerve and its two branches, zygomatic and posterior superior alveolar.
3. Pterygopalatine ganglion and its numerous branches containing fibres of the maxillary nerve mixed with autonomic nerves.

MAXILLARY NERVE See Chapter 24

SUMMARY OF PTERYGOPALATINE FOSSA

It contains three or multiple of three structures:

Three contents

- Maxillary nerve
- 3rd part of maxillary artery
- Pterygopalatine ganglion.

Three names of ganglion

- Sphenopalatine
- Pterygopalatine
- Ganglion of hay fever.

Three structures traversing the openings in posterior wall

- Maxillary nerve through foramen rotundum.
- Nerve of pterygoid canal through pterygoid canal.
- Pharyngeal branch through palatinovaginal canal.

Three structures through inferior orbital fissure

- Infraorbital nerve
- Zygomatic nerve
- Orbital branches of the ganglion

Three structures through inferior openings

- Anterior palatine nerve and greater palatine vessels
- Two posterior palatine nerves and lesser palatine vessels

Three structures through medial opening

- Nasopalatine nerve and sphenopalatine vessels
- Medial posterior superior nasal branches
- Lateral posterior superior nasal branches

Three roots of the ganglion: Sensory, sympathetic and secretomotor.

3 × 2 branches ofthe ganglion: Orbital, pharyngeal, for lacrimal gland, anterior palatine, posterior palatine and nasopalatine branches.

3 × 2 branches of 3rd part of maxillary artery: Posterior superior alveolar, infraorbital, sphenopalatine, pharyngeal, artery of pterygoid canal and greater palatine.

CLINICAL ANATOMY

- Little's area on the septum is a common site of bleeding from the nose or epistaxis.
- Pathological deviation of the nasal septum is often responsible for repeated attacks of common cold, allergic rhinitis, sinusitis, etc. It requires surgical correction.
- Common cold or rhinitis is the commonest infection of the nose.
- The paranasal air sinuses may get infected from the nose. Maxillary sinusitis is the commonest of such infections.
- The relations of the nose to the anterior cranial fossa through the cribriform plate, and to the lacrimal apparatus through the nasolacrimal duct are important in the spread of infection.
- Hypertrophy of the mucosa over the inferior nasal concha is a common feature of ***allergic rhinitis,*** which is characterized by sneezing, nasal blockage and excessive watery discharge from the nose.
- Infection of a sinus is known as sinusitis. It causes headache and persistent, thick, purulent discharge from the nose. Diagnosis is assisted by transillumination and radiography. A diseased sinus is opaque.
- The maxillary sinus is most commonly involved. It may be infected from the nose or from a carious tooth. Drainage of the sinus is difficult because its ostium lies at a higher level than its floor. Another factor is that cilia in the lining mucosa are destroyed by chronic infection. Hence, the sinus is drained surgically by making an artificial opening near the floor in one of the following two ways

  (a) Antrum puncture can be done by breaking the lateral wall of the inferior meatus and pushing in fluid and letting it drain through the natural orifice with head in dependent position.

(b) An opening can be made at the canine fossa through the vestibule of the mouth, deep to the upper lip (Caldwell-Luc operation).

- Carcinoma of the maxillary sinus arises from the mucosal lining. Symptoms depend on the direction of growth.

  (a) Invasion of the orbit causes proptosis and diplopia. If the infraorbital nerve is involved, there is facial pain and anaesthesia of the skin over the maxilla.

  (b) Invasion of the floor may produce a bulging and even ulceration of the palate.

  (c) Forward growth obliterates the canine fossa and produces a swelling of the face.

  (d) Backward growth may involve the palatine nerves and produce severe pain referred to the upper teeth.

  (e) Growth in a medial direction produces nasal obstruction, epistaxis and epiphora.

  (f) Growth in a lateral direction produces a swelling on the face and a palpable mass in the labiogingival groove.

- Frontal sinusitis and ethmoiditis can cause oedema of the lids secondary to infection of the sinuses.
- Trigeminal neuralgia affecting its maxillary branch produces symptoms in the area of its distribution. The nerve can be anaesthetized at the foramen rotundum.
- The pterygopalatine ganglion if irritated or infected causes congestion of the glands of palate and nose including the lacrimal gland producing running nose and lacrimation. The condition is called hay fever. The ganglion is called ganglion of hay fever.
- Maxillary nerve carries the afferent limb fibres of the sneeze reflex as it carries general sensation from the nasal mucous membrane.
- Adenoids or enlarged nasopharyngeal tonsil in the nasopharynx can be examined by posterior rhinoscopy. Adenoids cause mouth breathing, nasal obstruction and even blockage of pharyngotympanic tube.
- Fracture of cribriform plate of ethmoid with tearing off of the meninges

may tear the olfactory nerve rootlets. In such cases, CSF may drip from the nasal cavity. It is called CSF rhinorrhoea.

- Pain from ethmoid air sinus may be referred to forehead, as both are supplied by ophthalmic division of trigeminal nerve.
- Pain of maxillary sinusitis may be referred to upper teeth and infraorbital skin as all these are supplied by the maxillary nerve.

16. Larynx

Situation and Extent

The larynx lies in the anterior midline of the neck, extending from the root of the tongue to the trachea. In the adult male, it lies in front of the third to sixth cervical vertebrae, but in children and in the adult female it lies at a little higher level.

CARTILAGES OF LARYNX

The larynx contains nine cartilages, of which three are unpaired and three, paired.

Unpaired Cartilages

1. Thyroid
2. Cricoid
3. Epiglotti

Paired Cartilages

1. Arytenoid
2. Comiculate
3. Cuneiform

THYROID CARTILAGE

This cartilage is V-shaped in cross-section. It consists of right and left laminae (Fig. 16.1).

The lower parts of the anterior borders of the right and left laminae fuse and form a median projection called the *laryngeal prominence.*

The inferior cornua articulates with the cricoid cartilage to form the cricothyroid joint.

The *outer surface* of each lamina is marked by an oblique line. The inferior thyroid tubercle lies behind the middle of inferior border. The thyrohyoid and the inferior constrictor of pharynx are attached to the oblique line.

Lower border and inferior cornua gives insertion to triangular cricothyroid. Along the posterior border connecting superior and inferior cornua is the insertion of palatopharyngeus, salpinopharyngeus and stylopharyngeus.

On inner aspect are attached median thyroepiglottic ligament, thyroepiglottic muscle on each side, vestibular fold on each side, vocal fold on each side, thyroarytenoid and vocalis muscle on each side (Fig. 16.2).

CRICOID CARTILAGE

This cartilage is shaped like a ring. It encircles the larynx below the thyroid cartilage. It is thicker and stronger than the thyroid cartilage. The ring has a narrow anterior part called the ***arch,*** and a broad posterior part, called the ***lamina.***

Attachments: Anterior part of arch of cricoid gives origin to triangular cricothyroid muscle, a tensor of vocal cord.

Anterolateral aspect of arch gives origin to lateral cricoarytenoid muscle, an adductor of vocal cord.

Lamina of cricoid cartilage on its outer aspects gives origin to a very important “safety muscle”, the posterior cricoarytenoid muscle.

Cricothyroid membrane and cricovocal membranes are also attached.

EPIGLOTTIC CARTILAGE/EPIGLOTTIS

This is a ***leaf-shaped*** cartilage placed in the anterior wall of the upper part of the larynx. Its ***upper end*** is broad and free, and projects upwards behind the hyoid bone and the tongue.

The ***lower end*** or ***stalk*** is pointed and is attached to the upper part of the angle between the two laminae of the thyroid cartilage (Fig. 16.1).

The right and left margins of the cartilage provide attachment to the aryepiglottic folds. Its ***anterior surface*** is connected

(a) To the tongue by a median glossoepiglottic fold

(b) To the hyoid bone by the hyoepiglottic ligament (Fig. 16.2). The ***posterior surface*** is covered with mucous membrane, and presents a tubercle in the lower part

Thyroepiglottic muscle is attached between thyroid cartilage and margins of epiglottis. It keeps the inlet of larynx patent for breathing. Aryepiglottic muscle closes inlet during swallowing.

ARYTENOID CARTILAGE

These are two small ***pyramid-shaped*** cartilages lying on the upper border of the lamina of the cricoid cartilage. The ***apex*** of the arytenoid cartilage is curved posteromedially and articulates with the comiculate cartilage.

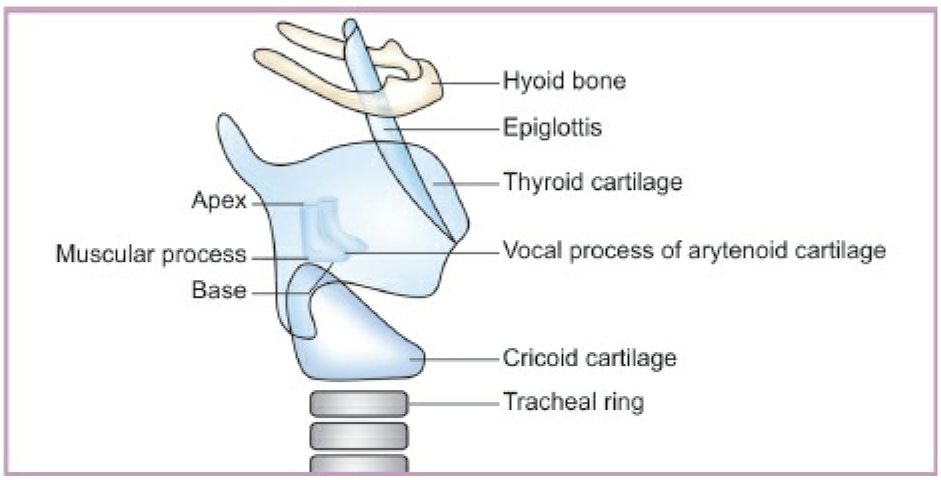


Fig. 16.1: Cartilages of the larynx: lateral view.

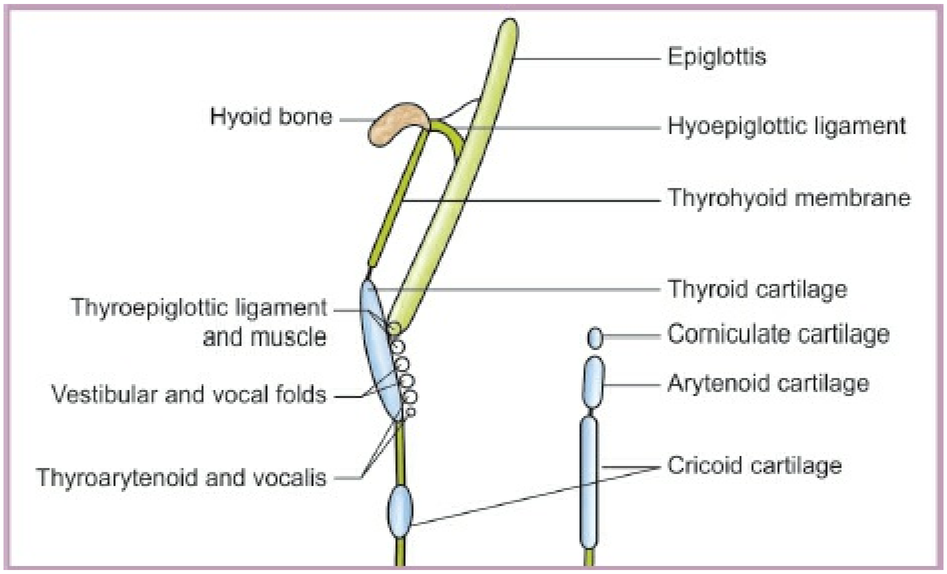


Fig. 16.2: Cartilages of the larynx as seen in sagittal section.

Its ***base*** is concave and articulates with the lateral part of the upper border of the cricoid lamina. It is prolonged anteriorly to form the vocal process, and laterally to form the muscular process. The ***surfaces*** of the cartilage are anterolateral, medial and posterior (Figs 16.1 and 16.2).

Vocal process: Vocal fold and vocalis muscle is attached

Above vocal process: Vestibular fold attached

Muscular process: Posterior aspect gives insertion to posterior cricoarytenoid

Anterior aspect gives insertion to lateral cricoarytenoid

Posterior surface: Transverse arytenoid across the two cartilages

Between base and apex of arytenoid is oblique arytenoid which continues as aryepiglottic muscle into two sides of epiglottis. Quadrangular membrane is attached between arytenoid, epiglottis and thyroid cartilages.

LARYNGEAL LIGAMENTS AND MEMBRANES

Extrinsic

1. The ***thyrohyoid membrane*** connects the thyroid cartilage to the hyoid bone

2. The ***hyoepiglottic ligament*** connects the upper end of the epiglottic cartilage to the hyoid bone
3. The ***cricotracheal ligament*** connects the cricoid cartilage to the upper end of the trachea.

Intrinsic

The ***quadrate membrane*** extends from the arytenoid cartilage to the epiglottis. It has a lower free border which forms the ***vestibular fold*** and an upper border which forms the ***aryepiglottic fold.***

The ***conus elasticus*** or ***cricovocal membrane*** extends upwards and medially from the arch of the cricoid cartilage. The anterior part is thick and is known as the cricothyroid ligament. The upper free border of the conus elasticus forms the ***vocal fold.***

CAVITY OF LARYNX

1. The ***inlet of the larynx*** is placed obliquely. It looks backwards and upwards, and opens into the laryngopharynx. The inlet is ***bounded anteriorly,*** by the epiglottis; ***posteriorly,*** by the interarytenoid fold of mucous membrane; and ***on each side,*** by the aryepiglottic fold.
2. Within the cavity of larynx, there are two folds of mucous membrane on each side. The upper fold is the ***vestibular fold,*** and the lower fold is the ***vocal fold.*** The space between the right and left vestibular folds is the ***rima vestibuli;*** and the space between the vocal folds is the ***rima glottidis.*** The vocal fold is attached anteriorly to the middle of the angle of the thyroid cartilage on its posterior aspect; and posteriorly to the vocal process of the arytenoid cartilage. The rima glottidis is limited posteriorly by an interarytenoid fold of mucous membrane. The rima, therefore, has an anterior intermembranous part (three-fifths) and a posterior intercartilaginous part.

INTRINSIC MUSCLES OF LARYNX

The attachments of intrinsic muscles of larynx are presented in Table 16.1 and their main action in Table 16.2.

Muscle	Origin	Fibres	Insertion
1. Cricothyroid The only muscle outside the larynx	Lower border and lateral surface of cricoid	Fibres pass backwards and upwards	Inferior cornua and lower border of thyroid cartilage. It is called 'tuning fork of larynx'
2. Posterior cricoarytenoid Triangular muscle	Posterior surface of the lamina of cricoid	Upwards and laterally	Posterior aspect of muscular process of arytenoid
3. Lateral cricoarytenoid	Lateral part of upper border of arch of cricoid	Upwards and backwards	Anterior aspect of muscular process of arytenoid
4. Transverse arytenoid Unpaired muscle	Posterior surface of one arytenoid	Transverse	Posterior surface of another arytenoid
5. Oblique arytenoid and aryepiglotticus	Muscular process of one arytenoid	Oblique	Apex of the other arytenoid. Some fibres are continued as *aryepiglottic* muscle to the edge of the epiglottis
6. Thyroarytenoid and Thyroepiglottic	Thyroid angle and adjacent cricothyroid ligament	Backwards and upwards	Anterolateral surface of arytenoid cartilage. Some fibres project into the vocal fold and are known as *vocalis*. Some of the upper fibres of thyroarytenoid curve upwards into the aryepiglottic fold to reach the edge of epiglottis. This is known as *thyroepiglottic*

Table 16.1: Intrinsic muscles of the larynx

Table 16.2: Muscles acting on the larynx

Movement	Muscles
1. Elevation of larynx	Thyrohyoid, mylohyoid
2. Depression of larynx	Sternothyroid, sternohyoid
3. Opening inlet of larynx	Thyroepiglotticus
4. Closing inlet of larynx	Aryepiglotticus
5. Abductor of vocal cords	Posterior cricoarytenoid only
6. Adductor of vocal cords	Lateral cricoarytenoid transverse, o blique arytenoids
7. Tensor of vocal cords	Cricothyroid
8. Relaxor of vocal cords	Thyroarytenoid

Nerve Supply of Muscles

All intrinsic muscles of the larynx are supplied by the recurrent laryngeal nerve except for the cricothyroid which is supplied by the external laryngeal nerve.

MOVEMENTS OF VOCAL FOLDS

Movements of the vocal folds affect the shape and size of the rima glottidis.

1. During quiet breathing or condition of rest, the intermembranous part of the rima is triangular, and the intercartilaginous part is quadrangular.
2. During phonation or speech, the glottis is reduced to a chink by the adduction of the vocal folds.
3. During forced inspiration, both parts of the rima are triangular, so that the entire rima is lozenge-shaped; the vocal folds are fully abducted.
4. During whispering, the intermembranous part of the rima glottidis is closed, but the intercartilaginous part is widely open.

CLINICAL ANATOMY

- When any foreign object enters the larynx, severe protective coughing is excited to expel the object. However, damage to the internal laryngeal nerve produces anaesthesia of the mucous membrane in the supraglottic part of the larynx breaking the reflex arc so that foreign bodies can readily enter it.
- Damage to the external laryngeal nerve causes some weakness of phonation due to loss of the tightening effect of the cricothyroid on the vocal cord.
- When both recurrent laryngeal nerves are interrupted, the vocal cords lie in the cadaveric position in between abduction and adduction and phonation is completely lost. Deep breathing also becomes difficult through the partially opened glottis.
- When only one recurrent laryngeal nerve is paralysed, the opposite vocal cord compensates for it and phonation is possible but there is hoarseness of voice. There is failure of forceful explosive part of voluntary and reflex coughing.
- The larynx can be examined either directly through a laryngoscope (direct laryngoscopy); or indirectly through a laryngeal mirror (indirect

laryngoscopy).

- By laryngoscopy, one can inspect the base of the tongue, the valleculae, the epiglottis, the aryepiglottic folds, the piriform fossae, the vestibular folds, and the vocal folds.
- Since the larynx or glottis is the narrowest part of the respiratory passages, foreign bodies are usually lodged here.
- Infection of the larynx is called ***laryngitis.*** It is characterized by hoarseness of voice.
- Laryngeal oedema may occur due to a variety of causes. This can cause obstruction to breathing.
- Misuse of the vocal cords may produce nodules on the vocal cords mostly at the junction of anterior one-third and posterior two-thirds. These are called ***Singer s nodules or Teacher s nodules.***
- ***Fïbreoptic flexible laryngoscopy:*** Under local anaesthesia flexible laryngoscope is passed and larynx well visualized.
- ***Microlaryngoscopy:*** This procedure is performed under operating microscope. Vocal cord tumors and diseases are excised by this method.
- ***External examination of larynx:*** Head is flexed in sitting position. Examiner stands behind and palpates larynx and neck with finger tips for tumor, swelling, lymphadenitis, etc.
- Speech analysis is also necessary in laryngeal diseases.
- ***Foreign body in larynx:*** At times fish bones may get impacted in the vallecula or piriform fossa. Often these bones just scratch the mucosa on their way down, and the person gets a feeling of foreign body sensation, due to a dull viscereal pain caused by the scratch.
- Piriform fossa lies between quadrate membrane and medial side of thyroid cartilage. It is traversed by internal laryngeal nerve. Piriform fossa is used to smuggle out precious stones, diamonds, etc. It is called smuggler’s fossa.
- Tumours in the piriform fossa cause dysphagia. These also cause referred pain in the ear. Pain of pharyngeal tumours may be referred to the ear, as X nerve carries sensation both from the pharynx and the external auditory meatus and tympanic membrane.

- Tumours of the vocal cords can be diagnosed early, because there are changes in the voice. Tumours in subglottic area present late so are diagnosed late and have poor prognosis.
- ***Laryngotomy:*** The needle is inserted in the midline of cricothyroid membrane, below the thyroid prominence. This is done as an emergency procedure.
- Tracheostomy is a permanent procedure. Part of 2nd-4th rings of trachea are removed after incising the isthmus of the thyroid gland.
- The mucous membrane of the larynx is supplied by X through superior laryngeal or recurrent laryngeal nerves. So laryngeal tumours may also cause referred pain in the ear partly supplied by auricular branch of X nerve.
- If the patient is unconscious, one must remember: A-Airway, B-Breathing, C-Circulation in that order. For the patency of airway, pull the tongue out and also endotracheal tube needs to be passed. The tube should be passed between the right and left vocal cords down to the trachea.
- ***Recurrent laryngeal nerve:*** Mediastinal tumours may press on the left recurrent laryngeal nerve, as it is given off in the thorax. The pressure on the nerve may present as alteration in the voice. Right recurrent laryngeal nerve is given off in the neck, so it is not affected by mediastinal tumours.
- Large foreign bodies may block laryngeal inlet leading to suffocation.
- Small foreign bodies may lodge in laryngeal ventricle, cause reflex closure of the glottis and suffocation.
- Inflammation of upper larynx may cause oedema of supraglottis. It does not extend below vocal cords because mucosa is adherent to vocal ligament.
- Suicidal wounds are made through thyrohyoid membrane damaging the carotid vessels.
- There is only one abductor of vocal cord while there are three adductors of vocal cord.
- ***Infant's larynx:*** Cavity of infant's larynx is short and funnel-shaped.
    - Size is one-third of an adult. Lumen is very narrow.

- Postion is higher than in adult.
- Epiglottis lies at C2 and during elevation, it reaches Cl, so that infant can use nasal airway for breathing while suckling.
- Laryngeal cartilages are softer, more pliable than in adult.
- Thyroid cartilage is shorter and broader.
- Vocal cords are only 4–4.5 mm long, shorter than in childhood and in adult.
- Supraglottic and subglottic mucosa are lax, swelling results in respiratory obstruction.
- One must be careful while giving anaesthesia to an infant (birth to one year).

Spaces around larynx

- ***Pre-epiglottic space:*** Space anterior to epiglottis and beyond the lateral margins of epiglottis. It is horseshoe in shape.

  Upper boundary: Hyoepiglottic membrane and median hyoepiglottic ligament

  Anterior boundary: Thyrohyoid membrane and median thyrohyoid ligament

  Lower boundary: Thyroepiglottic ligament, continuous with quadrangular membrane

  Upper lateral border: Greater cornua of hyoid bone

  Inferolaterally: Continuous with paraglottic space

  The space is continuous with mucosa of laryngeal surface of epiglottis via holes in the epiglottic cartilage. Malignancy of laryngeal surface of epiglottis may invade the preglottic space

- ***Paraglottic space:*** Space containing internal laryngeal nerve, laryngeal ventricle and laryngeal saccule

  Lateral boundary: Thyroid cartilage and thyrohyoid membrane

  Superomedially: Continuous with preglottic space

  Inferomedially: Cricovocal membrane

  Posteriorly: Mucosa of the piriform fossa

Inferiorly: Lower border of thyroid cartilage

- ***Subglottic space***

  Lateral boundary: Cricovocal membrane

  Medially: Mucosa of subglottic region

  Above: Under surface of Broyle's ligament in the midline

  Below: Inner surface of mucosa of the cricoid cartilage

17. Tongue

EXTERNAL FEATURES

The tongue has

1. A root
2. A tip, and
3. A body, which has
   (a) A curved upper surface or dorsum
   (b) An inferior surface

   The *dorsum* of the tongue is convex in all directions. It is divided into:
   (a) An *oral part* or anterior two-thirds.
   (b) A *pharyngeal part* or posterior one-third, by a faint V-shaped groove, the *sulcus terminalis*. The two limbs of the ‘V’ meet at a median pit, named the *foramen caecum.*

The *pharyngeal or lymphoid part of the tongue* lies behind the palatoglossal arches and the sulcus terminalis.

The posteriormost part of the tongue is connected to the epiglottis by three-folds of mucous membrane. These are the *median glossoepiglottic fold and the right and left lateral glossoepiglottic folds.* On either side of the median fold, there is a depression called the *vallecula*.

PAPILLAE OF THE TONGUE

These are projections of mucous membrane or corium which give the anterior two-thirds of the tongue its characteristic roughness. These are of the following three types.

1. *Vallate* or *circumvallate papillae:* They are large in size 1-2 mm in diameter and are 8-12 in number. They are situated immediately in front of the sulcus terminalis.
2. The *fungiform papillae* are numerous near the tip and margins of the tongue.
3. The *filiform papillae* or *conical papillae* cover the presulcal area of the dorsum of the tongue, and give it a characteristic velvety appearance.

MUSCLES OF THE TONGUE

Intrinsic Muscles

1. Superior longitudinal
2. Inferior longitudinal
3. Transverse
4. Vertical

Extrinsic Muscles

1. Genioglossus
2. Hyoglossus
3. Styloglossus
4. Palatoglossus

The ***intrinsic muscles*** occupy the upper part of the tongue, and are attached to the submucous fibrous layer and to the median fibrous septum. They alter the shape of the tongue.

The ***inferior longitudinal muscle*** is a narrow band lying close to the inferior surface of the tongue between the genioglossus and the hyoglossus.

The ***transverse muscle*** extends from the median septum to the margins.

The ***extrinsic muscles*** connect the tongue to the mandible via genioglossus; to the hyoid bone through hyoglossus; to the styloid process via styloglossus, and the palate via palatoglossus. These are described in Table 17.1.

ARTERIAL SUPPLY OF TONGUE

It is derived from the ***tortuous lingual artery*** a branch of the external carotid artery. The root of the tongue is also supplied by the tonsillar a branch of facial artery, and ascending pharyngeal branch of external carotid (Table A1.3).

LYMPHATIC DRAINAGE

1. The tip of the tongue drains bilaterally to the submental nodes.
2. The right and left halves of the remaining part of the anterior two- thirds of the tongue drain unilaterally to the submandibular nodes. A few central lymphatics drain bilaterally to the same nodes.
3. The posterior one-third of the tongue drains bilaterally to the jugulo-omohyoid nodes, these are known as the lymph nodes of the tongue.
4. The posterior most part of the tongue drains bilaterally into the upper deep cervical lymph nodes.

NERVE SUPPLY

Motor nerves: All the intrinsic and extrinsic muscles, except the palatoglossus, are supplied by the hypoglossal nerve.

Sensory nerves: The lingual nerve is the nerve of general sensation and the chorda tympani is the nerve of taste for the anterior two-thirds of the tongue except vallate papillae (Table 17.2).

Table 17.1: Extrinsic muscles of tongue

Muscle	Origin	Insertion	Action
Palatoglossus	Oral surface of palatine aponeurosis	Descends in the palatoglossal arch to the side of tongue at the junction of oral and pharyngeal parts	Approximates the palatoglossal arches and thus closes the oropharyngeal isthmus
Hyoglossus	Whole length of greater cornua and lateral part of hyoid bone	Side of tongue between styloglossus and inferior longitudinal muscle	Depresses tongue, makes dorsum convex, retracts the protruded tongue
Styloglossus	Tip and part of anterior surface of styloid process	Into the side of tongue	Pulls tongue upwards and backwards
Genioglossus fan-shaped bulky muscle	Upper genial tubercle of mandible	Upper fibres into the tip of tongue Middle fibres into the dorsum Lower fibres into the hyoid bone	Retracts and depresses the tongue. Pulls the posterior part of tongue forwards and protrude the tongue forwards. It is a *life saving muscle*

Table 17.2: Parts of the tongue

Nerve supply	Anterior two-thirds	Posterior one-third	Posterior most part or vallecula
Sensory	Lingual	Glossopharyngeal	Internal laryngeal branch of vagus
Taste	Chorda tympani except vallate papillae	Glossopharyngeal including the vallate papillae	Internal laryngeal branch of vagus
Development of epithelium from endodern	Lingual swellings of I arch	Third arch which forms large ventral part of hypobranchial eminence	Fourth arch which forms small dorsal part of hypobranchial eminence

Muscles develop from occipital myotomes, so the cranial nerve XII (hypoglossal nerve) supplies all Intrinsic and three extrinsic muscles. Only palatoglossus is supplied by cranial root of accessory through pharyngeal plexus and is developed from mesoderm of sixth arch.

DEVELOPMENT OF TONGUE

I. Epithelium

(a) ***Anterior two-thirds:*** From two lingual swellings and one tuberculum impar, which arise from the first branchial arch.

(b) ***Posterior one-third:*** From cranial large part of the hypobranchial eminence, i.e. from the third arch (Table 17.2).

(c) Posterior most part from the fourth arch.

II. Muscles

The muscles develop from the occipital myotomes which are supplied by the hypoglossal nerve.

III. Connective Tissue

The connective tissue develops from the local mesenchyme.

CLINICAL ANATOMY

- Glossitis is usually a part of generalized ulceration of the mouth cavity or stomatitis. In certain anaemias, the tongue becomes smooth due to atrophy of the filiform papillae.
- The presence of a rich network of lymphatics and of loose areolar tissue in the substance of the tongue is responsible for enormous swelling of the tongue in acute glossitis. The tongue fills up the mouth cavity and then protrudes out of it.
- The undersurface of the tongue is a good site along with the bulbar conjunctiva for observation of jaundice.
- In unconscious patients, the tongue may fall back and obstruct the air passages. This can be prevented either by making the patient lie on one side with head down (the ‘tonsil position’) or by keeping the tongue out mechanically.
- Carcinoma of the tongue is quite common. The affected side of the tongue is removed surgically. All the deep cervical lymph nodes are also removed, i.e. block dissection of neck because recurrence of malignant disease occurs in lymph nodes. Carcinoma of the posterior one-third of the tongue is more dangerous due to bilateral lymphatic spread.
- Lingual tonsil in the posterior one-third of tongue forms part of Waldeyer’s ring.
- Referred pain is felt in the ear in diseases of posterior part of the tongue, as ninth nerve is common supply to both the regions.
  (a) Pain of gall bladder is referred to right shoulder.
  (b) Pain of splenic rupture is referred to left shoulder.
  (c) Pain of myocardial infarction is referred to precordium and medial border of the left upper limb.
  (d) Pain of foregut in the epigastrium
  (e) Pain of midgut in the umbilical area

(f) Pain of hindgut in suprapubic area

(g) Pain of gall bladder also referred to inferior angle of right scapula and the epigastric region.

- Sorbitrate is taken sublingually for immediate relief from angina pectoris. It is absorbed fast because of rich blood supply of the tongue and bypassing the hepatic circulation.
- Genioglossus is called the 'safety muscle of the tongue' because if it is paralysed, the tongue will fall back on the oropharynx and block the air passage. During anaesthesia, the tongue is pulled forwards to clear the air passage.

18. Ear

Features of the Temporal Bone

(a) External auditory meatus is for air waves

(b) Internal auditory meatus is for passage of VII, VIII nerves and labyrinthine vessels.

(c) Suprameatal triangle is the landmark for mastoid antrum. It is bounded by supramastoid crest, posterosuperior margin of external acoustic meatus and a tangent drawn from the crest to the margin. Mastoid antrum lies about 15 mm deep to the suprameatal triangle in adult.

(d) Tympanic canaliculus lies on the bone between carotid canal and jugular fossa.

(e) Petrotympanic fissure gives passage to anterior tympanic artery, anterior ligament of malleus and chorda tympani nerve.

(f) Stylomastoid foramen gives passage to posterior tympanic artery for middle ear and facial nerve.

(g) Hiatus for greater petrosal nerve gives passage to nerve of the same name and a branch of middle meningeal artery.

(h) Tegmen tympani on the anterior face of petrous temporal bone, forms roof of the middle ear.

(i) The aqueduct of vestibule opens on posterior aspect of petrous temporal bone. It is plugged by ductus endolymphaticus.

(j) Organ of Corti is the end organ for hearing, situated in the cochlear duct.

(k) Crista is an end organ in the semicircular canal. These are kinetic balance receptors.

(l) Macula are end organs in the utricle and saccule and are static balance receptors.

EXTERNAL EAR

The external ear consists of

(a) The auricle or pinna

(b) The external acoustic meatus

AURICLE/PINNA

The auricle is the part seen on the surface, the part the layman calls the ear.

EXTERNAL ACOUSTIC MEATUS

The external auditory meatus conducts sound waves from the concha to the tympanic membrane. The canal is S-shaped.

The meatus or canal is about 24 mm long, of which the medial two- thirds or 16 mm is bony, and the lateral one-third or 8 mm is cartilaginous. Due to the obliquity of the tympanic membrane, the anterior wall and floor are longer than the posterior wall and roof.

TYMPANIC MEMBRANE

It is oval in shape, measuring 9 × 10 mm. It is placed obliquely at an angle of 55 degrees with the floor of the meatus. It faces downwards, forwards and laterally.

The membrane has outer and inner surfaces.

The outer surface of the membrane is lined by thin skin. It is concave.

The inner surface is convex. The point of maximum convexity lies at the tip of the handle of the malleus and is called the ***umbo.***

While the greater part of the tympanic membrane is tightly stretched and is, therefore, called the ***pars tensa,*** the part between the two malleolar folds is loose and is called the ***pars flaccida.*** The pars flaccida is crossed internally by the chorda tympani. This part is more liable to rupture than the pars tensa.

Structure

The tympanic membrane is composed of the following three layers:

1. The ***outer cuticular layer*** of skin.
2. The ***middle fibrous layer*** made up of superficial radiating fibres and deep circular fibres.
3. The ***inner mucous layer*** is lined by a low ciliated columnar epithelium.

Nerve Supply

1. ***Outer surface:*** The anteroinferior part is supplied by the auriculotemporal nerve, and the posterosuperior part by the auricular branch of the vagus nerve with a communicating branch from facial nerve.
2. ***Inner surface:*** This is supplied by the tympanic branch of the glossopharyngeal nerve through the tympanic plexus.

MIDDLE EAR

Shape and Size

The middle ear is shaped like a cube. Its lateral and medial walls are large, but the other walls are narrow, because the cube is compressed from side to side.

Communications

The middle ear communicates anteriorly with the nasopharynx through the auditory tube, and posteriorly with the mastoid antrum and mastoid air cells through the aditus to the mastoid antrum (Fig. 18.1).

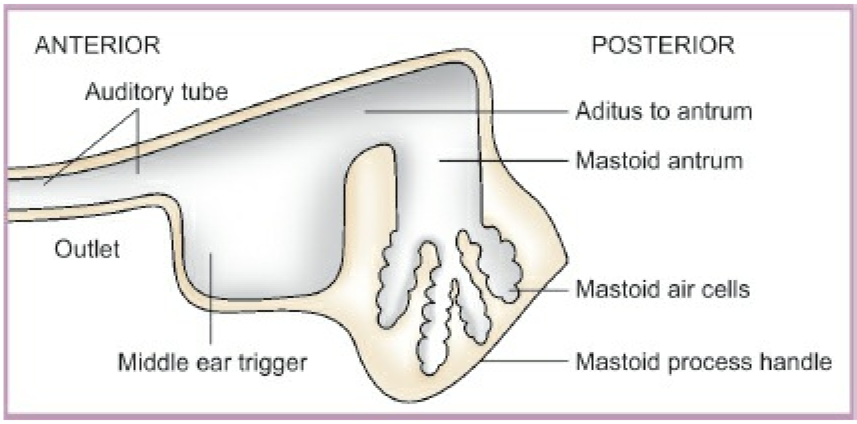


Fig. 18.1: Scheme to show some relationships of the middle ear cavity. Note that the cavity resembles a pistol.

Contents

The middle ear contains the following.

1. Three small bones or ossicles namely the malleus, the incus and the stapes. The upper half of the malleus, and the greater part of the incus lie in the epitympanic recess
2. Ligaments of the ear ossicles
3. Two muscles: the tensor tympani and the stapedius
4. Vessels supplying and draining the middle ear
5. Nerves: Chorda tympani and tympanic plexus
6. Air

Boundaries

Roof or Tegmental Wall

The roof separates the middle ear from the middle cranial fossa. It is formed by a thin plate of bone called the ***tegmen tympani.*** This plate is prolonged forwards as the roof of the canal for the tensor tympani.

Floor or Jugular Wall

The floor is formed by a thin plate of bone which separates the middle ear from the superior bulb of the internal jugular vein. This plate is a part of the temporal bone.

Anterior or Carotid Wall

1. The uppermost part of the anterior wall bears the opening of the canal for the tensor tympani.
2. The middle part has the opening of the auditory tube. The inferior part of the wall is formed by a thin plate of bone which forms the posterior wall of the carotid canal.

The bony septum between the canals for the tensor tympani and for the auditory tube is continued posteriorly on the medial wall as a curved lamina called the ***processes cochleariformis.***

Posterior or Mastoid Wall

1. Superiorly, there is an opening or ***aditus*** through which the epitympanic recess communicates with the mastoid or tympanic antrum.
2. A conical projection, called the ***pyramid,*** lies near the junction of the posterior and medial walls. It has an opening at its apex for passage of the tendon of the stapedius muscle.
3. Lateral to pyramid and near the posterior edge of the tympanic membrane, is the ***posterior canaliculus for the chorda tympani*** through which the nerve enters the middle ear cavity.

Lateral or Membranous Wall

The lateral wall separates the middle ear from the external acoustic meatus. It is formed

1. Mainly by the tympanic membrane along with the tympanic ring and sulcus.
2. Partly by the squamous temporal bone, in the region of the epitympanic recess.

Medial or Labyrinthine Wall

1. The ***promontory*** is a rounded bulging produced by the first turn of the cochlea. It is grooved by the tympanic plexus.
2. The ***fenestra vestibuli*** is an oval opening posterosuperior to the promontory.
3. The ***prominence of the facial canal*** runs backwards just above the fenestra vestibuli.

4. The ***fenestra cochleae*** is a round opening at the bottom of a depression posteroinferior to the promontory. It opens into the scala tympani of the cochlea, and is closed by the ***secondary tympanic membrane.***

Arterial Supply

The main arteries of the middle ear are as follows.

1. The anterior tympanic branch of the maxillary artery which enters the middle ear through the petrotympanic fissure.
2. The posterior tympanic branch of the stylomastoid branch of the posterior auricular artery which enters through the stylomastoid foramen.

EAR OSSICLES

Malleus

The malleus is so called because it resembles a hammer. It is the largest, and the most laterally placed ossicle (Fig. 18.2).

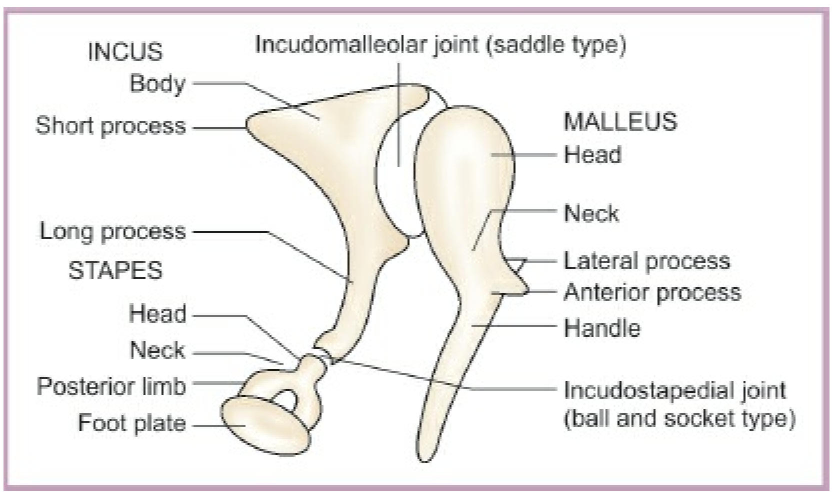


Fig. 18.2: Ossicles of the left ear, seen from the medial side.

Incus or Anvil

It is so called because it resembles an anvil, used by blacksmiths.

Stapes

This bone is so called because it is shaped like a stirrup. It is the smallest, and the most medially placed ossicle of the ear.

Joints of the Ossicles

1. The ***incudomalleolar joint*** is a saddle joint.
2. The ***incudostapedial joint*** is a ball and socket joint. Both of them are synovial joints. They are surrounded by capsular ligaments.

Muscles of the Middle Ear

The ***tensor tympani*** lies in a bony canal that opens at its lateral end on the anterior wall of the middle ear, and at the medial end on the base of the skull. The auditory tube lies just below this canal. The muscle arises from the walls of the canal in which it lies.

The tensor tympani is supplied by the ***mandibular nerve.*** It develops from the ***mesoderm of first branchial arch.***

The ***stapedius*** lies in a bony canal that is related to the posterior wall of the middle ear.

The muscle arises from the walls of this canal. Its tendon emerges through the pyramid and passes forwards to be inserted into the posterior surface of the neck of the stapes. The stapedius is supplied by the ***facial nerve.*** It develops from the ***mesoderm of the second branchial arch.***

INTERNAL EAR

Bony Labyrinth

The bony labyrinth consists of three parts:

(a) Cochlea anteriorly.
(b) Vestibule, in the middle.
(c) Semicircular canals posteriorly.

MEMBRANOUS LABYRINTH

It is in the form of a complicated, but continuous closed cavity filled with endolymph. Parts of the epithelium of the membranous labyrinth are specialized to form receptors for sound, the organ of Corti; for static balance, the maculae, and for kinetic balance, the cristae.

Like the bony labyrinth, the membranous labyrinth also consists of three main parts:

(a) The spiral duct of the cochlea or organ of hearing, anteriorly.

(b) The utricle and saccule, the organs of static balance, within the vestibule.

(c) The semicircular ducts the organs of kinetic balance, posteriorly (Fig. 18.3).

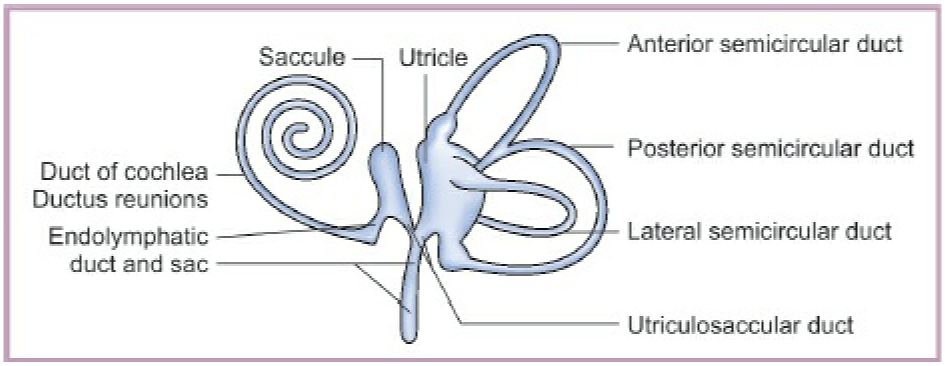


Fig. 18.3: Parts of the membranous labyrinth (as seen from the lateral side).

CLINICAL ANATOMY

- For examination of the meatus and tympanic membrane, the auricle should be drawn upwards, backwards and slightly laterally. However, in infants, the auricle is drawn downwards and backwards because the canal is only cartilaginous and the outer surface of the tympanic membrane is directed mainly downwards.
- Boils and other infections of the external auditory meatus cause little swelling but are extremely painful, due to the fixity of the skin to the underlying bone and cartilage. Ear should be dried after head bath or swimming.
- Irritation of the auricular branch of the vagus in the external ear by ear wax or syringing may reflexly produce persistent cough called ***ear cough,*** vomiting or even death due to sudden cardiac inhibition. On the other hand, mild stimulation of this nerve may reflexly produce

increased appetite.

- Accumulation of wax in the external acoustic meatus is often a source of excessive itching, although fungal infection and foreign bodies should be excluded. Troublesome impaction of large foreign bodies like seeds, grains, insects is common. Syringing is done to remove these.
- Involvement of the ear in herpes zoster of the geniculate ganglion depends on the connection between the auricular branch of the vagus and the facial nerve within the petrous temporal bone.
- Small pieces of skin from the lobule of the pinna are commonly used for demonstration of lepra bacilli to confirm the diagnosis of leprosy.
- Pinna is used as grafting material. Hair on pinna in male represents Y-linked inheritance.
- A good number of ear traits follow Mendelian inheritance.
- Infection of elastic cartilage may cause perichondritis.
- Throat infections commonly spread to the middle ear through the auditory tube and cause otitis media. The pus from the middle ear may take one of the following courses:
  - (a) It may be discharged into the external ear following rupture of the tympanic membrane.
  - (b) It may erode the roof and spread upwards, causing meningitis and brain abscess.
  - (c) It may erode the floor and spread downwards, causing thrombosis of the sigmoid sinus and the internal jugular vein.
  - (d) It may spread backwards, causing mastoid abscess.
- Chronic otitis media and mastoid abscess are responsible for persistent discharge of pus through the ear. Otitis media is more common in children than in adults.
- Fracture of the middle cranial fossa breaks the roof of the middle ear, rupture the tympanic membrane, and thus cause bleeding through the ear along with discharge of CSF.
- The inferior pouch of the outer attic or Prussak’s pouch does not drain easily, the pouch is bounded laterally by the pars flaccida of the

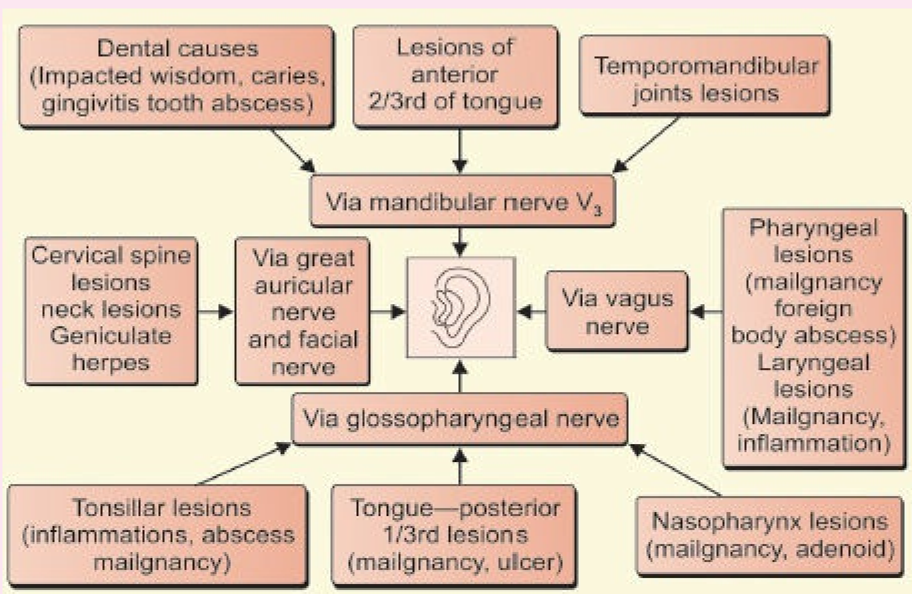
tympanic membrane, medially by the neck of the malleus, anteriorly and posteriorly by the malleolar folds, and superiorly by the lateral ligament of the malleus. Inflammatory exudates in the pouch often lead to perforation of the pars flaccida.

- Inflammation of the auditory tube (Eustachian catarrh) is often secondary to an attack of common cold. This causes pain in the ear which is aggravated by swallowing, due to blockage of the tube. Pain is relieved by installation of decongestant drops in the nose which helps to open the ostium.
- ***Otosclerosis:*** Sometimes bony fusion takes place between the foot plate of the stapes and the margins of the fenestra vestibuli. This leads to deafness. The condition can be surgically corrected by putting a prosthesis.
- Mastoid abscess is secondary to otitis media. It is difficult to treat. A proper drainage of pus from the mastoid requires on operation through the suprameatal triangle. The facial nerve can be injured during this operation.
- Infection from the mastoid antrum and air cells can spread to any of the structures related to them including the temporal lobe of the cerebrum, the cerebellum, and the sigmoid sinus.
- The ear on infected side is displaced laterally and can be appreciated from the back.
- Lesions of cochlear nerve causes hearing defects. Hearing power can be tested by means of a watch in one ear at a time. If there is any impairment of hearing one must determine whether it is really due to disease of the nerve, i.e. nerve deafness, or merely due to disease of the middle ear, i.e. conductive deafness. This is done by Rinne test and Weber test. The tests are based on the principle that normally aerial conduction of sound is better than bony conduction. In conductive deafness, bony conduction becomes better than aerial conduction. In nerve deafness, both types of conduction are lost.

  In Rinne test, a vibrating tuning fork is held opposite the ear. When one stops hearing the sound it is then placed on the mastoid process. The patient is asked to compare the relative loudness of the fork in the two instances.

In Weber test, the vibrating tuning fork is placed on the centre of the forehead. The fork is heard better on the side of middle ear disease than on the normal side.

- Bleeding within the auricle occurs between the perichondrium and auricular cartilage. If left untreated fibrosis occurs as haematoma compromises blood supply to cartilage. Fibrosis leads to “cauliflower ear”. It is usually seen in wrestlers.
- Endolymph is produced by striae vascularis. This process requires melanocytes. The disorders of melanocytes, i.e. albinism, are associated with deafness.
- Acoustic neuroma is a tumour of Schwann cells of VIII nerve. If neuroma extends into internal auditory meatus, VII nerve will get pressed. There will be VIII nerve paralysis and VII nerve paralysis as well.
- Ear ache can be due to reasons, depicted in flow chart below.



- Tympanic membrane is divided into an upper smaller sector, the pars flaccida bounded by anterior and posterior malleolar folds and a larger sector, the pars tensa. Behind pars flaccida lies the chorda tympani, so disease in pars flaccida should be treated carefully.
- ***Hyperacusis:*** Due to paralysis of stapedius muscle, movements of stapes are dampened; so sounds get distorted and get too high in

volume. This is called hyperacusis.

- When the tympanic membrane is illuminated for examination, the concavity of the membrane produces a 'cone of light' over the anteroinferior quadrant which is the farthest or deepest quadrant with its apex at the umbo. Through the membrane one can see the underlying handle of the malleus and the long process of the incus.
- The tympanic membrane is sometimes incised to drain pus present in the middle ear. The procedure is called ***myringotomy.*** The incision for myringotomy is usually made in the posteroinferior quadrant of the membrane where the bulge is most prominent. In giving an incision, it has to be remembered that the chorda tympani nerve runs downwards and forwards across the inner surface of the membrane, lateral to the long process of the incus, but medial to the neck of the malleus. If the nerve is injured taste from most of anterior two-thirds of tongue is not perceived. Also salivation from submandibular and sublingual glands gets affected.

19. Eyeball

OUTER COAT

Sclera

The sclera (*skleros*=hard) is opaque and forms the posterior five-sixths of the eyeball. It is weakest at the entrance of the optic nerve. Here the sclera shows numerous perforations for passage of fibres of the optic nerve.

The sclera is continuous anteriorly with the cornea at the *sclerocorneal junction or limbus*. The deep part of the limbus contains a circular canal, known as the *sinus venosus sclerae or the canal of Schlemm.*

The sclera is pierced by a number of structures:

(a) The *optic nerve* pierces it a little inferomedial to the posterior pole of the eyeball.

(b) The *ciliary nerves and arteries* pierce it around the entrance of the optic nerve.

(c) The *anterior ciliary arteries* derived from muscular arteries to the recti pierce it near the limbus.

(d) Four *venae vorticosae* or the choroid veins pass out through the sclera just behind the equator (Fig. 19.1).

Cornea

The cornea is transparent. It replaces the sclera over the anterior one- sixth of the eyeball. Its junction with the sclera is called the *sclerocorneal junction or limbus.*

The cornea is more convex than the sclera, but the curvature diminishes with age. It is separated from the iris by a space called the anterior chamber of the eye.

The cornea is avascular and is nourished by lymph which circulates in the numerous corneal spaces.

It is supplied by branches of the ophthalmic nerve (through the ciliary ganglion and the short ciliary nerves). Pain is the only sensation aroused from the cornea.

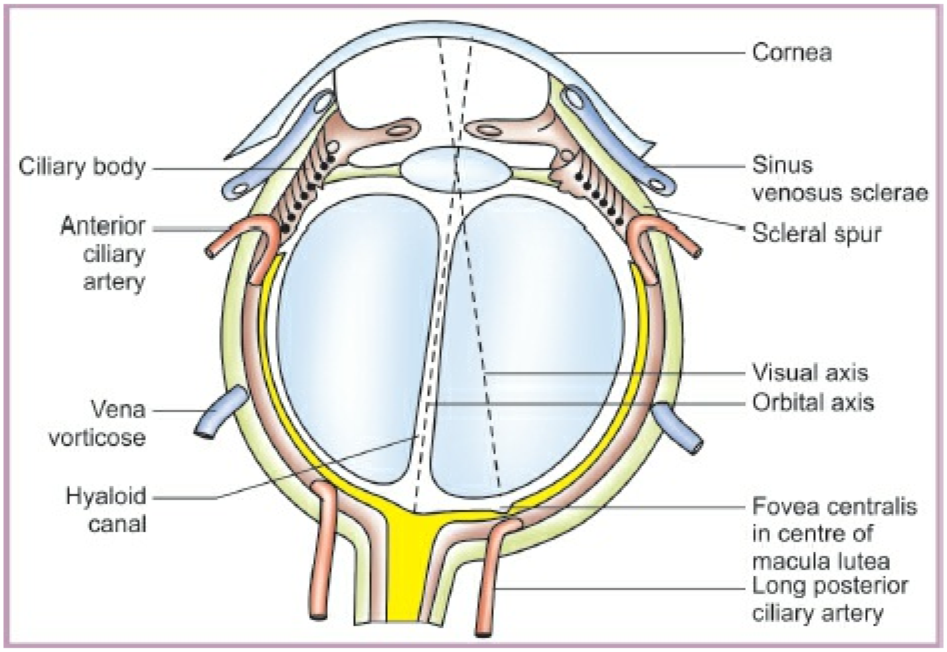


Fig. 19.1: Structures piercing the eyeball seen in a sagittal section.

MIDDLE COAT

Choroid

Choroid is a thin pigmented layer which separates the posterior part of the sclera from the retina. Anteriorly, it ends at the ora serrata by merging with the ciliary body. Posteriorly, it is perforated by the optic nerve to which it is firmly attached.

CILIARY BODY

Ciliary body is a thickened part of the uveal tract lying just posterior to the corneal limbus. It is continuous anteriorly with the iris and posteriorly with the choroid. It suspends the lens and helps it in accommodation for near vision.

1. The ciliary body is triangular in cross-section. It is thick in front and thin behind. The scleral surface of this body contains the ciliary muscle. The posterior part of the vitreous surface is smooth and black (pars plana). The anterior part is ridged anteriorly (pars plicata) to form about 70 ciliary processes. The central ends of the processes are free and rounded.
2. Ciliary zonule is thickened vitreous membrane fitted to the posterior surfaces of ciliary processes. The posterior layer lines hyaloid fossa and anterior thick layer form the suspensory ligament of the lens.
3. The ***ciliary muscle*** is a ring of unstriped muscle which are longitudinal or meridional, radial and circular.

   The contraction of all the parts relaxes the suspensory ligament so that the lens becomes more convex. All parts of the muscle are supplied by parasympathetic nerves. The pathway involves the Edinger-Westphal nucleus, oculomotor nerve and the ciliary ganglion.

IRIS

1. This is the anterior part of the uveal tract. It forms a circular curtain with an opening in the centre, called the ***pupil.*** By adjusting the size of the pupil, it controls the amount of light entering the eye, and thus behaves like an adjustable diaphragm.
2. The iris contains a well-developed ring of muscle called the ***sphincter pupillae*** which lies near the margin of the pupil. Its nerve supply (parasympathetic) is similar to that of the ciliary muscle. The ***dilator pupillae*** is an ill-defined sheet of radial muscle fibres placed near the posterior surface of the iris. It is supplied by sympathetic nerves.

INNER COAT/RETINA

1. This is the thin, delicate inner layer of the eyeball. It is continuous posteriorly with the optic nerve.
2. The retina diminishes in thickness from behind forwards and is divided into optic, ciliary and iridial parts. The ***optic part of the retina*** contains

nervous tissue and is sensitive to light.

3. The depressed area of the optic disc is called the ***physiological cup.*** It contains no rods or cones and is therefore insensitive to light, i.e. it is the ***physiological blind spot.*** At the posterior pole of the eye 3 mm lateral to the optic disc, there is another depression of similar size, called the ***macula lutea.*** It is avascular and yellow in colour. The centre of the macula is further depressed to form the ***fovea centralis.*** This is the thinnest part of the retina. It contains cones only, and is the site of maximum acuity of vision.

4. The retina is supplied by the ***central artery.*** This is an end artery. In the optic disc, it divides into an upper and a lower branch, each giving off nasal and temporal branches. The artery supplies the deeper layers of the retina up to the bipolar cells. The rods and cones are supplied by diffusion from the capillaries of the choroid. The retinal veins run with the arteries.

AQUEOUS HUMOUR

This is a clear fluid which fills the space between the cornea in front and the lens behind the anterior segment. This space is divided by the iris into anterior and posterior chambers which freely communicate with each other through the pupil.

LENS

The lens is a transparent biconvex structure which is placed between the anterior and posterior segments of the eye. It is circular in outline and has a diameter of 1 cm. The central points of the anterior and posterior surfaces are called the anterior and posterior ***poles.***

The posterior surface of the lens is more convex than the anterior. The anterior surface is kept flattened by the tension of the suspensory ligament. When the ligament is relaxed by contraction of the ciliary muscle, the anterior surface becomes more convex due to elasticity of the lens substance.

The lens is enclosed in a transparent, structureless elastic ***capsule*** which is thickest anteriorly near the circumference. Deep to capsule, the anterior surface of the lens is covered by a ***capsular epithelium.*** At the centre of the anterior surface, the epithelium is made up of a single layer of cubical cells, but at the periphery, the cells elongate to produce the ***fibres*** of the lens. The fibres are concentrically arranged to form the lens substance. The centre (nucleus) of the lens is firm (and consists of the oldest fibres), whereas the periphery (cortex) is soft and is made up of more recently formed fibres.

The ***suspensory ligament of the lens*** (or the zonule of Zinn) retains the lens in position and its tension keeps the anterior surface of the lens flattened. The ligament is made up of a series of fibres which are attached peripherally to the ciliary processes, to the furrows between the ciliary processes, and to the ora serrata. Centrally, the fibres are attached to the lens, mostly in front, and a few behind the equator.

VITREOUS BODY

It is a colourless, jelly like transparent mass which fills the posterior segment (posterior 4/5th) of the eyeball. It is enclosed in a delicate homogeneous ***hyaloid membrane.***

Development

Optic vesicle forms optic cup. It is an out pouching from the ***forebrain*** vesicle.

Lens from ***lens placode (ectodermal)***

Retina—pigment layer from the ***outer layer of optic cup;*** nervous layers from the ***inner layer of optic cup.***

Choroid, sclera—***mesoderm***

Cornea—***surface ectoderm***

CLINICAL ANATOMY

- Eye is a very sensitive organ and even a dust particle gives rise to pain.
- Cornea can be grafted from one person to the other, as it is avascular.
- Injury to cornea may cause opacities. These opacities may interfere with vision.
- Over production of aqueous humour or lack of its drainage or

combination of both raise the intraocular pressure. The condition is called ***glaucoma.*** It must be treated urgently.

- The central artery of retina is an ***end-artery.*** Blockage of the artery leads to sudden blindness.
- Bulbar conjunctiva is vascular. Inflammation of the conjunctiva leads to conjunctivitis. The look of palpebral conjunctiva is used to judge haemoglobin level.
- The anteroposterior diameter of the eyeball and shape and curvature of the cornea determine the focal point. Changes in these result in myopia or short-sightedness, hypermetropia or long-sightedness.
- Retinal detachment occurs between outer single pigmented layer and inner nine nervous layers. Actually, it is an inter-retinal detachment. Silicone sponge is put over the detached retina, which is kept in position by a "band".
- While looking at infinite, the light rays run parallel; ciliary muscle is relaxed, suspensory ligament is tense and lens is flat.
- While reading a book, the ciliary muscles contract and suspensory ligament is relaxed making the lens more convex.
- Human vision is coloured, binocular and three-dimensional. Normally, right and left eyes are focussed on one object. In squinting, fixing eye (F) focusses on the object, but the squinting eye (S) is "turned inwards" resulting in a convergent squint.
- Left third nerve paralysis causes partial ptosis and dilated pupil. The cornea is turned downwards and outwards.
- Homer's syndrome results in partial ptosis and miosis.
- Brainstem death—both the pupils are dilated and fixed.
- Eye sees everyone. One can see the interior of the eye by ophthalmoscope. Through the ophthalmoscope, one can see the small vessels in the retina and judge the changes in diabetes and hypertension. In addition, one can also examine the optic disc for evidence of papilloedema, caused by raised intracranial pressure.
- Lens becomes opaque with increasing age (cataract). Since the opacities cause difficulty in vision, lens has to be replaced.

20. Surface Marking

SURFACE MARKING OF VARIOUS STRUCTURES

Arteries

1. Facial Artery

It is marked on the face by joining these three points

(a) A point on the base of the mandible at the anterior border of the masseter muscle

(b) A second point 1.2 cm lateral to the angle of the mouth

(c) A point at the medial angle of the eye

The artery is tortuous in its course

2. Common Carotid Artery

It is marked by a broad line along the anterior border of the sternocleidomastoid muscle by joining the following two points.

(a) A point on the sternoclavicular joint

(b) A second point on the anterior border of the sternocleidomastoid muscle at the level of upper border of the thyroid cartilage.

The thoracic part of the left common carotid artery is marked by a broad line extending from a point a little to the left of the centre of the manubrium to the left sternoclavicular joint.

3. Internal Carotid Artery

It is marked by a broad line joining these two points

(a) A point on the anterior border of the sternocleidomastoid muscle at the level of the upper border of the thyroid cartilage

(b) A second point on the posterior border of the condyle of the mandible.

4. External Carotid Artery

The artery is marked by joining these two points

(a) A point on the anterior border of the sternocleidomastoid muscle at the level of the upper border of the thyroid cartilage

(b) A second point on the posterior border of the neck of the mandible

The artery is slightly convex forwards in its lower half and slightly concave forwards in its upper half.

5. Subclavian Artery

It is marked by a broad curved line, convex upwards, by joining these two points.

(a) A point on the sternoclavicular joint

(b) A second point at the middle of the lower border of the clavicle

The artery rises about 2 cm above the clavicle

The thoracic part of the left subclavian artery is marked by a broad vertical line along the left border of the manubrium a little to the left of the left common carotid artery.

6. Middle Meningeal Artery

It is marked by joining these points

(a) A point immediately above the middle of the zygoma. The artery enters the skull opposite this point

(b) A second point 2 cm above the first point. The artery divides deep to this point

(c) A third point (centre of pterion) 3.5 cm behind and 1.5 cm above the frontozygomatic suture

(d) A fourth point midway between the nasion and inion

(e) A fifth point (lambda) 6 cm above the external occipital protuberance

The line joining points (a) and (b) represents the stem of the middle meningeal artery inside the skull.

The line joining points (b), (c) and (d) represents the anterior (frontal) branch. It first runs upwards and forwards (b)-(c) and then upwards and backwards, towards the point ‘(d)’.

The line joining points (b) and (e) represents the posterior (parietal) branch. It runs backwards and upwards, towards the point '(e)'.

Veins

1. Facial Vein

It is represented by a line drawn just behind the facial artery

2. External Jugular Vein

The vein is usually visible through the skin and can be made more prominent by blowing with the mouth and nostrils closed

It can be marked, if not visible, by joining these points

(a) The first point a little below and behind the angle of the mandible

(b) The second point on the clavicle just lateral to the posterior border of the sternocleidomastoid

3. Internal Jugular Vein

Internal jugular vein is marked by a broad line by joining these two points.

(a) The first point on the neck medial to the lobule of the ear

(b) The second point at the medial end of the clavicle

The lower bulb of the vein lies beneath the lesser supraclavicular fossa between the sternal and clavicular heads of the sternocleidomastoid muscle.

4. Subclavian Vein

Subclavian vein is represented by a broad line along the clavicle extending from a little medial to its midpoint to the medial end of the bone.

5. Superior Sagittal Sinus

Superior sagittal sinus is marked by two lines (diverging posteriorly) joining these two points.

(a) One point at the glabella

(b) Two points at the inion, situated side by side, 1.2 cm apart

6. Transverse Sinus

Transverse sinus is marked by two parallel lines, 1.2 cm apart extending between the following two points.

(a) Two points at the inion, situated one above the other and 1.2 cm apart

(b) Two points at the base of the mastoid process, situated one in front of the other and 1.2 cm apart

The sinus is convex upwards, reaching 2 cm above Reid's baseline

7. Sigmoid Sinus

Sigmoid sinus is marked by two parallel lines situated 1.2 cm apart and extending between these two points.

(a) Two points at the base of the mastoid process, situated one in front of the other and 1.2 cm apart

(b) Two similar points near the posterior border and 1.2 cm above the tip of mastoid process.

Nerves

1. Facial Nerve

Facial nerve is marked by a short horizontal line joining the following two points.

(a) A point at the middle of the anterior border of the mastoid process. The stylomastoid foramen lies 2 cm deep to this point

(b) A second point behind the neck of mandible. Here the nerve divides into its five branches for the facial muscles.

2. Auriculotemporal Nerve

Auriculotemporal nerve is marked by a line drawn first backwards from the posterior part of the mandibular notch (site of mandibular nerve) across the neck of the mandible, and then upwards across the preauricular point.

3. Mandibular Nerve

Mandibular nerve is marked by a short vertical line in the posterior part of the mandibular notch just in front of the head of the mandible.

4. Lingual and Inferior Alveolar Nerves

Lingual nerve is marked by a curved line running downwards and forwards by joining these points.

(a) The first point on the posterior part of the mandibular notch, in line with the mandibular nerve

(b) The second point a little below and behind the last lower molar tooth.

(c) The third point opposite the first lower molar tooth

The concavity in the course of the nerve is more marked between the points (b) and (c) and is directed upwards.

Inferior alveolar nerve lies a little below and parallel to the lingual nerve.

5. Glossopharyngeal Nerve

Glossopharyngeal nerve is marked by joining the following points.

(a) The first point on the anteroinferior part of the tragus

(b) The second point anterosuperior to the angle of the mandible

From point (b), the nerve runs forwards for a short distance above the lower border of the mandible. The nerve describes a gentle curve in its course.

6. Vagus Nerve

The nerve runs along the medial side of the internal jugular vagus vein. It is marked by joining these two points

(a) The first point at the anteroinferior part of the tragus

(b) The second point at the medial end of the clavicle

7. Accessory Nerve (Spinal Part)

Accessory nerve (spinal part) is marked by joining these four points.

(a) The first point at the anteroinferior part of the tragus

(b) The second point at the tip of the transverse process of the atlas

(c) The third point at the middle of the posterior border of the sternocleidomastoid muscle

(d) The fourth point on the anterior border of the trapezius 6 cm above the clavicle

8. Hypoglossal Nerve

Hypoglossal nerve is marked by joining these points.

(a) The first point at the anteroinferior part of the tragus

(b) The second point, posterosuperior to the tip of the greater cornua of the hyoid bone

(c) The third point, midway between the angle of the mandible and the symphysis menti.

The nerve describes a gentle curve in its course.

9. Phrenic Nerve

Phrenic nerve is marked by a line joining the following points.

(a) A point on the side of the neck at the level of the upper border of the thyroid cartilage and 3.5 cm from the median plane

(b) The second point at the medial end of the clavicle

10. Cervical Sympathetic Chain

Cervical sympathetic chain is marked by a line joining the following points.

(a) A point at the sternoclavicular joint

(b) The second point at the posterior border of the condyle of the mandible

The superior cervical ganglion extends from the transverse process of the atlas to the tip of the greater cornua of the hyoid bone. The middle cervical ganglion lies at the level of the cricoid cartilage, and the inferior cervical ganglion, at a point 3 cm above the sternoclavicular joint.

11. Trigeminal Ganglion

Trigeminal ganglion lies a little in front of the preauricular point at a depth of about 4.5 cm.

Glands

Parotid Gland

Parotid gland is marked by joining these four points with each other.

(a) The first point at the upper border of the head of the mandible

(b) The second point, just above the centre of the masseter muscle

(c) The third point, posteroinferior to the angle of the mandible

(d) The fourth point on the upper part of the anterior border of the mastoid process.

The anterior border of the gland is obtained by joining the points (a)- (b)-(c); the posterior border, by joining the points (c)-(d); and the superior curved border with its concavity directed upwards and backwards, by joining the points a-d across the lobule of the ear.

Parotid Duct

To mark this duct first draw a line joining these two points.

(a) One point at the lower border of the tragus

(b) A second point midway between the ala of the nose and the red margin of the upper lip

The middle-third of this line represents the parotid duct

Submandibular Gland

The submandibular salivary gland is marked by an oval area over the posterior half of the base of the mandible, including the lower border of the ramus. The area extends 1.5 cm above the base of the mandible, and below to the greater cornua of the hyoid bone.

Thyroid Gland

The isthmus of thyroid gland is marked by two transverse parallel lines (each 1.2 cm long) on the trachea, the upper 1.2 cm and the lower 2.5 cm below the arch of the cricoid cartilage.

Each lobe extends up to the middle of the thyroid cartilage, below to the clavicle, and laterally to be overlapped by the anterior border of sternocleidomastoid muscle. The upper pole of the lobe is pointed, and the lower pole is broad and rounded.

Palatine Tonsil

Palatine tonsil is marked by an oval (almond-shaped) area over the masseter just anterosuperior to the angle of the mandible.

Paranasal Sinuses

Frontal Sinus

Frontal sinus is marked by a triangular area formed by joining these three points

(a) The first point at the nasion

(b) The second point 2.5 cm above the nasion

(c) The third point at the junction of medial one-third and lateral two- thirds of the supraorbital margin, i.e. at the supraorbital notch.

Maxillary Sinus

The roof of maxillary sinus is represented by the inferior orbital margin; the floor, by the alveolus of the maxilla; the base, by the lateral wall of the nose. The apex lies on the zygomatic process of the maxilla.

1. Appendix

CERVICAL PLEXUS

Ventral rami of Cl, C2, C3, C4 form the cervical plexus. Cl runs along hypoglossal and supplies geniohyoid and thyrohyoid. It also gives superior limb of ansa cervicalis, which supplies superior belly of omohyoid and joins with inferior limb to form ansa. Inferior limb of ansa cervicalis is formed by ventral rami of C2, C3. Branches from ansa supply sternohyoid, sternothyroid, inferior belly of omohyoid. Cervical plexus also gives four cutaneous branches lesser occipital (C2), great auricular (C2, C3), supraclavicular (C3, C4) and transverse or anterior nerve of neck (C2, C3).

PHRENIC NERVE

Phrenic nerve arises primarily from ventral rami of C4 with small contributions from C3 and C5 nerve roots or through nerve to subclavius. It is the only motor supply to its own half of diaphragm and sensory to mediastinal pleura, peritoneum and fibrous pericardium. Inflammation of peritoneum under diaphragm causes referred pain in the area of supraclavicular nerves supply, especially tip of the shoulders as their root value is also ventral rami of C3 and C4.

SYMPATHETIC TRUNK

Branches of cervical sympathetic ganglia of sympathetic trunk are given in Table A1.1.

PARASYMPATHETIC GANGLIA

Submandibular Ganglion

Situation: The submandibular ganglion lies superficial to hyoglossus muscle in the submandibular region. Functionally, it is connected to facial nerve, while topographically it is connected to lingual branch of mandibular nerve.

Table A1.1: Branches of cervical sympathetic ganglia

	Superior cervical ganglion	Middle cervical ganglion	Inferior cervical ganglion
Arterial branches	(i) Along internal carotid artery as internal carotid nerve (ii) Along common carotid and external carotid arteries	Along inferior thyroid artery	Along subclavian and vertebral arteries
Grey rami communicans	Along 1–4 cervical nerves	Along 5 and 6 cervical nerves	Along 7 and 8 cervical nerves
Along cranial nerves	Along cranial nerves IX, X, XI and XII	–	–
Visceral branches	Pharynx, cardiac	Thyroid, cardiac	Cardiac

Roots

The ganglion has sensory, sympathetic and secretomotor roots.

- Sensory root is from the lingual nerve. It is suspended by two roots of lingual nerve
- Sympathetic root is from the sympathetic plexus around the facial artery. This plexus contains postganglionic fibres from the superior cervical ganglion of sympathetic trunk. These fibres pass express through the ganglion and are vasomotor to the gland
- Parasympathetic/secretomotor root is from superior salivatory nucleus through nervus intermedius via chorda tympani which is a branch of cranial nerve VII. Chorda tympani joins lingual nerve. The parasympathetic fibres get relayed in the submandibular ganglion.

Branches

The ganglion gives direct branches to the submandibular salivary gland.

Some postganglionic fibres reach the lingual nerve to be distributed to sublingual salivary gland.

PTERYGOPALATINE GANGLION

Situation

Pterygopalatine or sphenopalatine is the largest parasympathetic ganglion, suspended by two roots of maxillary nerve. Functionally, it is related to cranial nerve VII. It is called the ganglion of "hay fever."

Roots

The ganglion has sensory, sympathetic and secretomotor roots.

- Sensory root is from maxillary nerve. The ganglion is suspended by 2 roots of maxillary nerve.
- Sympathetic root is from postganglionic plexus around internal carotid artery. The nerve is called ***deep petrosal.*** It unites with ***greater petrosal to form nerve of pterygoid canal.*** The fibres of deep petrosal do not relay in the ganglion.
- Parasympathetic/secretomotor root is from greater petrosal nerve which arises from geniculate ganglion of cranial nerve VII. These fibres relay in the ganglion.

Branches

The ganglion gives number of branches. These are as follows.

(i) ***For lacrimal gland:*** The postganglionic fibres pass through zygomatic branch of maxillary nerve. These fibres hitch hike through zygomaticotemporal nerve into the communicating branch between zygomaticotemporal and lacrimal nerve, then to the lacrimal nerve for supplying the lacrimal gland.

(ii) ***Nasopalatine nerve:*** This nerve runs on the nasal septum and ends in the anterior part of hard palate. It supplies secretomotor fibres to both nasal and palatal glands.

(iii) ***Palatine branches:*** These are one greater palatine and 2-3 lesser palatine branches. These pass through the respective foramina to supply sensory and secretomotor fibres to mucous membrane and glands of soft palate and hard palate.

(iv) ***Nasal branches:*** These are posterior superior medial for the supply of glands and mucous membrane of nasal septum; the largest is named nasopalatine; and posterior superior lateral for the supply of glands and mucous membrane of lateral wall of nasal cavity.

(v) ***Orbital branches*** for the orbital periosteum.

(vi) Pharyngeal branches for the glands of pharynx.

OTIC GANGLION

Situation

The otic ganglion lies deep to the trunk of mandibular nerve, between the nerve and the tensor veli palatini muscle in the infratemporal fossa, just distal to the foramen ovale. Topographically, it is connected to mandibular nerve, while functionally it is related to cranial nerve IX.

Roots

This ganglion has sensory, sympathetic, parasympathetic/secretomotor and motor roots.

Table A1.2: Connections of parasympathetic ganglia

1. Superior salivatory nucleus of VII nerve → VII nerve

↓

Chorda tympani branch

↓

via lingual nerve

↓

Submandibular ganglion

↓

Relays to supply submandibular gland directly and sublingual salivary gland via lingual nerve

2. Lacrimatory nucleus of VII nerve → VII nerve → greater petrosal nerve + deep petrosal nerve (sympathetic)

↓

Nerve of pterygoid canal

↓

Pterygopalatine ganglion

↓

Relays to supply glands of nose, palate, pharynx and pass along maxillary nerve, zygomatic nerve

↓

Zygomaticotemporal nerve, lacrimal nerve to supply lacrimal gland

3. Inferior salivatory nucleus of IX nerve → Tympanic branch

↓

Tympanic plexus

↓

Lesser petrosal nerve

↓

Relays in *otic ganglion*

↓

Fibres join auriculotemporal nerve → Parotid gland

4. Edinger-Westphal nucleus → III nerve → Nerve to inferior oblique

↓

Branch to *ciliary ganglion*

↓

Relay

↓

Short ciliary nerves supply ciliaris and constrictor pupillae muscles

- Sensory root is by the auriculotemporal nerve
- Sympathetic root is by the sympathetic plexus around middle meningeal artery
- Parasympathetic/secretomotor root is by the lesser petrosal nerve from the tympanic plexus formed by tympanic branch of cranial nerve IX.

Fibres of lesser petrosal nerve relay in the otic ganglion. Postganglionic fibres reach the parotid gland through auriculotemporal nerve.

- Motor root is by a branch from nerve to medial pterygoid. This branch passes unrelayed through the ganglion and divides into two branches to supply tensor veli palatini and tensor tympani.

Branches

The postganglionic branches of the ganglion pass through auriculotemporal nerve to supply the parotid gland.

The motor branches supply the two muscles mentioned above.

CILIARY GANGLION

Situation

The ciliary ganglion is very small ganglion present in the orbit. Topographically, the ganglion is related to nasociliary nerve, branch of ophthalmic division of trigeminal nerve, but functionally it is related to oculomotor nerve. This ganglion has no secretomotor fibres.

Roots

It has three roots: the sensory, sympathetic and motor. Only the motor root fibres relay to supply the intraocular muscles.

- Sensory root is from the long ciliary nerve
- Sympathetic root is by the long ciliary nerve from plexus around ophthalmic artery
- Parasympathetic root is from a branch to inferior oblique muscle. These fibres arise from Edinger-Westphal nucleus, join oculomotor nerve and leave it via the nerve to inferior oblique, to be relayed in the ciliary ganglion.

Branches

The ganglion gives 10-12 short ciliary nerves containing postganglionic fibres for the supply of constrictor or sphincter pupillae for narrowing the size of pupil and ciliaris muscle for increasing the curvature of anterior surface of lens required during accommodation of the eye.

Table A1.3: Arteries of head and neck		
	Beginning, course and termination	**Area of distribution**
Common carotid	it is a branch of brachiocephalic trunk on right side and a direct branch of arch of aorta on the left side. The artery runs upwards enclosed within the carotid sheath. The artery ends by dividing into internal carotid and external carotid at the upper border of thyroid cartilage	This artery has only two terminal branches. These are internal carotid and external carotid.
Internal carotid	lt is a terminal branch of common carotid artery. lt first runs through the neck (cervical), then passes through the petrous bone, (petrous), then courses through the sinus (cavernous) and lastly lies in relation to the brain (cerebral)	Cervical part—no branch. Petrous part—middle ear; cavernous part—hypophysis cerebri. The cerebral partophthalmic artery for orbit, anterior cerebral, middle cerebral, anterior choroidal and posterior communicating for the brain
External carotid	lt is the one of the terminal branches of common carotid artery and lies anterior to internal carotid artery. External carotid artery starts at the level of upper border of thyroid cartilage, runs upwards and laterally to terminate behind	it supplies structures in the front of neck, i.e. thyroid gland, larynx, muscles of tongue, face, scalp, ear

	the neck of mandible by dividing into larger maxillary and smaller superficial temporal branches	
Superior thyroid	it arises from anterior aspect of external carotid artery close to its origin. lt runs downwards and forwards deep to the infra hyoid muscles to the upper pole of thyroid gland	Superior laryngeal branch to supply larynx. Sternocleidomastoid branch and cricothyroid branches to these muscles. Terminal branches supply the thyroid gland
Lingual	it arises from anterior aspect of external carotid artery forms a typical loop which is crossed by XII nerve. Its 2nd part lies deep to the hyoglossus. The 3rd part runs along the anterior border of hyoglossus and 4th part runs forwards on the under surface of tongue	As the name indicates, it is the chief artery of the muscular tongue. lt supplies various muscles, papillae and taste buds of the tongue. lt also gives branches to the tonsil
Facial	This tortuous artery from anterior side also arises a little higher to lingual artery. lt runs in the neck as cervical part and in the face as facial artery	Cervical part gives off ascending palatine, tonsillar, glandular branches for the submandibular and sublingual salivary glands. The facial part lies on the face giving branches to muscles of face and skin
Occipital	It arises form the poste	lt gives two branches t

	rior aspect of external carotid artery and runs upwards along the low er border of posterior b elly of digastric muscle . Then it runs deep to mastoid process, cross es the apex of suboccip ital triangle and then it pierces trapezius 2.5 c m from midline to sup ply the layers of scalp	o sternocleidomastoid muscle, and branches t o neighbouring muscle s. lt also gives a menin geal and mastoid branc h
Posterior auricular	It arises from posterior aspect of external carot id artery, it runs along t he upper border of post erior belly of digastric muscle to reach the bac k of auricle	It gives branches to sca lp. Its stylomastoid bra nch enters the foramen ofthe same name to su pply mastoid antrum a nd air cells and the faci al nerve.
Ascending pharyngea l	It arises from the medi al side of external carot id artery, close to its lo wer end. lt runs upwar ds and between pharyn x and tonsil on medial side and medial wall of middle ear on the later al side	It gives branches to ton sil, pharynx and a few meningeal branches
Superficial temporal	lt is the smaller termin al palpable branch of e xternal carotid artery. l t begins behind the nec k of the mandible, runs upwards and crosses th e preauricular point. lt ends by dividing into a	Its two terminal branch es supply layers of scal p and superficial temp oral region. lt also sup plies parotid gland, fac ial muscles and tempor alis muscle

	nterior and posterior branches	
Maxillary	It is the larger terminal branch of external carotid artery. It is given off behind the neck of the mandible. Its course is divided into 1st, 2nd and 3rd parts. 1st parts lies below the lateral pterygoid, 2nd part lies on the lower head of lateral pterygoid and 3rd part lies between the two heads	Branches of 1st part: Deep auricular, anterior tympanic, middle meningeal and inferior alveolar. 2nd part: Muscular branches 3rd part: Posterior superior alveolar, infraorbital, greater palatine and sphenopalatine branches

Table A1.4: Branches of Maxillary artery

Branches	Foramina transmitting	Distribution
A. Of first part		
1. Deep auricular	Foramen in the floor (cartilage or bone) of external acoustic meatus	Skin of external acoustic meatus, and outer surface of tympanic membrane
2. Anterior tympanic	Petrotympanic fissure	Inner surface of tympanic membrane
3. Middle meningeal	Foramen spinosum	Supplies more of bone and less of meninges; also V and VII nerves, middle ear and tensor tympani
4. Accessory meningeal	Foramen ovale	Main distribution is extracranial to pterygoids
	Mandibular foramen	Lower teeth and myloh

5.	Inferior alveolar		yoid muscle
B. Of second part			
1.	Masseteric	–	Masseter
2.	Deep temporal	–	Temporalis
3.	Deep temporal	–	Temporalis
4.	Pterygoid	–	Lateral and medial pter ygoids
5.	Buccal	–	Skin of cheek
C. Of third part			
1.	Posterior superior a lveolar	Alveolar canals In bod y of maxilla	Upper molar and prem olar teeth and gums; m axillary sinus
2.	Infraorbital	Inferior orbital fissure	Lower orbital muscles; lacrimal sac; maxillary sinus; upper incisor an d canine teeth
3.	Greater palatine	Greater palatine canal	Soft palate; tonsil; pala tine glands and mucosa ; upper gums
4.	Pharyngeal	Pharyngeal (palatovagi nal) canal	Roof of nose and phary nx; auditory tube; sphe noidal sinus
5.	Artery of pterygoid canal	Pterygoid canal	Auditory tube; upper p harynx; and middle ear
6.	Sphenopalatine (ter minal part)	Sphenopalatine forame n	Lateral and medial wal ls of nose and various air sinuses

Table A1.5: Subclavian artery

Course	Branches and area of distribution
It is the chief artery of the upper limb. It also supplies part of neck and brain. On the right side, subclavian artery is a branch of the brachiocephalic trunk. On the left side, it is a direct branch of arch of aorta. The artery on either side ascends and enters the neck posterior to the sternoclavicular joint. The arteries of two sides have similar course. The artery arches from the sternoclavicular joint to the outer border of the first rib where it continues as the axillary artery. lt is divided into three parts by the crossing of scalenus anterior muscle	Branches of 1st part: • Vertebral artery is the largest branch. It supplies the brain. The artery passes through foramina transversaria of C6-C1 vertebrae, then it courses through suboccipital triangle to enter cranial cavity • Internal thoracic artery runs downwards and medially to enter thorax by passing behind first costal cartilage. It runs vertically 2 cm, on lateral side of sternum till 6th intercostal space to divide into musculophrenic and superior epigastric branches • Thyrocervical trunk is a short wide vessel which gives suprascapular, transverse cervical and important inferior thyroid branch. Inferior thyroid artery gives glandular branches to thyroid and parathyroid glands. In addition, this artery gives inferior laryngeal branch for the supply of mucous membrane of larynx • Costocervical trunk arises from 2nd part of subclavian artery on right side and from 1st part on left side. It ends by dividing into superior intercostal and deep cervical branches. • 3rd part has no branch

CLINICAL ANATOMY

Anaesthetist's arteries: These are the arteries used by the anaesthetists who are sitting at the head end of the patient being operated. The superficial temporal artery as it crosses the root of zygoma in front of ear, facial artery at the anteroinferior angle of masseter muscle, and common carotid at the anterior border of sternocleidomastoid are used.

Hilton's method of draining parotid gland abscess: The incision given to drain parotid abscess is the horizontal incision. This incision does not endanger the various branches of facial nerve, coursing through the gland.

Frey syndrome: The sign of Frey syndrome is the appearance of perspiration on the face while the patient eats food. In certain wounds, the auriculotemporal nerve and great auricular nerves may j oin with each other. When the person eats food, instead of saliva, sweat appears on the face.

Waldeyer's ring: It is the ring of lymphoid tissue present at the oropharyngeal junction. Its components are lingual tonsils anteriorly, palatine tonsils laterally, tubal tonsils above and laterally and pharyngeal tonsils posteriorly.

Killian's dehiscence: It is a potential gap between upper thyropharyngeus and lower cricopharyngeus parts of inferior constrictor muscle. Propulsive thyropharyngeus is supplied by pharyngeal plexus. Cricopharyngeus is the sphincteric part of the muscle supplied by recurrent laryngeal nerve. If there is incoordination between these two parts, bolus of food is pushed backwards in region of Killian's dehiscence, producing pharyngeal pouch or diverticula.

Safety muscle of larynx: Posterior cricoarytenoid muscle is the only abductor of vocal cords. The paralysis of both these muscles causes unopposed adduction of vocal cords, with severe dyspnoea. So posterior cricoarytenoid is the life saving muscle.

Singer's nodules: These are little swellings on the vocal cords at the junction of anterior and middle thirds of vocal cords. During phonation, the cords come close together, and there is slight friction as well. If friction is more and continuous, there is some inflammation with thickening of vocal cords, leading to Singer's or Teacher's nodules.

Tongue is pulled out during anaesthesia: Genioglossus muscles are responsible for protrusion of tongue. If these muscles are paralysed, the tongue falls back upon itself and blocks the airway. So tongue is pulled out during anaesthesia to keep the air passage clean.

Passavant's ridge: The horizontal fibres of right and left palatopharyngeus muscles form a Passavant's fold at the junction of nasopharynx and oropharynx. During swallowing, palatopharyngeus muscles form a ridge, which closes nasopharynx from oropharynx, so that bolus of food passes, through oropharynx only. In paralysis of this muscle, there is nasal regurgitation.

Ludwig's angina: When there is cellulitis of floor of the mouth, due to infected teeth, the condition is known as Ludwig's angina. The tongue is pushed upwards and mylohyoid is pushed downwards. This cellulitis may spread backwards to cause oedema of larynx and asphyxia.

Little's area of nose: This is the area in the anteroinferior part of nasal septum. Three arteries take part in Kiesselbach's plexus formed by, septal branch of superior labial from facial artery, branch of sphenopalatine artery and branch of anterior ethmoidal artery. Picking of the nose may give rise to nasal bleeding or epistaxis.

Syringing of ear causes decreased heart rate: The external auditory meatus is supplied by auricular branch of vagus. Vagus also supplies the heart with cardio-inhibitory fibres. During syringing of the ear, vagus nerve is stimulated which causes bradycardia.

Nerve of near vision: Oculomotor nerve is the nerve of close vision. It supplies medial rectus, superior and inferior recti, sphincter pupillae and ciliaris muscles. It also supplies levator palpebrae superiors which opens the eye.

Injury to spine of sphenoid: Chorda tympani nerve is related on the medial side of spine of sphenoid, while auriculotemporal nerve is related to the lateral side. Chorda tympani gives secretomotor fibres to submandibular and sublingual salivary glands, whereas auriculotemporal gives secretomotor fibres to the parotid gland. So injury to spine of sphenoid may injure both these nerves affecting the secretion from all three salivary glands.

Extradural haemorrhage: There is collection of blood due to rupture of middle meningeal vessels in the space between skull and the endosteum. It may press upon the motor area of brain. Blood has to be drained out from the point called ‘pterion’.

Loss of corneal blink reflex: In case of injury to ophthalmic nerve, there is loss of corneal blink reflex as the afferent part of reflex arc is damaged.

Loss of sneeze reflex: In injury to maxillary nerve, the sneeze reflex is lost, as afferent loop of the reflex arc formed by the maxillary nerve is damaged.

Loss ofjaw jerk reflex: The afferent and efferent limbs of the reflex arc are by V nerve. Damage to mandibular nerve causes loss of jaw jerk reflex.

Section II
Brain

- Introduction
- Meninges of the Brain and Cerebrospinal Fluid
- Spinal Cord
- Cranial Nerves
- Brainstem
- Cerebellum
- Fourth Ventricle
- Cerebrum
- Third Ventricle, Lateral Ventricles and Limbic System
- Blood Supply of Spinal Cord and Brain
- Appendix 2

21. Introduction

Nervous system is the chief controlling and coordinating system of the body. It adjusts the body to the surroundings and regulates all bodily activities both voluntary and involuntary. The sensory part of the nervous system collects information from the surroundings and helps in gaining knowledge and experience, whereas the motor part is responsible for responses of the body.

Average weight of adult brain in air is 1500 grams. Since brain floats in cerebrospinal fluid, it only weighs 50 grams which is comfortable.

There are about 200 billion neurons in an adult brain (very rich).

DIVISIONS OF NERVOUS SYSTEM

Anatomical

It is divided into

(a) Central nervous system (CNS) comprises brain and spinal cord
(b) Peripheral nervous system (PNS) includes 12 pairs of cranial nerves and 31 pairs of spinal nerves.

Neuron

Classification of Neurons

(a) Multipolar neurons
(b) Bipolar neurons
(c) Pseudounipolar neurons
(d) Unipolar neurons

Sensory Neurons

These are of three types

(a) Primary sensory neurons

(b) Secondary sensory neurons

(c) Tertiary sensory neurons

Motor Neurons

These carry impulses from CNS to distal part of the body. These are of two types

(1) Somatic motor neuron, (2) Autonomic neuron

1. ***Somatic motor neuron:*** (a) upper motor neurons, (b) lower motor neurons.
2. ***Autonomic neuron:*** (a) Preganglionic neurons in CNS, (b) postganglionic neurons in sympathetic chain.

Neuroglial Cells

Various types of neuroglial cells are as follows

(a) Astrocytes are concerned with nutrition of the nervous tissue

(b) Oligodendrocytes are counterparts of the Schwann cells. Schwann cells myelinate the peripheral nerves. Oligodendrocytes myelinate the tracts

(c) Microglia behave like macrophages of the CNS

(d) Ependymal cells are columnar cells lining the cavities of the CNS

Reflex Arc

A reflex arc is the functional unit of the nervous system. In its simplest form, (monosynaptic reflex arc) it consists of

(a) A receptor, e.g. the skin

(b) The sensory neuron

(c) The motor neuron

(d) The effector, e.g. the muscle

In complex forms of the reflex arc, the internuncial neurons (intemeurons) are interposed between the sensory and motor neurons. An involuntary motor response to a sensory stimulus is known as the reflex action. Only cortical responses are voluntary in nature. All subcortical responses are involuntary and therefore are the reflex activities. Reflex action is chief function of spinal cord. Knee jerk and ankle jerk are monosynaptic reflex arcs. Some common reflex arcs are put in Table 21.1.

PARTS OF THE NERVOUS SYSTEM

Peripheral Nervous System

1. Somatic (cerebrospinal) nervous system
2. Autonomic (splanchnic) nervous system

Parts of Brain

The main parts and their subdivisions are shown in Table 21.2.

The brainstem includes the midbrain, pons and medulla. Hindbrain includes pons, medulla and cerebellum. The dilated part of the central canal of spinal cord within the conus medullaris is known as the terminal ventricle. Similarly, the cavity of septum pellucidum is sometimes called as the fifth ventricle.

Table 21.1: Some common reflexes

Name of reflex	Way of eliciting	Result	Comment
Biceps jerk	Striking biceps tendon	Flexion of the elbow joint	C5, C6 segments intact Tendon jerks may be exaggerated in upper motor neuron lesion or lost in lower motor neuron lesion
Triceps jerk	Striking triceps tendon	Extension of the elbow joint	C7, C8, segments intact
Knee jerk	Striking the ligamentum patellae	Extension of the knee joint	L3, L4 segments of spinal cord intact
Ankle jerk	Striking tendocalcaneus	Plantar flexion of the ankle joint	S1, S2 segments intact
Abdominal reflex	Stroking a quadrant of abdomen	Contraction of abdominal muscles	Positive reflex indicates normal pyramidal tract with T7–T12 nerves intact
Plantar reflex	Scratching the sole of foot from lateral side towards big toe	Plantar flexion of the great toe and other toes	A normal plantar response indicates intact pyramidal tract
Babinski's sign	Same as in plantar reflex	Dorsiflexion of the great toe and fanning of other toes	Babinski's sign indicates pyramidal tract injury, except in infants

Table 21.2: Parts of brain

Parts	Subdivisions	Cavity
1. Forebrain (prosenc	A. Telencephalon (cer	Lateral ventricle

	ephalon)	ebrum), made up of two cerebral hemispheres and the median part in front of the interventricular foramen B. Diencephalon (thalamencephalon), hidden by the cerebrum, consists of: (a) Thalamus (b) Hypothalamus (c) Metathalamus, including the medial and lateral geniculate bodies, and (d) Epithalamus, including the pineal body, habenular trigone and posterior commissure (e) Subthalamus	Third ventricle
2.	Midbrain (mesencephalon)	Crus cerebri, substantia nigra, tegmentum, and tectum from before backwards	Cerebral aqueduct
3.	Hindbrain (rhombencephalon)	A. Metencephalon, made up of pons and cerebellum	Fourth ventricle

B.	Myelencephalon or medulla oblongata

CLINICAL ANATOMY

- If a nerve (axons) is injured or cut, a series of degenerative and then regenerative changes follow. The degenerative changes occur in
  (a) ***Cell body:*** It undergoes chromatolysis. Nissl granules disappear; cell becomes swollen and rounded; and the nucleus is pushed to the periphery.
  (b) ***The proximal part of the cutfibre:*** So long the mother cell is intact, it survives, and only a part near the cut end degenerates.
  (c) ***The distalpart of the cut fibre:*** It degenerates completely. Axis cylinder becomes fragmented; myelin sheath breaks up into fat droplets, and the nuclei of Schwann cells multiply and fill up the neurilemmal tube. During regeneration, the tip of the axon still connected with the cell body begins to grow through the neurilemmal tube. The rate of growth is about 1-2 mm per day in man. Myelin sheath is reformed. The role of neurilemmal tube as a guiding factor to the regenerating proximal axon is considered to be of paramount importance.

Thus a nerve can regenerate because it has a neurilemmal sheath.

A tract cannot regenerate because it has no such sheath.

22. Meninges of the Brain and Cerebrospinal Fluid

INTRODUCTION

The brain is a very important but delicate organ. It is protected by the following coverings

1. Bony covering of the cranium.
2. Three membranous coverings (meninges)
   (a) The outer dura mater (pachymeninx)
   (b) The middle arachnoid mater
   (c) The inner pia mater. The arachnoid and pia are together known as the leptomeninges.
3. The cerebrospinal fluid fills the space between the arachnoid and the pia maters (subarachnoid space) and acts as a water cushion.

DURA MATER

It is made up of two layers, an outer endosteal layer and an inner meningeal layer, enclosing the cranial venous sinuses between the two. The meningeal layer forms four folds which divide the cranial cavity into intercommunicating compartments for different parts of the brain (Table 22.1).

ARACHNOID MATER

The arachnoid mater is a thin transparent membrane that loosely surrounds the brain *without* dipping into its sulci.

Prolongations

Arachnoid villi are small, finger-like processes of arachnoid tissue, projecting into the cranial venous sinuses. They absorb CSF. With advancing age, the *arachnoid villi* enlarge in size to form pedunculated tufts, called *arachnoid granulations*. These granulations may produce depressions in bone.

Table 22.1: The meningeal layer sends inwards following folds of dura mater

Folds	Shape	Attachments	Venous sinuses enclosed
Falx cerebri	Sickle-shaped, separates the right from left cerebral hemisphere	Superior, convex margins are attached to sides of the groove lodging the superior sagittal sinus. Inferior concave margin is free Anterior attachment to crista galli, posterior to upper surface of tentorium cerebelli	Superior sagittal sinus Inferior sagittal sinus Straight sinus
Tentorium cerebelli	Tent-shaped, separates the cerebral hemispheres from hindbrain and lower part of mid-brain Lifts off the weight of occipital lobes from the cerebellum	Has a free anterior margin. Its ends are attached to anterior clinoid processes. Rest is free and concave. Posterior margin is attached to the lips of groove containing transverse sinuses, superior petrosal sinuses and to posterior clinoid processes	Transverse sinuses, superior petrosal sinuses
Falx cerebelli	Small sickle-shaped fold partly separating two cerebellar hemispheres	Base is attached to posterior part of inferior surface of tentorium cerebelli Apex reaches till foramen magnum	Occipital sinus
Diaphragma sellae	Small horizontal fold	Anterior attachment is to tuberculum sellae Posterior attachment is to dorsum sellae; laterally continuous with dura mater of middle cranial fossa	Anterior and posterior intercavernous sinuses

PIA MATER

The pia mater is a thin vascular membrane which closely invests the brain, dipping into various sulci and other irregularities of its surface.

Prolongations

It provides sheaths for the cranial nerves merging with the epineurium around them.

EXTRADURAL (EPIDURAL) AND SUBDURAL

SPACES

The extradural or epidural space is a potential space between the inner aspect of skull bone and the endosteal layer of dura mater.

The subdural space is also a potential space between the dura and arachnoid maters.

SUBARACHNOID SPACE

This is the space between the arachnoid and the pia maters.

Cisterns

At the base of the brain and around the brainstem, the subarachnoid space forms intercommunicating pools, called ***cisterns,*** which reinforce the protective effect of CSF on the vital centres situated in the medulla. The subarachnoid cisterns are as follows.

- Cerebellomedullary cistern or cistema magna (Fig. 22.1)
- Cistema pontis
- Interpeduncular cistern

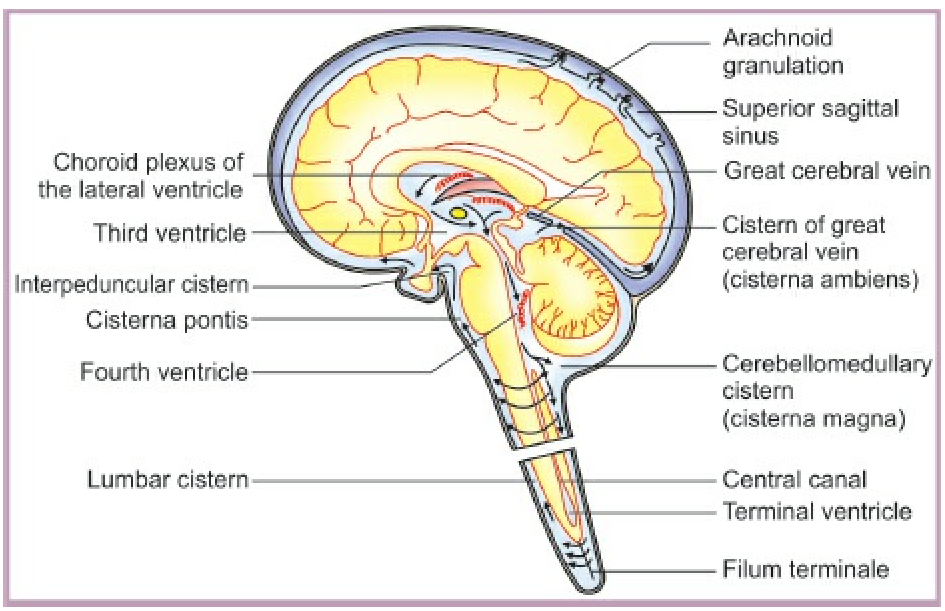


Fig. 22.1: Subarachnoid cisterns.

- Cistern of lateral sulcus
- Lumbar cistern
- Cistern of great cerebral vein (cistema ambiens)

Communications

The subarachnoid space communicates with the ventricular system of the brain at:

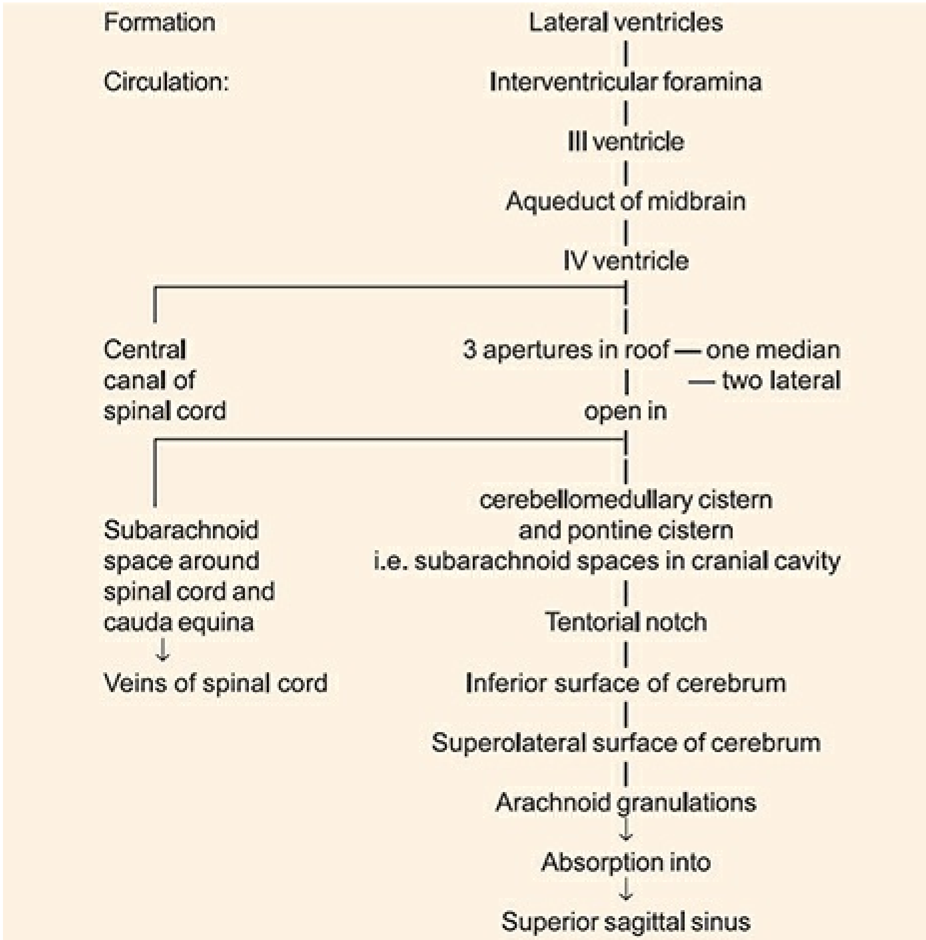
(a) A median foramen (of Magendie).

(b) Two lateral foramina (of Luschka), situated in the roof of the fourth ventricle. The CSF passes through these foramina from the fourth ventricle to the subarachnoid space.

CEREBROSPINAL FLUID (CSF)

The cerebrospinal fluid is a modified tissue fluid. It is contained in the ventricular system of the brain and in the subarachnoid space around the brain and spinal cord. CSF replaces lymph in the CNS (Table 22.2).

Table 22.2: Cerebrospinal fluid (CSF)



Functions of CSF

1. CSF decreases the sudden pressure or forces on delicate nervous tissue.
2. CSF nourishes nervous tissue. Only CSF conies in contact with neurons. Even blood cannot directly come in contact with neurons. It provides nourishment and returns products of metabolism to the venous sinuses.

CLINICAL ANATOMY

- CSF can be obtained by
  - (a) Lumbar puncture
  - (b) Cisternal puncture or
  - (c) Ventricular puncture

  Lumbar puncture is the easiest method and is commonly used It is done by passing a needle in the interspace between the third and fourth lumbar spines.

- Biochemical analysis of CSF is of diagnostic value in various diseases.
- Obstruction to the flow of CSF in the ventricular system of the brain leads to ***hydrocephalus*** in children, and raised intracranial pressure in adults.
- Drainage of CSF at regular intervals is of therapeutic value in meningitis. Certain intractable headaches of unknown aetiology are also known to have been cured by a mere lumbar puncture with drainage of CSF.
- Obstruction in the vertebral canal produces ***Froin's syndrome or loculation syndrome.*** This is characterized by yellowish discolouration of CSF (xanthochromia) below the level of obstruction, and its spontaneous coagulation after withdrawal due to a high protein content. Biochemical examination of such fluid reveals that the protein content is raised, but the cell content is normal. This is known as ***albumino-cytologic dissociation.***
- ***Hydrocephalus:*** It is the dilatation of the ventricular system and occurs due to obstruction of CSF circulation. It may be of the following types:

(a) ***Communicating:*** If the obstruction is outside the ventricular system,usually in the subarachnoid space or arachnoid granulations, it is termed as comminucating. This occurs due to fibrosis following meningitis. It is also called external hydrocephalus. Clinical features are

- Head size is rather large
- Tense anterior fontanelle
- Dilated veins over thin scalp

(b) ***Non-communicating:*** If the obstruction is within the ventricular system. It is called non-communicating or internal hydrocephalus.

This is usually caused by a tumour or inflammation. A shunt procedure is employed to divert the CSF from the ventricular system into the peritoneal cavity.

(c) ***Hydrocephalus ex vacuo:*** Occurs as a compensatory mechanism due to atrophy of brain parenchyma. It is seen in dementia or Alzheimer's.

- ***Papilloedema:*** The subarachnoid space sends extensions along the optic nerves till the back of eyeball. Increased CSF pressure compresses the wall of retinal vein leading to forward bulging of optic disc with oedema of the disc. Oedema of the optic disc is known as papilloedema. It can be viewed by an ophthalmoscope.
- ***Lumbar epidural:*** The epidural space is the space between vertebral canal and dura mater. The epidural space is deeper in the midline. The procedure is same as lumbar puncture, the needle should reach only in the epidural space and not deep to it in the dura mater. Epidural space is utilized for giving anaesthesia or analgesia.
- Inflammation of pia mater and arachnoid mater is known as ***meningitis.*** This is commonly tubercular or pyogenic. It is characterised by fever, marked headache, neck rigidity, and a changed biochemistry of CSF.

23. Spinal Cord

INTRODUCTION

The spinal cord is the long cylindrical lowest part of central nervous system. It occupies upper two-thirds of vertebral canal. It gives rise to 31 pairs of spinal nerves and retains the basic structural pattern.

Length: It is 18 inches or 45 cm in an adult male.

Extent: It extends from upper border of atlas vertebra to the lower border of first lumbar vertebra in an adult. Superiorly, it is continuous with the medulla oblongata, inferiorly it terminates as conus medullaris.

The level of spinal segment with their vertebral level is shown in Table 23.1. The dura and arachnoid along with subarachnoid space containing CSF extend up to 2nd sacral vertebra.

Enlargements

Limbs form the appendages of the trunk. Spinal cord presents cervical enlargement for supply of upper limb muscles. This extends from C4 to T2 spinal segments with maximum diameter at level of C6 segment.

Another enlargement is the lumbar enlargement for supply of muscles of lower limb. It extends from level of L2 to S3 segments. Its maximum diameter is at level of SI segment.

External Features of Spinal Cord

Anteriorly, the spinal cord reveals a deep anterior median fissure lodging the anterior spinal artery.

Table 23.1: Level of spinal segment and vertebral levels

Spinal segment	Vertebral level
C1-C3	C1-C3

C4-C8	C4-C7
T1-T6	T1-T4
T7-T12	T5-T9
L1-L5	T10-T11
S1-S5 and Co1	T12-L1

Posterior median sulcus is a thin longitudinal groove from which a septum runs in the depth of spinal cord.

Internal Structure

The grey matter is in the form of “H” with a grey commissure joining the grey matter of right and left sides. Grey matter comprises one posterior horn and one anterior horn on each side in the entire extent of the cord. Only in Tl-Ll and S2-S4 segments, there is an additional lateral horn for the supply of the viscera. This is part of autonomic nervous system. Shape and size of the horns differ in different segments due to functional reasons. These are placed in Table 23.2.

SPINAL NERVES

Spinal nerves arise in pairs, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral 1 coccygeal.

Each spinal nerve arises by a series of dorsal and ventral nerve rootlets. These rootlets unite in or near the intervertebral foramen to form the spinal nerve.

Dorsal Root Ganglion

As the dorsal rootlets converge, there is a swelling, the dorsal or posterior root ganglion (Fig. 23.1), which houses the cell bodies of all the sensory neurons in that particular nerve.

Branches of a Typical Nerve

Dorsal Ramus: It supplies the dorsal one-third of the body wall. Dorsal rami do not supply the limbs.

Table 23.2: Shape of horns in different segments of Spinal cord

Segments of spinal cord	Posterior horn	Lateral horn	Anterior horn
Cervical, oval shape	Slender	Absent	Broad in C4 to C8 segments for supply of upper limbs
Thoracic, circular shape	Slender	Present for thoraco-lumbar outflow	Slender in T3–T12 segments, broad in T1–T2 segments
Lumbar, circular shape	Bulbous	Present only in lumbar one segment	Bulbous for supply of lower limbs
Sacral, circular but smaller	Thick	Present in sacral 2–4 segments for sacral outflow	Bulbous for supply of lower limbs

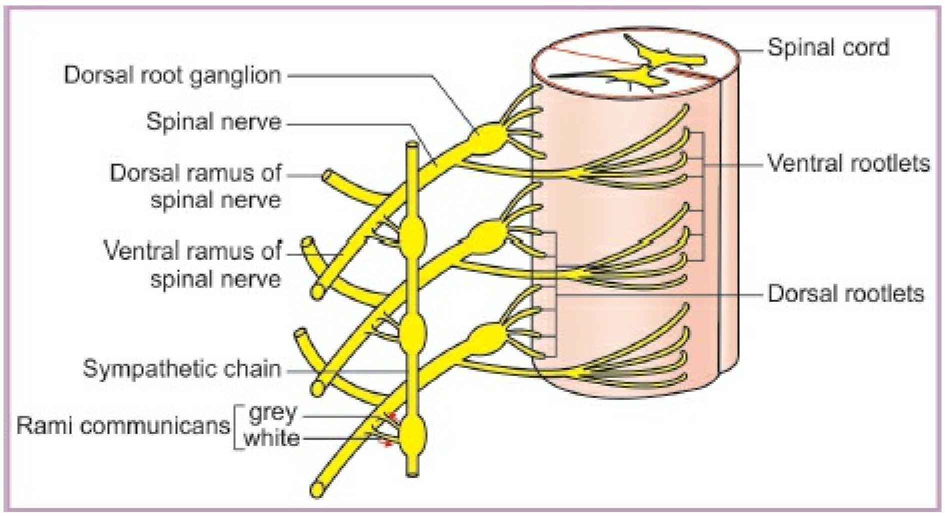


Fig. 23.1: Typical spinal nerve with sympathetic trunk.

Ventral Ramus: It supplies the ventral two-thirds of the body wall including the limbs.

Spinal Segment: Segment or part of spinal cord to which a pair of dorsal nerve roots, right and left and a pair of ventral nerve roots is attached is called a spinal segment.

Nuclei in Anterior Grey Column or Horn

(a) ***Medial group*** (Fig. 23.2)

(b) ***Lateral group***

(i) Anterolateral supplying proximal muscles of limbs (shoulder and arm/gluteal region and thigh).

(ii) Posterolateral supplying intermediate muscles of limbs (forearm/leg).

(iii) Post-posterolateral innervating the distal segment (hand/foot).

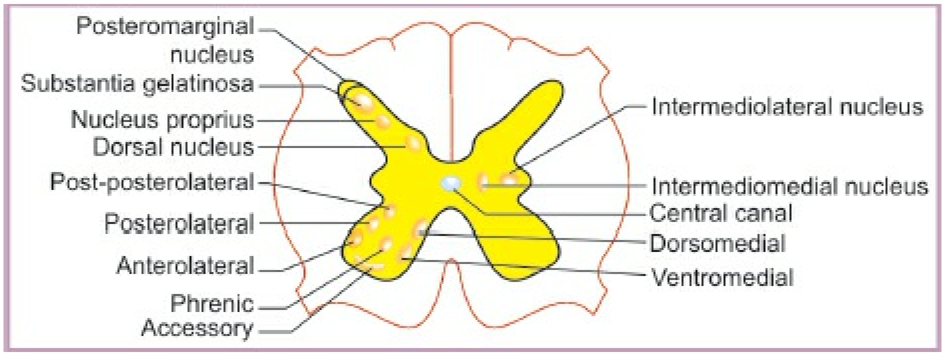


Fig. 23.2: Cell groups in spinal cord.

(c) ***Central group:*** Only in upper cervical segments as phrenic nerve nucleus and nucleus of spinal root of accessory nerve.

Nuclei in Lateral Horn

Intermediolateral nucleus: This acts as both efferent and afferent nuclear columns. This nucleus is seen at two levels.

(i) From T1 to L2 segments, giving rise to preganglionic sympathetic fibres (thoracolumbar outflow).

(ii) From S2 to S4 segments, giving rise to preganglionic parasympathetic fibres chiefly for the pelvic viscera.

SENSORY RECEPTORS

Functional classification:

(i) Exteroceptors

(ii) Proprioceptors

(iii) Interoceptors/Enteroceptors

(iv) Special sense receptors

TRACTS OF THE SPINAL CORD

Descending Tracts

A. The pyramidal or ***corticospinal tract*** descends from the cerebral cortex to the spinal cord. It consists of two parts:

   1. Lateral corticospinal tract, which lies in the lateral funiculus (Table 23.3).
   2. Anterior corticospinal tract which lies in the anterior funiculus (Fig. 23.3).

B. Extrapyramidal tracts. These are as follows.

   1. Rubrospinal tract
   2. Medial reticulospinal tract
   3. Lateral reticulospinal tract

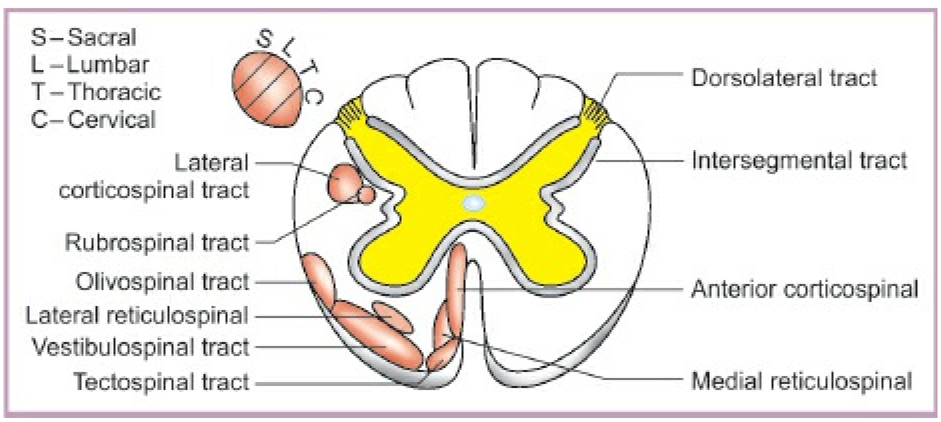


Fig. 23.3: Location of descending tracts in spinal cord (shown only on one side).

Table 23.3: The descending tracts

Name	Function	Crossed uncrossed	Beginning	Termination
Pyramidal tracts				
A1. Lateral corticospinal	Main motor tract for skillful voluntary movements	Crossed in medulla	Motor area of cortex area number 4,6	Anterior grey column cells alpha motor neurons
A2. Anterior corticospinal	Facilitates fexors	Crosses in corresponding spinal segement	Motor area of cortex area number 4,6	Anterior grey column alpha motor neurons
Extrapyramidal tracts				
B1. Rubrospinal	Efferent pathway for cerebellum and corpus striatum	Crossed	Red nucleus of midbrain	Anterior grey column cells
B2. Medial reticulospinal	Extrapyramidal tract Facilitates extensors	Uncrossed	Reticular formation of grey matter of pons	Anterior grey column cells (interneurons)
B3. Lateral reticulospinal	Extrapyramidal tract Facilitates flexors	Uncrossed and crossed	Reticular formation of grey matter of medulla oblongata	Anterior grey column cells (interneurons)
B4. Olivospinal	Extrapyramidal tract	Uncrossed	Inferior olivary nucleus	Anterior grey column cells
B5. Lateral vestibulospinal	Efferent pathway for equilibratory control	Uncrossed	Lateral vestibular nucleus	Anterior grey column cells
B6. Tectospinal	Efferent pathway for visual reflexes	Crossed	Superior colliculus	Anterior grey column cells

4. Olivospinal tract
5. Vestibulospinal tract
6. Tectospinal tract

Ascending Tracts

1. Lateral spinothalamic tract (Table 23.4)
2. Anterior spinothalamic tract (Fig. 23.4)
3. Fasciculus gracilis (medially)
4. Fasciculus cutaneous (laterally)
5. Dorsal or posterior spinocerebellar tract
6. Ventral or anterior spinocerebellar tract

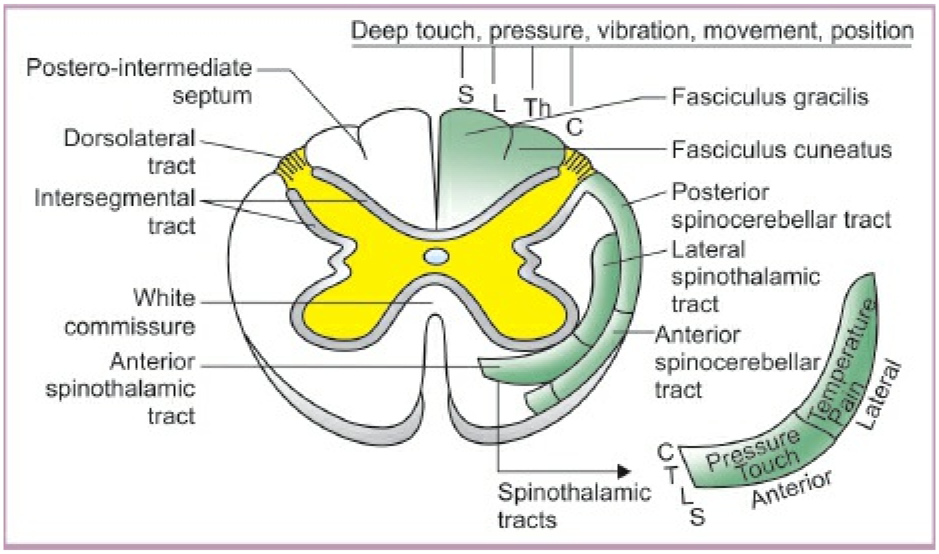


Fig. 23.4: Location of ascending tracts in spinal cord (shown only on one side).

CLINICAL ANATOMY

- ***Brown-Sequard's syndrome:*** This is caused due to hemisection of the spinal cord. Various features are as follows.

  Below the level of lesion

  (a) Ipsilateral upper motor neuron paralysis caused by pyramidal tract damage.

  (b) Ipsilateral loss of conscious proprioceptive sensations caused due to damage to posterior white column.

  (c) Contralateral loss of pain and temperature and touch caused due to damage to lateral spinothalamic and anterior spinothalamic tracts.

  At the level of lesion

  (a) Ipsilateral lower motor neuron paralysis caused due to damage to ventral nerve roots.

  (b) Ipsilateral anaesthesia over the skin of the segment due to injury to the ventral nerve roots.

  (c) Ipsilateral hyperaesthesia above the level of lesion due to irritation of dorsal nerve roots.

- ***Syringomyelia:*** There is formation of cavities around the central canal usually in the lower cervical region. Its features are

  (a) Bilateral loss of pain and temperature occurs due to injury to the decussating fibres of lateral spinothalamic fibres.

  (b) Bilateral loss of touch occurs due to injury to anterior spinothalamic tract.

  As the decussation of lateral and anterior spinothalamic tracts occurs at different levels, there is dissociated sensory loss.

  As this disease occurs in lower cervical and upper thoracic regions there is problem in both the upper limbs and front of chest. Syringomyelia disrupts the crossing fibres of anterolateral system. The medial lemniscal system is spared.

- ***Cauda equina syndrome:*** Damage to cauda equina results in:

  (a) Lower motor neuron type of paralysis in the lower limbs due to compression of ventral nerve roots.

  (b) Root pains is an important symptom due to involvement of dorsal nerve roots.

  (c) Bladder and bowel involvement is late.

- ***Conus medullaris syndrome:*** Due to injury to S2, S3, S4 segments of spinal cord. Features are as follows.

  (a) Anaesthesia in the perineum. The region is supplied by these three segments.

  (b) Involvement of bladder and bowel is early. S2, S3, S4 segments carry sacral component of the parasympathetic system which supplies the bladder and lower bowel.

  (c) Sexual functions are affected as same nerves carry out sexual functions as well.

- ***Tabes dorsalis***: It occurs during tertiary stage of syphilis. There is degenerative lesions of dorsal nerve roots and of posterior white columns. Its feature is severe pain in lower limbs, as the disease occurs in lower thoracic and lumbosacral segments, lower limbs are affected.

- ***Spinal cord and root compression***

Level of lesion: A lesion above LI vertebral body may damage both the cord and its roots. Below this level only the roots get damaged.

(a) ***Segmental:*** Deep continuous aching pain radiating into whole leg or one-half of body. It is not affected by movement.

(b) ***Roots:*** There is sharp burning shooting pain radiating into the area of skin distribution or muscle group supplied by the particular root. The pain increases by movement, coughing or straining.

(c) ***Bone:*** There is continuous dull pain over the affected area. Pain may or may not increase by movement.

- ***Lateral compressive lesion:*** Root or segmental damage leads to weakness in groups innervated by the involved segment or root with lower motor neuron signs. In addition, there is sensory defect of all sensations. Due to overlap from adjacent segments, the loss of sensations may not be detected.
- ***Partial cord lesion (unilateral):*** In high cervical lesions, there is weakness of finger movements accompanied by dragging of the leg.

(a) Upper motor neuron paralysis on the side of lesion.

(b) Sensory loss: Numbness on the side of lesion. Joint position sense and two point discrimination impaired on the side of lesion.

(c) Burning pain, pin prick and temperature sensation impaired on the opposite side.

- ***Poliomyelitis :*** It is a viral disease which involves anterior hom cells leading to flaccid paralysis of the affected segments. It is a lower motor neuron paralysis.

If poliomyelitis affects the upper cervical segments of spinal cord it may be fatal because of the involvement of C4 segment which supplies the diaphragm.

Table 23.4: The ascending tracts of the spinal cord

Name	Function	Crossed uncrossed	Beginning	Termination
1. Lateral spinothalamic (axons of 2nd order neurons)	Pain and temperature from opposite half of body	Crosses to opposite side in the same spinal segment	Substantia gelatinosa of posterior grey column	Forms spinal lemniscus in medulla, reaches posterolateral ventral nucleus of thalamus for another relay and ends in area 3, 1, 2
2. Anterior spinothalamic (axons of 2nd order neurons)	Touch (crude) and pressure from opposite half of body	Ascends to 2–3 spinal segments to cross to opposite side	Posterior grey column of opposite side	Joins medial lemniscus in brainstem reaches posterolateral ventral nucleus of thalamus for another relay and ends in area 3, 1, 2
3. Fasciculus gracilis (axons of 1st order sensory neurons)	Conscious proprioception Discriminatory touch Vibratory sense Stereognosis	Uncrossed	Dorsal root ganglion cells	Relays in nucleus gracilis, 2nd order fibres form medial lemniscus which reaches posterolateral ventral nucleus of thalamus for another relay and ends in area 3, 1, 2
4. Fasciculus cuneatus (axons of 1st order sensory neurons)	Same as above	Same as above	Same as above	Relays in nucleus cuneatus, rest is same as above
5. Posterior spino-cerebellar (axons of 2nd order neurons)	Unconscious proprio-ception from individual muscles of lower limb	Uncrossed	Thoracic nucleus of posterior grey column	Vermis of cerebellum (via inferior cerebellar peduncle)
6. Anterior spino-cerebellar (axons of 2nd order neurons)	Unconscious proprio-ception from lower limb as a whole	Crosses twice, once in spinal cord and recrosses in midbrain	Posterior grey column same side	Vermis of cerebellum (via superior cerebellar peduncle) via re-crossing

24. Cranial Nerves

Nuclei

The details of the nuclei of cranial nerves are summarized in Table 24.1.

FIRST CRANIAL NERVE

OLFACTORY (SMELL) PATHWAY

Receptors and the First Neuron

(a) The ***olfactory cells*** (16-20 million in man) are bipolar neurons. They lie in the olfactory part of the nasal mucosa, and serve both as receptors as well as the first neurons in the olfactory pathway.

(b) The ***olfactory*** nerves, about 20 in number, represent central processes of the olfactory cells.

Second Neuron

The mitral and tufted cells in the olfactory bulb give off fibres that form the ***olfactory tract*** and reach the primary olfactory areas.

Third Neuron

These are located in the primary olfactory cortex which includes the anterior perforated substance, and several small masses of grey matter around it.

Fourth Neuron

Fibres arising in the primary olfactory cortex go to the secondary olfactory cortex (or entorhinal area) located in the uncus and anterior part of the parahippocampal gyrus. Smell is perceived in both the primary and secondary olfactory areas.

Some impulses from uncus travel via medial forebrain bundle and reticular formation to ***dorsal nucleus of vagus*** and ***salívatory nuclei*** in medulla oblongata, where these may increase or decrease gastric secretion according to type of smell.

Table 24.1: Nuclei of the cranial nerves

Nerves	Nuclei	Location	Functions**	Function of the nerve component
I	—	—		Smell
II	—	—		Sight
III	Oculomotor nucleus	Midbrain, level of superior colliculus	GSE GVE GSA*	Movements of eyeball Contraction of pupil, accommodation Proprioceptive
IV	Trochlear nucleus	Midbrain, level of inferior colliculus	GSE GSA*	Movement of eyeball (superior oblique) Proprioceptive
V	1. Motor nucleus	Upper pons	BE/SVE	Movement of mandible
	2. Mesencephalic nucleus	Midbrain	GSA	Proprioceptive, muscles of mastication, face
	3. Superior sensory nucleus	Upper pons	GSA	Touch and pressure from skin and mucous membrane of facial region
	4. Spinal nucleus	From upper pons to C2 segment of spinal cord	GSA	Pain and temperature of face
VI	Abducent nucleus	Lower pons	GSE GSA*	Lateral movement of eyeball Proprioceptive
VII	1. Motor nucleus	Lower pons	BE/SVE	Facial expressions, elevation of hyoid
	2. Nucleus of tractus solitarius	Lower pons	SVA	Taste, anterior two-thirds tongue
	3. Superior salivatory nucleus	Lower pons	GVE	Secretomotor to submandibular and sublingual salivary glands
	4. Lacrimatory nucleus	Lower pons	GVE GSA	Secretomotor to lacrimal gland, nasal glands, etc. Proprioceptive
VIII Cochlear	Two cochlear nuclei dorsal and ventral	Junction of medulla and pons	SSA	Hearing
Vestibular	Four vestibular nuclei superior, spinal, medial and lateral	,,	SSA	Equilibrium of head
IX	1. Nucleus ambiguus	Medulla	BE/SVE	Elevation of larynx
	2. Inferior salivatory nucleus	,,	GVE	Secretomotor to parotid gland
	3. Nucleus of tractus solitarius	,,	SVA	Taste from posterior one-third of tongue
			GVA* GSA*	Sensations from mucous membrane of pharynx and posterior one-third of tongue go to dorsal nucleus of vagus and spinal nucleus of V nerve
X and cranial	1. Nucleus ambiguus	Medulla	BE/SVE	Movements of palate, pharynx and larynx
part of XI	2. Dorsal nucleus of vagus	,,	GVE	Motor and secretomotor to bronchial tree and gut; inhibitory to heart
			GVA	Sensations from viscera
	3. Nucleus of tractus solitarius	,,	SVA	Taste from posterior most part of tongue and epiglottis
			GSA*	Sensations from the skin of external ear reach the spinal nucleus of V nerve
Spinal part of XI	Spinal nucleus of accessory nerve	Spinal cord, CI-5	BE/SVE	Sternocleidomastoid and trapezius
XII	Hypoglossal nucleus	Medulla	GSE GSA	Movements of tongue Proprioceptive

* These components do not have corresponding nuclei and terminate in the nuclei of different nerves.

** Funtional components: GSE = general somatic efferent; BE = branchial efferent; GVE = general visceral efferent; GVA = general visceral afferent; SVA = special visceral afferent; GSA = general somatic afferent; SVA = special somatic afferent.

SECOND CRANIAL NERVE

OPTIC NERVE

Optic nerve is the nerve of sight and is a special sense

Human vision is binocular, though one sees with both the eyes, the inverted images formed are seen as one and straight only (Fig. 24.1).

Human vision is stereoscopic, i.e. one see height, width and thickness of the object

Human vision is colored, one sees different colors put up by nature

When one looks at an object, both eyes are focused on it. Right eye sees a little additional of right side whereas left eye sees a little additional of left side of the object. These visions are monocular visions. Main part is the binocular vision.

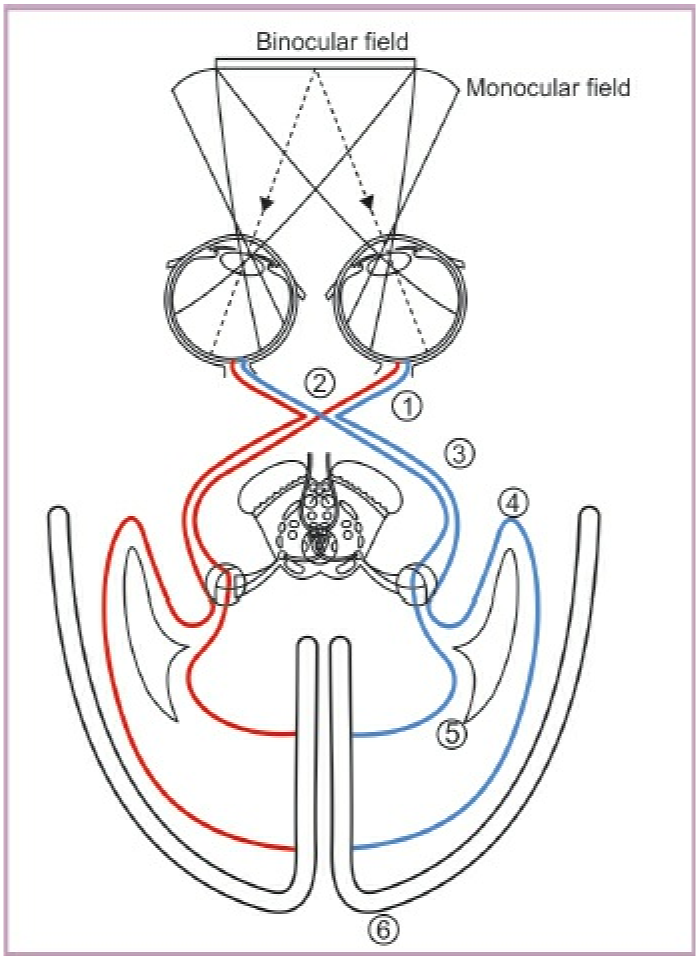


Fig. 24.1: Visual pathways. 1. Optic nerve, 2. Optic chiasma, 3.Optic tract, 4. Meyer's loop (fibres looping into temporal lobe), 5. Occipital lobe and 6. Occipital cortex.

VISUAL (OPTIC) PATHWAY

Structures in Visual Pathway

1. Retina
2. Optic nerve
3. Optic chiasma
4. Optic tract, with its lateral and medial roots
5. Lateral geniculate body

6. Optic radiation
7. Visual area in the cortex

Structures Concerned with Visual Reflexes

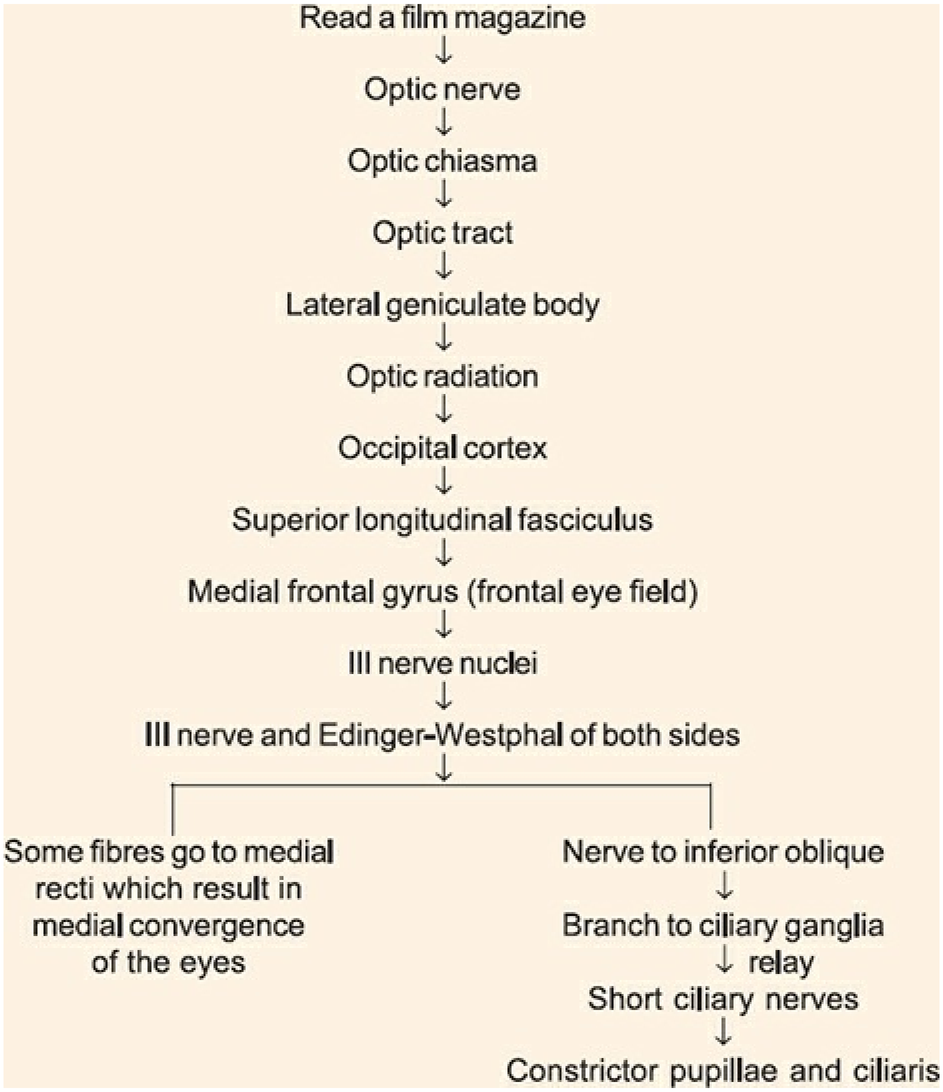
1. Pretectal nucleus
2. Oculomotor nucleus and nerve with ciliary ganglion
3. Frontal eye field of cerebral cortex
4. Superior colliculus with tectobulbar and tectospinal tracts

Reflexes

Pupillary light reflex—left eye and consensual light reflex—shown below:

Shining of torch light in left eye
↓
Optic nerve
↓
Optic chiasma
↓
Optic tract
↓
Few fibres go to pretectal nucleus of same and even opposite side
↓
Edinger-Westphal nuclei of both sides
↓
Ill nerve nuclei of both sides
↓
Branch to inferior oblique relay in ciliary ganglion
↓
Short ciliary nerves of both sides
↓
Sphincter pupillae muscle of both eyes constrict
↓
Both pupils constrict

Accommodation Reflex



Dilation of Pupil

Hypothalamus

↓

Brainstem

↓

Spinal cord-with lateral horn (thoracic segments)

↓

T1-T4 roots

↓

Superior cervical ganglion

↓

Relay
↓
Fibres pass along Internal carotid artery
↓
No relay in ciliary ganglion
↓
Dilator pupillae

Corneal/Conjunctival Reflex

Touching of cornea or conjunctiva
↓
Ophthalmic nerve
↓
Superior sensory nucleus of V
↓
Medial longitudinal bundle
↓
Motor nucleus of VII
↓
Orbicularis oculi

Visual Body Reflex

Retina
↓
Optic nerve
↓
Optic chiasma
↓
Optic tract
↓
Superior colliculus
↓

↓ Motor nuclei of cranial nerves for movements of head and neck	↓ Anterior horn cells of spinal cord for movements of body

THIRD CRANIAL NERVE

Oculomotor Nerve

This is the third cranial nerve. It is distributed to the extraocular as well as the intraocular muscles. Since it is a somatic motor nerve, it is in series with the IV, VI and XII cranial nerves, and also with the ventral root of spinal nerves.

Functional Components

1. General somatic efferent, for movements of the eyeball
2. General visceral efferent or parasympathetic, for contraction of pupil and accommodation
3. General somatic afferent column carries proprioceptive fibres from the extraocular muscles to spinal nucleus of V.

Course and Distribution

1. ***At the base of the brain,*** the nerve is attached to the oculomotor sulcus on the medial side of the crus cerebri.
2. The nerve ***enters the cavernous sinus*** by piercing the posterior part of its roof on the lateral side of the posterior clinoid process. It descends to the lateral wall of the sinus where it lies above the trochlear nerve. In the anterior part of the sinus, the nerve divides into upper and lower divisions.
3. The two divisions of the nerve ***enter the orbit*** through the middle part of the superior orbital fissure.
4. ***In the orbit,*** the smaller upper division ascends on the lateral side of optic nerve, and supplies the superior rectus and part of the levator palpebrae superioris.

   The larger, lower, division divides into three branches—the medial rectus, the inferior rectus and the inferior oblique. The nerve to the inferior oblique is the longest of these. It gives off the motor root to the ciliary ganglion and then supplies the inferior oblique muscle (Fig. 24.2).

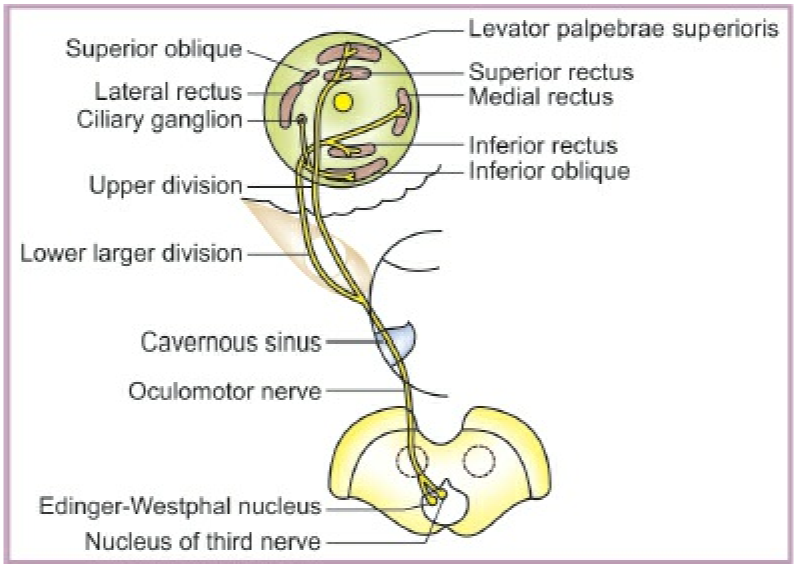


Fig. 24.2: The origin, course and the distribution of oculomotor nerve.

FOURTH CRANIAL NERVE

TROCHLEAR NERVE

This is the fourth cranial nerve. It supplies only the superior oblique muscle of the eyeball.

Functional Components

1. General somatic efferent, for lateral movement of the eyeball
2. The general somatic afferent, for proprioceptive impulses from the muscle to the spinal nucleus of V nerve.

Course and Distribution

1. In its ***intramural course,*** the nerve runs dorsally round the central grey matter to reach the upper part of the superior or anterior medullary velum where it decussates with the opposite nerve to emerge on the opposite side.
2. The nerve ***enters the cavernous sinus*** by piercing the posterior comer of its roof. Next it runs forwards in the lateral wall of cavernous sinus between the oculomotor and ophthalmic nerves. In the anterior part of

sinus, it crosses over the oculomotor nerve.

3. Trochlear nerve ***enters the orbit*** through the lateral part of the superior orbital fissure.
4. ***In the orbit,*** it passes medially, above the origin of levator palpebrae superioris and ends by supplying the superior oblique muscle on its orbital surface (Fig. 24.3).

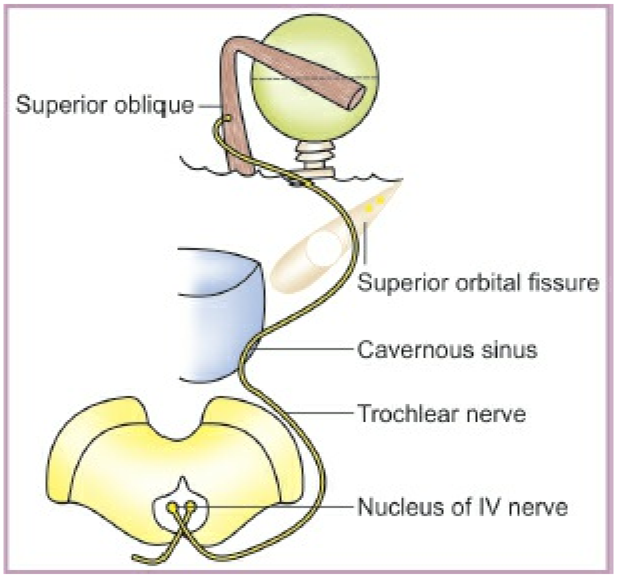


Fig. 24.3: The origin, course and the distribution of the trochlear nerve.

SIXTH CRANIAL NERVE

ABDUCENT NERVE

It is the sixth cranial nerve which supplies the lateral rectus muscle of the eyeball. One nerve fibre supplies only about six muscle fibres.

Functional Components

1. General somatic efferent, for lateral movement of the eyeball.
2. The general somatic afferent, for proprioceptive impulses from the muscle to the spinal nucleus of V nerve.

Course and Distribution

1. The nerve is attached to the lower border of the pons, opposite the upper end of the pyramid of the medulla.
2. The nerve then runs upwards, forwards and laterally through the cistema pontis and usually dorsal to the anterior inferior cerebellar artery to reach the cavernous sinus.
3. The abducent nerve ***enters the cavernous sinus*** by piercing its posterior wall at a point lateral to the dorsum sellae and superior to the apex of the petrous temporal bone. As the nerve crosses the superior border of the petrous temporal bone, it passes beneath the petrosphenoidal ligament, and bends sharply forwards. In the cavernous sinus, at first it lies lateral to the internal carotid artery and then inferolateral to it.
4. The abducent nerve ***enters the orbit*** through the middle part of the superior orbital fissure. Here it lies inferolateral to the oculomotor and nasociliary nerves.
5. ***In the orbit,*** the nerve ends by supplying only the lateral rectus muscle. It enters the ocular surface of the muscle.

FIFTH CRANIAL NERVE

TRIGEMINAL NERVE

Fifth cranial nerve is the largest cranial nerve. It comprises three branches, two of which are purely sensory and third, the largest branch is mixed nerve. It is the nerve of first brachial arch. Branches of this nerve provide sensory fibres to the four parasympathetic ganglia associated with cranial outflow of parasympathetic nervous system. These are ciliary, pterygopalatine, otic and submandibular. Nuclear columns are

(i) ***General somatic afferent column:*** This column has three nuclei. These are

- ***Spinal nucleus of V nerve:*** It takes pain and temperature sensations from most of the face area which relay here. The crossed fibres are called trigeminal lemniscus which go to ventroposteromedial nucleus of thalamus for another relay, to finally terminate in lower part of postcentral gyrus.

- ***Superior sensory nucleus of V nerve:*** Fibres carrying touch and pressure relay in this nucleus. Remaining path is same as of spinal nucleus.
- ***Mesencephalic nucleus:*** This nucleus extends from pons till the midbrain. It receives proprioceptive impulses from muscles of mastication, temporomandibular joint and teeth.

(ii) ***Branchial efferent column:*** The nucleus of V nerve is situated at the level of upper pons. The fibres of the motor nucleus supply eight muscles derived from first branchial arch.

Ophthalmic Nerve

Ophthalmic nerve is sensory. Its branches are as follows.

1. **Frontal**
   (a) ***Supratrochlear:*** Upper eyelid, conjunctiva, lower part of forehead
   (b) ***Supraorbital:*** Frontal air sinus, upper eyelid, forehead, scalp till vertex
2. **Nasociliary**
   (a) ***Posterior ethmoidal:*** Sphenoidal air sinus, posterior ethmoidal air sinuses
   (b) ***Long ciliary:*** Sensory to eyeball
   (c) Nerve to ciliary ganglion
   (d) ***Infratrochlear:*** Both eyelids, side of nose, lacrimal sac
   (e) ***Anterior ethmoidal***
      1. Middle and anterior ethmoidal sinuses
      2. Medial internal nasal
      3. Lateral internal nasal
      4. External nasal: Skin of ala of vestibule and tip of nose.
3. **Lacrimal:** Lateral part of upper eyelid; conveys secretomotor fibres from zygomatic nerve to lacrimal gland.

Maxillary Nerve

In Middle Cranial Fossa: Meningeal branch

In Pterygopalatine Fossa

1. Ganglionic branches
2. Zygomatic
   (a) Zygomaticotemporal
   (b) Zygomaticofacial
3. Posterior superior alveolar

In Infraorbital Canal

1. Middle superior alveolar
2. Anterior superior alveolar

On Face: Infraorbital:

(a) Palpebral
(b) Labial
(c) Nasal

Mandibular Nerve

Trunk

1. Meningeal
2. Nerve to medial pterygoid
   (a) Tensor veli palatini
   (b) Tensor tympani
   (c) Medial pterygoid

Anterior division

1. Deep temporal
2. Lateral pterygoid
3. Masseteric
4. Buccal-skin of cheek.

Posterior division

1. Auriculotemporal (Fig. 24.4)
   (a) Auricular

(b) Superficial temporal
(c) Articular to temporomandibular joint
(d) Secretomotor to parotid gland

2. Lingual—general sensation from anterior two-thirds of tongue.
3. Inferior alveolar—lower teeth and nerve to mylohyoid
   (a) Mylohyoid
   (b) Anterior belly of digastric.

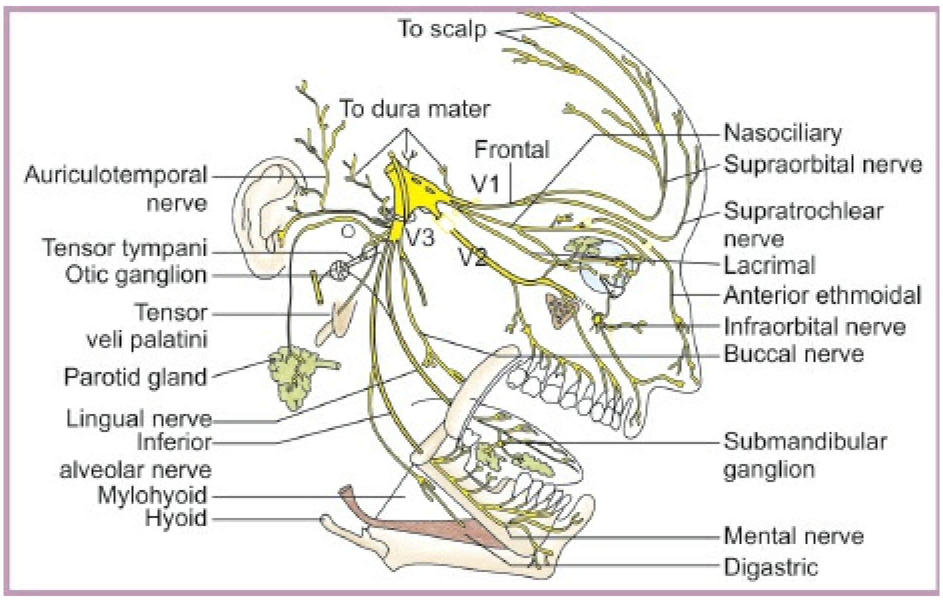


Fig. 24.4: Distribution of three branches of trigeminal nerve.

SEVENTH CRANIAL NERVE

FACIAL NERVE

Facial nerve is the nerve of the second branchial arch

Functional Components

1. Special visceral or ***branchial efferent,*** to muscles responsible for facial expression and for elevation of the hyoid bone (Table 24.1).

2. ***General visceral efferent*** or parasympathetic. These fibres are secretomotor to the submandibular and sublingual salivary glands, the lacrimal gland, and glands of the nose, the palate and the pharynx.
3. ***General visceral afferent*** component carries afferent impulses from the above-mentioned glands.
4. ***Special visceral afferent*** fibres carry taste sensations from the palate and from anterior two-thirds of the tongue except from vallate papillae.
5. ***General somatic afferent*** fibres probably innervate a part of the skin of the ear. The nerve does not give any direct branches to the ear, but some fibres may reach it through communications with the vagus nerve. Proprioceptive impulses from muscles of the face travel through branches of the trigeminal nerve to reach the mesencephalic nucleus of the nerve.

Nuclei

The fibres of the nerve are connected to four nuclei situated in the lower pons.

1. Motor nucleus or branchiomotor
2. Superior salivatory nucleus or parasympathetic
3. Lacrimatory nucleus is also parasympathetic
4. Nucleus of the tractus solitarius which is gustatory and also receives afferent fibres from the glands.

Course and Relations

The facial nerve is attached to the brainstem by two roots, motor and sensory. The sensory root is also called the ***nervus intermedins.***

The two roots of the facial nerve are attached to the lateral part of the lower border of the pons just medial to the eighth cranial nerve. The two roots run laterally and forwards, with the eighth nerve to reach the internal acoustic meatus.

In the meatus, the motor root lies in a groove on the eighth nerve, with the sensory root intervening. Here the seventh and eighth nerves are accompanied by the labyrinthine vessels. At the bottom or fundus of the meatus, the two roots, sensory and motor, fuse to form a single trunk, which lies in the petrous temporal bone.

Within the canal, the course of the nerve can be divided into three parts by two bends.

The first part is directed laterally above the vestibule; the second part runs backwards in relation to the medial wall of the middle ear, above the promontory. The third part is directed vertically downwards behind the promontory.

The first bend at the junction of the first and second parts is sharp. It lies over the anterosuperior part of the promontory, and is also called the ***genu.*** The geniculate ganglion of the nerve is so called because it lies on the genu. The second bend is gradual, and lies between the promontory and the aditus to the mastoid antrum.

The facial nerve leaves the skull by passing through the stylomastoid foramen.

In its ***extracranial course,*** the facial nerve crosses the lateral side of the base of the styloid process. It enters the posteromedial surface of the parotid gland, runs forwards through the gland crossing the retromandibular vein and the external carotid artery. Behind the neck of the mandible, it divides into its five terminal branches which emerge along the anterior border of the parotid gland.

Branches and Distribution

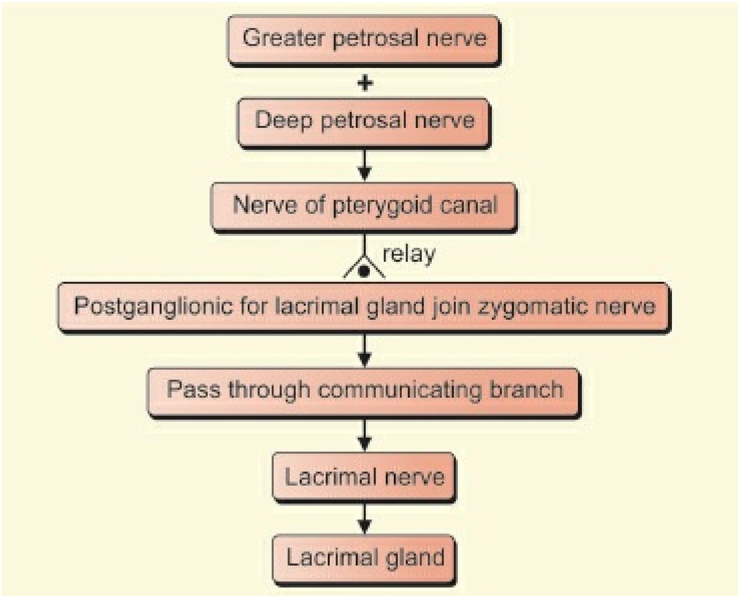
A. Within the facial canal
   1. Greater petrosal nerve
   2. The nerve to the stapedius
   3. The chorda tympani (Fig. 24.5).

B. At its exit from the stylomastoid foramen
   1. Posterior auricular
   2. Digastric
   3. Stylohyoid.

C. Terminal branches within the parotid gland
   1. Temporal
   2. Zygomatic

3. Buccal
4. Marginal mandibular
5. Cervical.

D. Communicating branches with adjacent cranial and spinal nerves. ***Greater petrosal nerve***—course has been traced in Flow chart 24.1.



Flow chart 24.1: Tracing nerve supply of lacrimal gland.

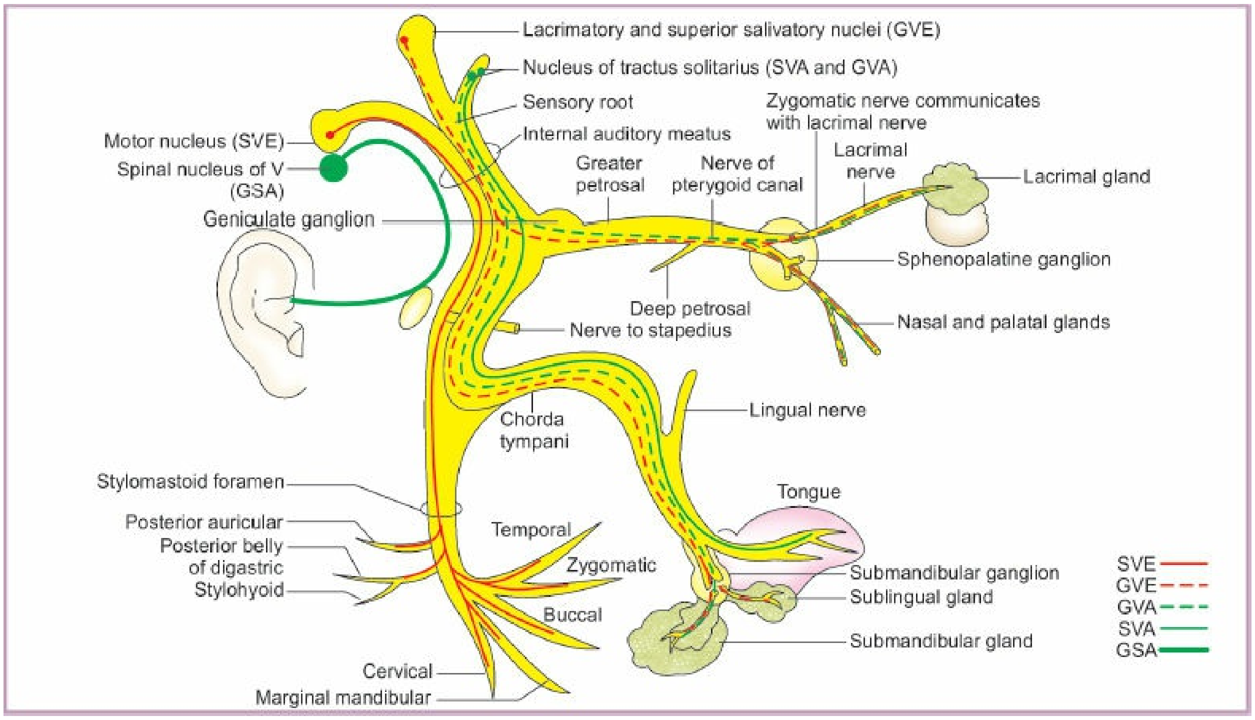


Fig. 24.5: Distribution of functional components of VII nerve.

EIGHTH CRANIAL NERVE

VESTIBULO-COCHLEAR NERVE

This nerve comprises of hearing and vestibular parts

Pathway of Hearing

1. The first neurons of the pathway are located in the spiral ganglion. They are bipolar. Their peripheral processes innervate the spiral organ of Corti, while central processes form the cochlear nerve (Fig. 24.6). This nerve terminates in the dorsal and ventral cochlear nuclei.
2. The second neurons lie in the dorsal and ventral cochlear nuclei. Most of the axons arising in these nuclei cross to the opposite side (in the trapezoid body) and terminate in the superior olivary nucleus. (Many fibres end in the nucleus of trapezoid body or of the lateral lemniscus.) Some fibres are uncrossed.

3. The third neurons lie in the superior olivary nucleus. Their axons form the lateral lemniscus and reach the inferior colliculus.
4. The fourth neurons lie in the inferior colliculus. Their axons pass through the inferior brachium to reach the medial geniculate body. (Some fibres of lateral lemniscus reach the medial geniculate body without relay in the inferior colliculus.)
5. The fifth neurons lie in the medial geniculate body. Their axons form the auditory radiation, which passes through the sublentiform part of the internal capsule to reach the auditory area in the temporal lobe.

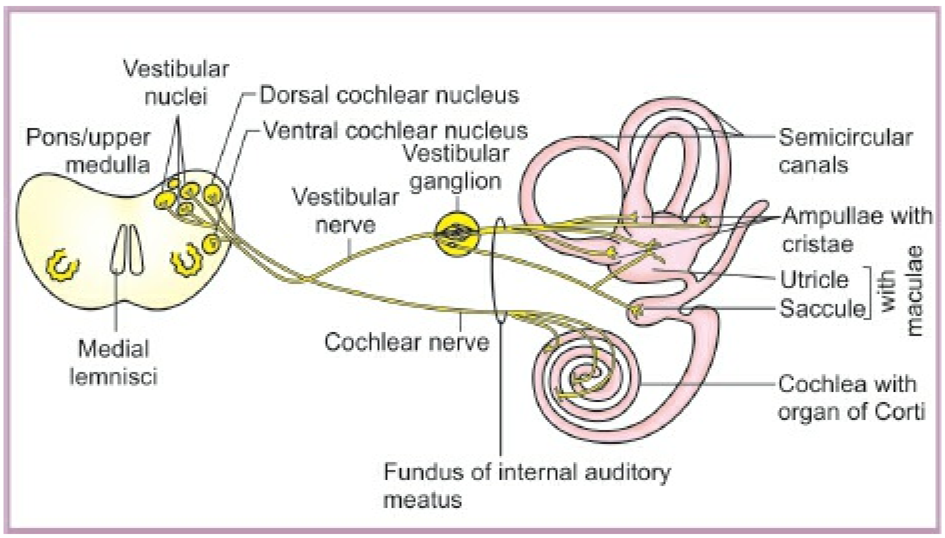


Fig. 24.6: Course of cochlear and vestibular nerves.

Vestibular Pathway

The vestibular receptors are the maculae of the saccule and utricle (for static balance) and in the cristae of the ampullae of semicircular ducts (for kinetic balance). Fibres from cristae of anterior and lateral semicircular canals and some fibres from the two maculae lie in superior vestibular area of internal acoustic meatus.

Fibres of crista of posterior semicircular canal lie in foramen singulare.

Most of the fibres from maculae of utricle and saccule lie in inferior vestibular area.

These three nerve divisions are peripheral processes of bipolar neurons of the vestibular ganglion. This ganglion is situated in the internal acoustic meatus. The central processes arising from the neurons of the ganglion form the vestibular nerve which ends in the vestibular nuclei.

The second neurons in the pathway of balance lies in the vestibular nuclei. These nuclei send fibres:

(a) To the archicerebellum through the inferior cerebellar peduncle (vestibulocerebellar tract).

(b) To the motor nuclei of the brainstem (chiefly of the III, IV and VI nerves) through the medial longitudinal bundle.

(c) To the anterior horn cells of the spinal cord through the vestibulospinal tract.

Through the vestibular pathway, the impulses arising in the labyrinth can influence the movements of the eyes, the head, the neck and the trunk.

NINTH CRANIAL NERVE

GLOSSOPHARYNGEAL NERVE

Glossopharyngeal is the ninth cranial nerve. It is the nerve of the third branchial arch. It is motor to the stylopharyngeus. It is secretomotor to the parotid gland and gustatory to the posterior one-third of the tongue including the circumvallate papillae.

It is sensory to the pharynx, the tonsil, soft palate, the posterior one- third of the tongue, carotid body and carotid sinus.

Functional Components

(a) ***Special visceral efferent*** fibres arise in nucleus ambiguus and supply the stylopharyngeus muscle.

(b) ***General visceral efferent*** fibres (preganglionic) arise in inferior salivatory nucleus and travel to the otic ganglion. Postganglionic fibres arising in the ganglion to supply the parotid gland (Table 24.2).

(c) ***General visceral afferent*** fibres are peripheral processes of cells in inferior ganglion of the nerve. They carry general sensations from the pharynx, carotid body and carotid sinus to the ganglion. The central processes convey these sensations to the nucleus of the solitary tract.

Table 24.2: Connections of parasympathetic ganglia

Ganglia	Sensory root	Sympathetic root	Parasympathetic/ secretomotor root	Motor root	Distribution
Ciliary	From nasociliary nerve	Plexus along ophthalmic artery	Edinger-Westphal nucleus → oculomotor nerve → nerve to inferior oblique	—	Ciliaris muscles Sphincter pupillae
Otic	Branch from auriculotemporal nerve	Plexus along middle meningeal artery	Inferior salivatory nucleus → glosso-pharyngeal nerve → tympanic branch → tympanic plexus → lesser petrosal nerve	Branch from nerve to medial pterygoid	Secretomotor to parotid gland via auriculotemporal nerve Tensor veli palatini and tensor tympani via nerve to medial pterygoid (unrelayed)
Pterygopalatine	2 branches from maxillary nerve	Deep petrosal from plexus around internal carotid artery	Lacrimatory nucleus → nervus intermedius → facial nerve → geniculate ganglion → greater petrosal nerve + deep petrosal nerve = nerve of pterygoid canal	—	Mucous glands of nose, paranasal sinuses, palate, nasopharynx Some fibres pass through zygomatic nerve – zygomaticotemporal nerve – communicating branch to lacrimal nerve – lacrimal gland
Submandibular	2 branches from lingual nerve	Branch from plexus around facial artery	Superior salivatory nucleus → facial nerve → chorda tympani- joins the lingual nerve	—	Submandibular, Sublingual and Anterior lingual glands

(d) ***Special visceral afferent*** fibres are also peripheral processes of cells in the inferior ganglion. They carry sensations of taste from the posterior one-third of the tongue including circumvallate papillae to the ganglion. The central processes convey these sensations to the nucleus of the solitary tract.

(e) ***General somatic afferent*** fibres are the peripheral processes of the cells in the inferior ganglion of the nerve. These carry general sensations (pain, touch, temperature) from posterior one-third of tongue and tonsil. The central processes carry these sensations to nucleus of spinal tract of trigeminal nerve.

Course and Relations

1. In their ***intramural course,*** the fibres of the nerve pass forwards and laterally, between the olivary nucleus and the inferior cerebellar peduncle.
2. At the base of the brain, the nerve is attached by 3 to 4 filaments to the upper part of the posterolateral sulcus of the medulla, just above the rootlets of the vagus nerve.

3. In their intracranial course, the filaments unite to form a single trunk which passes forwards and laterally towards the jugular foramen, crossing and grooving the jugular tubercle of the occipital bone.
4. The nerve ***leaves the skull*** by passing through the middle part of the ***jugular foramen,*** anterior to the vagus and accessory nerves. It has a separate sheath of dura mater.
5. In the jugular foramen, the nerve is lodged in a deep groove leading to the cochlear canaliculus, and is separated from the vagus and accessory nerves by the inferior petrosal sinus.

   In its ***extracranial course,*** the nerve descends:

   (i) Between the internal jugular vein and the internal carotid artery, deep to the styloid process and the muscles attached to it.

   (ii) It then turns forwards winding round the lateral aspect of the stylopharyngeus, passes between the external and internal carotid arteries, and reaches the side of the pharynx. Here it gives pharyngeal branches.

   (iii) It enters the submandibular region by passing deep to the hyoglossus, where it breaks up into tonsillar and lingual branches.

Branches and Distribution

1. The ***tympanic nerve*** is a branch of the inferior ganglion of the glossopharyngeal nerve. It enters the middle ear through the tympanic canaliculus, takes part in the formation of the tympanic plexus in the middle ear and distributes its fibres to the middle ear, the auditory tube, the mastoid antrum and air cells. One branch of the plexus is called the lesser petrosal nerve. It contains preganglionic secretomotor fibres for the parotid gland and relays in the otic ganglion. Postganglionic fibres join auriculotemporal nerve to reach the gland.
2. The ***carotid branch*** descends on the internal carotid artery and supplies the carotid sinus and the carotid body.
3. The ***pharyngeal branches*** take part in the formation of the pharyngeal plexus, along with vagal and sympathetic fibres. The glossopharyngeal fibres are distributed to the mucous membrane of the pharynx.
4. The ***muscular branch*** supplies the stylopharyngeus (Fig. 24.7).

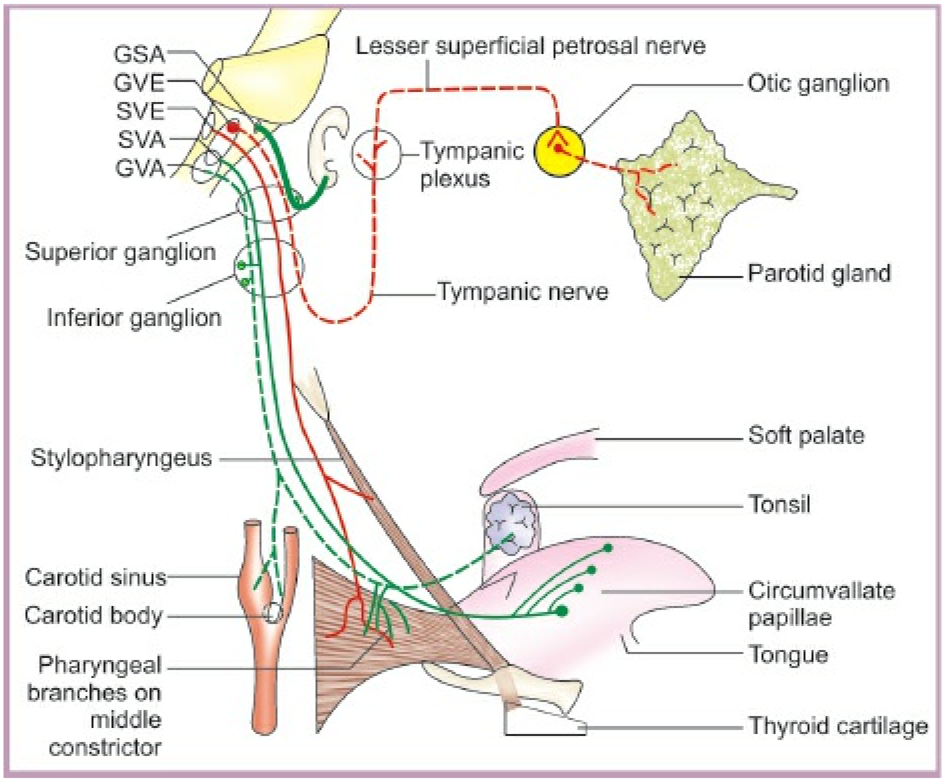


Fig. 24.7: Distribution of functional components of glossopharyngeal nerve.

5. The ***tonsillar branches*** supply the tonsil and join the lesser palatine nerves to form a plexus from which fibres are distributed to the soft palate and to the palatoglossal arches.
6. The ***lingual branches*** carry taste and general sensations from the posterior one-third of the tongue including the circumvallate papillae.

TENTH CRANIAL NERVE

VAGUS NERVE

Vagus nerve is the tenth cranial nerve. It is so called because of its extensive ('vague') course, through the head, the neck, the thorax and the abdomen. The fibres of the cranial root of the accessory nerve are also distributed through it.

The vagus nerve bears two ganglia, superior and inferior. The ***superior ganglion*** is rounded and lies in the jugular foramen. The ***inferior*** ganglion is cylindrical and lies near the base of the skull.

Functional Components

(a) ***Special visceral efferent*** fibres arise in the nucleus ambiguus and supply the muscles of the palate, pharynx and larynx.

(b) ***General visceral efferent*** fibres arise in the dorsal motor nucleus of the vagus. These are preganglionic parasympathetic fibres. They are distributed to thoracic and abdominal viscera. The postganglionic neurons are situated in ganglia lying close to (or within) the viscera to be supplied.

(c) ***General visceral afferent*** fibres are peripheral processes of cells located in the inferior ganglion of the nerve. They bring sensations from the pharynx, larynx, trachea, oesophagus and from the abdominal and thoracic viscera. These are conveyed by the central processes of the ganglion cells to the nucleus of the tractus solitarius. Some of these fibres terminate in the dorsal nucleus of the vagus.

(d) ***Special visceral afferent*** fibres are also peripheral processes of neurons in the inferior ganglion. They carry sensations of taste from the posterior most part of the tongue and from the epiglottis. The central processes of the cells concerned terminate in the lower part of the nucleus of the tractus solitarius.

(e) ***General somatic afferent*** fibres are peripheral processes of neurons in the superior ganglion and are distributed to the skin of the external ear. The central processes of the ganglion cells terminate in relation to the spinal nucleus of the trigeminal nerve.

Nuclei

1. ***Nucleus ambiguus (branchiomotor):*** Mostly a part of the cranial root of accessory nerve; partly of vagus.
2. ***Dorsal nucleus of vagus (parasympathetic):*** It is a mixed nucleus, being both motor (viscero-motor and secretomotor) and sensory (viscerosensory). Its fibres form the main bulk of the nerve.
3. ***Nucleus of tractus solitarius (gustatory):*** Distributed through internal laryngeal nerve to the taste buds of epiglottis and vallecula.
4. Nucleus of spinal tract of trigeminal.

Course and Relations in Head and Neck

1. In the ***intracranial course,*** fibres run forwards and laterally through the reticular formation of medulla, between the olivary nucleus and inferior cerebellar peduncle.
2. The nerve is attached, by about ten rootlets, to the posterolateral sulcus of medulla.
3. In the intracranial course, the rootlets unite to from a large trunk which passes laterally across the jugular tubercle along with the glossopharyngeal and cranial root of accessory nerves, and reaches the jugular foramen.
4. The nerve ***leaves the cranial cavity*** by passing through the middle part of the jugular foramen, between the sigmoid and inferior petrosal sinuses. In the foramen, it is joined by the cranial root of the accessory nerve.
5. Leaving the skull, the nerve descends within the carotid sheath, in between and posterior to the internal jugular vein (laterally), and the internal and common carotid arteries (medially).
6. At the ***root of the neck,*** the right vagus enters the thorax by crossing the first part of the subclavian artery, and then inclining medially behind the brachiocephalic vessels, to reach the right side of the trachea. The left vagus enters the thorax by passing between the left common carotid and left subclavian arteries, behind the internal jugular and brachiocephalic veins.
7. Vagus bears two ganglia, superior and inferior. The ***superior ganglion*** is rounded and lies in the jugular foramen. It gives meningeal and auricular branches of vagus, and is connected to glossopharyngeal and accessory nerves and to superior cervical ganglion of sympathetic chain. The ***inferior ganglion*** is cylindrical (2.5 cm) and lies near the base of skull. It gives pharyngeal, carotid, superior laryngeal branches and is connected to hypoglossal nerve, superior cervical ganglion and the loop between first and second cervical nerves.

Branches in Head and Neck

In the jugular foramen, the superior ganglion gives off:

1. Meningeal, and

2. Auricular branches

The ganglion also gives off communicating branches to the glossopharyngeal and cranial root of accessory nerves and to the superior cervical sympathetic ganglion.

The branches arising in the neck are as follows.

1. Pharyngeal
2. Carotid
3. Superior laryngeal
4. Right recurrent laryngeal
5. Cardiac

Meningeal branch supplies dura of the posterior cranial fossa. The fibres are derived from sympathetic and upper cervical nerves.

The ***auricular branch*** arises from the superior ganglion of the vagus. It passes behind the internal jugular vein, and enters the ***mastoid canaliculus*** (within the petrous temporal bone). It crosses the facial canal 4 mm above the stylomastoid foramen, emerges through the ***tympanomastoid fissure,*** and ends by supplying the concha and root of the auricle, the posterior half of the external auditory meatus, and the tympanic membrane (outer surface).

The ***pharyngeal branch*** arises from the upper part of the inferior ganglion of the vagus, and contains chiefly the fibres of the cranial root of accessory nerve. It passes between the external and internal carotid arteries, and reaches the upper border of the middle constrictor of the pharynx where it takes part in forming the pharyngeal plexus. Its fibres are ultimately distributed to the muscles of the pharynx and soft palate (except the tensor veli palatini which is supplied by the mandibular nerve).

The ***carotid branches*** supply the carotid body and carotid sinus.

The ***superior laryngeal nerve*** arises from the inferior ganglion of the vagus, runs downwards and forwards on the superior constrictor deep to the internal carotid artery, and reaches the middle constrictor where it divides into the external and internal laryngeal nerves.

The ***external laryngeal nerve*** is thin. It accompanies the superior thyroid artery, pierces the inferior constrictor and ends by supplying the cricothyroid muscle. It also gives branches to the inferior constrictor and to the pharyngeal plexus.

The ***internal laryngeal nerve*** is thick. It passes downwards and forwards, pierces the thyrohyoid membrane (above the superior laryngeal vessels) and enters the larynx. It supplies the mucous membrane of the larynx up to the level of the vocal folds.

The ***right recurrent laryngeal nerve*** arises from the vagus in front of the right subclavian artery, winds backwards below the artery, and they runs upwards and medially behind the subclavian and common carotid arteries to reach the tracheo-oesophageal groove. In the upper part of the groove, it is related to the inferior thyroid artery. It may be superficial or deep to the artery. Occasionally, some branches are in front of the nerve, and some are behind it. The nerve then passes deep to the lower border of the inferior constrictor, and enters the larynx behind the cricothyroid joint. It supplies

(a) All intrinsic muscles of the larynx, except the cricothyroid

(b) Sensory nerves to the larynx below the level of the vocal cords

(c) Cardiac branches to the deep cardiac plexus

(d) Branches to the trachea and oesophagus

(e) To the inferior constrictor

The ***left recurrent laryngeal nerve*** arises from the vagus in the thorax, as the latter crosses the left side of the arch of the aorta. It loops around the ligamentum arteriosum and reaches the tracheo-oesophageal groove. Its distribution is similar to that of the right nerve. It does not have to pass behind the subclavian and carotid arteries; and usually it is posterior to the inferior thyroid artery.

The ***cardiac branches*** are superior and inferior. Out of the four cardiac branches of the vagi (two on each side), the left inferior branch goes to the superficial cardiac plexus. The other three cardiac nerves go to the deep cardiac plexus.

ELEVENTH CRANIAL NERVE

ACCESSORY NERVE

Accessory nerve is the eleventh cranial nerve. It has two roots, cranial and spinal. The cranial root is accessory to the vagus, and is distributed through the branches of the latter. The spinal root has a more independent course.

Functional Components

1. The cranial root is ***special visceral (branchial) efferent.*** It arises from the lower part of nucleus ambiguus. It is distributed through the branches of vagus to the muscles of the palate, the pharynx, the larynx, and possibly the heart.
2. The spinal root is also special visceral efferent. It arises from a long spinal nucleus situated in the lateral part of the anterior grey column of the spinal cord extending between segments Cl to C5. Its fibres supply the sternocleidomastoid and the trapezius muscles.

Course and Distribution of the Cranial Root

1. The cranial root emerges in the form of 4 to 5 rootlets which are attached to the posterolateral sulcus of the medulla. Just below, the rootlets soon join together to form a single trunk.
2. It runs laterally with the glossopharyngeal vagus and spinal accessory nerves, crosses the jugular tubercle, and reaches jugular foramen.
3. In the jugular foramen, the cranial root unites for a short distance with the spinal root, and again separates from it as it passes out of the foramen.
4. The cranial root finally fuses with the vagus at its inferior ganglion, and is distributed through the branches of the vagus to the muscles of the palate, the pharynx, the larynx and possibly the heart.

Course and Distribution of the Spinal Root

1. It arises from the upper five segments of the spinal cord
2. The nerve ***enters the cranium*** through the foramen magnum lying behind the vertebral artery.
3. The nerve ***leaves the skull*** through the middle part of the jugular foramen where it fuses with a short length of the cranial root. It soon separates from the latter and passes out of the foramen.
4. In its ***extracranial course***, the nerve descends vertically between the internal jugular vein and the internal carotid artery deep to the parotid and to the styloid process.

The nerve pierces the anterior border of the sternocleidomastoid at the junction of its upper one-fourth with the lower three-fourths, and communicates with second and third cervical nerves within the muscle. The nerve enters the posterior triangle of the neck by emerging through the posterior border of the sternocleidomastoid a little above its middle. In the triangle, it runs downwards and backwards embedded in the fascial roof of the triangle. Here it lies over the levator scapulae. It is related to the superficial lymph nodes. The nerve leaves the posterior triangle by passing deep to the anterior border of the trapezius 5 cm above the clavicle. On the deep surface of the trapezius, the nerve communicates with spinal nerves C3 and C4, and ends by supplying the trapezius.

5. ***Distribution:*** The spinal accessory nerve supplies:

   (a) The sternocleidomastoid

   (b) The trapezius

   Cervical nerves provide a proprioceptive supply to these muscles.

TWELFTH CRANIAL NERVE

HYPOGLOSSAL NERVE

Hypoglossal is the twelfth cranial nerve. It supplies the muscles of the tongue.

Functional Components/Nuclear Columns

1. ***General somatic efferent column:*** The fibres arise from the hypoglossal nucleus which lies in the medulla, in the floor of fourth ventricle deep to the hypoglossal triangle.
2. ***General somatic afferent column:*** The nucleus is spinal nucleus of V cranial nerve where proprioceptive fibres from tongue end.

Course and Relations

1. In their ***intraneural course,*** the fibres pass forwards lateral to the medial longitudinal bundle, medial lemniscus and pyramidal tract.
2. The nerve is attached to the anterolateral sulcus of the medulla, between

the pyramid and the olive, by 10 to 15 rootlets.

Extracranial Course

(i) The nerve first lies deep to the internal jugular vein, but soon inclines laterally between the internal jugular vein and the internal carotid artery.

(ii) It then descends between the internal jugular vein and the internal carotid artery

(iii) At the lower border of the posterior belly of the digastric, it curves forwards, hooks round the lower sternocleidomastoid branch of the occipital artery, crosses the internal and external carotid arteries and the loop of the lingual artery, and passes deep to the posterior belly of the digastric again to enter the submandibular region.

(iv) The nerve then continues forwards on the hyoglossus and genioglossus, deep to the submandibular gland and the mylohyoid, and enters the substance of the tongue to supply all its intrinsic muscles and most of its extrinsic muscles.

Branches and Distribution

In addition to its own fibres, the nerve also carries some fibres that reach it from spinal nerve Cl, and are distributed through it.

Branches containing fibres of the hypoglossal nerve proper. They supply the extrinsic and intrinsic muscles of the tongue. Extrinsic muscles are styloglossus, genioglossus, hyoglossus and intrinsic muscles are superior longitudinal, inferior longitudinal, transverse and vertical muscles. Only extrinsic muscle, the palatoglossus is supplied by fibres of the cranial accessory nerve through the vagus and the pharyngeal plexus.

Branches of the hypoglossal nerve containing fibres ofnerve Cl. These fibres join the nerve at the base of the skull.

1. The ***meningeal branch*** contains sensory and sympathetic fibres. It enters the skull through the hypoglossal canal, and supplies bone and meninges in the anterior part of the posterior cranial fossa.
2. The ***descending branch*** continues as the descendens hypoglossi or the upper root of the ansa cervicalis.
3. Branches are also given to the thyrohyoid and geniohyoid muscles.

CLINICAL ANATOMY

First Cranial Nerve

- ***Anosmia:*** Loss of olfactory fibres with ageing.
- Sense of smell is tested separately in each nostril.
- Allergic rhinitis causes temporary olfactory impairment.
- ***Head injury:*** Olfactory bulbs may be tom away from olfactory nerves as these pass through fractured cribriform plate of ethmoid leading to anosmia. Such a fracture may also cause CSF rhinorrhoea, i.e. CSF leakage through the nose.
- Abscess of frontal lobe of brain or meningioma in the anterior cranial fossa may press on the olfactory bulb or olfactory tract resulting in anosmia.
- ***Uncinate fits:*** Lesion of lateral olfactory area may cause temporal lobe epilepsy or uncinate fits. These fits are of imaginary disagreeable odors with involvement of tongue and lips.

Second Cranial Nerve

- Lesion in retina leads to scotoma, that is certain points may become blind spots.
- Optic nerve damage results in complete blindness of that eye
- Optic chiasma lesion if central will lead to bitemporal hemianopia; but if peripheral on both sides will lead to binasal hemianopia
- Complete destmction of optic tract, lateral geniculate body, optic radiation or visual cortex of one side results in loss of the opposite half of field of vision
- A lesion on the right side leads to left homonymous hemianopia
- ***Papilloedema:*** Results due to increased intracranial pressure. It leads to swelling of optic disc due to blockage of tributaries of the retinal veins
- ***Optic neuritis:*** Lesion of optic nerve that results in decrease of visual acuity. Optic disc appears pale and smaller. Methyl alcohol is a usual

toxic chemical leading to blindness.

- Argyll Robertson pupil: In this condition, the accommodation reflex is present but the light reflex is absent. The pretectal area is affected.

Third Cranial Nerve

- Complete and total paralysis of the third nerve results in:
  - (a) Ptosis, i.e. drooping of the upper eyelid
  - (b) Lateral squint
  - (c) Dilatation of the pupil
  - (d) Loss of accommodation
  - (e) Slight proptosis, i.e. forward projection of the eye
  - (f) Diplopia or double vision
- Ptosis or drooping of upper eyelid due to paralysis of voluntary part of levator palpebrae superioris muscle
- Pupillary light reflex in affected eye is absent
- Dilatation of pupil due to paralysis of parasympathetic fibres to sphincter pupillae muscle. Eyeball gets turned downwards and laterally due to unopposed action of lateral rectus and superior oblique muscles
- Loss of accommodation due to paralysis of ciliary muscles
- Pupil dilates and becomes fixed to light

  Features of reflexes

  Light shown in affected right eye

  - No light reflex in affected eye
  - Consensual light reflex in normal left eye
    Light shown in normal eye
  - Light reflex in normal eye
  - No consensual light reflex in affected eye
- A midbrain lesion causing contralateral hemiplegia and ipsilateral paralysis of the third nerve is known as ***Weber s syndrome.***
- Supranuclear paralysis of the third nerve causes loss of conjugate movement of the eyes.

- ***Compression of III nerve:*** Compression of III nerve due to extradural haematoma causes dilatation of pupil. Parasympathetic fibres lying superficial get affected first. Pupil dilates on affected side and there is little response to light.
- ***Aneurysm of posterior cerebral or superior cerebellar artery :*** Aneurysm of any of these two arteries may compress III nerve as it passes between them.

Fourth Cranial Nerve

- When trochlear nerve is damaged, diplopia occurs on looking downwards; vision is single so long as the eyes look above the horizontal plane.
- Paralysis of the trochlear nerve results in

  (a) Defective depression of the adducted eye, (b) Diplopia

Sixth Cranial Nerve

- Sixth nerve paralysis is one of the commonest false localizing signs in cases with raised intracranial pressure. Its susceptibility to such damage is due to its long course in the cistema pontis, to its sharp bend over the superior border of petrous temporal bone and the downward shift of the brainstem towards the foramen magnum produced by raised intracranial pressure.
- Sixth nerve paralysis causes failure of abduction of the affected eye.
- Diplopia occurs due to paralysis of right lateral rectus muscle. On shifting the head towards right side, diplopia decreases.

Fifth Cranial Nerve

- Fifth cranial nerve subserves sensation from face and neighbouring areas. It also innervates the muscles of mastication
- Proprioceptive fibres terminate in mesencephalic nucleus
- Light touch fibres end in the main sensory or superior sensory nucleus
- Pain and temperature fibres terminate in nucleus of spinal tract of trigeminal
- Motor fibres begin from the motor nucleus of trigeminal

- The separate location of main sensory nucleus and spinal nucleus account for dissociated sensory loss, i.e. low pontine or medullary lesion will result in loss of pain and temperature sensation while light sensation is preserved
- Low pontine, medullary and cervical lesions produce a characteristic 'onion skin' distribution of pin prick and temperature loss
- An ascending lesion spares the muzzle area till last (openings of nose and mouth)
- Test pin prick, temperature and light touch over each side of the whole face
- The sensations in three branches of V nerve can be tested clinically
- ***Motor examination:*** Look for wasting or thinning of temporalis muscle. There may be 'hollowing out' of the temporal fossa
- Ask the patient to press upper and lower teeth together and feel for temporalis and masseter muscles
- Ask patient to open the mouth. If pterygoid muscles are weak, the jaw would deviate to weak side as the normal muscles will push the jaw to the weak side
- In injury to

  Ophthalmic nerve: There is loss of corneal blink reflex. This reflex is mediated by V_1 which is afferent pathway and VII nerve which subserves as efferent pathway

  Maxillary nerve: There is loss of sneeze reflex. This branch is the afferent path of sneeze reflex

  Mandibular nerve: There is loss of jaw jerk reflex
- ***Trigeminal neuralgia:*** The principal disease affecting sensory root of V nerve is characterized by attacks of severe pain In the area of distribution of maxillary or mandibular divisions. Maxillary nerve is most frequently involved
- The trigeminal ganglion harbours the herpes zoster virus causing shingles in the distribution of the nerve
- Flaccid paralysis of muscles of mastication in injury of mandibular nerve leading to decrease strength of bite

- Hypoacusis, i.e. partial deafness to low pitched sounds due to paralysis of tensor tympani muscle

Seventh Cranial Nerve

- ***Bell's palsy:*** Sudden paralysis of facial nerve at the stylomastoid foramen. Result is asymmetry of comer of mouth, inability to close the eye, disappearance of nasolabial fold and loss of wrinkling of skin of forehead on the same side.
- Lesion above the origin of chorda tympani nerve will show symptoms of Bell's palsy plus loss of taste from anterior two-thirds of tongue except vallate papillae.
- Lesion above the origin of nerve to stapedius will cause symptoms 1,2. It also causes hyperacusis.
- The above-mentioned lesions are lower motor neuron type. Upper motor neuron paralysis will not affect the upper part of face, i.e. orbicularis oculi, only lower half of opposite side of face is affected. The upper half of face has bilateral representation, whereas lower half has only ipsilateral representation.
- Facial nerve can be injured at any level during its course. The symptoms are according to level of injury of VII nerve.

  Lower motor neuron paralysis of VII nerve causes paralysis of ipsilateral half of face, i.e. both upper quadrant and lower quadrant of same side as the injury. Upper motor neuron paralysis of VII nerve results in paralysis of contralateral lower quadrant of face only.
- ***Facial nerve palsy in newborn:*** The mastoid process is absent in newborn and stylomastoid foramen is superficial. Manipulation of baby's head during delivery may damage the VII nerve. This leads to paralysis of facial muscles especially the buccinator, required for sucking the milk.
- ***Crocodile tears syndrome:*** Lacrimation during eating occurs due to aberrant regeneration after trauma.

  In case of damage to facial nerve proximal to geniculate ganglia, regenerating fibres for submandibular salivary gland grow in endoneural sheaths of preganglionic secretomotor fibres supplying the lacrimal gland. That is why patient lacrimates while eating food.

- ***Ramsay Hunt syndrome:*** Involvement of geniculate ganglia by herpes zoster results in this syndrome. It shows following symptoms.
  (a) Hyperacusis
  (b) Loss of lacrimation
  (c) Loss of sensation of taste in anterior two-thirds of tongue
  (d) Bell's palsy and lack of salivation
  (e) Vesicles on the auricle

Eighth Cranial Nerve

Deafness

Three types of hearing loss are seen

1. Conductive deafness is the failure of sound waves to reach to the cochlea.
2. Sensorineural deafness is the failure of production or transmission of action potential due to cochlear disease, cochlear nerve disease or defects in cochlear nerve central connections.
3. Cortical deafness is a bilateral or dominant posterior temporal lobe lesion. It results in a failure to understand spoken language even though hearing is preserved.

- ***Vertigo:*** This is an illusion of rotatory movement due to disturbed orientation of the body in space. The patient feels that the environment is moving. It is due to disease of vestibular nerve.
- Tinnitis is a sensation of buzzing, ringing, hissing or singing quality. Tinnitis may be unilateral or bilateral; high or low pitch; continuous or intermittent.
- Meniere's syndrome is characterized by recurrent attacks of tinnitus, vertigo and hearing loss accompanied by a sensitivity to noises. It affects middle aged or older persons. In this condition there is an increase in volume of endolymph.
- Acoustic neuroma is a slow growing benign tumor of neurolemmal cells. It causes an early loss of hearing.

Ninth Cranial Nerve

- Lesion of this nerve causes
  (a) Absence of secretions of parotid gland
  (b) Absence of taste from posterior one-third of tongue and the circumvallate papillae
  (c) Loss of pain sensations from tongue tonsil, pharynx and soft palate
  (d) Gag reflex is absent
- ***Glossopharyngeal neuralgia:*** It is a short sharp severe attacks of pain affecting posterior part of pharynx or tonsillar area
- Jugular foramen syndrome is due to injury at the jugular foramen resulting in multiple cranial nerve palsies
- The glossopharyngeal nerve is tested clinically in the following way: (a) On tickling the posterior wall of the pharynx, there is reflex contraction of the pharyngeal muscles. No such contraction occurs when the ninth nerve is paralysed.
  (b) Taste sensibility on the posterior one-third of the tongue can also be tested. It is lost in ninth nerve lesions.
- Isolated lesions of the ninth nerve are almost unknown. They are usually accompanied by lesions of the vagus nerve.
- Pharyngitis may cause referred pain in the ear as both are supplied by IX nerve. However, in these cases eustachian catarrh should be excluded.

Tenth Cranial Nerve

- The vagus nerve is tested clinically by comparing the palatal arches on the two sides. On the paralysed side, there is no arching, and the uvula is pulled to the normal side.
- Paralysis of the vagus nerve produces:
  (a) Nasal regurgitation of swallowed liquids
  (b) Nasal twang in voice
  (c) Hoarseness of voice
  (d) Flattening of the palatal arch
  (e) Cadaveric position of the vocal cord

(f) Dysphagia

- Irritation of the auricular branch of the vagus in the external ear (by ear wax, syringing, etc.) may reflexly cause persistent cough (ear cough), vomiting, or even death due to sudden cardiac inhibition.
- Stimulation of the auricular branch may reflexly produce increased appetite.
- Irritation of the recurrent laryngeal nerve by enlarged lymph nodes in children may also produce a persistent cough.
- Some fibres arising in the geniculate ganglion of facial nerve pass into the vagus through communications between the two nerves. They reach the skin of auricle through the auricular branch of vagus. Sometimes a sensory ganglion may have a viral infection (called herpes zoster) and vesicles appear on the area of skin supplied by the ganglion. In herpes zoster of the geniculate ganglion, vesicles appear on the skin of auricle.
- Injury to pharyngeal branch causes dysphagia. Paralysis of muscles of soft palate results in nasal regurgitation of fluids and nasal tone of voice. Lesions of superior laryngeal nerve produces anaesthesia in the upper part of larynx and paralysis of cricothyroid muscle. The voice is weak and gets tired easily.
- Injury to right recurrent laryngeal nerve results in hoarseness and dysphonia due to paralysis of the right vocal cord.
- Paralysis of both vocal cords results in aphonia and inspiratory stridor (high pitched and harsh respiratory sound). It may occur during thyroid surgery.

Eleventh Cranial Nerve

- The accessory nerve is tested clinically

  (a) Absenc

  (b) By asking the patient to shrug his shoulders (trapezius) against resistance and comparing the power on the two sides.

  (c) By asking the patient to turn the chin to the opposite side (sternocleidomastoid) against resistance and again comparing the power on the two sides.

- Lesions of spinal root of accessory nerve cause drooping of the shoulder and inability to turn the chin to opposite side.

- Irritation of the nerve during biopsy of enlarged caseous lymph nodes, may produce torticollis or wry neck.
- Supranuclear connections act on the ipsilateral sternocleidomastoid and on the contralateral trapezius. This results in turning of the head away from relevant hemisphere during seizure.
- Unilateral lower motor neuron weakness causes drooping of the shoulder on affected side and weakness in turning the head to opposite side.

Twelfth Cranial Nerve

- The hypoglossal nerve is tested clinically by asking the patient to protrude his/her tongue. Normally, the tongue is protruded straight forwards. If the nerve is paralysed, the tongue deviates to the paralysed side.
- An infranuclear lesion of the hypoglossal nerve produces paralysis of the tongue on the affected side. There is gradual atrophy of the paralysed half of the tongue. The tongue looks shrunken.
- Supranuclear lesions of the hypoglossal nerve causes paralysis without wasting. The tongue moves sluggishly resulting in defective speech. On protrusion, the tongue deviates to opposite side.

25. Brainstem

INTRODUCTION

The brainstem consists of the medulla oblongata, the pons and the midbrain. It connects the spinal cord to cerebrum.

MEDULLA OBLONGATA

External Features

1. The anterior region is in the form of a longitudinal elevation called the ***pyramid.*** The pyramid is made up of corticospinal fibres. In the lower part of the medulla, many fibres of the right and left pyramids cross in the midline forming the ***pyramidal decussation.***
2. The upper part of the lateral region shows an oval elevation, the olive. It is produced by an underlying mass of grey matter called the ***inferior olivary nucleus.***
3. The rootlets of the hypoglossal nerve emerge from the anterolateral sulcus between the pyramid and the olive.
4. The rootlets of the cranial nerves IX and X and of the cranial part of the accessory nerve emerge through the posterolateral fissure, behind the olive.
5. The posterolateral region lies between the posterolateral sulcus and the posterior median fissure. The upper part of this region is marked by a V-shaped depression which is the lower part of the floor of the fourth ventricle. Below the floor we see three longitudinal elevations. From medial to lateral side, these are the fasciculus gracilis, the fasciculus cuneatus and the inferior cerebellar peduncle. The upper ends of fasciculus gracilis and cuneatus expand to form the ***gracile and cuneate***

tubercles. These tubercles are formed by underlying masses of grey matter called the ***nucleus gracilis*** and ***nucleus cuneatus.***

5. The medulla is divided in two parts: The lower ***closed part*** with a central canal; and the upper open part where the central canal opens out to form the fourth ventricle.

Internal Structure

Transverse Section through the Lower Part of the Medulla Passing through the Pyramidal Decussation

It resembles a transverse section of the spinal cord in having the same three funiculi and the same tracts (Fig. 25.1).

Grey Matter

1. The decussating pyramidal fibres separate the anterior horn from the central grey matter. The ***separated anterior horn*** forms the spinal nucleus of the accessory nerve laterally and the supraspinal nucleus for motor fibres of the first cervical nerve medially.
2. The central grey matter (with the central canal) is pushed backwards.
3. The nucleus gracilis and the nucleus cuneatus are continuous with the central grey matter.
4. Laterally, the central grey matter is continuous with the nucleus of the spinal tract of the trigeminal nerve. A bundle of fibres overlying this nucleus forms the spinal tract of the trigeminal nerve.

White Matter

1. The pyramids, anteriorly.
2. The decussation of the pyramidal tracts forms the most important features of the medulla at this level. The fibres of each pyramid run backwards and laterally to reach the lateral white column of the spinal cord where they form the lateral corticospinal tract.
3. The fasciculus gracilis and the fasciculus cuneatus occupy the broad posterior white column.

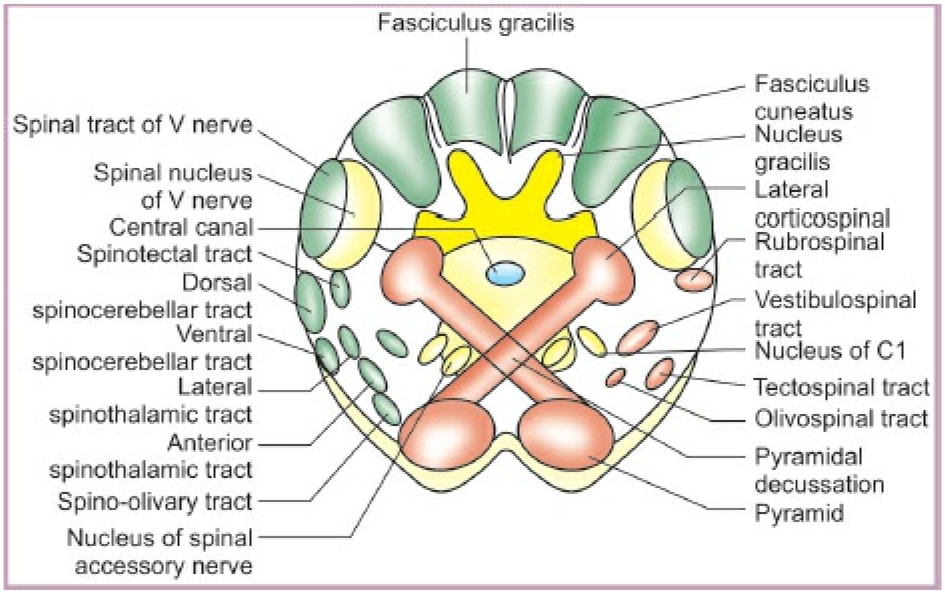


Fig. 25.1: TS of medulla oblongata at the level of pyramidal decussation.

4. The other features of the white matter are similar to those of the spinal cord.

Transverse Section through the Middle of Medulla (through the sensory decussation)

Identify the following features in Fig. 25.2.

Grey Matter

1. The nucleus gracilis and the nucleus cuneatus are much larger and are separate from the central grey matter. The fasciculus gracilis and the fasciculus cuneatus end in these nuclei.
2. Lateral to the cuneate nucleus we see the ***accessory cuneate nucleus*** which relays unconscious proprioceptive fibres from the upper limbs.
3. The ***nucleus of the spinal tract of the trigeminal nerve*** is also separate from the central grey matter
4. The lower part of the ***inferior olivary nucleus*** is seen
5. The central grey matter contains the following.
   (a) Hypoglossal nucleus
   (b) Dorsal nucleus of the vagus
   (c) Nucleus of tractus solitarius

White Matter

1. The nucleus gracilis and cuneatus give rise to the ***internal arcuate fibres.*** These fibres cross to the opposite side where they form a paramedian band of fibres, called the ***medial lemniscus.*** In the lemniscus, the body is represented with the head posteriorly and the feet anteriorly.

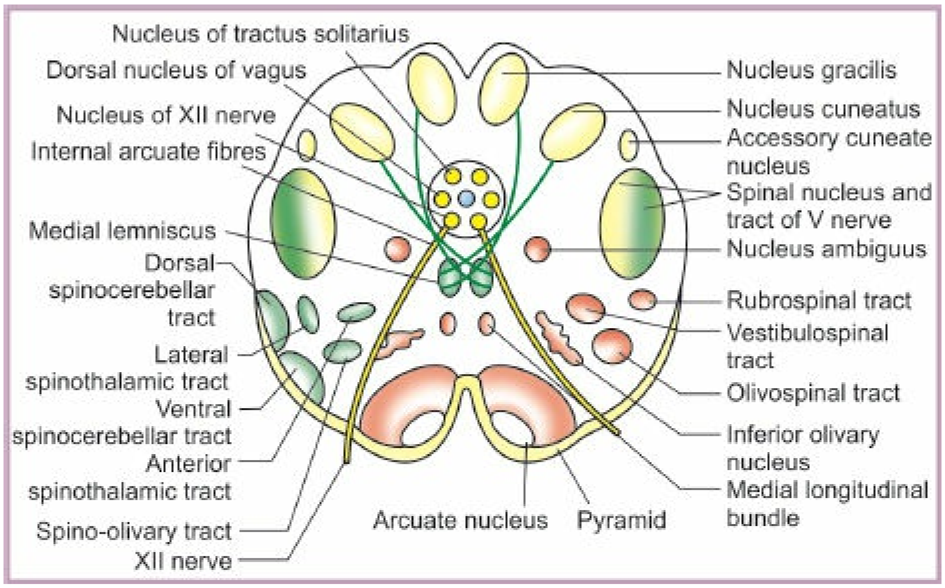


Fig. 25.2: TS of medulla oblongata at the level of sensory decussation.

2. The ***pyramidal tracts*** lie anteriorly.
3. The ***medial longitudinal bundle*** lies posterior to the medial lemniscus.
4. The ***spinocerebellar, lateral spinothalamic*** and other tracts lie in the anterolateral area.
5. Emerging fibres of XII nerve.

Transverse Section through the Upper Part of Medulla Passing through the Floor of Fourth Ventricle

Identify the following in Fig. 25.3.

Grey Matter

1. The nuclei of several cranial nerves are seen in the floor of the fourth ventricle:
   (a) The ***hypoglossal nucleus,*** in a paramedian position.
   (b) The ***dorsal nucleus of the vagus,*** lateral to the XII nerve nucleus.

(c) The ***nucleus of the tractus solitarius,*** ventrolateral to the dorsal nucleus of vagus.

(d) The ***inferior and medial vestibular nuclei,*** medial to the inferior cerebellar peduncle.

2. The ***nucleus ambiguus*** lies deep in the reticular formation of the medulla. It gives origin to motor fibres of the cranial nerves IX, X and XI.

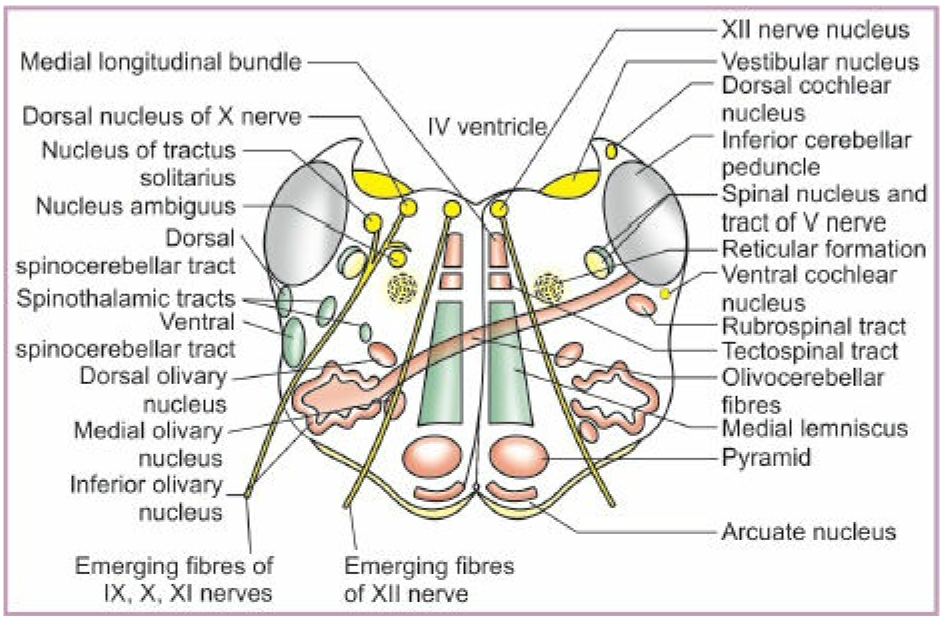


Fig. 25.3: TS of medulla oblongata at the level of olivary nucleus passing through floor of fourth ventricle.

3. The dorsal and ventral cochlear nuclei lie on the surface of the inferior cerebellar peduncle. These nuclei receive fibres of the cochlear nerve.

4. The ***nucleus of the spinal tract*** of the trigeminal nerve lies in the dorsolateral part.

5. The ***inferior olivary nucleus*** is the largest mass of grey matter seen at this level. It is responsible for producing the elevation of the olive. Its grey matter appears like a crumpled purse.

   Close to the inferior olivary nucleus there are the medial and dorsal accessory olivary nuclei.

6. The ***arcuate nucleus*** lies anteromedial to the pyramidal tract.

   Visceral centres are

(a) Respiratory centre

(b) Cardiac centre for regulation of heart rate

(c) Vasomotor centre for regulation of blood pressure

White Matter

It shows the following important features.

1. The inferior cerebellar peduncle occupies the posterolateral part, lateral to the fourth ventricle.
2. The ***olivocerebellar fibres*** are seen prominently in actual sections. The fibres emerge at the hilum of the inferior olivary nucleus and pass to the opposite inferior cerebellar peduncle, on their way to the opposite half of the cerebellum.
3. ***Striae medullares*** are seen in the floor of the fourth ventricle.
4. Identify the various ascending tracts in the anterolateral part of medulla.
5. Emerging fibres of IX, X, XI nerve.

PONS

The pons is the middle part of the brainstem, connecting the midbrain with the medulla. Literally, the word pons, means ‘bridge’.

External Features

The pons has ***two surfaces,*** ventral and dorsal. The ***ventral or anterior surface*** is convex in both directions and is transversely striated. In the median plane, it shows a vertical ***basilar sulcus*** which lodges the basilar artery.

Laterally, the surface is continuous with the middle cerebellar peduncle. The trigeminal nerve is attached to this surface at the junction of the pons with the peduncle. The nerve has two roots, a small motor root which lies medial to the much larger sensory root. The abducent, facial and vestibulocochlear nerves are attached at the lower border of the ventral surface.

The ***dorsal or posterior surface*** is hidden by the cerebellum, and forms the upper half of the floor of the fourth ventricle.

Internal Structure of Pons

Basilar Part of Pons

Grey Matter

It is represented by the ***pontine nuclei*** which are scattered among longitudinal and transverse fibres. The pontine nuclei form an important part of the corticopontocerebellar pathway.

White Matter

It consists of longitudinal and transverse fibres.

1. The longitudinal fibres include
   (a) The ***corticospinal*** and ***corticonuclear*** (pyramidal) tracts
   (b) The ***corticopontine*** fibres ending in the pontine nuclei
2. The transverse fibres are ***pontocerebellar*** fibres beginning from the pontine nuclei and going to the opposite half of the cerebellum, through the middle cerebellar peduncle.

Tegmentum in the Lower Part of the Pons

Identify the following in Fig. 25.4.

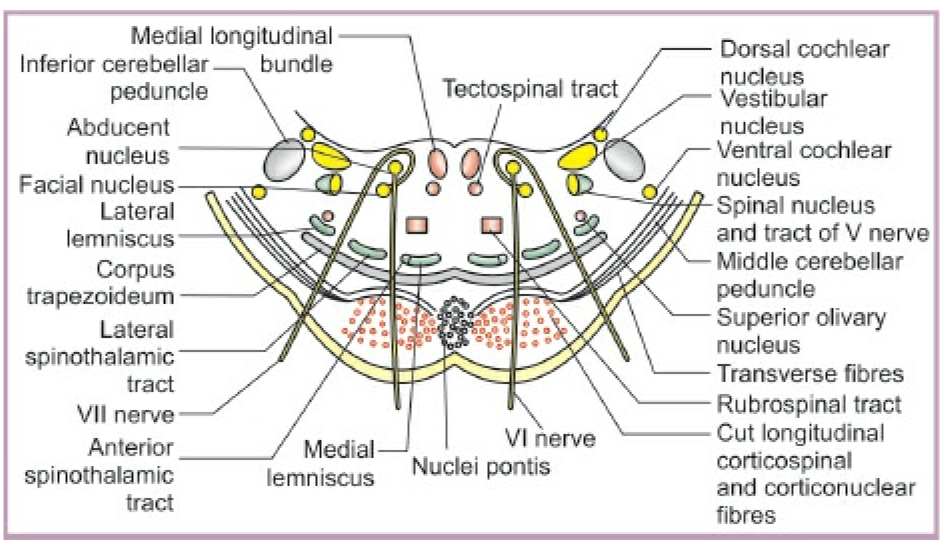


Fig. 25.4: TS of lower part of pons or TS at the level of facial colliculus.

Grey Matter

1. The ***sixth nerve nucleus*** lies beneath the facial colliculus.

2. The ***seventh nerve nucleus*** lies in the reticular formation of the pons.
3. The vestibular and cochlear nuclei lie in relation to the inferior cerebellar peduncle. The ***vestibular nuclei*** lie deep to the vestibular area in the floor of the fourth ventricle, partly in the medulla and partly in the pons. They are divisible into four parts, superior, inferior, medial and lateral. The dorsal and ventral ***cochlear nuclei*** are situated dorsal and ventral to the inferior cerebellar peduncle. They receive the fibres of the cochlear nerve, and give efferents mostly to the superior olivary nucleus and partly to nuclei of the corpus trapezoideum, and to nuclei of the lateral lemniscus. These fibres form the trapezoid body.

White Matter

1. The ***trapezoid body*** is a transverse band of fibres lying just behind the ventral part of the pons.
2. The medial lemniscus forms a transverse band on either side of the midline, just behind the trapezoid body.
3. The lateral spinothalamic tract (spinal lemniscus) lies lateral to the medial lemniscus.
4. The inferior cerebellar peduncle lies lateral to the floor of the fourth ventricle.
5. The fibres of the facial nerve follow a peculiar course. They first pass backwards and medially to reach the medial side of the abducent nucleus. They then form a loop dorsal to the abducent nucleus. This loop is responsible for producing an elevation, the facial colliculus, in the floor of the fourth ventricle.

Tegmentum in the Upper Part of Pons

Identify the following in Fig. 25.5.

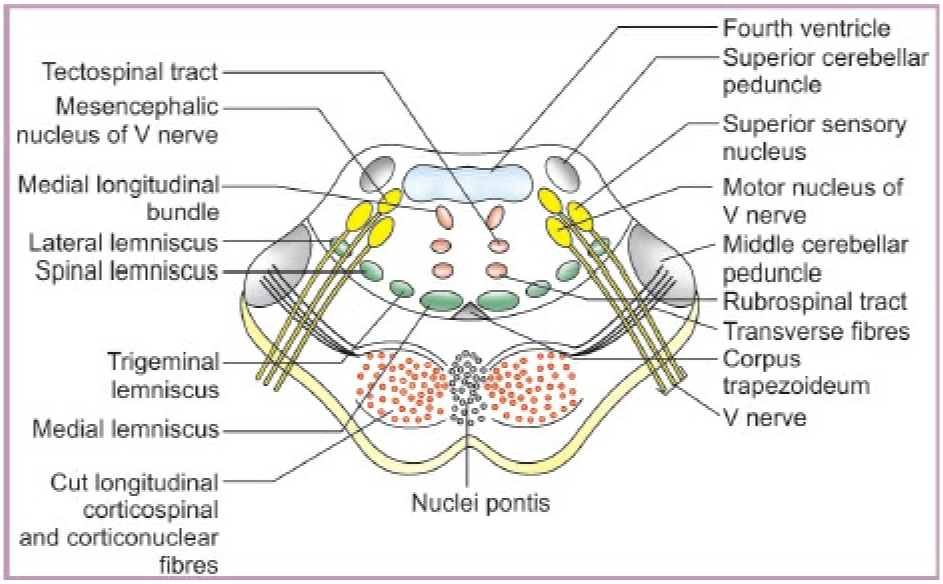


Fig. 25.5: TS of upper pons.

Grey Matter

The special features are the ***motor, mesencephalic and superior sensory nuclei of the trigeminal nerve.*** The motor nucleus is medial to the superior sensory nucleus.

White Matter

1. Immediately behind the ventral part of the pons there is a transverse band of fibres that is made up (from medial to lateral side) of the medial lemniscus, the trigeminal lemniscus, the spinal lemniscus, and the lateral lemniscus (MTSL).
2. The medial longitudinal bundle is made up of fibres that interconnect the nuclei of the cranial nerves III, IV, VI and VIII and the spinal part of the accessory nerve. It coordinates movements of the head and neck in response to stimulation of the cranial nerve VIII. However, the majority of fibres in the medial longitudinal bundle arise in the vestibular nuclei.

MIDBRAIN

The midbrain is also called the ***mesencephalon.*** It connects the hindbrain with the forebrain. Its cavity is known as the cerebral aqueduct. It connects the third ventricle with the fourth ventricle.

Subdivisions

When one examines a transverse section through the midbrain one can make out the following major subdivisions.

A. The ***tectum*** is the part posterior to aqueduct. It is made up of the right and left superior and inferior colliculi.

B. Each half of the midbrain anterior to the aqueduct is called the ***cerebral peduncle.*** Each cerebral peduncle is subdivided into

(a) Crus cerebri, anteriorly

(b) Substantia nigra, in the middle

(c) Tegmentum, posteriorly

Transverse Section of Midbrain at the Level of Inferior Colliculi

Grey Matter

1. The central (periaqueductal) grey matter contains:

(a) The ***nucleus of the trochlear nerve*** in the ventromedial part; and

(b) The ***mesencephalic nucleus*** of the trigeminal nerve in the lateral part. The mesencephalic nucleus is made up of unipolar cells (first neuron) and receives proprioceptive impulses from the muscles of mastication, the facial and ocular muscles, the teeth (Fig. 25.6) and temporomandibular joint.

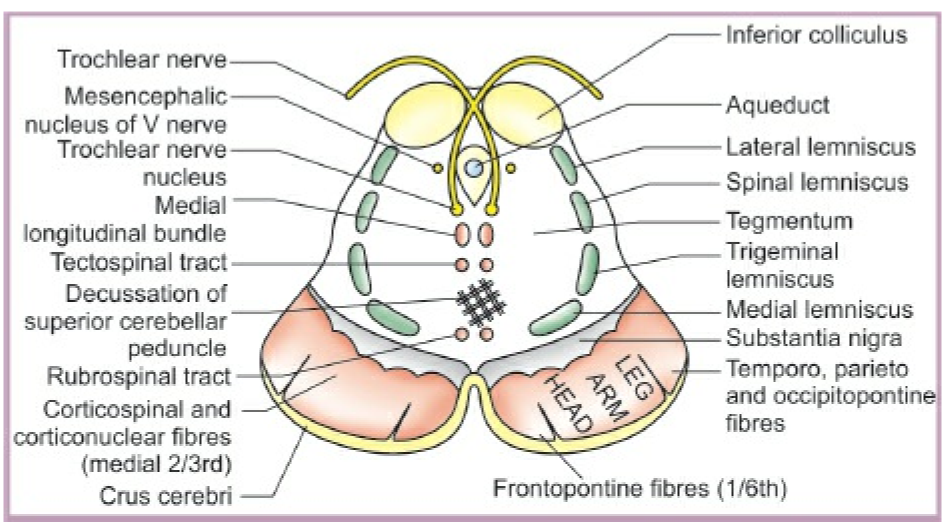


Fig. 25.6: TS of mid brain at the level of Inferior colliculus.

2. The ***inferior colliculus*** receives afferents from the lateral lemniscus, and gives efferents to the medial geniculate body. In the past, it has been considered as the centre for auditory reflexes, but the available evidence indicates that it helps in localizing the source of sounds.
3. The ***substantia nigra*** is a lamina of grey matter made up of deeply pigmented nerve cells. It is concerned with muscle tone.

White Matter

1. The ***crus cerebri*** contains
   (a) The corticospinal tract in the middle
   (b) Frontopontine fibres in the medial one-sixth
   (c) Temporopontine, parietopontine and occipitopontine fibres in the lateral one-sixth.
2. The ***tegmentum*** contains ascending tracts as follows.
   (a) The ***lemnisci*** (medial, trigeminal, spinal and lateral) are arranged in the form of a band in which they lie in the order mentioned (from medial to lateral side).
   (b) The ***decussation of the superior cerebellar peduncles*** is seen in the median plane.
3. The trochlear nerve passes laterally and dorsally round the central grey matter. It decussates in the superior medullary velum, and emerges lateral to the frenulum veli.

Transverse Section of Midbrain at the Level of Superior Colliculi

Grey Matter

1. The central grey matter contains
   (a) Nucleus of ***oculomotor nerve*** with Edinger-Westphal nucleus in the ventromedial part.
   (b) ***Mesencephalic nucleus*** of the trigeminal nerve in the lateral part. The oculomotor nuclei of the two sides are very close to each other (Fig. 25.7).
2. ***Superior colliculus*** receives afferents from the retina (visual), and various other centres.

3. ***Pretectal nucleus*** lies deep to the superolateral part of the superior colliculus. It receives afferents from the lateral roots of the optic tract. It gives efferents to the Edinger-Westphal nuclei of both sides.
4. ***Red nucleus*** is about 0.5 cm in diameter. It receives afferents from the superior cerebellar peduncle, globus pallidus, subthalamic nucleus and cerebral cortex. It gives efferents to the spinal cord (***rubrospinal tract),*** reticular formation, thalamus, olivary nucleus, subthalamic nucleus, etc. It has an inhibitory influence on muscle tone.
5. ***Substantia nigra***

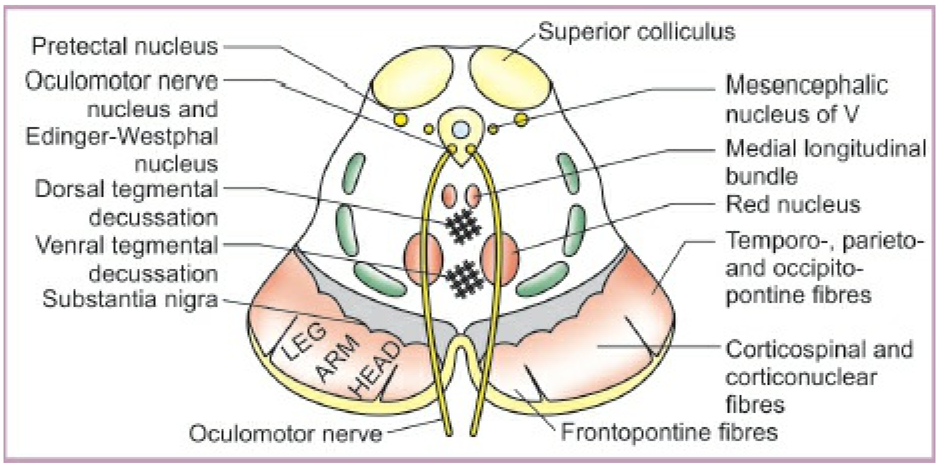


Fig. 25.7: TS of midbrain at the level of superior colliculus.

White Matter

1. The ***crus cerebri*** has the same tracts as described above.
2. The ***tegmentum*** contains the following
   (a) The same lemnisci as seen in the lower part except for the lateral lemniscus which has terminated in the inferior colliculus
   (b) The decussation of the tectospinal and tectobulbar tracts forms the dorsal tegmental decussation
   (c) The decussation of the rubrospinal tracts forms the ventral tegmental decussation
   (d) Medial longitudinal bundle
   (e) Emerging fibres of oculomotor nerve

3. The ***tectum*** shows the posterior commissure connecting the two superior colliculi.

CLINICAL ANATOMY

- ***Medial medullary syndrome:*** It occurs due to blockage of anterior spinal artery. Features are
  (a) Contralateral hemiplegia due to damage to pyramid of medulla.
  (b) Loss of sense of vibration and position due to damage to medial lemniscus.
  (c) Paralysis of muscles of tongue on the same side due to injury to XII cranial nerve.
- ***Lateral medullary syndrome:*** Occurs due to blockage of posterior inferior cerebellar artery. Features are as follows.
  (a) Ipsilateral paralysis of most of muscles of soft palate, pharynx and larynx due to injury to nucleus ambiguous which gives fibres to IX, X and XI cranial nerves.
  (b) Loss of pain and temperature on same side of face due to involvement of spinal nucleus and spinal tract of trigeminal nerve.
  (c) Loss of pain and temperature on opposite side of the body due to involvement of lateral spinothalamic tract.
  (d) Giddiness due to involvement of vestibular nuclei
- ***Injury to lower part of medulla oblongata:*** Injury in this part may be fatal due to injury to the vital centres like respiratory centre and cardiovascular centre.
- ***Pontine haemorrhage:*** This entity has following features
  (a) Bilateral paralysis of face and limbs due to involvement of VII nerve nucleus and all corticospinal fibres.
  (b) Deep coma due to damage to the reticular formation.
  (c) Hyperpyrexia due to cutting off of the temperature regulating fibres from the hypothalamus.
  (d) Pin point pupil due to damage to sympathetic ocular fibres. Pontine

haemorrhage is usually fatal.

- ***Cerebellopontine angle***: The anatomical structures located in the cerebello-pontine angle include choroid plexuses of IV ventricle, flocculus, VII and VIII cranial nerves. A tumour, acoustic neuroma in this angle arises usually in relation to VIII nerve. Features are
  (a) Ipsilateral facial paralysis and loss of taste in anterior two-thirds of tongue due to damage to fibres of facial nerve.
  (b) Deafness and vertigo due to damage to both the parts of VIII nerve.
  (c) Ataxia on the affected side due to involvement of the flocculus.
  (d) Absence of corneal reflex on the side of lesion due to damage to nucleus of V nerve including its spinal tract.
- ***Millard Gubler's syndrome:*** In this condition, there is damage to fibres of VI and VII nerves along with pyramidal fibres. Features are
  (a) Paralysis of VII nerve on the same side due to damage to VII nerve fibres.
  (b) Ipsilateral loss of abduction of the eye due to damage to VI nerve.
  (c) Contralateral hemiplegia due to lesion of the pyramidal fibres.
- ***Tumours of pons:*** Astrocytoma is the most common tumour of brainstem, usually in childhood. Signs and symptoms vary according to area of origin of tumour.
- ***Argyll Robertson pupil:*** In this condition, light reflex is lost but accommodation reflex is retained due to lesion in the vicinity of pretectal nucleus.
- ***Weber’s syndrome:*** This syndrome involves III nerve nucleus and corticospinal fibres. Features are as follows.
  (a) Hemiplegia on the opposite side due to involvement of corticospinal fibres.
  (b) Pupil points downwards and laterally due to paralysis of III nerve.
- ***Benedikt’s syndrome:*** In this condition, most of the tegmentum of midbrain is damaged. Lesion includes loss of medial lemniscus, red nucleus, superior cerebellar peduncle and fibres of III nerve. Features are as follows.

(a) Loss of proprioception due to lesion of medial lemniscus.

(b) Pupil points downwards and laterally due to injury to III nerve.

(c) Tremors and twitching of opposite side due to damage to red nucleus and superior cerebellar peduncle.

- ***Parinaud's syndrome:*** Lesion of superior colliculi leads to this syndrome. Features are weakness of upward gaze and vertical nystagmus due to lesion of superior colliculus.

26. Cerebellum

INTRODUCTION

Cerebellum, though small in size, subserves important functions for maintaining tone, posture, equilibrium and movements of the body. Cerebellum controls the same side of the body directly or indirectly. The grey matter is highly folded to accommodate millions of neurons in a small area and the arrangement is called "arbor vitae" (vital tree of life). The structure of cerebellum is uniform throughout, i.e. it is homotypical. Damage to cerebellum gives rise to very typical symptoms.

The cerebellum (little brain) is the largest part of the hindbrain. It is situated in the posterior cranial fossa behind the pons and medulla. It is an infratentorial structure that coordinates voluntary movements of the body.

EXTERNAL FEATURES

The cerebellum consists of two cerebellar hemispheres that are united to each other through a median *vermis.* It has two surfaces *superior and inferior*.

PARTS OF CEREBELLUM

The cerebellum is subdivided into numerous small parts by fissures. Each fissure cuts the vermis and both hemispheres. Out of the numerous fissures, however, only the following are worth remembering.

1. The *horizontal fissure* separates the superior surface from the inferior surface.
2. The *primary fissure (fissure prima)* separates the anterior lobe from the middle lobe on the superior surface of the cerebellum.

3. The *posterolateral fissure* separates the middle lobe from the flocculonodular lobe on the inferior surface.

Table 26.1 shows parts of vermis and associated subdivision of cerebellar hemisphere.

Table 26.1

Parts of vermis	***Subdivisions of the cerebellar hemi sphere***
1. Lingula	–
2. Central lobule	Ala
3. Culmen	Quadrangular lobule
4. Declive	Simple lobule
5. Folium	Superior semilunar lobule
6. Tuber	Inferior semilunar lobule
7. Pyramid	Biventral lobule
8. Uvula	Tonsil
9. Nodule	Flocculus

Functionally the anterior and posterior lobes are organized into 3 longitudinal zones: lateral, intermediate and vermis.

Lateral Zone

Connected with association areas of the brain and is involved in planning and programming muscular activities.

Intermediate Zone

Concerned with control of muscles of hands, fingers, feet and toes.

Vermis

Concerned with control of muscles of trunk, neck, shoulders and hips.

Flocculonodular Lobe

This lobe functions with vestibular system in controlling equilibrium.

Connections of Cerebellum

The fibres entering or leaving the cerebellum are grouped to form three peduncles which connect the cerebellum to the midbrain, the pons and the medulla. The constituent fibres in them are given in Table 26.2.

It is clear from Table 26.2 that the middle and inferior peduncles are chiefly afferent to the cerebellum and that the superior cerebellar peduncle is chiefly efferent in nature.

Functions of Cerebellum

Cerebellum controls the same side of the body. Its influence is ipsilateral. This is in marked contrast to other parts of brain most of which control the opposite half of the body. Functions of cerebellum are that it coordinates voluntary movements so that they are smooth, balanced and accurate.

Cerebellum controls tone, posture and equilibrium. This is chiefly done by the archicerebellum and paleocerebellum.

Table 26.2: Constituents of the cerebellar peduncles

Peduncle	Afferent tracts	Efferent tracts
A. Superior cerebellar peduncle	1. Anterior spinocere bellar 2. Tectocerebellar	1. Cerebellorubral 2. Dentatothalamic 3. Dentatoolivary 4. Fastigioreticular
B. Middle peduncle ce rebellar	Pontocerebellar (part o f the corticopontocereb ellar pathway)	–
C. Inferior cerebellar peduncle	1. Posterior spinocere bellar 2. Cuneocerebellar (p	1. Cerebellovestibular 2. Cerebelloolivary 3. Cerebelloreticular

osterior external ar cuate fibres)

3. Olivocerebellar
4. Parolivocerebellar
5. Reticulocerebellar
6. Vestibulocerebellar
7. Anterior external ar cuate fibres
8. Striae medullares
9. Trlgemlnocerebella r

Flocculonodular lobe is connected to vestibular nuclei. It is involved in maintenance of muscle tone and posture Spinocerebellum, vermis and intermediate regions receive afferents from motor cortex via cortico-ponto-cerebellar fibres.

All sensory information of muscles, joints, cutaneous, auditory and visual parts are relayed here. Spinocerebellar tracts carry information from the same side.

Vermal part controls axial muscles, and thus maintains posture. Paramedian areas are involved in control of distal group of muscles to bring smooth coordinated activity.

Cerebellum functions as “comparator”. It receives information from cerebrum and spinal cord. It corrects and modifies ongoing movements through thalamocortical projections, reticulospinal and rubrospinal tracts.

Neocerebellum is responsible for fine tuning of motor performance for precise movements. It helps in planning and production of skilled movements along with cerebrum.

It has been seen by functional magnetic resonance imaging (FMRI) that if fingers of right hand are moved repetitively, the activity is seen in precentral gyrus of left cerebral cortex and in anterior quadrangular lobule of right cerebellar hemisphere.

Development

Cerebellum develops from the neurons of alar lamina of metencephalic part of the rhombencephalic vesicle. These neurons migrate dorsally and form the rhombic lip which forms the cerebellum. The earliest part to develop is the archicerebellum. In its centre, the paleocerebellum develops, splitting the archicerebellar parts into two parts. Lastly, the paleocerebellar part is also split by the development of neocerebellum in its centre.

CLINICAL ANATOMY

Cerebellar Dysfunction

Vermis lesions lead to truncal ataxia as connection of vermis to the vestibular nuclei are involved.

Nystagmus is due to loss of labyrinthine connections of vermis to labyrinth. Vermis is also related to emotions.

Anterior lobe lesion: Lesion of anterior lobe causes gait ataxia. There is incoordination of the lower limbs resulting in staggering gait and inability to walk in a straight line. It is also seen in alcoholics.

Neocerebellar lesions: These lesions cause incoordination of voluntary movements of the upper limbs. It results in intention tremor, action tremor and overshoot movements.

Speech is also defective: Phonation is defective due to loss of smoothness in expiratory muscles. Articulation is defective as there is less coordination between muscles of lip, tongue and palate.

If there is thrombosis of one of six arteries that is two superior cerebellar, two anterior inferior cerebellar and two posterior inferior cerebellar nurturing cerebellum, “cerebellum cognitive affective syndrome” develops. These patients show inattention, grammatical errors in speech and patchy memory loss. Involvement of vermis results in dulling of emotional response.

Cerebellar syndrome: It is characterised by

(a) Muscular hypotonia

(b) Intention tremors (tremors only during movements) tested by finger-nose and heel-knee tests.

(c) Adiodochokinesia which is inability to perform rapid and regular alternating movements, like pronation and supination.

(d) Nystagmus is to and fro oscillatory movements of the eyeballs while looking to either side.

(e) Scanning speech is jerky and explosive speech.

(f) Ataxic or unsteady gait.

27. Fourth Ventricle

INTRODUCTION

The cavity of hindbrain is called the fourth ventricle. It is a tent-shaped space situated between the pons and upper part of medulla oblongata in front and cerebellum behind. So it lies dorsal to pons and upper part of medulla oblongata and ventral to cerebellum.

It has lateral boundaries, floor, roof and a cavity.

LATERAL BOUNDARIES

On each side, fourth ventricle is bounded.

(a) Inferolaterally by gracile, cuneate tubercles and inferior cerebellar peduncles.

(b) Superolaterally by the superior cerebellar peduncles.

FLOOR

It is also called ‘Rhomboid fossa’ because of its rhomboidal shape. The floor is formed by:

(a) Posterior (dorsal) surface of lower or closed part of pons

(b) Posterior (dorsal) surface of open or upper part of medulla oblongata

Common Features of the Floor

(i) Median sulcus divides the floor into two symmetrical halves

(ii) *Median eminence*

(iii) A sulcus limits the medial eminence on the lateral side, in the upper most part (pontine part) the sulcus limitans overlies an area that is bluish in colour and is called *locus coeruleus.* The colour is due to presence of pigmented neurons which constitute *substantia ferruginea.* The upper part of sulcus limitans is marked by a depression, the superior fovea which lies just lateral to facial colliculus.

In the medullary part of floor. These are hypoglossal triangle medially and vagal triangle laterally.

(iv) ***Vestibular area:*** This lies lateral to the inferior fovea (sulcus limitans) which overlies the vestibular nuclei. This area is partly in the pons and partly in the medulla.

ROOF

The roof of the ventricle is diamond-shaped and can be divided into superior and inferior parts. The superior or cranial part of roof is formed by superior cerebellar peduncles and superior medullary velum.The inferior part is formed by inferior medullary velum.

Tela Choroidea of Fourth Ventricle

It is a double layer of pia mater which occupies the interval between the cerebellum and the lower part of the ventricle. The tela choroidea with vascular fringes covered by secretory ependyma form the choroid plexuses of fourth ventricle. These project into lower part of roof of fourth ventricle. Each plexus (left or right) consists of a vertical limb lying next to midline and a horizontal limb extending into lateral recesses. The vertical limb of the two plexuses lie side by side so that whole structure is T-shaped. The vertical limbs of the T-shaped structure reach the median aperture and project into the subarachnoid space through it. The lateral ends of horizontal limbs reach the lateral apertures. The arterial supply of these plexuses is from the posterior inferior cerebellar arteries.

Communication

The cavity of the fourth ventricle communicates inferiorly with the central canal and superiorly with cerebral aqueduct.

Openings in the Roof

In the caudal part of roof of fourth ventricle there are three openings, one median and two lateral.

RECESSES OF FOURTH VENTRICLE

These are extensions of the main cavity of ventricle. Five recesses have been identified.

(i) Two lateral recesses one on each side. Each lateral recess passes laterally in the interval between the inferior cerebellar peduncle (ventrally) and the peduncle of flocculus dorsally reaching as far as the medial part of flocculus.

(ii) One recess present in the median plane, is known as median dorsal recess. It extends dorsally into white core of cerebellum and lies cranial to nodule.

(iii) Two lateral dorsal recesses, one on each side. Each lateral dorsal recess extend dorsally lateral to the nodule and cranial to the inferior medullary velum.

CLINICAL ANATOMY

- Vital centres are situated in the vicinity of vagal triangle. An injury to this area, therefore would prove fatal.
- Infratentorial brain tumours block the foramina of Luschka and Magendie situated in the roof of fourth ventricle. This results in marked and early rise of intracranial pressure which causes headache, vomiting and papilloedema, etc.

28. Cerebrum

CEREBRAL HEMISPHERE

External Features

Each hemisphere has the following features:

Three Surfaces

1. The *superolateral surface* is convex and is related to the cranial vault.
2. The *medial surface* is flat and vertical. It is separated from the corresponding surface of the opposite hemisphere by the falx cerebri and the longitudinal fissure (Fig. 28.1).
3. The *inferior surface* is irregular. It is divided into an anterior part, the *orbital surface*, and a posterior part, the *tentorial surface*. The two parts are separated by a deep cleft called the stem of the lateral sulcus (Fig. 28.2).

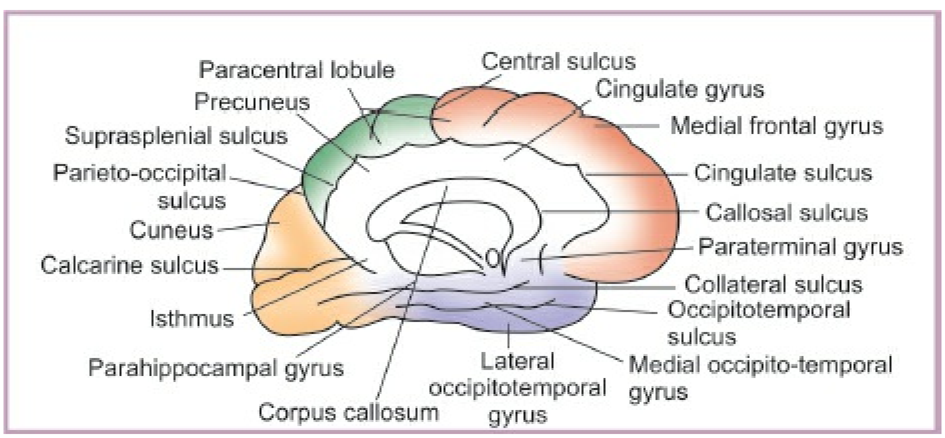


Fig. 28.1: Sulci and gyri on the medial surface of left cerebral hemisphere.

Four Borders

1. *Superomedíal border* separates the superolateral surface from the medial surface.
2. *Inferolateral border* separates the superolateral surface from the inferior surface. The anterior part of this border is called the *superciliary border*.

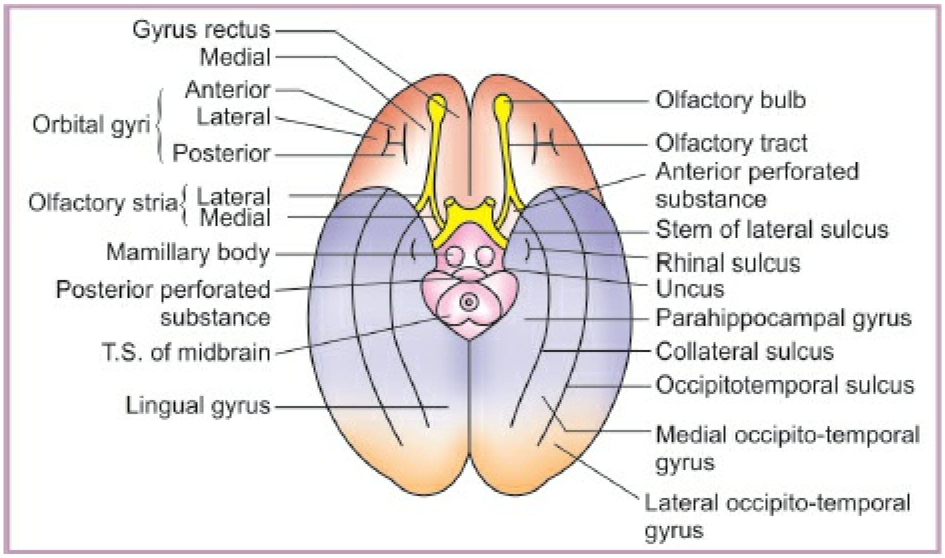


Fig. 28.2: Gyri and sulci on the inferior aspect of cerebral hemisphere.

There is a depression on the inferolateral border situated about 5 cm in front of the occipital pole: it is called the preoccipital notch.

3. ***Medial orbital border*** separates the medial surface from the orbital surface.
4. ***Medial occipital border*** separates the medial surface from the tentorial surface.

Three Poles

1. ***Frontal pole,*** at the anterior end.
2. ***Occipital pole,*** at the posterior end.
3. ***Temporal pole,*** at the anterior end of the temporal lobe.

Lobes of Cerebral Hemisphere

Each cerebral hemisphere is divided into four lobes—frontal, parietal, occipital and temporal.

Cerebral Sulci and Gyri

See Table 28.1.

Functional or Cortical Areas of Cerebral Cortex

There are three basic functional divisions of cerebral cortex:

1. Motor areas
2. Sensory areas
3. Association areas

Motor Areas

See Table 28.2.

Table 28.1: Sulci and gyri of the cerebrum

Surface/Lobe	Sulci	Gyri
Superolateral surface		
1. Frontal lobe	A. Precentral B. Superior frontal C. Inferior frontal	(a) Precentral (b) Superior frontal (c) Middle frontal (d) Inferior frontal which also contains horizontal and anterior ascending rami of the lateral sulcus, and the pars orbitalis, pars triangularis and pars opercularis
2. Parietal lobe	A. Postcentral B. Intraparietal	(a) Postcentral (b) Superior parietal lobule (c) Inferior parietal lobule, which is divide

			d into 3 parts: (i) the anterior, supramarginal, (ii) the middle, angular, and (iii) the posterior, over the upturned end of inferior temporal sulcus
3.	Temporal lobe	A. Superior temporal B. Inferior temporal	(a) Superior temporal, with 3 transverse temporal gyri (b) Middle temporal (c) Inferior temporal
4.	Occipital lobe	A. Transverse occipital B. Lateral occipital C. Lunate D. Superior and inferior polar	(a) Arcus parieto-occipitalis (b) Superior occipital (c) Inferior occipital (d) Gyrus descendens
	Medial surface	A. Anterior parolfactory B. Posterior parolfactory C. Cingulate D. Callosal E. Suprasplenial or subparietal F. Parieto-occipital G. Calcarine	(a) Paraterminal (b) Parolfactory (subcallosal area) (c) Medial frontal (d) Paracentral lobule (e) Cingulate (f) Cuneus (g) Precuneus
	Inferior surface	A. Olfactory	(a) Gyrus rectus

	B. H-shaped orbital su lci	(b) Anterior orbital
	C. Collateral	(c) Posterior orbital
	D. Rhinal	(d) Medial orbital
	E. Occipitotemporal	(e) Lateral orbital
		(f) Lingual
		(g) Uncus
		(h) Parahippocampal
		(i) Medial occipitotem poral
		(j) Lateral occipitotem poral

Table 28.2: Functional areas of the cerebral cortex

Lobe	Area	Area no.	Location	Function
Frontal lobe	Motor area	4	Precentral gyrus and paracentral lobule	Controls voluntary activities of the opposite half of body
	Premotor area	6	Posterior parts of superior, middle and inferior frontal gyri	Controls extra-pyramidal system
	Frontal eye field	6, 8	Posterior part of middle frontal gyrus	Controls horizontal conjugate movements of eyes
	Motor speech area	44, 45	Pars triangularis and pars opercularis	Controls the spoken speech
	Prefrontal area	—	The remaining large, anterior part of frontal lobe	Controls emotion, concentration, attention and judgement
Parietal lobe	Sensory (somesthetic)	3, 1, 2	Postcentral gyrus and paracentral lobule	Perception of exteroceptive (touch, pain and temperature) and proprioceptive impulses
	Parietal area	—	Between sensory and visual areas	Stereognosis and sensory speech
Occipital lobe	Visuosensory area or striate area	17	In and around the postcalcarine sulcus	Reception and perception of the isolated visual impressions of colour, size, form, motion, illumination and transparency
	Visuopsychic area parastriate and peristriate areas	18, 19	Surround the striate area	Correlation of visual impulses with past memory and recognition of objects seen, and also the depth
Temporal lobe	Auditosensory area	41, 42	Posterior part of superior temporal gyrus and anterior transverse temporal gyrus	Reception and perception of isolated auditory impressions of loudness, quality and pitch
	Auditopsychic area	22	Rest of the superior temporal gyrus	Correlation of auditory impressions with past memory and identification (interpretation) of the sounds heard

Functions of Cerebral Cortex

1. ***Cerebral dominance:*** One cerebral hemisphere dominates the other one in relation to handedness, speech, perception of language and spatial judgement. In 80-95% subjects, the left hemisphere dominates the right

one. Since left hemisphere controls the right half of the body, all these subjects are right-handed. The left hemisphere is verbal, mathematical, analytical and has direct link to consciousness.

The right hemisphere is active in understanding geometrical figures, and important for temporal synthesis and spatial comprehension. It helps in recognition of faces, figures and appreciating music.

Localisation of speech on left side in 70% of left handed and 98% of right handed is well known. Association of negative emotions with right prefrontal activity and of positive emotions with left prefrontal activity is also known. Mahatma Gandhi, father of the nation; Bill Clinton, Bill Gates, Amitabh Bachchan and Abhishek Bachchan are all left handed. Functional asymmetry in a structurally symmetrical structure is a great and ingenious way of economising on neural tissue. It practically doubles the capabilities of the brain.

2. ***Discriminatory aspects:*** Sensory cortex is not concerned with recognition only, but is also involved with discrimination of sensory function as:
   (i) Recognition of spatial relationship
   (ii) Graded response to stimuli of different intensities
   (iii) Appreciation of similarities and differences in external objects, brought into contact with surface of body.
3. ***Associative functions:*** The information thus discriminated and classified is correlated with previous experience. This association forms the basis of memory patterns. These are transmitted to frontal cortex which synthesizes it and forms basis of thinking and related intellectual activities.
4. The motor area of one cerebral hemisphere controls voluntary movements of opposite side of the body.

DIENCEPHALON

THALAMUS

The thalamus (inner chamber) is a large mass of grey matter situated in the lateral wall of the third ventricle and in the floor of the central part of the lateral ventricle. It has anterior and posterior ends, superior, inferior, medial and lateral surfaces (Table 28.3).

The ***anterior end*** with anterior nucleus is narrow and forms the posterior boundary of the interventricular foramen.

Table 28.3: Connections and functions of thalamic nuclei

Nucleus	Afferents	Efferents	Function
Anterior nucleus	Mamillothalamic tract	To cingulate gyrus	Relay station for hippocampal impulses
Medial nucleus	From hypothalamus, frontal lobe in front of area 6, corpus striatum,	To same parts from which the afferents are received	Relay station for visceral impulses
Lateral nucleus: Lateral dorsal, lateral posterior and pulvinar	From precuneus and superior parietal lobule;	To precuneus and superior parietal lobule	Correlative in function
Ventral anterior nucleus	From globus pallidus (subthalamic fasciculus)	To areas number 6 and 8 of cortex	Relay station for striatal impulses
Ventral lateral nucleus	From cerebellum (dentatothalamic fibres) and red nucleus	To motor areas number 4 and 6	Relay station for cerebellar impulses
Ventral posterolateral nucleus	Spinal and medial lemnisci	To postcentral gyrus (areas no. 3, 1, 2)	Relay station for exteroceptive and proprioceptive impulses from body, except face and head
Ventral posteromedial nucleus	Trigeminal and solitariothalamic lemnisci	To postcentral gyrus (areas no. 3, 1, 2)	Relay station for impulses from the face, head and taste impulses
Intralaminar,midline, and reticular nuclei	Reticular formation of brainstem	To all parts of cerebral cortex	Participate in arousal reactions
Centromedian nucleus	From parts of corpus striatum; from spinal, medial, trigeminal lemnisci, ascending reticulothalamic fibres	Connected to other thalamic nuclei and corpus striatum	Receive pain fibres
Medial geniculate body	Auditory fibres from inferior colliculus	Primary auditory area (41, 42)	Relay station for auditory impulses
Lateral geniculate body	Optic tract	Primary visual cortex (area 17)	Relay station for visual impulses

The ***posterior end*** is expanded, and is known as the pulvinar. It overhangs the lateral and medial geniculate bodies, and the superior colliculus with its brachium (Fig. 28.3).

The ***superior surface*** is divided into a lateral ventricular part which forms the floor of the central part of the lateral ventricle.

The ***inferior surface*** rests on the subthalamus and the hypothalamus.

The ***medial surface*** forms the posterosuperior part of the lateral wall of the third ventricle. The medial surfaces of two thalami are interconnected by an interthalamic adhesion.

The ***lateral surface*** forms the medial boundary of the posterior limb of the internal capsule.

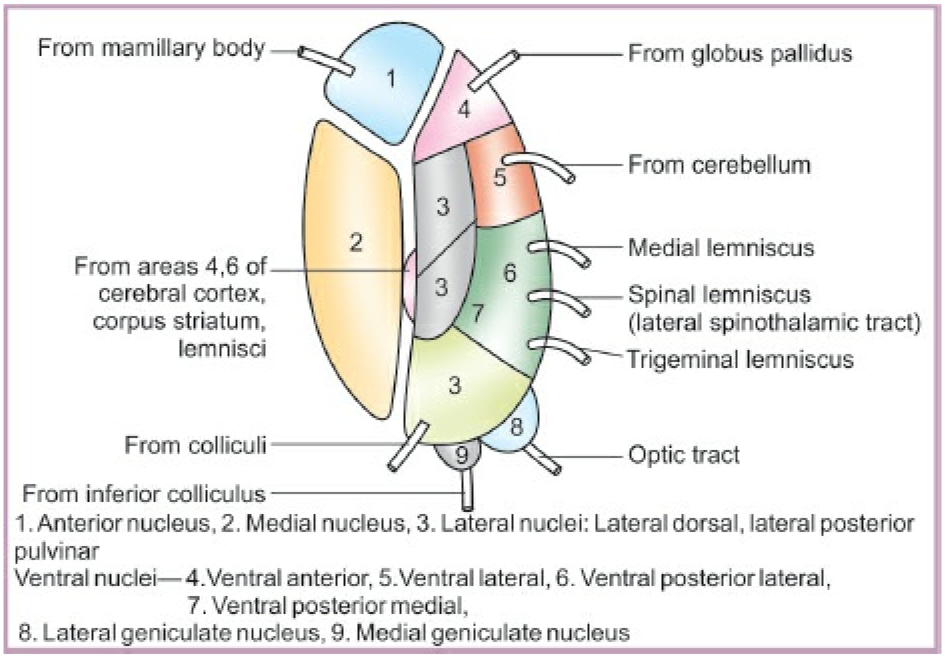


Fig. 28.3: Parts of the thalamus. The afferents to the nuclei of thalamus are also indicated.

Structure and Nuclei of Thalamus

Grey Matter

The grey matter is divided to from several nuclei.

1. ***Anterior nucleus*** in the anterior part.
2. ***Medial nucleus*** in the medial part. The anterior and medial nuclei together represent the ***paleothalamus*** (Fig. 28.3).
3. The lateral part of the thalamus is largest and represents the ***neothalamus.*** It is divided into the ***lateral nucleus*** in the dorsolateral part, and the ***ventral nucleus*** in the ventromedial part. The ventral nucleus is subdivided into anterior, intermediate and posterior groups. The posterior group is further subdivided into the posterolateral and posteromedial groups.
4. Intralaminar nuclei including centromedian nucleus (located in the internal medullary lamina), midline nuclei (periventricular grey on the medial surface) and reticular nuclei (on the lateral surface) are also present.

Connections and Functions of Thalamus

See Table 28.3.

METATHALAMUS (Part of Thalamus)

The metathalamus consists of the medial and lateral geniculate bodies, which are situated on each side of the midbrain, below the thalamus (Table 28.3).

EPITHALAMUS

The epithalamus occupies the caudal part of the roof of the diencephalon and consists of

1. The right and left habenular nuclei, each situated beneath the floor of the corresponding habenular trigone
2. The pineal body or epiphysis cerebri
3. The habenular commissure
4. The posterior commissure

Pineal Body

Structure

The pineal gland is composed of two types of cells, pinealocytes and neuroglial cells, with a rich network of blood vessels and sympathetic fibres. The vessels and nerves enter the gland through the connective tissue septa which partly separate the lobules. Sympathetic ganglion cells may be present.

Calcareous concretions are constantly present in the pineal after the 17th year of life and may form aggregations ***(brain sand).*** Spaces or cysts may also be present.

Functions

The pineal body has for long been regarded as a vestigial organ of no importance. Recent investigations have shown that it is an endocrine gland of great importance. It produces hormones that may have an important regulatory influence on many other endocrine organs (including the adenohypophysis, the neurohypophysis, the thyroid, the parathyroids, the adrenal cortex and medulla, and the gonads). The best known hormone is ***melatonin*** which causes changes in skin colour in some species. The synthesis and discharge of melatonin is remarkably influenced by exposure of the animal to light. Increase secretion occurs during dark periods.

HYPOTHALAMUS

The hypothalamus is a part of the diencephalon. It lies in the floor and lateral wall of the third ventricle. It has been designated as the head ganglion of the autonomic nervous system because it takes part in the control of many visceral and metabolic activities of the body.

Parts of the Hypothalamus

The hypothalamus is subdivided into optic, tuberal and mamillary parts. The nuclei present in each part are as follows.

Optic part

1. Supraoptic nucleus, above the optic chiasma.
2. Paraventricular nucleus, just above the supraoptic nucleus.

Tuberal part

3. Ventromedial nucleus.
4. Dorsomedial nucleus.
5. Tuberal nucleus, lateral to the ventromedial nucleus.

Mamillary part

6. Posterior nucleus, caudal to the ventromedial and dorsomedial nuclei.
7. Lateral nucleus, lateral to the posterior nucleus.

The nuclei 3, 4 and 6 (medial) are separated from nuclei 5 and 7 (lateral) by the column of the fomix, the mamillothalamic tract and the fasciculus retroflexus.

Important Connections

Afferents: The hypothalamus receives visceral sensations through the spinal cord and brainstem (reticular formation). It is also connected to several centres associated with olfactory pathways, including the piriform cortex; with the cerebellum; and with the retina.

Efferents

1. Supraopticohypophyseal tract from the optic nuclei to the pars posterior, the pars tuberalis and the pars intermedia of the hypophysis cerebri.
2. Mamillothalamic tract.
3. Mamillotegmental tract (periventricular system of fibres).

Functions of Hypothalamus

Endocrine Control: By forming ***releasing hormones*** or ***release inhibiting hormones,*** the hypothalamus regulates secretion of thyrotropin (TSH), corticotropin (ACTH), somatotropin (STH), prolactin, luteinizing hormone (LH), follicle stimulating hormone (FSH) and melanocyte stimulating hormone, by the pars anterior of the hypophysis cerebri.

Neurosecretion: Oxytocin and vasopressin (antidiuretic hormone, ADH) are secreted by the hypothalamus and transported to the infundibulum.

General Autonomic Effect: The anterior parts of the hypothalamus chiefly mediate parasympathetic activity, and the posterior parts, chiefly mediate sympathetic activity.

Temperature Regulation: The hypothalamus maintains a balance between heat production and heat loss of the body.

Regulation of Food and Water Intake: The ***hunger*** or ***feeding centre*** is placed laterally, the ***satiety centre,*** medially. Stimulation of the feeding centre or damage of the satiety centre causes hyperphagia (overeating) leading to obesity.

Sexual Behaviour and Reproduction: Through its control of the anterior pituitary, the hypothalamus controls gametogenesis, various reproductive cycles (uterine, ovarian, etc.) and the maturation and maintenance of secondary sexual characteristics.

Biological Clocks: Many tissues and organ-systems of the body show a cyclic variation in their functional activity during the 24 hours of a day (circadian rhythm). Sleep and wakefulness is an outstanding example of a circadian rhythm.

Emotion, Fear, Rage, Aversion, Pleasure and Reward: These faculties are controlled by the hypothalamus, the limbic system and the prefrontal cortex.

SUBTHALAMUS

The subthalamus lies between the midbrain and thalamus, medial to internal capsule and the globus pallidus. It consists of the following:

Grey Matter

1. The cranial ends of the red nucleus and substantia nigra extend into it.
2. Subthalamic nucleus.
3. Zona incerta.

White Matter

1. Cranial ends of lemnisci, lateral to the red nucleus.
2. Dentatothalamic tract along with the rubrothalamic fibres.
3. Ansa lenticularis (ventral).
4. Fasciculus lenticularis (dorsal).
5. Subthalamic fasciculus (intermediate fibres).

BASAL NUCLEI

The basal nuclei are subcortical, intracerebral masses of grey matter forming important parts of the extrapyramidal system.

1. The ***corpus striatum,*** which is partially divided by the internal capsule into two nuclei: (a) The ***caudate nucleus,*** (b) The ***lentiform nucleus.***
2. The ***amygdaloid body*** forms a part of the limbic system.
3. ***Claustrum.***

CORPUS STRIATUM

Corpus striatum comprises the caudate nucleus and lentiform nucleus.

Caudate Nucleus

It is a C-shaped or comma-shaped nucleus which is surrounded by the lateral ventricle. The concavity of‘C’ encloses the thalamus and the internal capsule.

The nucleus has a head, a body, and a tail

The ***head*** forms the floor of the anterior horn of the lateral ventricle

The ***body*** forms the floor of the central part of the lateral ventricle

The tail forms the roof of the inferior horn of the lateral ventricle, and ends by joining the amygdaloid body at the temporal pole.

Lentiform Nucleus

This is a large lens-shaped (biconvex) nucleus, forming the lateral boundary of the internal capsule. It lies beneath the insula and the claustrum.

The lentiform nucleus is divided into two parts by a thin lamina of white matter.

The larger lateral part is called the ***putamen.*** Structurally, it is similar to the caudate nucleus and contains small cells.

The smaller medial part is called the ***globus pallidus.*** It is made up of large (motor) cells.

Connections of Corpus Striatum

The caudate nucleus and putamen are afferent nuclei, while the globus pallidus is the efferent nucleus, of the corpus striatum. The connections are shown in Table 28.4.

Functions of Corpus Striatum

1. The corpus striatum regulates muscle tone and thus helps in smoothening voluntary movements.

Table 28.4: Connections of the corpus striatum

Nucleus	Afferents	Efferents
A. Caudate nucleus an d putamen	From: 1. Cerebral cortex (ar eas 4 and 6) 2. Thalamus (medial, intralaminar and mi dline nuclei)	Chiefly to globus palli dus, but also to substan tia nigra and thalamus

	3. Substantia nigra	
B. Globus pallidus	Mainly from: 1. Caudate nucleus 2. Putamen Also from: 1. Thalamus 2. Subthalamic nucleus 3. Substantia nigra	Efferents from three bundles, namely: 1. Ansa lenticularls, ventrally 2. Fasciculus lenticularis, dorsally 3. Subthalamic fasciculus from the middle part of the globus pallidus These bundles terminate in the following: (a) Thalamus (b) Hypothalamus (c) Subthalamic nucleus (d) Red nucleus (e) Olivary nucleus (f) Substantia nigra (g) Reticular nuclei

2. It controls automatic associated movements, like the swinging of arms during walking. Similarly, it controls the coordinated movements of different parts of the body for emotional expression.
3. It influences the precentral motor cortex which is supposed to control the extrapyramidal activities of the body.

WHITE MATTER OF CEREBRUM

The fibres are classified into three groups: association fibres, commissural fibres, and projection fibres.

ASSOCIATION (ARCUATE) FIBRES

These are the fibres which connect different cortical areas of the same hemisphere to one another. These are subdivided into the following two types.

Short association fibres connect adjacent gyri to one another.

Long association fibres connect more widely separated gyri to one another. Some examples are

1. The ***uncinate fasciculus,*** connecting the temporal pole to the motor speech area and to the orbital cortex.
2. The ***cingulum,*** connecting the cingulate gyrus to the parahippocampal gyrus.
3. The ***superior longitudinal fasciculus,*** connecting the frontal lobe to occipital and temporal lobes.
4. The ***inferior longitudinal fasciculus,*** connecting the occipital and temporal lobes.

COMMISSURAL FIBRES

These are the fibres which connect corresponding parts of the two hemispheres. They constitute the commissures of the cerebrum. They are

1. The ***corpus callosum*** connecting the cerebral cortex of the two sides.
2. The ***anterior commissure*** connecting the archipallia (olfactory bulbs, piriform area.
3. The ***posterior commissure*** connecting the superior colliculi.
4. The ***commissure of the fornix (hippocampal commissure)*** connecting the crura of the fornix and thus the hippocampal formations of the two sides.

Corpus Callosum

The corpus callosum is the largest commissure of the brain. It connects the two cerebral hemispheres. Since it is the neopallial commissure, it attains enormous size in man (10 cm long).

Parts of Corpus Callosum

1. The ***genu*** is the anterior end. It lies 4 cm behind the frontal pole.
2. The ***rostrum*** is directed downwards and backwards from the genu, and ends by joining the lamina terminalis, in front of the anterior commissure.
3. The ***trunk*** or body is the middle part, between the genu and the splenium. Its ***superior surface*** is convex from before backwards and concave from side to side.
4. The ***splenium*** is the posterior end forming the thickest part of the corpus callosum. It lies 6 cm in front of the occipital pole.

Fibres of Corpus Callosum

1. The rostrum connects the orbital surfaces of the two frontal lobes.
2. The ***forceps minor*** is made up of fibres of the genu that connect the two frontal lobes.
3. The ***forceps major*** is made up of fibres of the splenium connecting the two occipital lobes.
4. The ***tapetum*** is formed by some fibres from the trunk and splenium of the corpus callosum. The tapetum forms the roof and lateral wall of the posterior horn, and the lateral wall of the inferior horn of the lateral ventricle.

PROJECTION FIBRES/INTERNAL CAPSULE

Gross Anatomy

The internal capsule is a large band of fibres, situated in the inferomedial part of each cerebral hemisphere. In horizontal sections of the brain, it appears V-shaped with its concavity directed laterally. The concavity is occupied by the lentiform nucleus (Fig. 28.4).

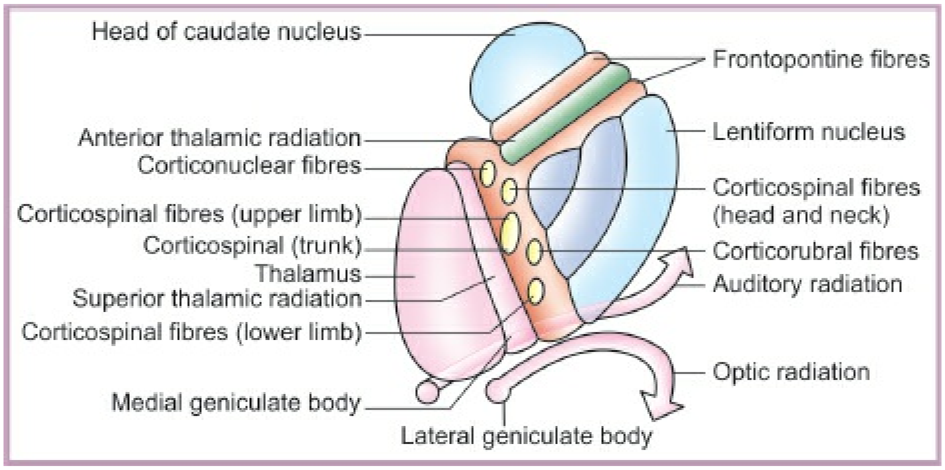


Fig. 28.4: Boundaries and parts of internal capsule.

When traced ***upwards,*** the fibres of the capsule diverge and are continuous with the corona radiata. When traced ***downwards,*** its fibres converge and many of them are continuous with the crus cerebri of the midbrain.

The internal capsule is divided into the following parts.

1. The ***anterior limb*** lies between the head of the caudate nucleus and the lentiform nucleus.
2. The ***genu*** is the bend between the anterior and posterior limbs.
3. The ***posterior limb*** lies between the thalamus and the lentiform nucleus.
4. The ***retrolentiform part*** lies behind the lentiform nucleus.
5. The ***sublentiform part*** lies below the lentiform nucleus. It can be seen in a coronal section, whereas the rest of the parts are seen in a horizontal section.

Fibres of Internal Capsule

See Table 28.5.

Table 28.5: Fibres in the internal capsule

Part	Descending tracts	Ascending tracts	Arterial supply
Anterior limb	Frontopontine fibres (a part of the corticoponto-cerebellar pathway)	Anterior thalamic radiation (fibres from anterior and medial nuclei of thalamus)	Recurrent branch of anterior cerebral Direct branches from anterior cerebral
Genu	Corticonuclear fibres (a part of the pyramidal tract going to motor nuclei of cranial nerves and forming their supranuclear pathway	Anterior part of the superior thalamic radiation (fibres from posterior ventral nucleus of thalamus)	Direct branches from internal carotid Posterior communicating
Posterior limb	1. Corticospinal tract (pyramidal tract for the upper limb, trunk and lower limb) 2. Corticopontine fibres 3. Corticorubral fibres	1. Superior thalamic radiation 2. Fibres from globus pallidus to subthalamic nucleus	Lateral striate branches of middle cerebral Medial striate branches of Middle cerebral Anterior choroidal
Retrolentiform part	1. Parietopontine and occipitopontine fibres 2. Fibres from occipital cortex to superior colliculus and pretectal region	Posterior thalamic radiation made up of: 1. Mainly optic radiation 2. Partly fibres connecting thalamus to the parietal and occipital lobes	Branches of posterior cerebral
Sublentiform part	1. Parietopontine and temporopontine fibres 2. Fibres between temporal lobe and thalamus	Auditory radiation Fibres connecting thalamus to temporal lobe	Branches of posterior cerebral Anterior choroidal

Blood Supply

The arteries supplying different parts of the internal capsule are depicted in Fig. 28.5.

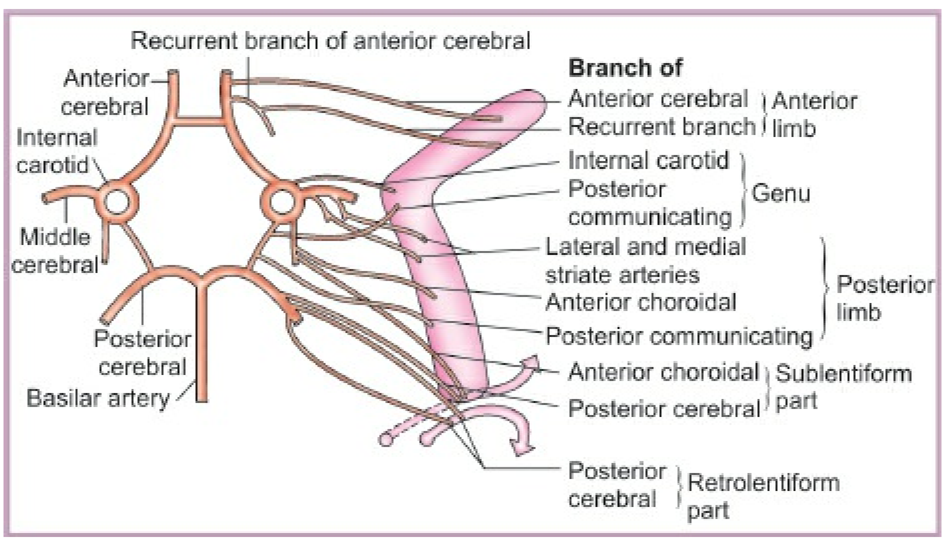


Fig. 28.5: Arteries supplying the internal capsule.

CLINICAL ANATOMY

Cerebral Cortex

- Motor areas

(a) Destructive lesion of primary motor area (area 4) results in voluntary paresis of the affected part of body. Spastic voluntary paralysis of the opposite side of body characteristically, follows if the lesion spreads beyond area 4 or that interrupts projection fibres in the medullary centre or internal capsule. Irritative lesion of the motor area leads to focal convulsive movements of the corresponding part of body, referred to as Jacksonian epilepsy.

(b) ***Lesion of supplementary motor area (area 6) leads to apraxia:*** This is the condition which involves difficulty in performing the skilled movements once learnt, in absence of paralysis, ataxia or sensory loss. When the disability affects writing it is called agraphia.

(c) ***Frontal eyefield:*** Destruction of this area causes conjugate deviation of the eyes towards the side of lesion. The patient cannot voluntarily move his eyes in the opposite direction, but this movement occurs involuntarily when he observes an object moving across the field of vision.

(d) ***Speech area:*** Lesion of Broca's area on the dominant side of hemisphere causes expressive aphasia. It is characterised by hesitant and distorted speech with relatively good comprehension.

(e) A lesion involving language areas that is Wernicke's area and Broca's area both leads to receptive aphasia. In this condition, auditory and visual comprehension of language that is naming of objects and repetition of a sentence spoken by the examiner are all defective.

(f) A lesion involving Wernicke's area and superior longitudinal fasciculus or arcuate fasciculus results in jargon aphasia in which speech is fluent but unintelligible jargon.

(g) Voluntary smile in a stroke patient will accentuate the asymmetry. A genuine smile which uses only extrapyramidal pathways, will be symmetrical and there will be no asymmetry for the duration of the smile. One needs to remember that motor cortex is required only for voluntary moment.

- ***Sensory areas***

  (a) First somesthetic or general sensory area (areas 3, 1 and 2 of Brodmann). When this part of cortex is the site of destructive lesion, a crude form of awareness persists for the sensation of pain, heat and cold on the opposite side of lesion. There is poor localization of stimulus. There is loss of discriminative sensations of fine touch and movements and position of part of the body.

  (b) Somesthetic association cortex (superior parietal lobule) area 5 and 7 of Brodmann. A lesion in this area leads to defect in understanding the significance of sensory information, which is called agnosia. A lesion that destroys a large portion of this association cortex causes tactile agnosia and astereognosis which are closely related. This is the condition when a person is unable to recognize the objects held in the hand, while the eyes are closed. He is unable to correlate the surface texture, shape, size and weight of the object or to compare the sensations with previous experience.

- ***Special sensory areas***

  (a) Primary visual area (area 17) lesion of this area, leads to loss of vision in the visual field of the opposite side—homonymous hemianopia.

  (b) Auditory area

    - Primary auditory area (areas 41 and 42): A unilateral lesion involving the auditory area causes diminution in the acuity of hearing in both ears and the loss is greater in the opposite ear. However, the impairment is slight because of the bilateral projection to the cortex and the deficit is difficult to detect by clinical tests.

    - Auditory association cortex or secondary area (area 22). In lesions of this area, interpretation of the sounds is lost.

Table 28.6: Summary of functions and effects of damage of lobes of brain

Lobar functions	Functions	Effects of damage
Frontal	Personality, emotional control, social behavi our, contralateral mot or control, language, micturition	Lack of initiation, anti social behaviour, impa ired memory and inco ntinence
Parietal lobe (non-do minant)	Spatial orientation, re cognition of faces, ap preciation of music	Spatial disorientation, non-recognition of fac es
Parietal lobe (domina nt)	Language, calculation , analytical, logical, ge ometrical	Dyscalculia, dyslexia, apraxia (inability to d o complex movements) agnosia (inability to recognize)
Temporal (non-domin ant)	Auditory perception, pitch perception, non-verbal memory, smell, balance	Reception aphasia, im paired musical skills
Temporal (dominant)	Language, verbal me mory, auditory percep tion	Dyslexia, verbal mem ory impaired, receptiv e aphasia
Occipital	Visual processing	Visual loss, visual agn osia.

- Table 28.6 depicts summary of functions and effects of damage of lobes of brain.
- ***Ageing:*** Usually after 60-70 years or so there are changes in the brain. These are
  - (a) Prominence of sulci due to cortical shrinkage
  - (b) The gyri get narrow and sulci get broad
  - (c) The subarachnoid space becomes wider. There is enlargement of the ventricles
- ***Dementia:*** In this condition, there is slow and progressive loss of

memory, intellect and personality. The consciousness of the subject is normal. Dementia usually occurs due to Alzheimer's disease.

- ***Alzheimer s disease:*** The changes of normal ageing are pronounced in the parietal lobe, temporal lobe, and in the hippocampus.

Diencephalon

- Lesions of the thalamus cause impairment of all types of sensibilities; joint sense (posture and passive movements) being the most affected.
- The thalamic syndrome is characterized by disturbances of sensations, hemiplegia, or hemiparesis together with hyperaesthesia and severe spontaneous pain. Pleasant as well as unpleasant sensations or feelings are exaggerated.
- Lesions of the hypothalamus give rise to one of the following syndromes.
  - (a) Obesity. Frolich's syndrome, or Laurence-Moon-Biedl syndrome
  - (b) Diabetes insipidus
  - (c) Diencephalic autonomic epilepsy. This is characterized by flushing, sweating, salivation, lacrimation, tachycardia, retardation of respiratory rate, unconsciousness, etc.
  - (d) Sexual disturbance. Either precocity or impotence
  - (e) Disturbance of sleep. Somnolence (persistent sleep), or narcolepsy (paroxysmal sleep)
  - (f) Hyperglycaemia and glycosurea
  - (g) Acute ulcerations in the upper part of the gastrointestinal tract
- Discrete lesions of the subthalamic nucleus result in hemiballismus characterised by involuntary choreiform movements on the opposite side of the body. The condition is abolished by ablation of the globus pallidus or of its efferent tracts, the anterior ventral nucleus of the thalamus, area 4 of the cerebral cortex, or of the corticospinal tract. From these facts, it appears that the subthalamic nucleus has an inhibitory control on the globus pallidus and on the cerebral cortex.

Basal Ganglia

- Lesions of basal ganglia and cerebellum do not cause paralysis. These produce abnormal movements or posture or changes in tone.
- ***Parkinsonism:*** Lesions of corpus striatum leads to parkinsonism. Its features are as follows.

  (a) Hypertonicity or lead pipe rigidity

  (b) Loss of automatic associated movements and also of facial expression

  (c) Involuntary movements like tremors, choreiform movements, athetoid movements

  (d) Continuous writhing movements of trunk and limbs may continue even in sleep. Voluntary movements may be impossible.
- ***Chorea:*** Chorea means dancing. Chorea is form of involuntary movement characterised by fine random movements of hands and feet. These movements are rather disorganized.

  This occurs due to disease of caudate nucleus.
- ***Athetosis:*** It is a form of movement which is slow repetitive and writhing in nature. It is due to lesion of putamen.
- ***Ballismus:*** This is characterized by irregular movements of trunk, girdles and both the limbs. It is due to disease of subthalamic nucleus.
- L-dopa (a precursor of dopamine) is used as a replacement therapy in parkinsonism because dopamine, the normal neurotransmitter in the striatum, is reduced in these cases. The nigrostriate fibres are considered important in the genesis of parkinsonism tremor, since its neurons utilize dopamine in the neuro-transmission.

  Neurosurgically, palidectomy and thalamodectomy have been used with success to control the contralateral tremors in different types of disease of corpus striatum.

Internal Capsule

- Lesions of the internal capsule are usually vascular, due to involvement of the medial and lateral striate branches of the middle cerebral artery. They give rise to hemiplegia on the opposite half of the body (paralysis of one half of the body, including the face).

It is an upper motor neuron type of paralysis. The larger lateral striate artery is called “Charcot’s artery of cerebral haemorrhage”.

- Thrombosis of the recurrent branch of the anterior cerebral artery gives rise to an upper motor neuron type of paralysis of the opposite upper limb and of the face.
- A lesion in the genu of the internal capsule would produce sensory and motor loss in the contralateral side of the head. This may not be complete since there is bilateral cortical innervation of most cranial nerve nuclei.

29. Third Ventricle, Lateral Ventricles and Limbic System

THIRD VENTRICLE

The third ventricle is a median cleft between the two thalami.

Communications

Posteroinferiorly, in the median plane, it communicates with the fourth ventricle through the cerebral aqeduct.

Recesses

Recesses are extensions of the cavity. These are

(a) Suprapineal

(b) Pineal

(c) Infundibular

(d) Optic

Boundaries

The third ventricle lies between the two thalami. The components of its boundaries and recesses are enumerated:

Anterior wall: Lamina terminalis, anterior commissure, anterior column of fornix.

Posterior wall: Pineal body, cerebral aqueduct.

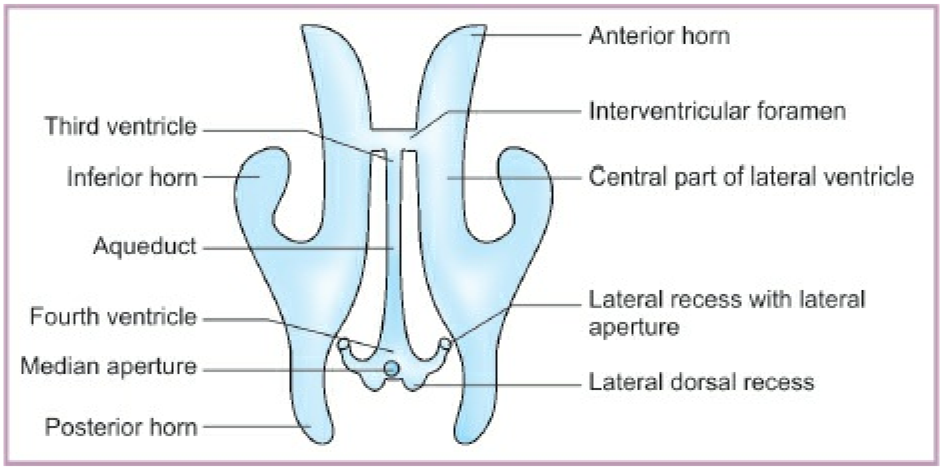


Fig. 29.1: Ventricles of brain (superior view).

Floor: Optic chiasma, tubercinerium, infundibulum, mammillary body, posterior perforated substance, tegmentum of midbrain.

Roof: Ependyma, tela choroidea.

Lateral wall: Medial surface of thalamus, medial aspect of hypothalamus, epithalamus, interventricular foramen.

Recesses: Infundibular recess, optic recess, pineal recess, suprapineal recess.

LATERAL VENTRICLE

The lateral ventricle comprises a central body and three horns—anterior, posterior and inferior. Their wall are enumerated.

Body or Central Part

Roof: Trunk of corpus callosum.

Floor: Superior surface of thalamus, thalamostriate vein, stria terminalis, body of caudate nucleus.

Medial: Septum pellucidum, body of fornix.

Anterior Horn

Roof: Anterior part of trunk of corpus callosum.

Anterior: Genu and rostrum of corpus callosum.

Floor: Head of caudate nucleus.

Medial wall: Septum pellucidum and column of fornix.

Posterior Horn

Roof and lateral wall: Tapetum of corpus callosum.

Medial wall: Bulb of posterior horn above and calcar avis below.

Inferior Horn

Roof and lateral wall: Tapetum, tail of caudate nucleus, stria terminalis, amygdaloid nucleus.

Floor: Pes hippocampus, hippocampus, alveus, fimbria, dentate gyrus, collateral eminence.

LIMBIC SYSTEM

Constituent Parts

1. Olfactory nerves, bulb, tract, striae and trigone.
2. Anterior perforated substance.
3. Pyriform lobe, consisting of the uncus, the anterior part of the parahippocampal gyrus, and few small areas in the region.
4. Posterior part of the parahippocampal and cingulate gyri.
5. Hippocampal formation, including the hippocampus, the dentate gyrus, indusium griseum and longitudinal striae.
6. ***Amygdaloid nuclei:*** It is a part of limbic system. Amygdala evokes anxiety and rage. Its afferents are from olfactory area and from cerebral cortex. Its efferent pass via stria teπninalis and also go to uncus. Injury to amygdala causes placity, orality and hypersexuality
7. Septal region
8. Fomix, stria teπninalis, stria habenularis, anterior commissure.

Functions

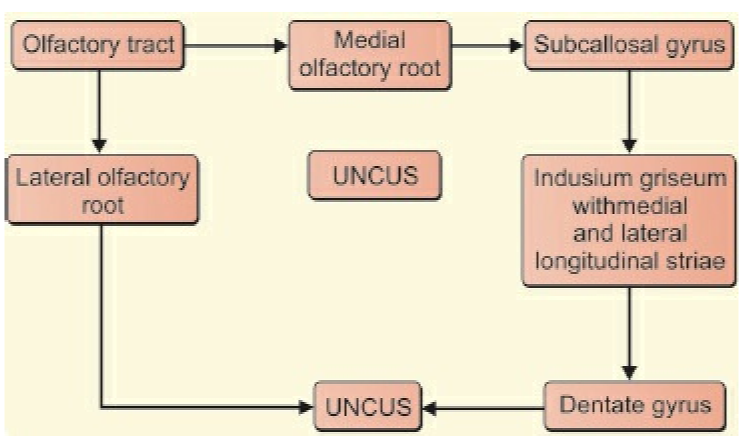
1. It controls food habits necessary for survival of the individual.

2. It controls sex behaviour necessary for survival of the species.
3. It controls emotional behaviour expressed in form of joy and soπow, fear, fight and friendship, liking and disliking, associated with a variety of somatic and autonomic bodily alterations. This requires integration of olfactory, somatic and visceral impulses reaching the brain.

Following are the terms with their components related to limbic system.

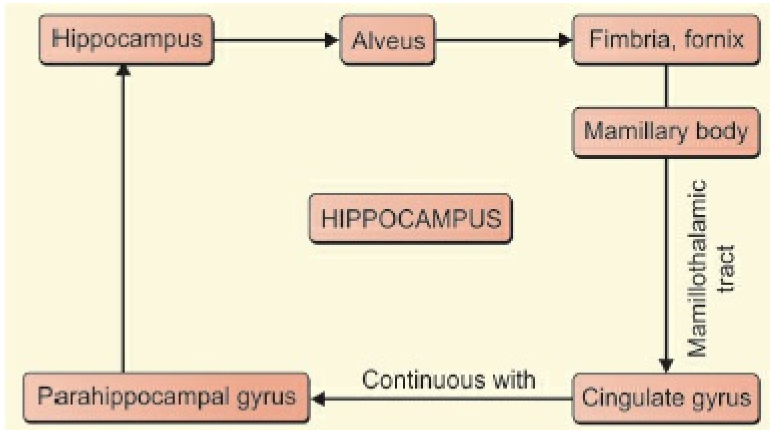
1. ***Rhinencephalon:*** It comprises the following:
   (i) Olfactory mucosa
   (ii) Olfactory bulb
   (iii) Olfactory tract—3 roots:
      (a) Medial root ends in subcallosal or parolfactory gyrus (Flow chart 29.1a).
      (b) Intermediate root ends in anterior perforated substance and diagonal band of Broca.
      (c) Lateral, olfactory, root ends in pyriform lobe (uncus, anterior part of parahippocampal gyrus, cortex in region of limen insulae, dorsomedial part of amygdaloid nucleus).

Flow chart 29.1a: Olfactory tracts



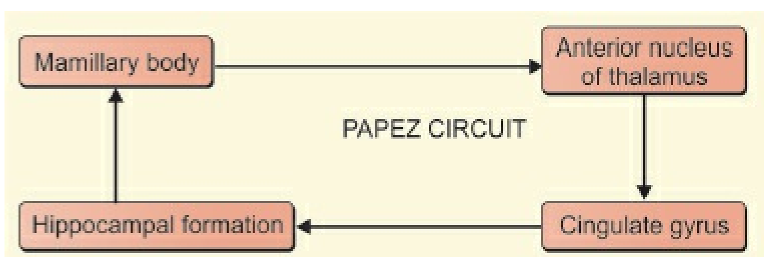
2. ***Limbic lobe:*** Hippocampus, parahippocampal gyrus, cingulate gyrus, subcallosal gyrus, amygdala. These are non-neocortical structures.
3. ***Hippocampal formation:*** Hippocampus, dentate gyrus, part of parahippocampal gyrus (Flow chart 29.1b).

Flow chart 29.1b: Hippocampus



4. ***Limbic system:*** This is a functioning group. It includes hypothalamus, some nuclei of thalamus, tectum of midbrain, frontal lobe, insular cortex. These are all concerned with emotional states and behaviour.
5. ***Connecting pathways:*** Alveus, fimbria, fornix mamillary body, mamillothalamic tract, stria terminalis.
6. ***Papez circuit:*** It interconnects limbic structures, hippocampus, fornix, mamillary body, mamillo-thalamic tract, anterior nucleus of thalamus, cingulate gyrus, cingulum, parahippocampal gyrus (Flow chart 29.1c).

Flow chart 29.1c: Papez circuit



CLINICAL ANATOMY

- The third ventricle is a narrow space which is easily obstructed by local brain tumours or by developmental defects. The obstruction leads to raised intracranial pressure in adults and hydrocephalus in infants.
- Tumours in the lower part of the third ventricle give rise to hypothalamic symptoms, like diabetes insipidus, obesity, sexual

disturbance, disturbance of sleep, hyperglycaemia and glycosurea.

- The site of obstruction can be found out by CT scan/MRI (magnetic resonance imaging) scans, where, the third ventricle is seen, normally, as a narrow, vertical midline shadow. Dilatation of the third ventricle would indicate obstruction at a lower level, e.g. the cerebral aqueduct. If the obstruction is in the third ventricle, both the lateral ventricles are dilated symmetrically. Obstruction at an interventricular foramen causes unilateral dilatation of the lateral ventricle of that side.
- Hippocampus can be regarded as the cortical centre for autonomic reflexes. Hippocampal-amygdala complex is related to the memory of recent events. Lesions of this complex are associated with a loss of memory for recent events only. Patient is unable to commit any new facts to memory and does not remember recent events. In spite of this, his general intelligence remains unaltered.
- Destruction of olfactory nerves results in loss of the sense of smell (anosmia).
- A tumour, usually a meningioma, in the floor of anterior cranial fossa may interfere with the sense of smell because of pressure on olfactory bulb and the olfactory tract. It is necessary to test each nostril separately because the olfactory loss is likely to be unilateral.
- A lesion that affects the uncus and amygdaloid body may cause, “uncinate fits” characterised by an imaginary disagreeable odour, by movements of lips and tongue, and often by a “dreamy state”.

30. Blood Supply of Spinal Cord and Brain

BLOOD SUPPLY OF SPINAL CORD

The spinal cord receives its blood supply from three longitudinal arterial channels that extend along the length of the cord. The *anterior spinal artery* is present in relation to the anterior median sulcus. Two posterior spinal arteries (one on each side) run along the posterolateral sulcus (i.e. along the line of attachment of the dorsal nerve roots). In addition to these channels, the pia mater covering the spinal cord has an arterial plexus (called the *arteria vasocorona)* which also sends branches into the substance of the cord (Fig. 30.1).

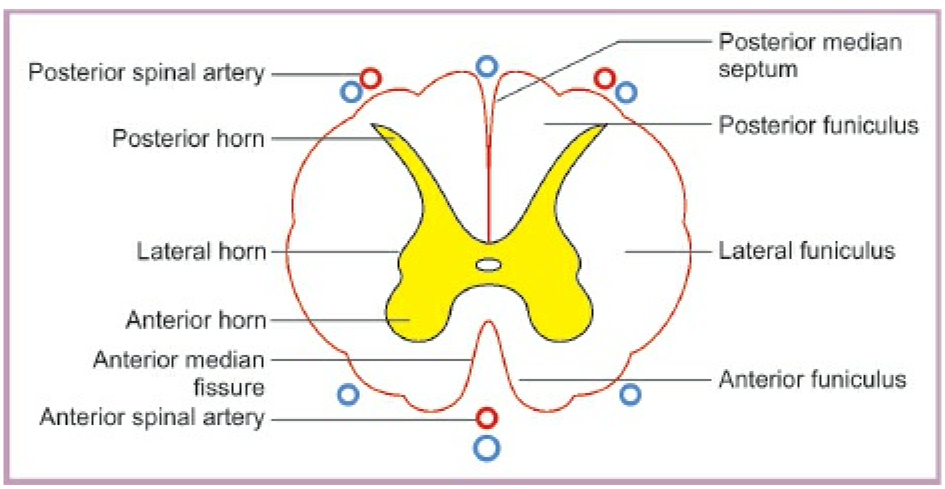


Fig. 30.1: Blood supply of spinal cord.

The main source of blood to the spinal arteries is from the vertebral arteries (from which the anterior and posterior spinal arteries take origin). However, the blood from the vertebral arteries reaches only up to the cervical segments of the cord. The spinal arteries also receive blood through radicular arteries that reach the cord along the roots of spinal nerves. These radicular arteries arise from spinal branches of the vertebral, ascending cervical, deep cervical, intercostal, lumbar and sacral arteries.

Many of these radicular branches are small and end by supplying the nerve roots. A few of them, which are larger, contribute blood to the spinal arteries. Frequently, one of the anterior radicular branches is very large and is called the ***arteria radicularis magna.*** Its position is variable. This artery may be responsible for supplying blood to as much as the lower two-thirds of the spinal cord.

The veins draining the spinal cord are arranged in the form of six longitudinal channels. These are anteromedian and posteromedian channels that lie in the midline; and anterolateral and posterolateral channels that are paired. These channels are interconnected by a plexus of veins that form a venous vasocorona. The blood from these veins is drained by radicular veins that open into a venous plexus lying between the dura and the vertebral canal (epidural or internal vertebral plexus) and through it into various segmental veins.

ARTERIES OF BRAIN

See Table 30.1.

Table 30.1: Arteries of brain

1. **Vertebral artery a branch of 1st part of subclavian artery is divide d into four part**
   (a) ***First part:*** Lies deep in the neck in the vertebral triangle; gives no branches.
   (b) ***Second part:*** Passes in the foramen transversaria of C6-C1 verteb rae; gives spinal branches for supply of meninges and spinal cord (Fig. 30.2).
   (c) ***Third part:*** Lies in the suboccipital triangle, on the posterior arch of atlas vertebra and gives branches to muscles of suboccipital trian gle.

(d) ***Fourth part:*** Enters the cranial cavity through foramen magnum. Joins with the same artery of opposite side to form basilar artery at the lower border of pons. The fourth part gives

   (i) Meningeal branches
   (ii) Posterior spinal artery
   (iii) Anterior spinal artery
   (iv) Posterior inferior cerebellar artery
   (v) Medullary branches.

2. Right and left vertebral arteries unite at the lower border of the po ns to form a median basilar artery, which gives following branches :

(a) Anterior inferior cerebellar
(b) Pontine branches
(c) Labyrinthine branches
(d) Superior cerebellar
(e) Posterior cerebral

3. Internal Carotid Artery

(a) Cervical part gives no branches.
(b) Petrous part gives
   (i) Caroticotympanic for the middle ear, and
   (ii) Pterygoid branch.
(c) Cavernous part gives branches to
   (i) Trigeminal ganglion and
   (ii) Superior and inferior hypophyseal branches.
(d) Cerebral part gives following branches:
   (i) Ophthalmic artery which supplies outer two layers of eyeball andthrough central artery of retina (end artery), the retina.
   (ii) Anterior cerebral
   (iii) Middle cerebral

(iv) Posterior communicating

(v) Anterior choroidal

4. **Circle of Willis**

Circle of Willis is formed by union of posterior cerebral of vertebral art eryand posterior communicating branch of internal carotid arteries on e achside (Fig. 30.3). It gives

(a) ***Central branches:*** These are long thin, numerus end arteries with supplydeeper structures like internal capsule and basal ganglia.

(b) ***Choroidal branches*** of internal carotid and posterior cerebral sup plychoroid plexuses of the ventricles.

(c) ***Cortical branches:*** These are

(i) *Anterior cerebral:* Chief artery on the medial surface of cereb ralhemisphere till parieto-occipital sulcus. It also supplies one cm.wide area on the superolateral surface, along the superome dialborder. The area includes motor and sensory areas of lowe r limband perineum (Fig. 30.4).

(ii) *Middle cerebral:* Main artery of the superolateral surface supp lyingmajor parts of motor and sensory areas. It also supplies motorspeech area, auditory and vestibular areas (Fig. 30.5).

(iii) *Posterior cerebral:* Chief artery of the tentorial surface and oc cipitallobe. This is the artery of visual cortex (Fig. 30.6).

CLINICAL ANATOMY

- Anterior spinal artery supplies anterior two-thirds while posterior spinal artery supplies posterior one-third of spinal cord. Posterior column gets affected in posterior spinal artery thrombosis. Anterolateral columns get affected in anterior spinal artery thrombosis.
- Hemiplegia is a common condition. It is an upper motor neuron type of paralysis of one-half of the body, including the face. It is usually due to an internal capsule lesion caused by thrombosis of one of the lenticulostriate branches of middle cerebral artery (cerebral thrombosis).

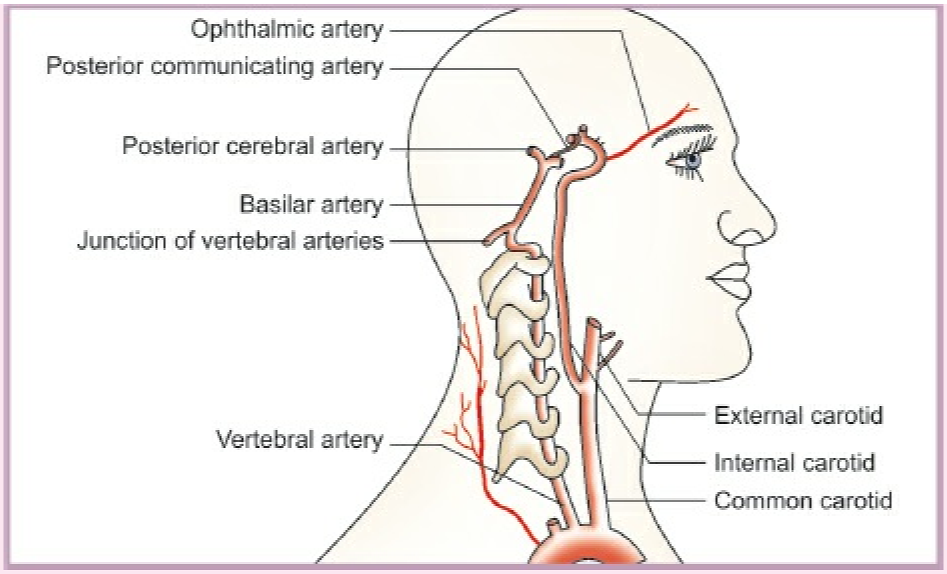


Fig. 30.2: Arteries of brain.

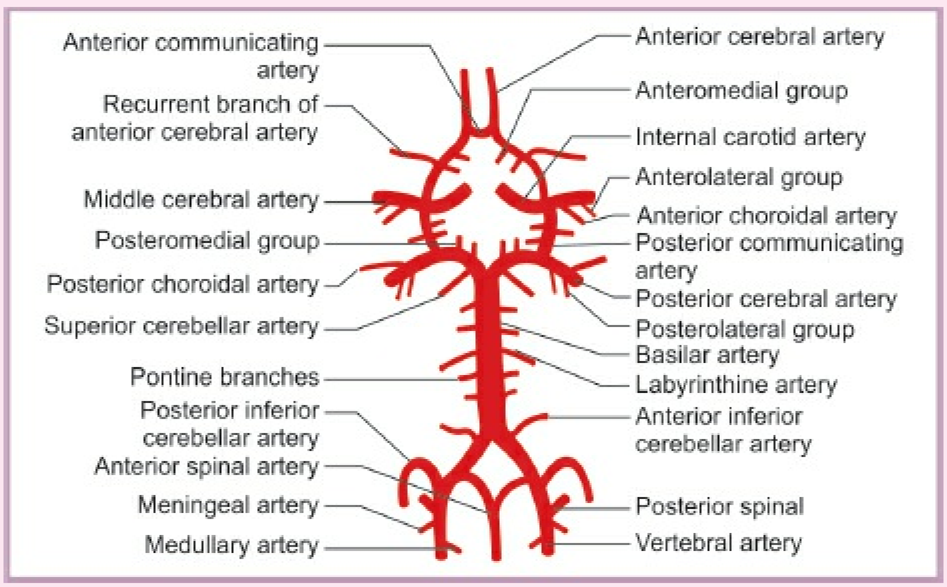


Fig. 30.3: Circle of Willis and the branches of arteries supplying the brain.

One of the lenticulostriate branches is most frequently ruptured (cerebral haemorrhage); it is known as Charcot's artery of cerebral haemorrhage. This lesion also produces hemiplegia with deep coma, and is ultimately fatal.

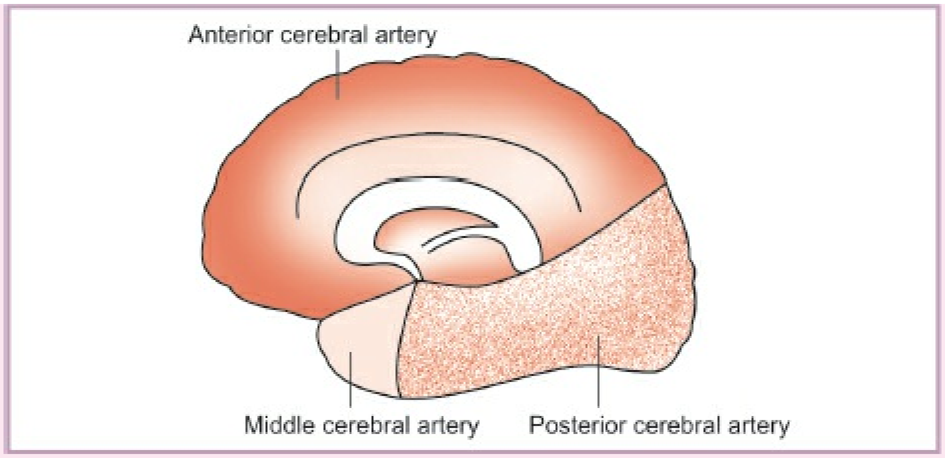


Fig. 30.4: Arterial supply of medial and tentorial surfaces of cerebral hemisphere.

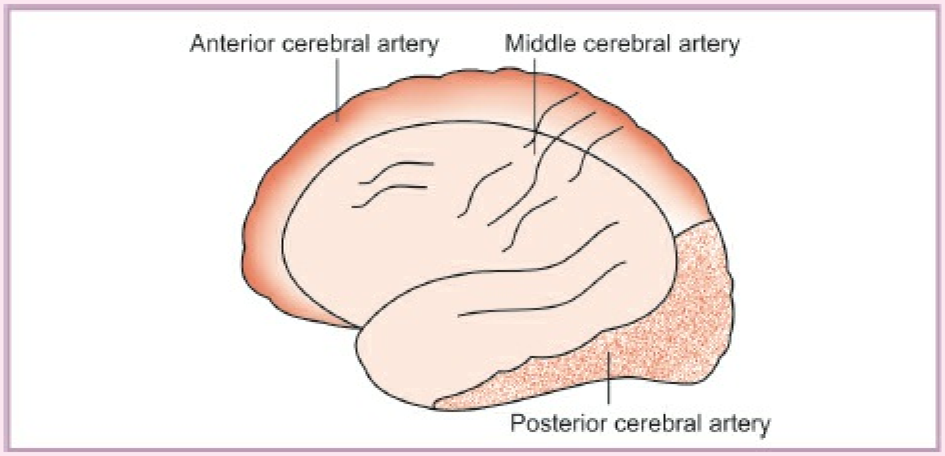


Fig. 30.5: Arterial supply of superolateral surface of cerebral hemisphere.

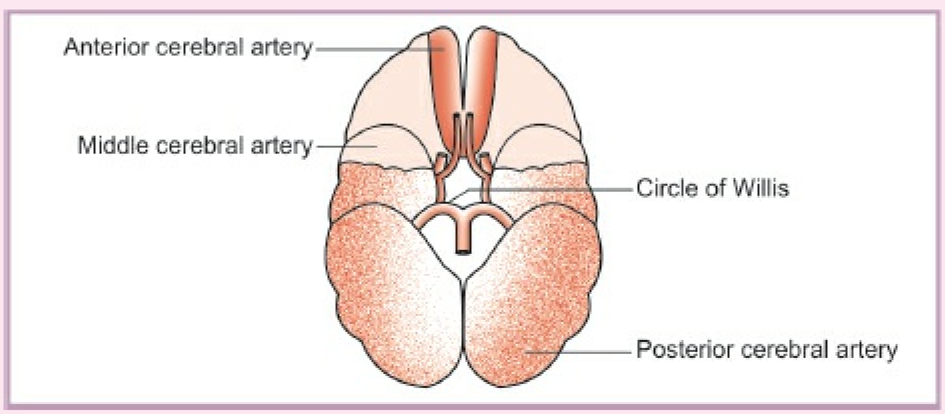


Fig. 30.6: Arterial supply of inferior surface of cerebral hemisphere.

- Thrombosis of Heubner's recurrent branch of the anterior cerebral artery causes contralateral upper monoplegia.
- Occlusion proximal to the anterior communicating artery is normally well tolerated because of the cross flow.

  Distal occlusion results in weakness and cortical sensory loss in the contralateral lower limb with associated incontinence.
- Thrombosis of the paracentral artery (terminal cortical branch of the anterior cerebral artery) causes contralateral lower limb monoplegia.
- Thrombosis of lateral striate branches of middle cerebral artery causes motor and sensory loss to the opposite side of body.
- Thrombosis of posterior cerebral artery results in homonymous hemianopia on the opposite side.
- Thrombosis of superior cerebellar artery results in loss.

  (a) Cerebellum: Disturbed gait, limb ataxia

  (b) Brainstem: Ipsilateral Homer's syndrome

  Contralateral sensory loss—pain and temperature (including face).
- Damage to anterior inferior cerebellar artery results.

  (a) Cerebellum: Ipsilateral limb ataxia

  (b) Brainstem: Ipsilateral—Homer's syndrome

  Sensory loss—pain and temperature of face

  Facial weakness and paralysis of lateral gaze

  Contralateral sensory loss—pain and temperature of limbs and trunk.
- Thrombosis of posterior inferior cerebellar artery causes damage as under:

  (a) Cerebellum: Dysarthria, ipsilateral limb ataxia, vertigo and nystagmus (due to damage to vestibulo-floccular connections).

  (b) Brainstem: Ipsilateral—Homer's syndrome
  Sensory loss—pain and temperature of face
  Pharyngeal and laryngeal paralysis.

  Contralateral sensory loss—pain and temperature of limbs and trunk.
- Pontine haemorrhage is characterized by:

(a) Paralysis (contralateral hemiplegia)

(b) Deep coma

(c) Hyperpyrexia

(d) Pinpoint pupil: It is invariably fatal

- ***Anastomotic and end arteries:*** In the circle of Willis, the blood in the three communicating arteries is normally static. Following occlusion of one of the three large arteries contributing to the circle, the other two compensate more or less completely, via communicating arteries. With occlusion of one internal carotid, the other internal carotid may perfuse both anterior cerebral arteries. With occlusion of basilar, each posterior cerebral artery may be perfused by the internal carotid of its own side.

  Further anastomosis occur between cortical branches of cerebral arteries, prior to perforation of the branches into brain substance. Once the cortical and central branches perforate, they become end arteries hardly communicating at capillary level.

- Cerebral vascular disease is quite common in old age and manifest in different ways.

  (a) Haemorrhage—cortical or subcortical

  (b) Thrombosis

  (c) Embolism

- Hypertensive encephalopathy is a manifestation of sustained elevation of diastolic blood pressure in the form of multiple diffuse small lesions distributed all over, result in a variegated picture of the circle of Willis (berry aneurysm).
- The arteries of the brain are supplied with sympathetic nerves which run on to them from carotid and vertebral plexuses. They are extremely sensitive to injury and readily react by passing into prolonged spasms. This by itself may be sufficient to cause damage to brain tissue since even the least sensitive neurons cannot withstand absolute loss of blood supply for a period more than 5-7 minutes.

2. Appendix

SUMMARY OF THE VENTRICLES OF THE BRAIN

Lateral Ventricle

The lateral ventricle comprises a central body and three horns—anterior, posterior and inferior. Their wall are enumerated.

Body or Central Port

Roof: Trunk of corpus callosum.

Floor: Superior surface of thalamus, thalamostriate vein, stria terminalis, body of caudate nucleus.

Medial: Septum pellucidum, body of fornix.

Anterior Horn

Roof: Anterior part of trunk of corpus callosum.

Anterior: Genu and rostrum of corpus callosum.

Floor: Head of caudate nucleus.

Medial wall: Septum pellucidum and column of fornix.

Posterior Horn

Roof and lateral wall: Tapetum of corpus callosum.

Medial wall: Bulb of posterior horn above and calcar avis below.

Inferior Horn

Roof and lateral wall: Tapetum, tail of caudate nucleus, stria terminalis, amygdaloid nucleus.

Floor: Pes hippocampus, hippocampus, alveus, fimbria, dentate gyrus, collateral eminence.

Third Ventricle

The third ventricle lies between the two thalami. The components of its boundaries and recesses are enumerated:

Anterior wall: Lamina terminalis, anterior commissure, anterior column of fornix.

Posterior wall: Pineal body, cerebral aqueduct.

Floor: Optic chiasma, tubercinerium, infundibulum, mamillary body, posterior perforated substance, tegmentum of midbrain.

Roof: Ependyma, tela choroidea.

Lateral wall: Medial surface of thalamus, medial aspect of hypothalamus, epithalamus, interventricular foramen.

Recesses: Infundibular recess, optic recess, pineal recess, suprapineal recess.

Fourth Ventricle

The cavity of fourth ventricle is situated dorsal to pons and upper part of medulla oblongata and ventral to the cerebellum. Its boundaries, recesses, apertures and continuations are mentioned here:

Lateral Boundaries: Gracile tubercle, cuneate tubercle inferior cerebellar peduncles, superior cerebellar peduncles.

Floor

Upper part: Facial colliculus on the dorsal surface of pons.

Intermediate part: Vestibular nuclei, medullary striae.

Lower part: Upper part of medulla oblongata containing hypoglossal and vagal triangles.

Roof: Superior medullary velum, thin sheet of pia mater and ependyma with median aperture, inferior medullary velum.

Recesses in roof: One median dorsal, two lateral dorsal and two lateral.

Apertures: One median — foramen of Magendie, two lateral — foramina of Lushka.

Continuity: Above with cerebral aqueduct

Below with central canal of spinal cord.

NUCLEAR COMPONENTS OF CRANIAL NERVES

CN I. Olfactory

Part of forebrain

CN II. Optic

Part of forebrain

CN III. Oculomotor

(a) General somatic efferent column for 5 extraocular muscles at level of superior colliculus.

(b) General visceral efferent column for 2 sets of intraocular muscles (Chart A2.1).

(c) General somatic afferent-spinal nucleus of CN V. It receives proprioceptive impulses from extraocular muscles.

Chart A2.1

Edinger-Westphal nucleus

↓
Ill nerve
↓
Nerve to inferior oblique
↓
Branch to ciliary ganglion
↓
Relay
↓
Short ciliary nerves supply ciliaris and constrictor pupillae muscles

Superior sallvatory nucleus

↓
VII nerve

↓

Chorda tympani branch via lingual nerve

↓

Submandibular ganglion

↓

Relays to supply submandibular gland directly and sublingual salivary glan d via lingual nerve

Lacrimatory nucleus

↓

VII nerve

↓

Greater petrosal nerve + deep petrosal nerve (sympathetic)

↓

Nerve of pterygoid canal

↓

pterygopalatine ganglion

↓

Relays to supply glands of nose, palate, pharynx and lacrimal fibres pass al ong zygomatic nerve

↓

Zygomaticotemporal nerve, communicating branch, lacrimal nerve to supp ly lacrimal gland

Inferior salivatory nucleus of IX nerve

↓

Tympanic branch

↓

Tympanic plexus

↓

Lesser petrosal nerve

↓

Relays in otic ganglion

↓

Fibres join auriculotemporal nerve

↓

Parotid gland

Vagus carries preganglionic fibres for the glands in respiratory system , foregut and midgut derivatives of GIT.

S2, S3, S4 preganglionic fibres relay in the ganglia in the walls of the o rgans developing from hlndgut and cloaca to supply them.

CN IV. Trochlear

(a) General somatic efferent column for supply of only superior oblique muscle at level of inferior colliculus.

(b) General somatic afferent-spinal nucleus of CN V. It receives proprioceptive impulses from the superior oblique muscle.

CN V. Trigeminal

(a) Special visceral efferent column for 4 muscles of mastication and 4 other muscles at upper level of pons

(b) General somatic afferent column:

- (i) Spinal nucleus of CN V for pain and temperature from face
- (ii) Superior sensory nucleus of CN V for touch and pressure from face
- (iii) Mesencephalic nucleus of CN V for proprioceptive impulses from extraocular muscles, muscles of tongue and mastication.

CN VI. Abducent

(a) General somatic efferent column for lateral rectus at lower level of pons.

(b) General somatic afferent-spinal nucleus of CN V. It receives proprioceptive impulses from the lateral rectus muscle.

CN VII. Facial

(a) Special visceral efferent column for muscles of facial expression at lower level of pons.

(b) General visceral efferent for lacrimal, nasal, palatal and submandibular, sublingual glands (Chart A2.1).

(c) Special visceral afferent and general visceral afferent (nucleus of tractus solitarius) for carrying taste from most of anterior two-thirds of tongue and afferents from glands supplied by it.

(d) General somatic afferent from part of skin of auricle.

CN VIII. Vestibulocochlear

Special somatic afferent colum: Two parts are as follows.

- ***Vestibular nuclei:*** Medial, superior, spinal, lateral
- ***Cochlear nuclei:*** Dorsal and ventral

All at ponto-medullary junction

CN IX. Glossopharyngeal

(a) Special visceral efferent for one muscle of larynx—the stylopharyngeus in medulla oblongata.

(b) General visceral efferent for parotid gland (Chart A2.1).

(c) Special and general visceral afferent (nucleus of tractus solitarius) for sensations of taste from posterior one-third tongue and circumvallate papillae, Also carries general sensations from posterior one-third of tongue, carotid body and carotid sinus.

(d) General somatic afferent for proprioceptive fibres from the muscle.

CN X. + CN XI. Vagus and Cranial Part of CN XI

(a) Special visceral efferent for muscles of larynx, pharynx, soft palate in medulla oblongata.

(b) Special and general visceral afferents carry (nucleus of tractus solitarius) taste from posterior most part of tongue, epiglottis and afferents from foregut and midgut derivatives.

(c) General visceral efferent for glands of respiratory system and gastrointestinal tract till right two-thirds of transverse colon.

(d) General somatic afferent from skin of external auditory meatus.

CN XI. Spinal Part of Accessory Nerve

(a) Special visceral efferent coloumn in C1-C4 ventral hom cells of spinal cord for sternocleidomastoid and trapezius.

(b) General somatic afferent-dorsal horns of C2-C4 segments of spinal cord. These receive proprioceptive impulses from the above two muscles.

CN XII. Hypoglossal

(a) General somatic efferent column for all 4 intrinsic muscles of tongue and three extrinsic muscles: Styloglossus, genioglossus andhyoglossus in medulla oblongata.

(b) General somatic afferent-spinal nucleus of CN V. It receives proprioceptive impulses from the muscles of tongue.

EFFERENT PATHWAYS OF CRANIAL PART OF PARASYMPATHETIC NERVOUS SYSTEM

Preganglionic parasympathetic fibres are present in 4 cranial nerves, e.g. cranial nerves III, VII, IX, X and along spinal nerves S2, S3, S4. Four ganglia namely ciliary, pterygopalatine, submandibular and otic are concerned with efferent parasympathetic fibres. Their pathways are shown in Chart A2.1.

CLINICAL TERMS

Brown-Sequard's syndrome: The signs and symptoms are due to injury to one-half of the spinal cord. Following are at the level of injury

(a) Ipsilateral upper motor neuron paralysis.

(b) Ipsilateral loss of conscious proprioception.

(c) Contralateral loss of pain and temperature.

Following are due to injury to various tracts below the level of injury:

(a) Ipsilateral lower motor neuron paralysis.

(b) Ipsilateral loss of sensation over the cranial dermatome.

These (a) and (b) are due to injury to nerve root at the level of injury. **Cauda equina syndrome:** It occurs due to compression of cauda equina in the vertebral canal. L2-S5 nerve roots are affected. Its features are

(a) Loss of knee and ankle jerks.

(b) Sensory loss in nerve root distribution.

(c) Asymmetric areflexic lower motor neuron type of paralysis.

(d) Later involvement of bowel and bladder.

Syringomyelia: There are cavities around the central canal. There is bilateral loss of spinothalamic fibres. Lateral spinothalamic tracts cross at once while anterior spinothalamic first ascend and then cross. There is loss of pain and temperature at one level and loss of touch and pressure at another level. So it is called "dissociated sensory loss".

Conus medullaris syndrome: It is produced due to pressure on conus medullaris of spinal cord from where S2, S3 and S4 nerves arise. The symptoms and signs are as follows.

(a) Saddle-shaped anaesthesia on the bottom

(b) Loss of anal sphincteric reflex

(c) Urinary bladder and bowel get affected early

There is no motor weakness and patient has normal knee and ankle reflexes.

Medial medullary syndrome: This syndrome occurs due to thrombosis of anterior spinal artery. There is paralysis of muscles of tongue on same side, associated with hemiplegia and loss of position sense in limbs on the opposite side.

Tabes dorsalis: Tabes dorsalis affects the posterior white column of spinal cord. It leads to bilateral loss of proprioceptive sensations and tactile discrimination below the side of lesion. The finger nose test is past pointing with eyes closed.

Lateral medullary syndrome or Wallenberg's syndrome: The lateral medullary syndrome leads to symptoms as

(a) ***On the side of lesion:*** Vertigo, vomiting, nystagmus (vestibular nuclei affected), ataxia of limbs (inferior cerebellar peduncle). Homer's syndrome (sympathetic fibres), dysphagia, hoarseness (nucleus ambiguous).

(b) ***On the opposite side of lesion:*** Loss of pain and temperature from limbs and trunk.

Cerebellopontine angle syndrome: The anatomical structures located in cerebello pontine angle are choroid plexus of 4th ventricle, 7th and 8th nerves. A tumour here gives symptoms: Facial nerve paralysis and 8th nerve paralysis leading to deafness and vertigo. Flocculus of cerebellum involved leads to ataxia on the affected side.

Millard-Gubler syndrome: Millard-Gubler syndrome occurs due to lesion in the lower pons affecting pyramidal tract and fibres of 6th and 7th cranial nerves. The symptoms are as follows.

(a) Ipsilateral medial squint

(b) Ipsilateral paralysis of muscles of facial expression

(c) Contralateral hemiplegia

Benedikt's syndrome: Benedikt's syndrome results due to lesion of tegmentum of midbrain involving superior brachium, fibres of 3rd nerve, red nucleus and medial lemniscus.

Weber's syndrome: Weber's syndrome involves corticospinal tract and 3rd nerve nucleus. There is lateral squint on same side and hemiplegia on the opposite side of body.

Parinaud's syndrome: This syndrome occurs due to compression of superior colliculi when these get pressed by tumour of pineal gland. There is paralysis of upper gaze only. Other eye movements are unaffected.

Thalamic syndrome: Thalamic syndrome is due to a vascular lesion. It is characterized by disturbances of sensations, hemiparesis or hemiplegia with hyperaesthesia and severe spontaneous pain. Pleasant as well as unpleasant sensations are exaggerated.

Subarachnoid haemorrhage: Subarachnoid haemorrhage is the collection of blood in the subarachnoid space at the base of brain. These are also called the cisterns. The circle of Willis lies in the interpeduncular cistern. Any small branch usually due to persistent hypertension may rupture to give rise to subarachnoid haemorrhage.

Cerebral stroke: The neurological signs and symptoms due to lack of blood supply constitute the cerebral stroke. It is mostly due to rupture of any of the arteries especially central branch of middle cerebral artery supplying the internal capsule.

Charcot's artery of cerebral haemorrhage: The largest branch of anterolateral central branches of middle cerebral artery is called Charcot's artery of cerebral haemorrhage. It supplies internal capsule which has motor fibres for one side of body. Damage to artery causes opposite side hemiplegia.

Sparing of macula in thrombosis of posterior cerebral artery:

Macula is represented at the occipital pole. It is supplied by branches of middle cerebral artery or by anastomosis between middle and posterior cerebral arteries. So thrombosis of posterior cerebral artery does not harm the macula.

Hydrocephalus: Hydrocephalus is an abnormal increase in the volume of CSF within the skull. It may be due to increased production, blockage in circulation or decreased absorption of CSF.

Hydrocephalus may be "internal" within ventricular system causing increased intracranial pressure and brain damage. If CSF accumulates in the subarachnoid space the condition is called external hydrocephalus.

Parkinsonism: Lesion of corpus striatum leads to Parkinsonism. It gives rise to

(a) Lead pipe rigidity or hypertonicity

(b) Movements are slow

(c) Loss of automatic associated movements and also loss of facial expression

(d) Involuntary movement like tremors, pin rolling movements of hand.

(e) Bends forwards during walking

Babinski's sign: In case of lesion of corticospinal tract there is dorsiflexion of big toe and fanning of other toes in response to scratching the skin on the lateral side of sole. This sign is positive in case of upper motor neuron lesion.

When corticospinal tract is damaged, the influence of other tracts becomes obvious which cause dorsiflexion of 1st toe and fanning of other toes. In infants and children up to two years Babinski's sign is normally present as the tracts are not fully myelinated.

Poliomyelitis: It is a viral disease which involves anterior hom cells leading to flaccid paralysis of the affected segments. It is lower motor neuron paralysis.

Following is the comparison between upper motor neuron and lower motor neuron paralysis

LMN Paralysis	UMN Paralysis
Muscle tone abolished	Muscle tone increased
Leads to flaccid paralysis	Leads to spastic paralysis
Muscles atropy later	No atrophy of muscles
Reaction of degeneration seen	Reaction of degeneration not seen
Tendon reflexes absent	Tendon reflexes exaggerated
Limited damage	Extensive damage

Cerebral vascular disease: It is quite common in old age and manifest in different ways.

(a) Haemorrhage - cortical or subcortical

(b) Thrombosis

(c) Embolism

Hypertensive encephalopathy: This is a manifestation of sustained elevation of diastolic blood pressure in the form of multiple diffuse small lesions distributed all over, result in a variegated picture of the circle of Willis (berry aneurysm).

Nerve supply: The arteries of the brain are supplied with sympathetic nerves which run onto them from carotid and vertebral plexuses.

They are extremely sensitive to injury and readily react by passing into prolonged spasms. This by itself may be sufficient to cause damage to brain tissue since even the least sensitive neurons cannot withstand absolute loss of blood supply for a period more than 5-7 minutes.