Chapter 27: The ear, intracranial region and cranial nerves

Ear

The ear is the organ of hearing and balance. It is divided into an external ear directing sound waves to the tympanic membrane, a middle ear relaying the vibrations of the membrane to the internal ear, and the cochlea of the internal ear which translates these vibrations into nerve impulses. The organ of balance, the semicircular canals, is also in the inner ear.

The External Ear

This consists of the auricle and the external acoustic meatus.

The auricle is formed of an irregularly shaped piece of fibrocartilage covered by firmly adherent skin. It has dependent lobule and an anterior tragus which overlaps the opening of the meatus. To the auricle are attached three vestigial muscles supplied by the facial nerve. They are of little functional value in man. The external acoustic meatus is cartilage laterally and bone medially. It passes nearly horizontally from the tragus to the tympanic membrane and is about 4 cm long. The cartilaginous lateral third is continuous with the cartilage of the auricle. The bony medial two-thirds is formed mainly by the tympanic part of the temporal bone completed posterosuperiorly by the squamous temporal bone. The direction of the canal is slightly posterior in the lateral portion; slightly anterior in the medial portion. The canal is lined with skin richly endowed with wax secreting (ceruminous) glands. It receives its blood supply from the maxillary and superficial temporal arteries and is innervated by the auriculotemporal nerve anteriorly and the vagus nerve posteriorly.

The translucent tympanic membrane (ear drum) separates the external ear from the middle ear. It is oval in shape and lies obliquely with its lateral surface facing downwards and forwards. It consists of an incomplete fibrous layer covered laterally by modified skin and medially by modified mucous membrane of the middle ear. The handle of the malleus, attached to the medial surface, can be seen through the drum extending upwards from the centre to the superior flaccid part of the membrane where the fibrous layer is deficient. The lower end of the handle produces a small elevation on the drum and on inspection with an auriscope, a cone of light is seen passing downwards and forwards from this point.

The Middle Ear (Tympanic Cavity)

The middle ear lies within the temporal bone and may be likened to a narrow room. The height and length are about 15 mm. The lateral and medial walls curve inwards and are about 2 mm apart at the middle and about 6 mm apart at the roof. The cavity is lined in places by ciliated columnar epithelium and contains three small bones (auditory ossicles).

The lateral wall is formed mainly by the tympanic membrane. The chorda tympani passes forwards between the membrane and the handle of the malleus laterally and the incus medially. Above and behind the membrane there is an upward extension of the cavity, the epitympanic recess which accommodates the head of the malleus and body of the incus.
The **medial wall** has a central bulge, the **promontory**, formed by the first turn of the cochlea. Above and behind the bulge is the **fenestra vestibuli** (oval window) and below and behind is the **fenestra cochleae** (round window), both foramina leading into the inner ear. The fenestra vestibuli is closed by the footplate of the stapes and the fenestra cochleae by a fibrous disc. The facial nerve, in a bony canal, crosses the medial wall superiorly from before backwards and then descends on the posterior wall.

The **anterior wall** has two openings inferiorly, separated by a bony shelf. The upper transmits tensor tympani whose tendon turns laterally around a projection of the bony shelf and is attached to the handle of the malleus. The lower is the opening of the auditory tube through which the cavities of the middle ear and nasopharynx are in continuity.

High on the **posterior wall** is the **aditus**, the opening into the mastoid ( tympanic) antrum. Below it there is a projection of bone, the pyramid, out of which the tendon of the stapedius muscle passes to the stapes. Lateral to this there is a small foramen out of which passes the chorda tympani. The canal for the facial nerve passes down the medial side of the wall.

The **roof** is covered by a thin plate of the petrous temporal bone (the tegmen tympani) which separates the cavity from the middle cranial fossa. The bony **floor** separates the cavity from the carotid canal in front and the jugular foramen behind.

The middle ear contains three small ossicles, the malleus, the incus and the stapes; they extend in line from the tympanic membrane to the fenestra vestibuli and transmit the vibrations of the membrane to the inner ear. The **malleus** has a handle which is attached to the tympanic membrane, and a rounded superior head which lies in the epitympanic recess and articulates with the body of the incus. The incus has a body and two processes; one process rests on the posterior wall of the middle ear, the other articulates with the **stapes** (stirrup-shaped), the footplate of which occupies the fenestra vestibuli. The malleus and incus develop from the cartilage of the 1st pharyngeal arch, the stapes from the 2nd. Decreased mobility of the ossicles in middle and old age produces degrees of conductive deafness.

Two small muscles, the **tensor tympani** (supplied by the mandibular nerve) and the **stapedius** (supplied by the facial nerve) are attached to the malleus and the stapes respectively; they modify the transmission of the sound waves.

The middle ear receives its blood supply from the internal carotid and maxillary arteries and is innervated by the glossopharyngeal nerve through the tympanic plexus. Lymph passes to the retropharyngeal lymph nodes.

**Mastoid ( tympanic) antrum**

This is a cavity within the mastoid part of the petrous temporal bone. It communicates with the cavity of the middle ear through the aditus. At birth the antrum is small and lies very superficially. As the mastoid process enlarges, the antrum becomes more deeply placed and mastoid air cells develop as diverticula around it. Posteromedially the antrum is separated by a thin plate of bone from the posterior cranial fossa with the cerebellum and the sigmoid
venous sinus. Superiorly it is related to the temporal lobe of the brain. Laterally are the muscles attached to the mastoid process.

The communication of the nasopharynx with the middle ear along the auditory tube provides a pathway for infection to pass from the throat to the mastoid antrum and mastoid air cells. Here an abscess may develop and this is of serious consequence for it is related to the temporal lobe of the brain and the cerebellum, being separated from them only by thin plates of bone. Meningitis and brain abscess are thus occasional complications of a middle ear or mastoid infection.

The Internal Ear

The internal ear lies within the petrous temporal bone. It consists of a complicated membranous sac (the membranous labyrinth) filled with a clear fluid (endolymph) and contained within a larger bony cavity (the bony labyrinth). The space between the membranous and bony labyrinths is filled with fluid (perilymph).

The bony labyrinth

The bony labyrinth comprises the cochlea anteriorly, the vestibule in the middle and the semicircular canals posteriorly. The cavities are in continuity. The **cochlea** is a spirally coiled bony tube of 2.75 turns, around a central bony pillar, the **modiolus**. The medial wall of the coil has a narrow plate of bone, the **spiral lamina**, which projects into the cavity and partly divides it. The basal turn of the cochlea opens into the **vestibule** which lies anterolateral to the internal acoustic meatus. The lateral wall of the vestibule opens on to the middle ear at the vestibular and cochlear fenestrae. The anterior, posterior and lateral **semicircular canals** each form two-thirds of a circle and open at both ends into the vestibule; as the anterior and posterior canals have a conjoined medial end, there are only five openings into the vestibule. The lateral end of each canal possesses a dilatation, the ampulla. The canals lie in three planes at right angles to each other; the anterior and posterior canals are set vertically, the lateral horizontally.

The membranous labyrinth

The membranous labyrinth comprises the duct of the cochlea, the saccule, the utricle and the three semicircular ducts from before backwards; all are in continuity. The **duct of the cochlea** lies within the bony cochlea placed between the projecting edge of the spiral lamina and the opposite wall. It divides the bony cavity into three: an upper **scala vestibuli** containing perilymph, a middle **scala media** (the cavity of the duct) containing endolymph, and a lower **scala tympani** containing perilymph. The scala vestibuli extends from the fenestra vestibuli to the apex of the coil where it communicates by a small opening, the **helicotrema**, with the scala tympani. The latter extends to the fenestra cochleae. Lying on the basilar membrane which separates the scala media and scala tympani, are hair cells supporting the **membrana tectoria**. The hair cells are stimulated by the disturbance of perilymph in the scala vestibuli and scala tympani set up by movement of the stapes at the fenestra vestibuli. The **spiral organ** (end organ of hearing) consists of the hair cells (amongst which are the endings of the cochlear nerves) and the tectorial membrane.
The **saccule** and **utricle** are two sacs within the vestibule; they are united by the narrow Y-shaped endolymphatic duct. The saccule is joined to the duct of the cochlea by the narrow ductus reuniens, the utricle receives the five openings of the semicircular ducts. Both sacs possess a small thickened area of columnar cells with projecting hairs. These are the **maculae**, the end organs of static balance.

The narrow **semicircular ducts** lie within their respective bony canals. They each have a dilated ampulla containing a sensory area, the **crista**. The cristae are similar to the maculae but are the end organs of kinetic balance. The maculae and cristae contain nerve fibres which are stimulated when the supporting hair cells are deformed either by movement of the endolymph or of the otoliths, small calcium carbonate crystals in the fluid.

Blood is supplied by the labyrinthine branch of the basilar artery. Venous blood passes to the superior and inferior petrosal sinuses. The maculae and cristae are innervated by the vestibular division of the eighth cranial nerve, the spiral organ of the cochlea by the cochlear division of the nerve. The cochlear ganglion is in the modiolus and the vestibular ganglion is in the internal acoustic meatus.

**Intracranial Region**

The cranial cavity contains the brain and its membranes. The vault of the skull covers the hemispheres superiorly, and inferiorly the base of the skull forms the anterior, middle and posterior cranial fossae which contain the frontal lobes, temporal lobes and hindbrain respectively.

**The vault**

The vault is formed from the frontal, parietal, squamous temporal and occipital bones. There are two foramina for the parietal emissary veins near the vertex. The inner surface shows shallow impressions for the cerebral gyri and is grooved in the sagittal plane by the superior sagittal sinus as far back as the internal occipital protuberance. On each side of the groove are pits for the **lateral recesses** containing the **arachnoid granulations**. The lateral side of the vault shows markings for the anterior and posterior branches of the middle meningeal vessels.

**The anterior cranial fossa**

This is formed by the orbital plates of the frontal bone, the cribriform plate of the ethmoid bone with its upward midline projection, the **crista galli**, and the lesser wings of the sphenoid which project posteromedially to form the anterior clinoid processes. The fossa houses the frontal lobes of the brain and overlies the nasal and orbital cavities. The cribriform plates underlie the olfactory bulbs and their foramina transmit bundles of the olfactory nerves with their meningeal coverings, and the anterior ethmoidal vessels and nerves. The orbital plates of the frontal bone show markings for the orbital gyri of the frontal lobes and contain the posterior parts of the frontal air sinuses.
The middle cranial fossa

This has a median portion and two larger lateral compartments. The median part is formed by the body of the sphenoid which is hollowed out to form the pituitary fossa (the sella turcica). Anteriorly a transverse ridge, the tuberculum sellae, separates the fossa from the shallow optic groove which leads to the optic canal on each side. Posteriorly a plate of bone, the dorsum sellae, projects upwards and forwards; its two corners are the posterior clinoid processes. On each side of the body a shallow carotid groove leads posteriorly to the foramen lacerum. The body of the sphenoid contains the sphenoidal air sinuses, lies under the pituitary gland and cavernous venous sinuses, and above the nasopharynx. Each optic canal transmits the optic nerve with its meningeal coverings and the ophthalmic artery. The foramen lacerum lies between the occipital bone behind, the greater wing of the sphenoid bone in front, and the apex of the petrous temporal laterally. It is irregular in shape, and in life it is filled with fibrocartilage. The cartilage in the foramen forms the floor of the medial end of the carotid canal. The internal carotid artery, and the greater and deep petrosal nerves pass medially over the cartilage.

The lateral compartments are formed, from before backwards, by the lesser and greater wings of the sphenoid, and the squamous and petrous parts of the temporal bone. They support the temporal lobes of the brain, separating them from the temporal and infratemporal regions. One fissure and three foramina are found towards the medial side of each compartment.

1. **The superior orbital fissure** lies between the greater and lesser wings of the sphenoid. It opens into the orbit and transmits the oculomotor, trochlear, branches of the ophthalmic, and abducent nerves and the ophthalmic veins.

2. **The foramen rotundum** is in the greater wing of the sphenoid behind the medial end of the superior orbital fissure. It opens into the pterygopalatine fossa and transmits the maxillary nerve.

3. **The foramen ovale** is also in the greater wing and is about 1.5 cm behind the foramen rotundum. It opens into the infratemporal fossa and transmits the mandibular nerve, the lesser petrosal nerve and an accessory meningeal artery.

4. **The foramen spinosum** lies just posterolateral to the foramen ovale. It transmits the middle meningeal vessels and meningeal branches of the mandibular nerve. The vessels groove the bone as they pass laterally and divide into anterior and posterior branches. The anterior branch lies deep in the pterion.

The anterior surface of the petrous temporal bone has a depression near its apex for the trigeminal ganglion. Further laterally the surface has an elevation, the arcuate eminence, produced by the anterior semicircular canal. Anterior and lateral to the eminence a thin plate of bone, the tegmen tympani, overlies the mastoid antrum, the middle ear and the auditory tube. Grooves for the greater and lesser petrosal nerves are found medial to the eminence.
The posterior cranial fossa

This is the largest and deepest of the three fossae. It is formed from the sphenoid, temporal, occipital and parietal bones. Anterolaterally the fossa is limited by the dorsum sellae and the upper border of the petrous temporal bones. Posterolaterally the grooves for the transverse venous sinus on the occipital and parietal bones from the upper limit of the fossa. The fossa contains the cerebellum, pons and medulla. It is roofed in by the tentorium cerebelli on which lie the occipital lobes of the cerebral hemispheres. The following foramina are present:

1. The foramen magnum is large and lies in the midline in the floor of the fossa, bounded on each side by the occipital condyles. It transmits the spinal cord with its coverings, the vertebral and spinal arteries, and the spinal root of the accessory nerves.

2. The jugular foramen lies between the occipital and petrous temporal bones. It is irregular in outline and contains the upper bulb of the internal jugular vein, and transmits the inferior petrosal sinus and the glossopharyngeal, vagus and accessory nerves.

3. The internal acoustic meatus lies on the posterior aspect of the petrous temporal bone. Each is directed laterally and transmits the facial and vestibulocochlear nerves and the labyrinthine artery, all surrounded by a meningeal sheath. The ganglion of the vestibular nerve lies in the meatus.

4. The hypoglossal canal lies above and anterior to the occipital condyle; it transmits the hypoglossal nerve.

5. & 6. The condylar canal (behind the condyle) and the mastoid foramen transmit emissary veins.

The posterior surface of the petrous temporal bone is grooved above the superior petrosal sinus, medially by the inferior petrosal sinus and laterally by the sigmoid part of the transverse sinus. The internal occipital protuberance lies at the point of union of the two transverse sinuses in the midline posteriorly.

Cranial Nerves

The 12 pairs of cranial nerves originate in the brain and leave the cranial cavity through its basal foramina. The nerves have motor and sensory components of the somatic, visceral and special visceral (branchial) varieties in varying proportions. The olfactory and optic nerves are not usually included in this classification.

The somatic motor component supplies muscles derived from somatic mesoderm and is present in the oculomotor, trochlear, abducent and hypoglossal nerves. The general somatic sensory component supplies the skin of the face by the trigeminal nerve. The special somatic sensory component supplies the organ of balance and hearing by the vestibulocochlear nerve. The general visceral (parasympathetic) motor components are in the oculomotor, facial, glossopharyngeal and vagus nerves. The special visceral motor component supplies muscles derived from pharyngeal arch mesoderm and is present in the trigeminal, facial,
glossopharyngeal, and vagus nerves. The special visceral sensory component provides taste fibres in the facial and glossopharyngeal nerves. The general visceral sensory (reflex) components are in the glossopharyngeal and vagus nerves.

The course of the sensory nerves (the olfactory, optic and vestibulocochlear) will be described as approaching the brain, and motor and mixed nerves as leaving it.

1. Olfactory Nerves

They supply the olfactory mucous membrane in the upper part of the nasal cavity. The nerve fibres originate in the bipolar olfactory cells of the mucosa and join to form 15-20 olfactory bundles which pass through the cribriform plate of the ethmoid bone to reach the olfactory bulb.

2. Optic Nerve

It is the sensory nerve of the retina. Its fibres originate in the ganglion layer and converge on the posterior part of the eyeball. The nerve passes backwards through the orbit and optic canal into the middle cranial fossa where it unites with the nerve of the opposite side to form the optic chiasma.

Relations

Within the orbit the nerve is enclosed in a meningeal sheath containing cerebrospinal fluid, and surrounded by the cone of extraocular muscles embedded in fat. The ciliary ganglion lies on its lateral side and the ophthalmic artery and nasociliary nerve pass forwards and medially above it. The central artery of the retina (a branch of the ophthalmic artery) enters the substance of the nerve in this part of its course. In the optic canal the nerve with its meningeal sheath is accompanied by the ophthalmic artery. The short intracranial portion lies on the sphenoid bone and is medial to the internal carotid artery. The optic chiasma lies anterosuperior to the pituitary gland.

3. Oculomotor Nerve

This nerve has somatic motor and general visceral (parasympathetic) motor fibres. The somatic fibres supply the bulbar muscles, except superior oblique and lateral rectus. The parasympathetic fibres synapse in the ciliary ganglion and supply the sphincter pupillae and ciliary muscle.

The nuclei of the nerve are situated in the upper midbrain in the periaqueductal grey matter. The nerve fibres pass forwards through the midbrain and leave it between the cerebral peduncles. The nerve passes through the posterior and middle cranial fossae and divides into superior and inferior divisions near the superior orbital fissure.

Relations

In the posterior cranial fossa - the nerve passes between the posterior cerebral and superior cerebral arteries, then medial to the trochlear nerve and lies near the edge of the
tentorium cerebelli. In the middle cranial fossa - it pierces the cerebral layer of dura to pass forwards on the lateral wall of the cavernous sinus where it is at first above but later descends medial to the trochlear nerve.

**Branches**

(i) The superior division passes through the superior orbital fissure within the tendinous ring of the extraocular muscles and supplies superior rectus and levator palpebrae superioris.

(ii) The inferior division also passes through the tendinous ring and supplies the medial and inferior recti and inferior oblique. The nerve to inferior oblique gives the parasympathetic branch to the ciliary ganglion.

Because of its close relationship to the free edge of the tentorium cerebelli the oculomotor nerve may be damaged by a lateral shift of the brain. One of the earliest localising signs of rapidly increasing intracranial pressure may be dilatation of the pupil due to damage of the parasympathetic fibres passing the ciliary ganglion.

4. **Trochlear Nerve**

This is the somatic motor nerve supply to the superior oblique. Its nucleus lies in the lower midbrain in the periaqueductal grey matter. The fibres pass posteriorly and undergo a dorsal decussation with the nerve of the opposite side caudal to the inferior colliculi. The nerve then passes forwards through the posterior and middle cranial fossae, enters the orbit through the superior orbital fissure and supplies superior oblique.

**Relations**

*In the posterior cranial fossa* the nerve passes forwards around the midbrain, then between the posterior cerebral and superior cerebellar arteries, following the edge of the tentorium, lateral to the oculomotor nerve. *In the middle cranial fossa* it pierces the cerebral layer of dura and lies between the oculomotor and ophthalmic nerves in the lateral wall of the cavernous sinus. The oculomotor later descends medial to it. It passes through the superior orbital fissure outside the tendinous ring, passes medially between levator palpebrae superioris and the roof of the orbit and reaches the superior oblique.

5. **Trigeminal Nerve**

This nerve has general somatic sensory and special visceral motor fibres. The sensory fibres supply the anterior part of the scalp and dura, the face, the nasopharynx, the nasal and oral cavities, and the paranasal air sinuses. The motor fibres supply the muscles of mastication. The nerve has four nuclei: the spinal (in the medulla), the mesencephalic (in the midbrain), and the superior sensory and motor (in the pons). The first three are sensory in function.

The nerve arises in the pons and emerges at the junction of the pons and the middle cerebellar peduncle as a large sensory and smaller motor root. It passes forwards to the
The trigeminal ganglion on the apex of the petrous temporal bone in the middle cranial fossa. The ganglion is semilunar in shape and lies on the anterior aspect of the petrous temporal bone lateral to the cavernous sinus. It is partly surrounded by a dural sheath carried forwards by the nerve. The ophthalmic, maxillary and mandibular divisions emerge from the anterior border of the ganglion. The motor root of the nerve passes medial to the ganglion and joins the mandibular division.

**Ophthalmic division**

This is the smallest division; it passes forwards on the lateral wall of the cavernous sinus below the oculomotor and trochlear nerves and above the maxillary division. Near the superior orbital fissure it divides into the lacrimal, frontal and nasociliary nerves, which pass through the fissure into the orbit.

(a) **Lacrimal nerve** - Passes through the lateral part of the superior orbital fissure, outside the tendinous ring and above lateral rectus to reach the lacrimal gland. It then enters the upper eyelid and supplies the skin and conjunctiva on the lateral side. A communicating branch from the zygomaticotemporal nerve conveys parasympathetic fibres from the pterygopalatine ganglion to the lacrimal gland.

(b) **Frontal nerve** - Passes through the superior orbital fissure just outside the tendinous ring and then forwards between levator palpebrae superioris and the roof of the orbit. In the orbit it divides into supraorbital and supratrochlear nerves. The former leaves the orbit through the supraorbital notch and its branches supply the upper eyelid, the frontal sinuses and the scalp as far back as the vertex. The latter passes forwards above the trochlea for the superior oblique tendon, and supplies the skin of the upper eyelid and the medial part of the forehead.

(c) **Nasociliary nerve** - Passes through the superior orbital fissure within the tendinous ring, forwards and then medially above the optic nerve and ends on the medial wall of the orbit as the anterior ethmoidal and infratrochlear nerves.

**Branches**

(i) **Anterior ethmoidal nerve** - Passes through a foramen on the medial wall of the orbit and enters the anterior cranial fossa. It then descends through the cribriform plate, passes through the nasal cavity, and emerges between the nasal bone and the nasal cartilages as the external nasal nerve. It supplies the dura of the anterior cranial fossa, the anterior ethmoidal air cells, the upper anterior part of the nasal cavity and the skin over the sides and tip of the nose.

(ii) **Posterior ethmoidal nerve** - Supplies the posterior ethmoidal and sphenoidal air sinuses.

(iii) **Infratrochlear nerve** - Passes forwards below the trochlea for the superior oblique tendon and supplies the medial part of the upper eyelid, conjunctiva and adjacent part of the nose.
(iv) Long ciliary nerves - two or three branches pass to the sclera and cornea. They also convey sympathetic fibres to the dilator pupillae from the internal carotid plexus.

(v) Branches via the ciliary ganglion to the eyeball.

Maxillary Division

This passes forwards through the middle cranial fossa, the foramen rotundum, the pterygopalatine fossa and the inferior orbital fissure, where it becomes the infraorbital nerve.

Relations

In the middle cranial fossa the nerve lies for a short distance in the lateral wall of the cavernous sinus below the ophthalmic division; it leaves the fossa through the foramen rotundum. In the pterygopalatine fossa the pterygopalatine ganglion is suspended from it and it is related to the terminal branches of the maxillary artery.

Branches

(a) Fibres to the pterygopalatine ganglion, through which they pass without synapsing, to the nose, palate and nasopharynx. The nasal and nasopalatine nerves pass through the sphenopalatine foramen into the nose; the greater and lesser palatine nerves descend between the maxillary and palatine bones to the palate; and the pharyngeal nerves pass backwards to the nasopharynx.

(b) Zygomatic nerve - Passes forwards on the lateral wall of the orbit and divides into temporal and facial branches which, passing through small foramina in the zygomatic bone, supply the skin over the temple and cheek. In the orbit a communication with the lacrimal nerve carries parasympathetic fibres from the pterygopalatine ganglion to the lacrimal gland.

(c) Posterior superior alveolar nerve - Three or four branches descend through foramina in the posterior aspect of the maxilla to the upper molar and premolar teeth.

(d) Infraorbital nerve - Is the continuation of the maxillary nerve out of the orbit. It lies in the infraorbital groove and canal and emerges at the infraorbital foramen on to the face where its terminal branches supply the lower eyelid and conjunctiva, the side of the nose and the upper lip. Its anterior superior alveolar branch, given off in the canal, supplies the canine and incisor teeth, the lower part of the lateral wall of the nose and the maxillary air sinus.

Mandibular Division

This carries the motor root of the trigeminal nerve. It leaves the middle cranial fossa through the foramen ovale and soon divides into its branches. The nerve lies between tensor veli palatini and lateral pterygoid and has the otic ganglion on its medial side.

1. Motor branches to the muscles of mastication, tensor tympani and tensor veli palatini. The fibres to the tensor muscles leave the nerve to medial pterygoid and pass through
the optic ganglion without synapsing. Fibres to the mylohyoid and the anterior belly of digastric are described below.

2. Sensory branches have a wide distribution.

(a) Meningeal branch - A small twig which passes through the foramen spinosum and supplies the dura of the middle cranial fossa.

(b) Buccal nerve - passes forwards between the two heads of lateral pterygoid and medial to the mandible. It gives off cutaneous branches then pierces buccinator and supplies the mucous membrane of the cheek.

(c) Auriculotemporal nerve - passes laterally between the sphenomandibular ligament and the neck of the mandible, and above the parotid gland. It then ascends behind the joint, with the superior temporal artery, to the temporal region of the scalp. The nerve carries sensory fibres to the anterior part of the tympanic membrane, external acoustic meatus and the auricle, to the joint and to the temporal region of the scalp. It conveys parasympathetic fibres to the parotid gland from the otic ganglion and sympathetic fibres to the gland from the plexus on the middle meningeal artery, around which the nerve often divides.

(d) Inferior alveolar nerve - descends to the mandibular foramen where it enters the mandibular canal. It lies between the medial pterygoid and the ramus of the mandible, and the sphenomandibular ligament lies medial to it as it enters the foramen.

Branches

(i) Mylohyoid nerve - leaves the nerve before it enters the mandibular foramen, passes forwards close to the mandible and supplies mylohyoid and the anterior belly of digastric.

(ii) Dental branches - arise in the mandibular canal and supply adjacent gums and teeth.

(iii) Incisor nerve - supplies the canine and incisor teeth and the central incisor of the opposite side.

(iv) Mental nerve - emerges through the mental foramen and supplies the skin and mucous membrane of the lower lip and chin, and the gum above the foramen.

(e) Lingual nerve - arises anterior to the previous nerve and passes forwards along the side of the tongue. The nerve supplies sensory branches to the anterior two-thirds of the tongue, the floor of the mouth and the lingual gum. It receives the chorda tympani branch of the facial nerve about 3 cm below the base of the skull. The chorda tympani carries parasympathetic and taste fibres: the former synapse in the submandibular ganglion and supply the submandibular and sublingual salivary glands; the latter are from the anterior two-thirds of the tongue and have their cell bodies in the geniculare ganglion of the facial nerve.

Relations: The nerve lies between four pairs of structures from above downwards -
(a) tensor veli palatini and lateral pterygoid, (b) medial pterygoid and ramus of the mandible,
(c) mucous membrane of the mouth and the roots of the 3rd lower molar tooth, (d) hyoglossus and mylohyoid. Between the last pair of muscles the nerve is overlapped by the submandibular gland and then passes from lateral to medial below the submandibular duct.

6. Abducent Nerve

It is a somatic motor nerve supplying lateral rectus. Its nucleus is situated in the lower pons. The nerve leaves the inferior border of the pons near the midline, passes forwards through the posterior and middle cranial fossae, the cavernous sinus and the orbit, and supplies lateral rectus.

Relations

In the posterior cranial fossa the nerve lies between the pons and the basilar part of the occipital bone. It pierces the inner layer of dura covering the dorsum sellae, passes over the apex of the petrous temporal bone and through the cavernous sinus lateral to the internal carotid artery. It enters the orbit through the superior orbital fissure within the tendinous ring and supplies lateral rectus. This thin nerve with a long intracranial course is prone to damage in patients with increased intracranial pressure.

7. Facial Nerve

This nerve carries special visceral motor, special visceral sensory, and general visceral (parasympathetic) motor fibres. The special visceral motor fibres arise in the facial nucleus in the lower pons and upper medulla, and are distributed to the muscles of the face region. The special visceral sensory fibres carry taste sensation from the anterior two-thirds of the tongue to the nucleus of the tractus solitarius in the medulla. The cell bodies of the fibres are in the genicular ganglion of the facial nerve. The parasympathetic fibres are secretomotor to the submandibular and sublingual glands (synapses are in the submandibular ganglion) and to the lacrimal gland and the mucous membrane of the nose, pharynx and mouth (synapses are in the pterygopalatine ganglion). The preganglionic parasympathetic fibres arise in the superior part of the salivary nucleus in the medulla. Intracranially the sensory and parasympathetic fibres are usually gathered together in a separate root, the nervus intermedius.

The nerve leaves the lower lateral surface of the pons and passes laterally, with the vestibulocochlear nerve, through the internal acoustic meatus to the facial (geniculare) ganglion. It here turns sharply posteriorly through a bony canal on the medial wall of the middle ear and then downwards behind the same cavity to emerge from the temporal bone at the stylomastoid foramen. The nerve then runs forward into the parotid gland where it divides into a number of branches. The genicular ganglion contains the cell bodies of the taste and other sensory fibres.

Branches

(a) Greater petrosal nerve - Carries secretomotor fibres to the pterygopalatine ganglion. It leaves the facial nerve at the genicular ganglion, and passes through the petrous temporal bone into the middle cranial fossa. It traverses the fossa, reaches the foramen lacerum and, joining the deep petrosal nerve (a sympathetic branch from the internal carotid
plexus), forms the nerve of the pterygoid canal. The nerve passes through its canal in the sphenoid bone to the pterygopalatine ganglion in the pterygopalatine fossa. Some sensory fibres may be present in the nerve and have their cell bodies in the genicular ganglion.

(b) Nerve to stapedius muscle.

c) **Chorda tympani** - arises just above the stylomastoid foramen, passes forwards through the middle ear between the tympanic membrane and the handle of the malleus laterally and the incus medially. It emerges from the petrotympanic fissure of the temporal bone and joins the lingual nerve about 3 cm below the base of the skull. It contains taste fibres from the anterior two-thirds of the tongue (the cell bodies are in the genicular ganglion) and parasympathetic fibres which synapse in the submandibular ganglion.

d) Nerves to the posterior belly of digastric and stylohyoid, and the posterior auricular nerve to occipitalis and the auricular muscles arise just below the stylomastoid foramen.

e) Within the parotid gland the temporal, zygomatic, buccal, mandibular and cervical motor branches are formed; they supply the muscles of facial expression and also buccinator and platysma muscles.

Lower motor neurone facial paralysis may result from virus infections, from trauma, i.e. during surgical removal of a parotid tumour, or from neoplastic infiltration.

8. Vestibulocochlear Nerve

This is a special somatic sensory nerve consisting of two parts: the vestibular nerve, concerned with balance, and the cochlear nerve, concerned with hearing.

The nerve is formed in the internal acoustic meatus by the union of the two parts, and passes medially to enter the cerebellomedullary angle of the brain stem. Fibres from the cochlear duct pass to the bipolar cells of the spiral ganglion within the modiolus and the central connections pass to the dorsal and ventral cochlear nuclei in the upper medulla. Vestibular fibres pass from the semicircular ducts, saccule and utricle to the bipolar cells of the vestibular ganglion in the internal acoustic meatus, and the central fibres pass to the vestibular nuclei in the floor of the 4th ventricle.

9. Glossopharyngeal Nerve

This has general and special visceral sensory, special visceral motor and general visceral motor (parasympathetic) fibres. The general visceral sensory fibres come from the middle ear, pharynx, posterior third of the tongue and the carotid sinus and carotid body. The special visceral sensory fibres (taste) come from the posterior one-third of the tongue. Their cell bodies are in the ganglion of the glossopharyngeal nerve and their central fibres enter the medulla (nucleus of the tractus solitarius). The parasympathetic (secretomotor) fibres arise in the salivary nucleus (inferior part), synapse in the otic ganglion and supply the parotid gland. The special visceral motor fibres arise in the nucleus ambiguus and supply stylopharyngeus.
The nerve rootlets leave the medulla lateral to the olive. The nerve passes through the jugular foramen medial to the vagus and accessory nerves and the internal jugular vein, and lateral to the inferior petrosal sinus. It passes forwards between the internal and external carotid arteries, pierces the pharyngeal wall between the superior and middle constrictor muscles near the lower pole of the palatine tonsil and ends in the posterior one-third of the tongue. The nerve has two small sensory ganglia situated in the jugular foramen.

**Branches**

(a) Tympanic nerve - passes to the tympanic plexus on the promontory of the middle ear and supplies the mucous membrane of this cavity. The lesser petrosal nerve arises from the plexus and conveys the parasympathetic to the parotid gland via the otic ganglion.

(b) Nerve to stylopharyngeus.

(c) Sensory branches, including taste, from the mucous membrane of the oropharynx, tonsil, soft palate and posterior one-third of the tongue (including the vallate papillae).

(d) Sensory branches from the carotid body and carotid sinus.

**10. Vagus Nerve**

These nerve has general visceral motor (parasympathetic), special visceral motor, general and special visceral sensory, and somatic sensory fibres. The parasympathetic fibres supply the heart, lungs and alimentary canal nearly to the splenic flexure. The special visceral motor fibres innervate the striated muscles of the larynx, pharynx and palate. The general visceral sensory fibres come from the mucous membrane of the palate, pharynx and larynx, and from the heart, lungs and alimentary canal. The special visceral sensory (taste) fibres come from the valleculae and epiglottis. The somatic sensory fibres supply the posterior part of the external acoustic meatus and the tympanic membrane. The nuclei, which lie in the medullae, are the dorsal motor and sensory (parasympathetic), the nucleus ambiguus (special visceral motor) and nucleus of the tractus solitarius (visceral sensory). The somatic sensory fibres pass to the sensory nucleus of the trigeminal nerve.

The nerve emerges from the medulla lateral to the olive as rootlets and leaves the skull through the jugular foramen with the inferior petrosal sinus and the glossopharyngeal nerve medially and the accessory nerve and internal jugular vein laterally. It descends through the neck and thorax to the oesophageal plexus where it joins with its fellow of the opposite side to form the anterior and posterior vagal trunks. Near the base of the skull the vagus has superior and inferior sensory ganglia.

**Relations (in the neck)**

The nerve lies deeply in the carotid sheath, between the internal jugular vein laterally and the internal and common carotid arteries medially. It lies on the prevertebral fascia and muscles. In the root of the neck the right nerve passes forwards in front of the subclavian artery and enters the thorax. The left nerve runs between the common carotid and subclavian arteries as it enters the thorax.
**Branches (in the neck)**

(a) *Auricular nerve* - Supplies the posterior part of the external acoustic meatus and the tympanic membrane.

(b) *Pharyngeal nerves* - Pass between the internal and external carotid arteries to reach the pharyngeal plexus and supply the muscles and mucous membrane of the pharynx and soft palate.

(c) **Superior laryngeal nerve** - Descends between the pharynx medially and the internal and external carotid arteries, and divides below the hyoid bone into internal and external branches. The internal nerve pierces the thyrohyoid membrane and supplies the mucous membrane of the larynx above the vocal folds. The external nerve descends on the larynx and supplies cricothyroid muscle.

(d) *Cervical cardiac branches* - On each side they descend to the cardiac plexuses.

(e) **Right recurrent laryngeal nerve** - Loops around the right subclavian artery and then ascends in the groove between the oesophagus and trachea. It enters the larynx and supplies the intrinsic muscles, except cricothyroid, and the mucous membrane below the vocal folds.

Vagus nerve, in the thorax (see previously).

**11. Accessory Nerve**

This has somatic motor fibres which supply sternocleidomastoid and trapezius and have their nuclei in the upper five cervical segments of the spinal cord. The somatic motor fibres constitute the spinal root of the accessory nerve. The nerve arises in the vertebral canal; it ascends behind the ligamenta denticulata and through the foramen magnum into the posterior cranial fossa. It then leaves the fossa through the jugular foramen and below the skull it passes laterally in front of the internal jugular vein and the transverse process of the atlas into the substance of sternocleidomastoid. It crosses the posterior triangle of the neck lying on levator scapulae and reaches the deep surface of trapezius.

Inside the skull, fibres from the nucleus ambiguus join the accessory nerve but quickly return to the vagus. These special visceral efferent fibres are called the cranial root of the accessory nerve.

**12. Hypoglossal Nerve**

This nerve is the somatic motor supply to all the intrinsic and extrinsic muscles of the tongue, except palatoglossus. Its nucleus is situated in the medulla in the floor of the 4th ventricle.

The nerve emerges from the medulla between the pyramid and the olive as 15-20 rootlets, and leaves the posterior cranial fossa through the hypoglossal canal. It descends behind the carotid sheath before passing forwards around the pharynx to the tongue.
Relations

Below the base of the skull the nerve lies behind the internal carotid artery and the vagus nerve on the prevertebral fascia. It passes forwards between the internal carotid artery and the internal jugular vein and crosses in turn the internal and external carotid arteries, the loop of the lingual artery on the middle constrictor muscle and then hypoglossus. As it runs forwards it is covered laterally by the posterior belly of the digastric, the submandibular gland and the mylohyoid. Anterior to hyoglossus, the nerve turns medially to ramify in the substance of the tongue.

The hypoglossal nerve receives fibres from the ventral ramus of the 1st cervical nerve near the base of the skull. It conveys some of them to geniohyoid and thyrohyoid, and then forms the superior root of the ansa cervicalis which (with the inferior root from the 2nd and 3rd cervical nerves) supplies the infrahyoid group of muscles.