

Clinical Case 40.1

Patient Bobby F. This 5-year-old preschooler has had a history of recurring upper respiratory infections with accompanying middle ear infections (otitis media). The episodes were treated by antibiotic therapy, but the child's mother had to miss a number of days at work while caring for the child during the treatment. When you examined the nasopharynx you could see an abundant amount of lymphoid tissue ("adenoids") that surrounded the opening of the auditory tube. You assume that your clinical supervisor (who is an otolaryngologist) will remove this tissue to facilitate the drainage capacity of the middle ear. However she elects to install a small tube in each eardrum to drain the middle ear into the external ear. The tubes are placed in the inferior posterior quadrant of each tympanic membrane. *Followup:* Subsequent upper respiratory infections during the next year are not accompanied by the severely painful earaches. The pediatrician intends to remove the ear tubes when the child's facial growth permits the natural drainage through the auditory tube—i.e., if they have not dropped out accidentally meanwhile.

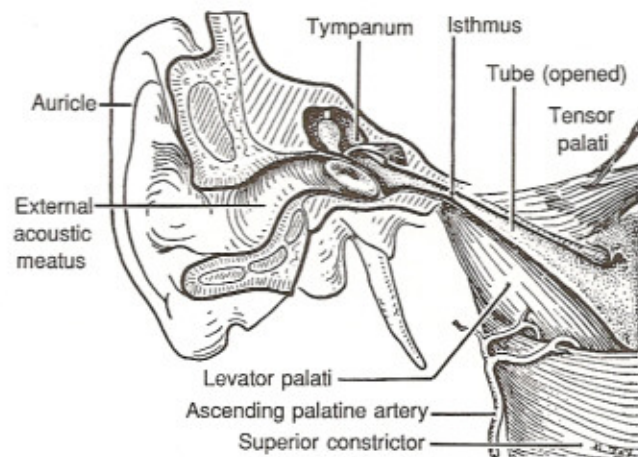


Figure 40.1. The external and middle ears and the auditory tube, opened throughout.

AURICLE

The framework of the auricle is made of a single piece of elastic cartilage (fig. 40.2) except at its most inferior portion, **the lobule**. The lobule, or ear lobe, is made of fibroareolar tissue. The auricular cartilage is continuous with the cartilage of the external acoustic meatus (L. meatus = canal).

The skin covering the cartilage and fibroareolar lobule is closely adherent to the underlying connective tissue skeleton of the ear. The surface anatomy of the skin of the ear is illustrated in Figure 40.3. The sensory supply to the skin of the ear is of significance in the clinical examination. The superior portion of the ear is innervated by V³ via the auriculotemporal nerve. The inferior portion of the ear, particularly the lobule, is innervated by fibers of the greater auricular nerve from the cervical plexus (C2, 3). The external (acoustic) meatus and the skin surrounding its opening, **the concha**, intervenes between these two surface areas. They are innervated by nerve X for pain, temperature, touch, and pressure. Some touch may also be carried by nerve VII from the external auditory canal. A neurological examination of the skin

External Ear

The external ear consists of an auricle and an external acoustic meatus (fig. 40.1).

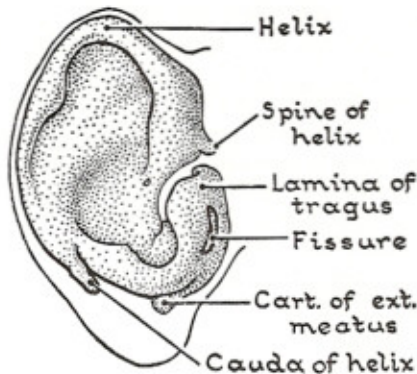


Figure 40.2. The cartilage of the auricle.

of the ear can therefore give a physician an insight into the neurologic status of the upper spinal cord (C2, 3), medulla (X), and pons (V) region of the brainstem.

Movement of the ear is by the posterior, superior, and anterior auricular muscles. These muscles of facial expression are innervated by the posterior auricular branch of VII.

MEATUS

This canal extends from the concha to the **tympanic membrane** or eardrum (fig. 40.1).

The lateral one-third of the meatus is chiefly cartilaginous and is attached to the outer edge of the bony meatus, which forms the medial two-thirds of the canal.

The meatus is sinuous, being convex superiorly and convex posteriorly. One must therefore pull the ear upward, backward, and laterally to straighten out the external auditory meatus, and then one can directly inspect the tympanic membrane with an ear speculum.

The cartilaginous portion of the meatus is lined with skin in which there are hairs, sebaceous glands, and mod-

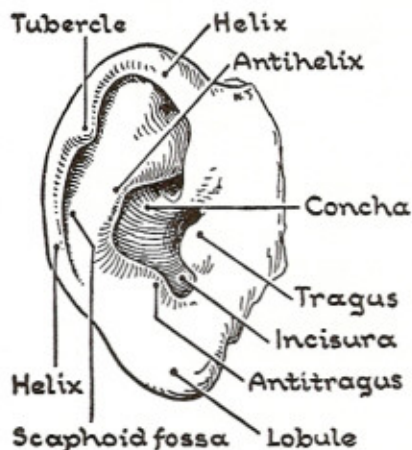


Figure 40.3. The auricle.

ified sweat glands, which secrete cerumen or ear wax. Infections (boils) may occur here and, because of the close adherence of the skin to the cartilage, can cause great discomfort. The bony meatus is lined by a thin stratified squamous epithelium that also lines the external surface of the tympanic membrane. The auricular branch of the vagus nerve is the principal sensory supply to the external acoustic meatus.

Middle Ear or Tympanum

Sound waves that enter the external acoustic meatus create a pressure on the tympanic membrane. The subsequent vibration of the tympanic membrane moves the three bony ossicles (**malleus**, **incus**, and **stapes**) within the middle ear. This bony movement in turn compresses the fluid in the inner ear by vibrating the oval window, the **fenestra vestibuli**, on the medial wall of the middle ear (fig. 40.4). This conversion of airwaves, to vibrations in a solid, to fluid vibration, is a highly efficient means of amplifying the sound waves that are entering the external acoustic meatus. Figure 40.4 also depicts the difference in the size of the larger tympanic membrane and the much smaller oval window membrane, which is attached to the stapes. This concentration of vibrating surface area is also an amplifier of sound energy. Disorders that block the efficient transmission of these energies will therefore create varying degrees of deafness.

The middle ear is actually a modified air sinus within the petrous temporal bone. It communicates with the mastoid air cells through the **aditus** and also with the nasopharynx through the **auditory tube** (figs. 40.5 and 40.6). The middle ear cavity (tympanum) is a vertically oriented cavity whose shape resembles that of a red blood cell. The width at the center is only 2 mm, while the roof is 6 mm wide and the floor is 4 mm wide. The vertical height is approximately 15 mm. One can appreciate that the size of this cavity is comparable to a dime standing on its edge.

TYMPANIC CAVITY AND ITS WALLS

The **roof**, or **tegmen tympani** (figs. 40.7 and 40.8), is a thin layer of petrous temporal bone separating the middle cranial fossa from the middle ear. Just below this roof, the middle ear cavity is expanded into the **epitympanic recess**. This area provides space for the articular joint between the **head of the malleus** and the **body of the incus**.

The **floor** of the tympanic cavity is also a thin layer of petrous bone that rests upon the **superior jugular bulb**.

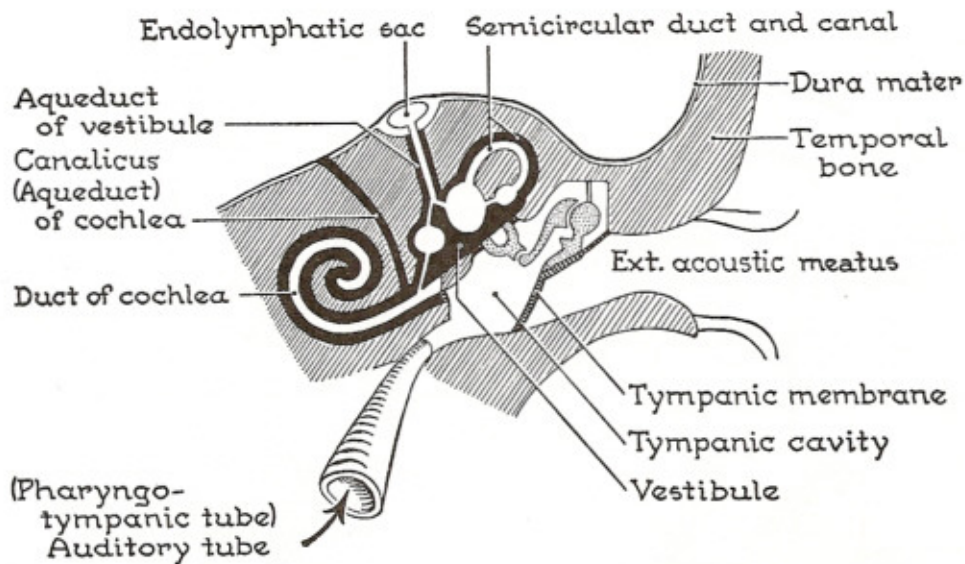


Figure 40.4. General plan of the 3 parts of the ear.

Figures 40.7 and 40.8 illustrate the relationship of the floor of the tympanic cavity and the superior aspect of the carotid sheath. The internal carotid artery and the internal jugular vein diverge from their close relationship in the carotid sheath at the floor of the tympanic cavity. The internal carotid artery courses anteriorly into the middle cranial fossa, while the internal jugular vein passes posteriorly into the posterior cranial fossa. The IX and X nerves that are within the carotid sheath also send their auricular branches into the tympanic cavity through foramina in its bony floor.

The lateral wall of the tympanic cavity is closed by the tympanic membrane (figs. 40.8 and 40.9). This wall is visualized by the clinician when the tympanic membrane is examined with an otoscope. The epitympanic recess rises a few millimeters about the tympanic membrane and contributes a bony component to the superior aspect of the lateral wall (fig. 40.8).

Anteriorly, the roof and floor of the tympanic cavity converge to form the bony component of the **auditory (Eustachian) tube**. The bony auditory tube is divided by a shelf of bone, the **processus cochleariformis** (fig. 40.8),

into a superior compartment containing the **tensor tympani muscle** and a lower compartment that joins to the cartilaginous auditory tube. The free edge of the **processus cochleariformis**, which projects into the tympanic membrane, serves as a pulley for the tendon of the **tensor tympani** as it projects laterally to insert onto the handle of the malleus. The ascending carotid artery is also associated with the anterior wall of the tympanic cavity but is separated from the cavity by a thin layer of bone. In some clinical disorders, the patient can hear the pulsation of the blood in the carotid artery as it ascends through this portion of the anterior wall of the middle ear.

The posterior wall near the roof (figs. 40.6 and 40.7) has a tunnel, the **aditus**, that connects the cavity of the middle ear with the mastoid antrum. The aditus serves as a pathway for the fluids in the mastoid air cell to drain into the tympanum, then into the auditory tube and then into the nasopharynx. Upper respiratory infections that affect this drainage pathway can result in a fluid collection within the cavity of the middle ear. Below the aditus, the **facial nerve (VII)** enters the posterior wall of the mid-

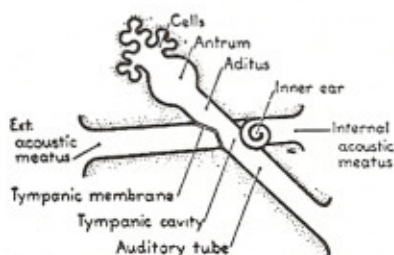


Figure 40.5. The 2 meatuses, which have blind ends, and the line of the airway (tube, cavity, aditus, and antrum), which passes between them, viewed from above.

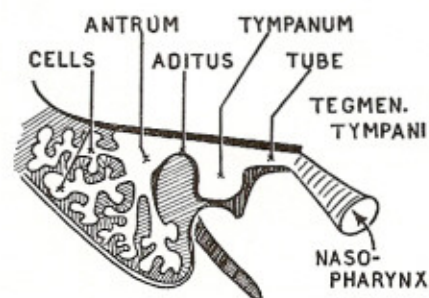


Figure 40.6. Tegmen tympani and passages it covers.

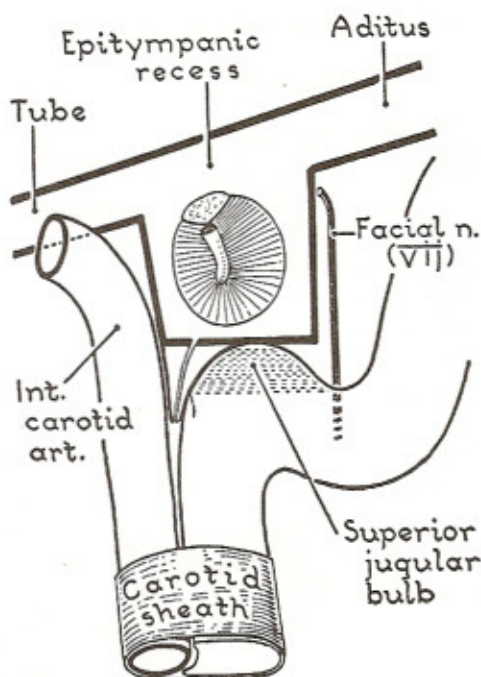


Figure 40.7. Tympanic cavity and its neighbors.

dle ear and descends to exit from the base of the temporal bone through the stylomastoid foramen (figs. 40.8 and 40.10). The **chorda tympani** arises from the facial nerve within the posterior wall of the middle ear, then courses along the lateral wall over the tympanic membrane and then exits into the infratemporal fossa via the **petrotympanic fissure** (fig. 40.8). The posterior wall also has a

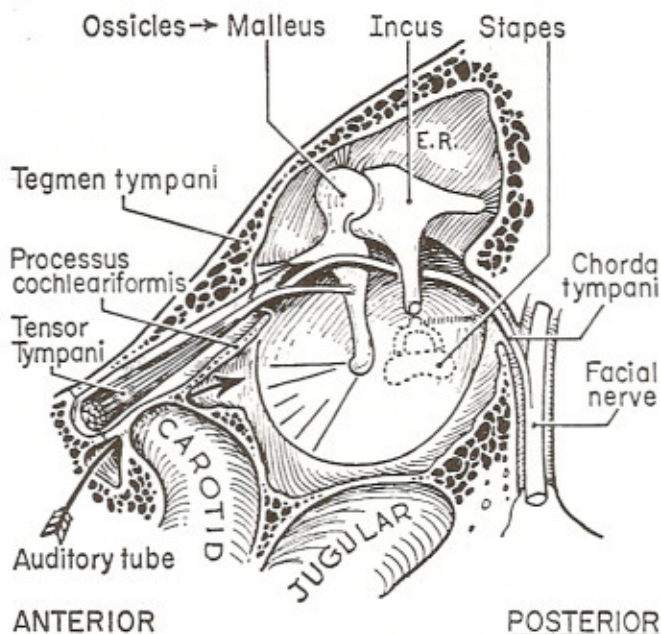


Figure 40.8. Lateral wall of the tympanic cavity and the ossicles. *ER*, epitympanic recess.

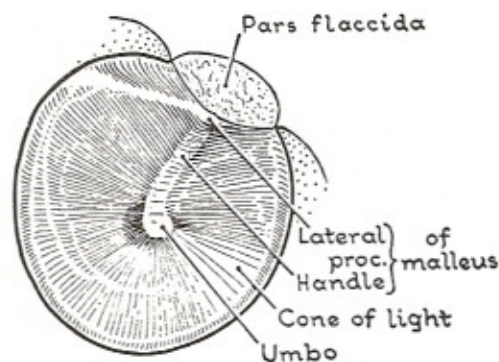


Figure 40.9. Tympanic membrane (lateral view).

small bony projection, the **pyramid** (fig. 40.10). At the apex of the pyramid is an orifice through which the tendon of the **stapedius** muscle passes to insert onto the neck of the stapes. The stapedius muscle acts to retract the footplate of the stapes away from the oval window (fenestra vestibuli) and thereby reflexively attenuates loud sounds by reducing the vibration to the fluid of the inner ear. The **stapedius muscle** receives its motor supply from VII, and in some cases of facial nerve palsy, patients complain of a sensitivity to loud sounds.

The **medial wall** of the tympanic cavity faces the portion of the petrous temporal bone, which contains the inner ear (fig. 40.4). In the center of the medial wall is a prominent bony swelling, the **promontory**, which overlies the first turn of the cochlea of the inner ear (fig. 40.10). Within the mucosa that covers the promontory is a plexus of nerves, the **tympanic plexus**. Branches of VII, IX, and X intermingle within this tympanic plexus and supply sensory fibers to the middle and external ear as well as preganglionic secretomotor fibers to the petrosal nerves.

Posterior and superior to the promontory on an oblique line projecting to the aditus are: (a) fenestra vestibuli; (b) the canal for the facial nerve and (c) the prominence formed by the lateral semicircular canal. The **fenestra vestibuli** is an **oval window** that is an opening between the vestibule of the inner ear and the tympanic cavity. This opening is approximately 3 mm across in its horizontal dimension and its form matches the surface of the footplate of the stapes, which overlies the oval window.

The **canal for the facial nerve** runs horizontally and connects the internal acoustic meatus with the descending facial canal within the posterior wall (fig. 40.10). The bone covering the horizontally oriented canal of the facial nerve is very thin and may be absent in some areas, leaving VII in contact with the mucosal lining of the middle ear cavity. The **lateral semicircular canal** also lies horizontally and bulges into the aditus.

Posterior and inferior to the promontory is a second opening in the medial wall, the **fenestra cochleae** or **round window**. It is between the cavity of the middle ear and the scala tympani of the inner ear. This bony opening is closed by a membrane.

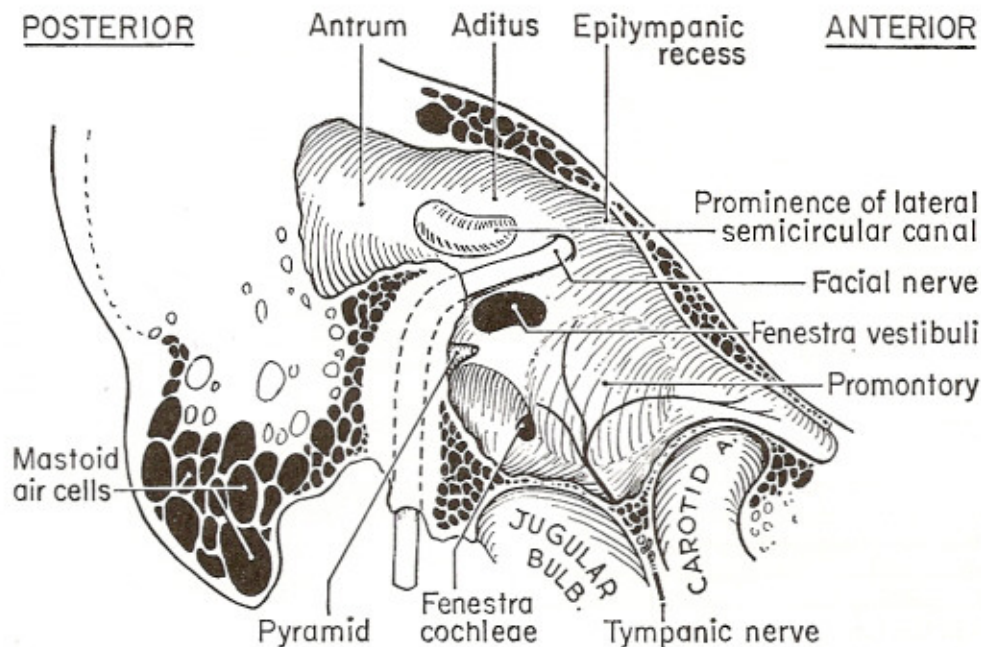


Figure 40.10. Medial wall of the tympanic cavity.

TYPANIC MEMBRANE

This membrane or eardrum (fig. 40.9) is nearly circular, being 9 mm high and 8 mm wide. It is set in a sulcus of the tympanic bone. The tympanic membrane faces laterally, anteriorly, and inferiorly as though it were oriented to "catch" the sounds reflected from the ground as one advances. It is composed of circular and radial fibers and is lined by an ectodermally derived epidermis laterally and an endodermally derived mucous membrane medially. The handle of the malleus is attached to the fibrous tissue of the tympanic membrane and separated from the cavity of the middle ear by the overlying mucous membrane. The radial fibers of the tympanic membrane radiate from the inferior extent of the handle of the malleus. A relaxed superior portion of the tympanic membrane, the **pars flaccida**, attaches to the lateral process of the malleus. In "puncturing" an eardrum to drain the middle ear, one should avoid this pars flaccida region because of the underlying chorda tympani (fig. 40.8).

AUDITORY OSSICLES, JOINTS, AND MUSCLES

Ossicles

There are 3 ossicles—malleus (hammer), incus (anvil) and stapes (stirrup) (figs. 40.4 and 40.8). They intervene

between the tympanic membrane and the oval window and have two synovial joints within their bony chain.

The **malleus** is approximately 8 mm long and vertically oriented within the tympanic cavity. It has a round **head** with an articulating facet for the incus facing posteriorly. The **neck** of the malleus joins the head with the long **manubrium** (handle) that extends inferiorly onto the upper half of the tympanic membrane. The membrane is attached to the manubrium from the **lateral process** superiorly to the inferior tip. An **anterior process** of the malleus is directed anteriorly and connected to a stabilizing ligament.

The **incus** is shaped like a molar tooth. It has a body and 2 diverging processes. The **short crus** (L. = leg-like process) is horizontal and has a ligament that attaches the incus to the posterior wall of the epitympanic recess (fig. 40.8). The **long crus** is vertically oriented and descends into the tympanic cavity. At the tip of the long crus is a medially projecting **lenticular process**. This articulates with the head of the stapes. The **body** of the incus articulates with the head of the malleus and has a prominent articular facet on its anterior aspect.

The **stapes** has a head with a concaved socket for articulation with the lenticular process of the incus. The head is supported by a short **neck** that intervenes between the two limbs (posterior and anterior) that attach to the medial **footplate** or **base**. The footplate covers the oval window and is attached to the margin of the oval window by an **annular ligament**.

Joints of the Ossicles

The joints between the malleus and the incus and the incus and the stapes have synovial cavities. Movement of the malleus is induced by vibration of the tympanic membrane. The free articulation of the incus with both the malleus and the stapes is necessary for the amplification of the sound energy that has caused the vibration of the tympanic membrane. The joints are affected in **otosclerosis** and a subsequent hearing loss is experienced by the patient. Surgical procedures on these impaired joints can correct this form of "deafness."

Sound Conduction

Transferring energy waves from a gas (air) directly to a fluid (perilymph) is ineffective since most of the energy is reflected from the interphase of the gas and the fluid. The vibrating eardrum and attached ossicle chain are an efficient means of converting the air waves in the external ear to fluid waves in the inner ear.

The effective vibratory area of the tympanic membrane is 55 mm² and the average size of the stapes footplate is 3.2 mm². Hence the hydraulic ratio (membrane to footplate) is 17:1.

The lever ratio of the malleus to the incus is 1.3:1.0, and the total transformer ratio is thus 22:1 (von Békésy).

Muscles of the Ossicles

There are two muscles that attach to the ossicles. Contraction of either muscle will result in an attenuation of sound by decreasing the movement of the ossicle to which they attach.

The **tensor tympani** is a muscle within the bony auditory tube. As its tendon leaves the bony canal, it uses the "lip" of the *processus cochleariformis* as a pulley (fig. 40.8). The tendon then courses laterally in the tympanic cavity to insert onto the handle of the malleus. Contraction of the tensor tympani pulls the tympanic membrane medially and thereby tenses the membrane. More energy is thereby needed in the vibrating air to move the membrane and attached malleus. The tensor tympani is innervated by a branch from the trunk of V³ as it exits from the foramen ovale.

The **stapedius** is contained in the hollow **pyramidal process** of the posterior wall of the tympanic membrane (fig. 40.10). Its tendon leaves the foramen at the apex of the pyramid and passes anteriorly to insert onto the neck of the stapes. When it contracts, it will pull the footplate away from the oval window and "dampen" the sound energy, which is being relayed to the fluid in the vestibule of the inner ear. The stapedius is innervated by the facial nerve (VII). Paralysis of the facial nerve can therefore cause a sensitivity to loud sounds (hyperacusis) when the stapes is fully opposed to the oval window.

Clinical Case 40.2

Patient Nancy D. This 35-year-old woman developed complete inner-ear deafness bilaterally following a severe febrile illness when she was 11 years old. She was trained in sign language and was able to maintain fairly good speech patterns. Recently, she returned from a major audiology center that specializes in research and treatment by surgically implanting "cochlear prostheses." At ENT Rounds this morning, her case is presented. She demonstrates her substantial ability to understand and repeat sentences spoken behind her back. The ensuing lengthy discussion of hearing problems challenges your knowledge of the inner ear and related structures.

Internal Ear

The internal ear contains the specialized neurologic mechanisms and receptors for both hearing and balancing (vestibular) functions. It is contained within the petrous bone and has 2 parts: the **bony labyrinth** and the **membranous labyrinth**, which is within the bony labyrinth.

BONY LABYRINTH (fig. 40.11)

This has 3 parts—**cochlea**, **vestibule** and **semicircular canals**. They are related to the medial wall of the tympanic cavity. The cochlea lies deep to the promontory, the vestibule is associated with the oval window, and the lateral semicircular canal bulges into the aditus (fig. 40.10). The entire bony labyrinth is only 17 mm long.

The **cochlea** resembles a snail's shell with 2½ coils. It contains the neurological receptors for hearing. Vibration of the perilymph in the vestibule is transmitted to the fluids of the cochlea. The wave patterns in the fluids of the cochlea stimulate the hearing receptors in the inner ear, and the sound is perceived in the temporal lobe of the cerebral cortex.

The **vestibule** lies between the cochlea and the semicircular canals (fig. 40.12). It communicates with both of these chambers in the petrous bone. It opens laterally through the oval window into the tympanic cavity. The

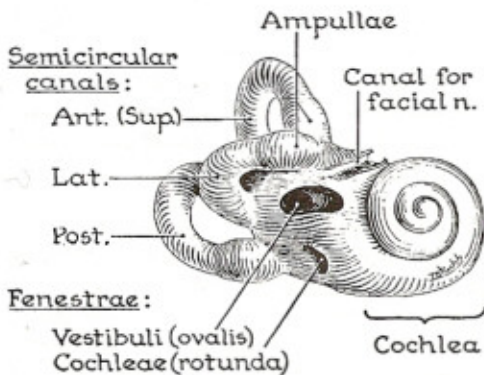


Figure 40.11. The bony labyrinth.

fluid (perilymph) within the vestibule contacts the footplate of the stapes in the oval window. The perilymph also surrounds the membranous labyrinth within the cochlea and the semicircular canals. While the perilymph has a composition similar to subarachnoid cerebrospinal fluid, it is not felt that the two spaces communicate on the surface of the petrous bone (Young).

The **three semicircular canals**—anterior (superior), posterior, and lateral—are set at right angles to each other and occupy 3 planes in space. The lateral canals of opposite sides of the ear are horizontal and lie in the same plane. The anterior canal of the one side lies in the same plane as the posterior canal of the opposite side and the two internal ears function together to maintain a proper equilibrium.

The lateral semicircular canal is horizontal and projects laterally forming the prominence in the medial wall of the aditus. The other anterior and posterior semicircular canals are vertically oriented. The anterior semi-

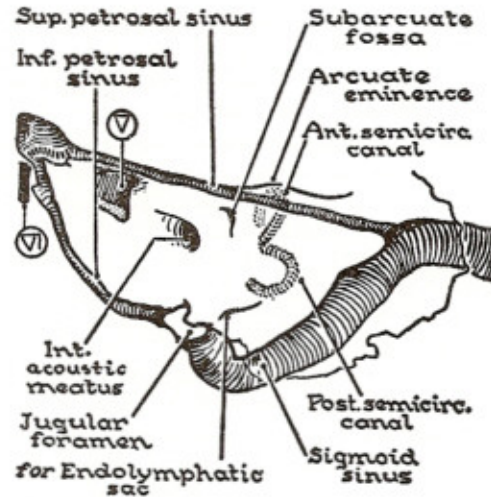


Figure 40.13. The posterior surface of the petrous bone is bounded by venous sinuses.

circular canal is oriented at a 90° angle to the transverse axis of the petrous bone, while the posterior semicircular canal is immediately deep to the posterior (cerebellar) surface of the petrous bone and parallel to this surface (fig. 40.13).

MEMBRANOUS LABYRINTH (fig. 40.12)

This has three components: (a) the cochlear duct; (b) the saccule and utricle; and (c) the 3 semicircular canal ducts. It is a closed system containing endolymph. A stalk, the **ductus endolymphaticus**, passes from the saccule and utricle through a canal (aqueduct of the vestibule) in the

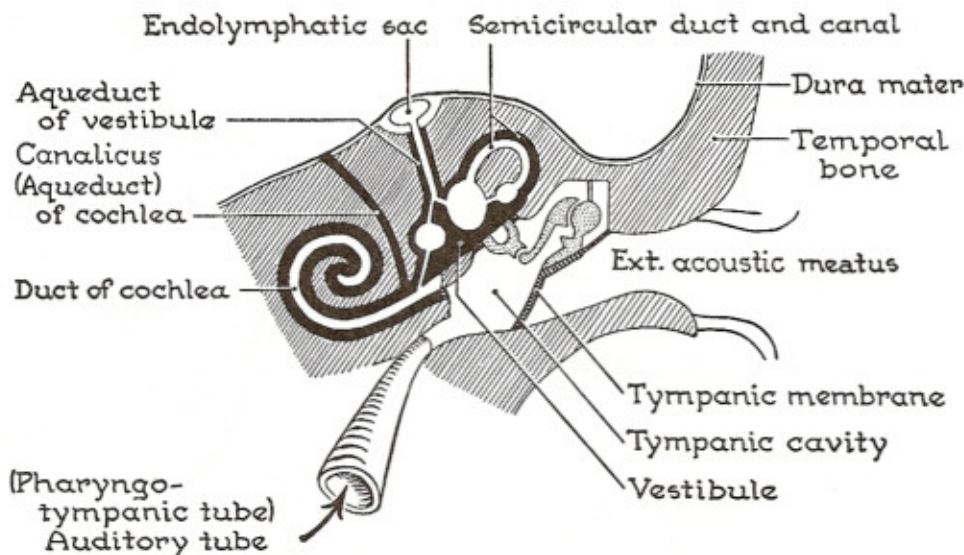


Figure 40.12. General plan of the 3 parts of the ear.

petrous bone to a fissure lateral to the internal acoustic meatus (fig. 40.12). There the duct, which acts as a "safety" expansion **endolymphatic sac**, is placed extradurally.

Vibration of the stapes creates fluid waves in the underlying perilymph, which in turn creates fluid waves in the endolymph of the cochlear duct. This is the basis for mechanical stimulation of the hearing receptors. Angular acceleration of the endolymph within the semicircular canals causes a shift of endolymph in the ducts of the semicircular canals, and this is the mechanical basis for stimulating the vestibular receptors in the ampulla of the semicircular canal. The utricle and saccule are receptors for head position based on gravitational forces on their receptor mechanisms. The utricle detects head movement in the sagittal plane (up and down), and the saccule detects head movement in the coronal plane (side to side).

NERVOUS AND ARTERIAL SUPPLY TO THE INTERNAL EAR

Nerve VIII supplies the special sensory receptors in the internal ear. The **auditory nerve** is better termed the **vestibulocochlear nerve** to depict both of its special functions of equilibrium and hearing. Clinical testing of nerve VIII should include both tests for hearing and balance. Hearing is tested with a "tuning fork" held in the air outside the external auditory meatus and then placed on the mastoid process. This tests air conduction through the tympanic membrane and ossicles and fluid vibration through the temporal bone. If the tympanic membrane or ossicles are impaired, the bone conduction should be heard normally when the tuning fork is placed on the mastoid process. Patients with neurologic damage in nerve VIII will also have hearing loss through bone conduction as well as air conduction.

Vestibular function may be tested by having the patients stand with their feet close together and their eyes closed. If the vestibular system or nerve VIII is defective, the patient will tend to fall to the affected side.

The blood vessels to the internal ear enter the internal acoustic meatus with VII and VIII. The **labyrinthine artery** is a branch of the anterior inferior cerebellar artery and can be affected in patients who have suffered "strokes" in their vertebral arterial system.

Facial Nerve (Intrapetrous Part)

The **facial nerve** (VII) leaves the posterior cranial fossa through the internal acoustic (auditory) meatus with VIII. VII lies above VIII within the canal. VII is mainly a motor nerve to the muscles derived from the second branchial

(pharyngeal) arch of the embryo—the muscles of facial expression, stylohyoid, posterior belly of the digastric, and stapedius. There is also a **nervus intermedius** component of the facial nerve in the internal acoustic meatus that contains the special sensory (taste) and preganglionic parasympathetic secretomotor fibers to all the glands of the face except the parotid.

VII courses laterally within the internal auditory meatus above the vestibule of the bony labyrinth to reach the medial wall of the tympanic cavity (fig. 40.14). It makes an abrupt bend (genu) on the medial wall and courses posteriorly within the bone above the oval window to reach the posterior wall of the tympanic cavity. A second bend occurs at the posterior wall, and nerve VII then descends inferiorly through the facial canal of the petrous bone to exit the base of the skull through the **stylomastoid foramen**.

At the genu on the medial wall of the tympanic cavity is the **geniculate ganglion**. It contains the pseudo-unipolar cell bodies for the taste fibers from the anterior two-thirds of the tongue and the palate. **There are no synapses in the geniculate ganglion.** The **greater superficial petrosal nerve** branches from VII at the geniculate ganglion to pierce the anterior wall of the tympanic cavity and enter the middle cranial fossa. The superficial petrosal nerve contains taste fibers from the palate and secretomotor fibers for glands in the roof of the oral cavity, nasal cavity, and orbit.

The descending part of VII gives off the **motor branch to the stapedius muscle** and the **chorda tympani**. The chorda tympani courses between the handle of the malleus and vertical process of the incus to exit into the

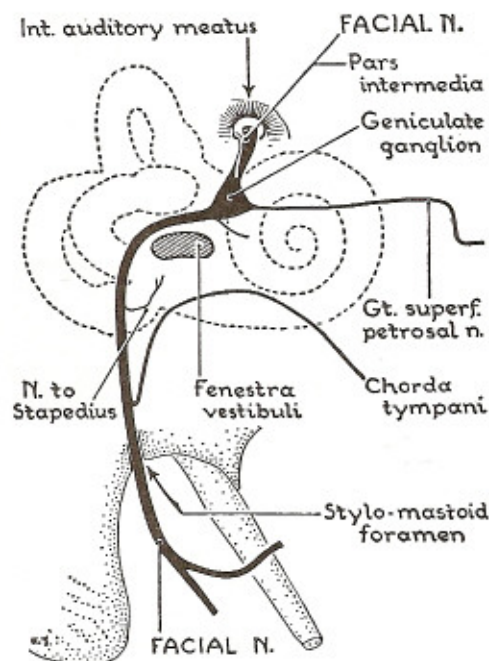


Figure 40.14. Intrapetrous course of facial nerve.

infratemporal fossa through the **petrotympanic fissure**. The chorda tympani contains taste fibers from the anterior two-thirds of the tongue and secretomotor fibers to the submandibular ganglion. The cell bodies for the taste fibers are in the geniculate ganglion on the medial wall of the tympanic cavity. Damage to nerve VII in the intratympanic portion is tested by "back-tracking" the branches of VII above the stylomastoid foramen. If the patient has a paralysis of the facial muscles on one side of the face, the clinician would then test (a) taste in the anterior of the tongue (**chorda tympani**), (b) for signs of hyperacusis (**nerve to stapedius**) and (c) lacrimation on same side (**greater superficial petrosal nerve**). The lack of tearing on the side of facial paralysis presents a serious clinical situation. Since the lacrimal gland moistens the cornea, a lack of lacrimation causes desiccation of the cornea and can produce ulceration of the cornea and subsequent blindness. Corneal desiccation induces a painful stimulus, which is carried by V¹. Thus, a facial paralysis with associated corneal disorders may result from trauma to VII between the brainstem and the geniculate ganglion. The most common form of nerve VII paralysis is Bell's Palsy, and this usually only affects the branches of the nerve below the stylomastoid foramen.

Clinical Mini-Problems

1. Severe earache and infection in the external auditory meatus may cause patients to vomit.
 - (a) Which nerve provides sensory innervation to the mucous membrane in the external auditory meatus?
 - (b) Does this nerve have any sensory relationship with the gag reflex or gastrointestinal tract?
2. Why would eruption of the molar teeth in children or adolescents sometimes "refer" a pain in the ear?
3. Which cranial nerve provides sensory and secretomotor innervation to the mucosa lining the middle ear?
4. Why would a clinician restrict the opening of the tympanic membrane to the lower one-half and particularly the postero-inferior quadrant?
5. Why would a nerve VII lesion in the internal acoustic meatus make the patient sensitive to loud noises?
6. Where in the temporal bone would one expect a lesion that gave signs of right-sided facial paralysis, dryness of the right eye, decreased auditory reception in the right ear, and a tendency to fall to the right side when standing with one's eyes closed?

(Answers to these questions can be found on p. 587.)

Orbital Cavity and Contents

Clinical Case 41.1

Patient Frank S. This 63-year-old plumber with a 2-year history of intermittent headaches complained to his physician that he was experiencing "double vision." The physician examined his eyes and noted that the right eye deviated laterally and inferiorly at rest. The patient was unable to move the right eye medially (adduction), and the pupil was dilated and unresponsive to light, but no visual impairment was noted in the retina. The left eye was completely normal in its motor and sensory function. Now he is an inpatient at the University Hospital. Further tests reveal a meningioma (tumor of the dura) that is invading the upper aspects of the superior orbital fissure. At *combined neurology-ophthalmology ward rounds*, faculty and students discuss the alternatives for best treatment. You only have your anatomical knowledge to help you follow the debate.

Bony Orbital Cavity

Each orbital cavity is a pyramid-shaped compartment (figs. 41.1 and 41.2) with the base oriented toward the face and the apex directed into the middle cranial fossa. The roof of the orbit forms most of the floor of the anterior cranial fossa. The medial walls of each orbit parallel each other and are separated by the nasal cavities. The lateral walls of each orbit do not parallel each other. They diverge as they project anteriorly and are approximately at right angles to each other. The optic canal and the su-

perior orbital fissure are located at the apex of each orbital cavity.

ORBITAL MARGIN

The **frontal**, **maxillary**, and **zygomatic** bones each constitute approximately one-third of the orbital margin (fig. 41.2). The orbital margin is subcutaneous and readily palpable in a physical examination. The inferior margin of the orbit continues medially as the **anterior lacrimal crest** of the **maxilla**. The superior orbital margin continues medially on the **frontal** bone to join the **posterior lacrimal crest** of the **lacrimal bone**. These lacrimal crests delineate the bony fossa that contain the **lacrimal sac** on the medial wall of the orbit. The orbital margin provides a suitable bony protection to the anterior of the eye except at the lateral margin. (Protective eye guards for squash or handball players are designed to complement the protective features of the orbital margin and still provide maximal peripheral vision.)

OPTIC CANAL

This bony channel is located in the sphenoid bone at the root of the lesser wing. It contains the **optic nerve (II)** and the **ophthalmic artery**, as they traverse between the orbit to the middle cranial fossa.

The length of the optic canal is 3–9 mm, and it parallels the plane of the lateral wall of the orbit. The canal is not visible in a standard head x-ray (anterior-posterior projection) (Plate 41.1). To demonstrate this canal in head films a special projection is used which requires that the x-rays parallel the long axis of the optic canal (Plates 41.1 and 41.2).

FISSURES AND SUTURES IN THE ORBITAL CAVITY

The **superior orbital fissure** is at the apex of the orbital cavity between the **lesser** and **greater wings** of the sphenoid bone. The superior orbital fissure contains connective tissue, cranial nerves **III**, **IV**, **V¹**, **VI**, and the **superior ophthalmic veins**. This non-bony component of the or-

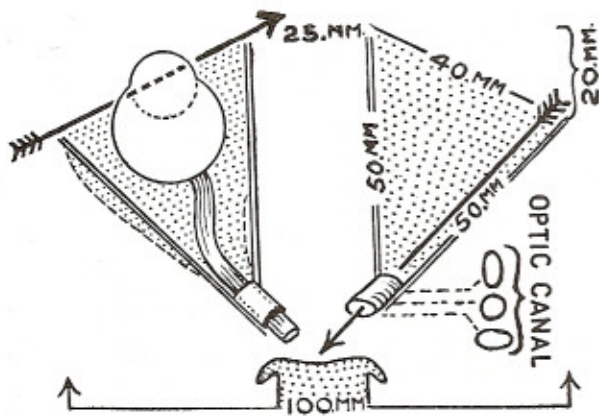


Figure 41.1. The orbital cavities on horizontal section, and their dimensions.

bital cavity appears as a radiolucent (dark) area on an x-ray film (Plate 41.1). The superior orbital fissure is lateral to the optic canal and inferiorly communicates with the **inferior orbital fissure**. The inferior orbital fissure lies between the greater wing of the sphenoid and the maxilla. It transmits the **infraorbital branch of V²**, the **infraorbital vessels**, and the **inferior ophthalmic veins**.

The infraorbital groove on the orbital plate of the maxilla extends anteriorly from the inferior orbital fissure. It communicates with the face throughout the infraorbital foramen in the maxilla below the inferior margin of the orbit. The infraorbital nerve and vessels traverse this foramen and groove in their course between the face and the posterior aspect of the orbital cavity.

The sutural lines between the individual bones that make up the orbital cavity are shown in Figure 41.2. Six

different skull bones: **frontal, maxilla, zygoma, sphenoid, ethmoid, and lacrimal**; fuse in sutural articulation to make a stable bony orbit.

WALLS OF THE ORBITAL CAVITY (fig. 41.2)

The medial wall is "paper-thin" and translucent in the dried skull. It separates the orbital cavity from the **ethmoid air cells** (sinuses) of the nasal cavity (see fig. 41.5). The **anterior** and **posterior ethmoid foramina** are openings in the wall that transmit nerves and vessels between the orbit and the ethmoid sinuses. The **lacrimal fossa** is also located anteriorly on the medial wall at the angle between the floor and the medial wall.

The inferior wall (floor) of the orbit is formed mainly by the **orbital process** of the **maxilla**. It contains the **infraorbital groove**, the **infraorbital fissure**, and the inferior part of the suture between the maxilla and zygoma.

The lateral wall is strong and functions as a major "force-transmitter" for the occlusal forces that project superiorly from the upper molar teeth. A **foramen for the zygomatic (V²) nerve** is located in the lateral wall. A fossa for the **lacrimal gland** is also associated with the lateral wall at its angle with the frontal bone.

The superior wall (roof) of the orbit is formed by the **frontal bone**. The **supra-orbital notch** (sometimes a foramen) is a palpable defect on the superior margin of the orbit. The supra-orbital nerve (V¹) and vessels pass beneath the roof of the orbit, as they communicate with the skin and subcutaneous tissues over the superior margin of the orbit and forehead.

The bony orbit is lined internally by a periosteum (**the periorbital**). This tough connective tissue lining is easily detached from the roof and the medial wall during sur-

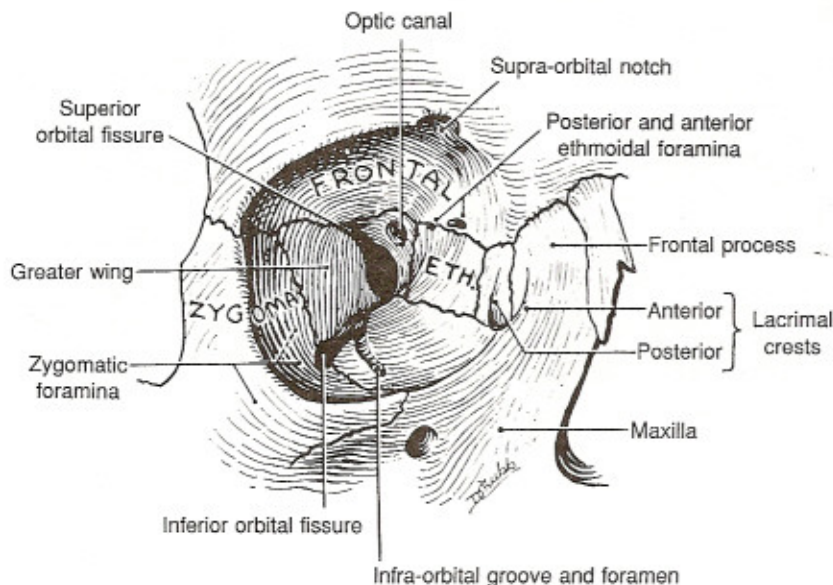


Figure 41.2. The bony walls of the orbit (orbital cavity).



Plate 41.1. An anteroposterior projection of the orbital region of the skull. Superior orbital fissures appear as radiolucencies inferior to the lesser wing of the sphenoid.

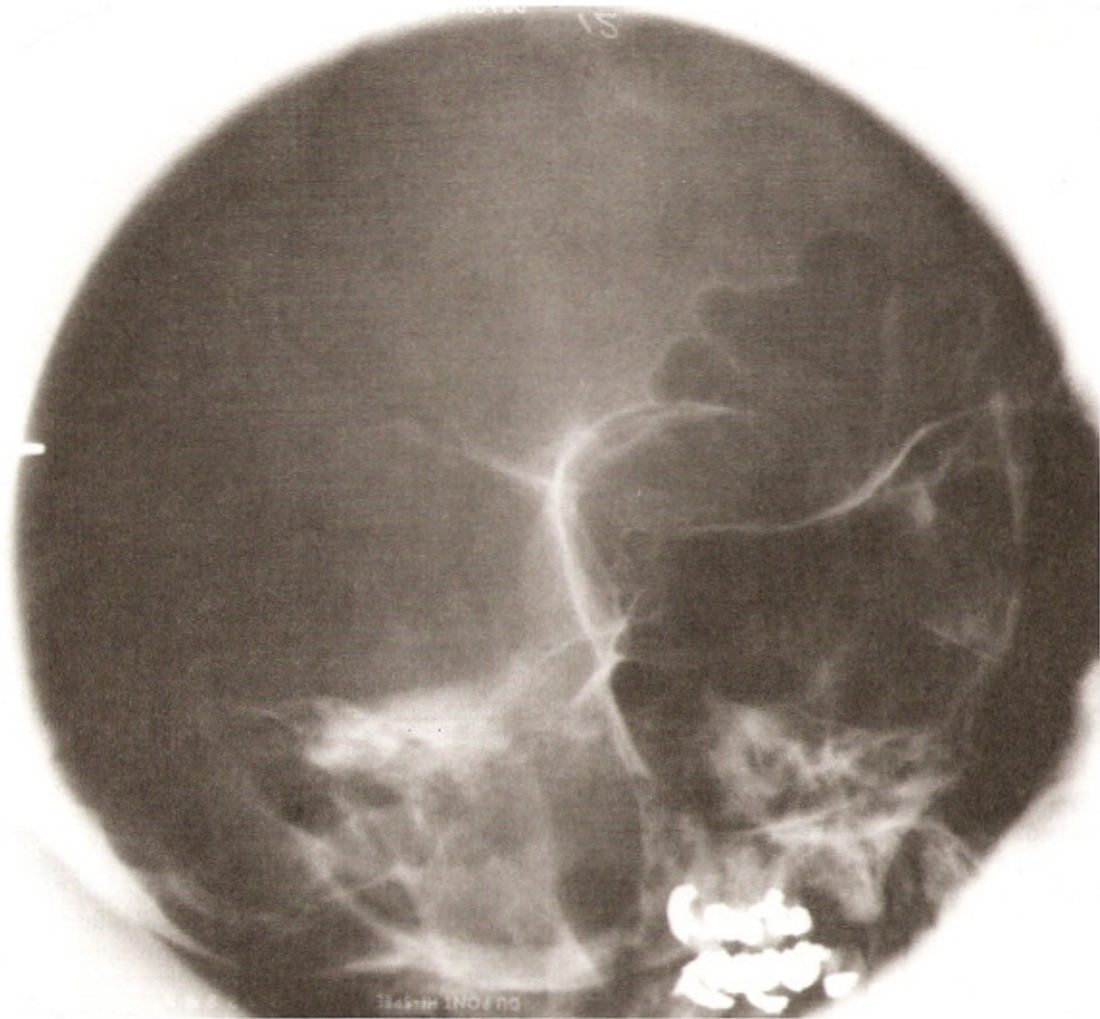


Plate 41.2. An oblique view of the orbit showing the optic canal in the lesser wing of the sphenoid.

gery. It is continuous with the **endosteal dura** of the middle cranial fossa at the superior orbital fissure.

Contents of the Orbital Cavity

EYEBALL (BULBUS OCULI)

The eye occupies the anterior half of the orbital cavity, while its associated muscles and nerves occupy the posterior half. Although the eye projects slightly beyond the bony orbital margin, the overlying soft tissues prevent a

flat surface object, such as a book, from contacting the cornea when placed over the eye (figs. 41.1 and 41.3).

The posterior five-sixths of the eye is covered by a tough, white fibrous tissue (**the sclera**). The transparent anterior one-sixth is the **cornea**. The sclera and the cornea are continuous at the **corneoscleral junction**. The center of the cornea forms the **anterior pole** of the eye and the **posterior pole** is opposite.

A line joining the anterior and posterior poles is termed the **anteroposterior, sagittal, or optic axis**. This is a distance of approximately 24 mm. The eye reaches its adult size in early childhood (2–3 years), which correlates with the growth of the forebrain. The orbital and cranial growth in a young child is more prominent than facial growth in the lower half of the face. The latter region normally reaches its maximal growth after puberty in the late teens.

The **retina** lines the inner surface of the eye posterior

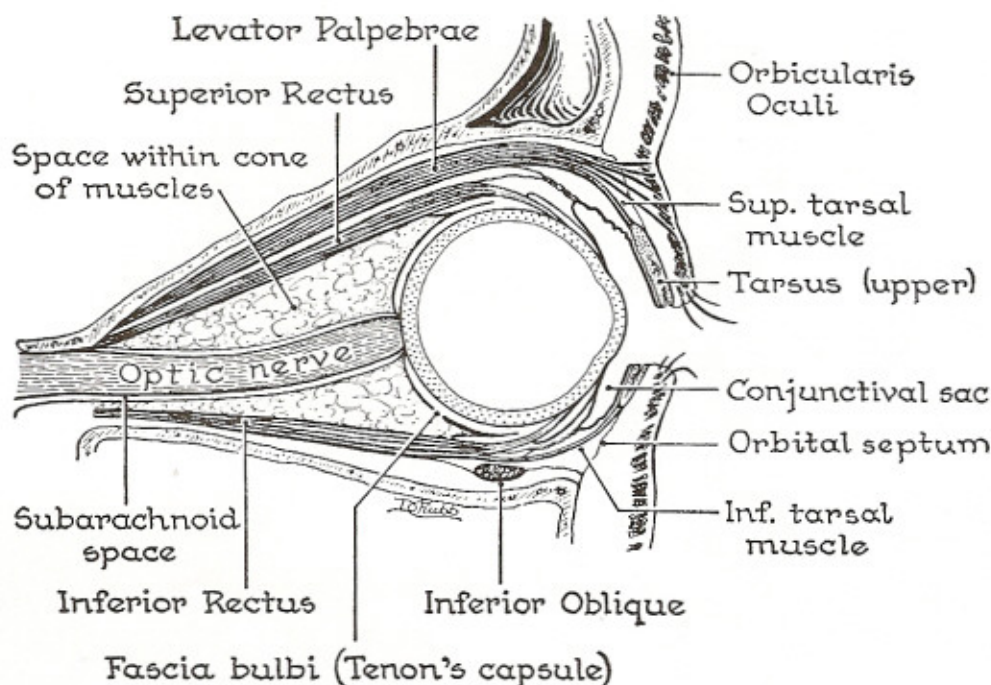


Figure 41.3. Diagram of the orbital cavity (on sagittal section).

to the corneoscleral junction. Vision is perceived most keenly (**visual acuity**) on the retina at the posterior pole. This is the region of the **macula** (yellow spot) (see figs. 41.12 and 41.14), where the retinal receptors are all cones. The **optic nerve** (II) joins the eye in the region of the posterior pole 3 mm medial (nasally) from the macula (see fig. 41.14). The fibers of II penetrate the entire posterior wall of the eye to surface on the retina at the **optic disc (papilla)**, which is nonreceptive and a blind spot on the retina.

OPTIC NERVE (II)

The optic nerve carries the sensory impulses generated by stimulation of the receptors (rods and cones) in the retina. It passes posteriorly from the back of the eye, through the orbit to enter the optic canal in the lesser wing of the sphenoid bone. The optic nerves form the optic chiasm and optic tracts within the middle cranial fossa after they exit the optic canals via the optic foramen. The course of each optic nerve within the orbital cavity is somewhat sinuous (fig. 41.1). This permits a certain degree of unrestrained movement of the eye within the orbital cavity.

The optic nerve is a part of the brain and is therefore covered by meninges. Figure 41.3 shows the very important relationship of the optic nerve and the dura mater and its underlying subarachnoid space. The dura is continuous with the sclera of the eye, and the subarachnoid space abuts against the posterior aspect of the retina around

the optic disc. Increased pressure in the subarachnoid space is therefore readily detectable in an eye examination with an ophthalmoscope. The bulging of the retina around the optic disc creates the sign of "**papilledema**," which is characteristic of increased intracranial pressure.

The optic nerve and the retina are supplied by a **central artery of the retina**, which arises from the ophthalmic artery within the optic canal. It is a very small but extremely important artery. Occlusion (thrombosis) of the central artery will cause blindness in the affected eye.

MUSCLES OF THE EYEBALL

There are six muscles that control the movement of each eyeball. Four of these muscles project in a straight line from the apex of the orbital cavity to the sclera, 6–8 mm behind the corneoscleral junction. They are called the **rectus** (straight) muscles. The two remaining muscles approach the eyeball from a medial and anterior direction, and they are termed **oblique** muscles (figs. 41.4 and 41.5).

The **superior rectus**, **inferior rectus**, **medial rectus**, and **lateral rectus** muscles arise from a fibrous, annular cuff at the apex of the orbital cavity (fig. 41.6). This annular arrangement of muscle origins encircles the opening of the optic canal and part of the superior orbital fissure as they communicate with the orbital cavity. The insertion of each rectus muscle into the sclera is just posterior to the conjunctiva that covers the corneoscleral junction on the anterior surface of the eye.

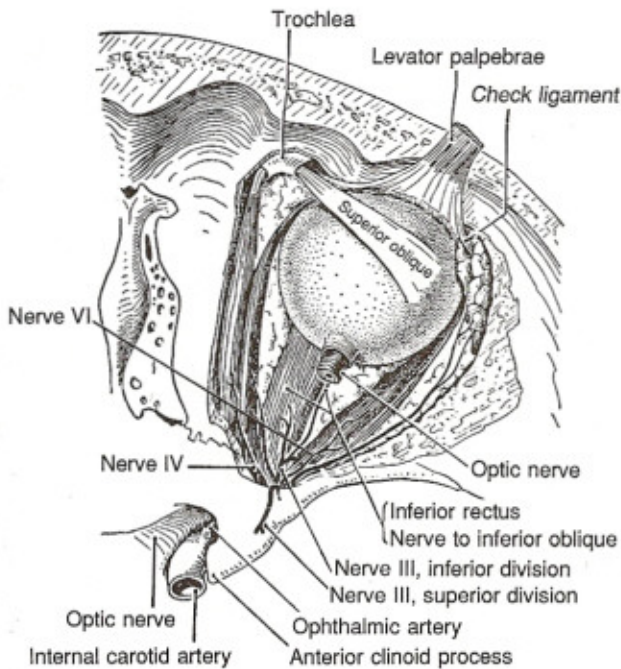


Figure 41.4. Dissection of orbit from above.

The rectus muscles diverge to their respective quadrants on the eyeball. The rectus muscles form a cone of muscles in the posterior half of the orbit surrounding the optic nerve. The space within the muscular cone is filled with fatty tissue, which helps to support the contents of the orbit (fig. 41.3).

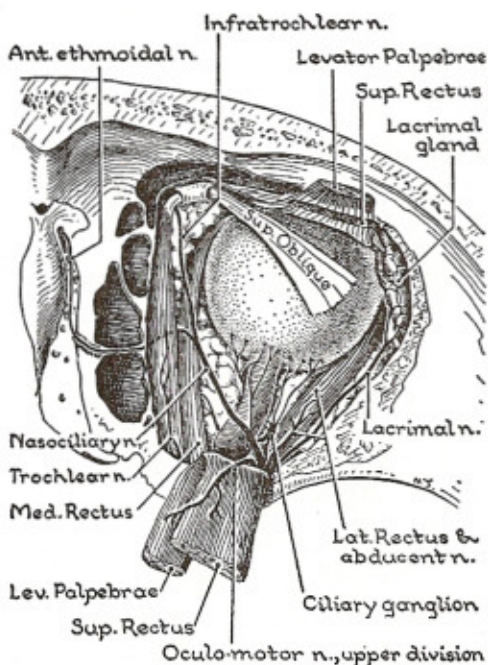


Figure 41.5. Dissection of orbital contents.

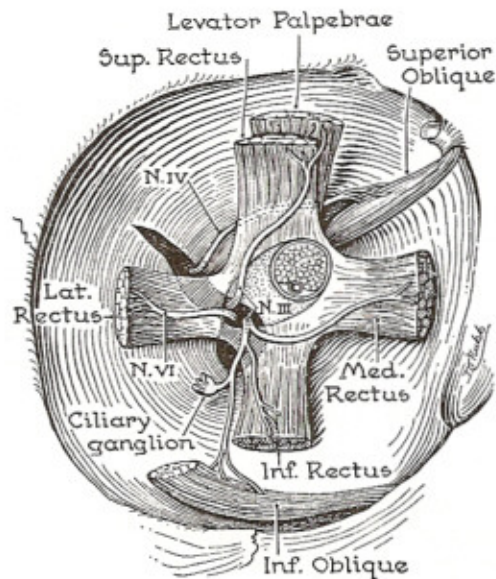


Figure 41.6. Sketch of the distribution of cranial nerves III, IV and VI.

The **superior and inferior oblique muscles** are skeletal muscles that project from the medial wall of the orbit in a posterior and lateral direction into the sclera on the posterior half of the eye. The oblique muscle passes inferior to the associated rectus muscles as they cross the superior and inferior surfaces of the eyeball (fig. 41.7).

The superior oblique arises from the apex of the orbit in the medio-superior angle just outside the ring of fibrous tissues that serves as the origin for the recti muscles. The muscular part of the superior oblique projects anteriorly to a connective tissue pulley, the **trochlea**, which is located in the superomedial angle just inside the anterior margin of the orbit (figs. 41.4 and 41.5). The tendon of the superior oblique passes through the trochlea and then "fans" out as it projects to insert into the sclera of the posterolateral quadrant of the eye. The muscle therefore shortens along the medial wall of the orbit and its effective force is redirected by the trochlea to pull on the eye from a medial and anterior direction.

The inferior oblique arises from the periorbita on the medial wall on the inferomedial angle near the lacrimal fossa. It passes posteriorly and laterally beneath the inferior rectus to insert into the posterior lateral quadrant of the undersurface of the eyeball (fig. 41.6).

The **levator palpebrae superioris** muscle is delaminated from the superior portion of the superior rectus muscle. It shares a similar nerve supply with the superior rectus but inserts into the eyelid and **not** the eyeball. The muscles work congruently so that as the superior rectus rotates the eye superiorly, the levator palpebrae raises the eyelid to expand the visual field of the patient.

The details of the insertion of the levator palpebrae superioris are illustrated in Figure 41.3 and are clinically

important in diagnosing head and neck disorders. Four points of insertion are noted:

1. Most skeletal muscle fibers penetrate the subcutaneous tissue and orbicularis oculi muscle and insert into the skin of the eyelid. Its edges extend to the medial and lateral palpebral ligaments and are attached with them. This component of the muscle is innervated by cranial nerve III.
2. A sheet of **smooth muscle, the superior tarsal muscle**, inserts into the superior tarsal plate (upper tarsus). This component of the levator palpebrae superioris is innervated by sympathetic fibers. Loss of sympathetic innervation to this smooth muscle results in a partial ptosis (drooping upper eyelid).
3. Fascial components of the levator palpebrae superioris and the superior rectus attached to the superior fornix of the conjunctiva.
4. Drooping of the eyelid (Ptosis) is a clinical sign that reflects either damage to nerve III or the sympathetic

fibers that innervate the levator palpebrae superioris. Since nerve III also carries parasympathetic innervation to the pupil as well, a 3rd nerve lesion would usually produce a full ptosis and a dilated pupil. Sympathetic damage would result in a partial ptosis and pupillary constriction.

ACTION OF THE SIX MUSCLES OF THE EYEBALL (see fig. 41.7)

The eyeball rotates on three separate axes (vertical, horizontal, and sagittal). The action of the medial and lateral recti muscles are simple and straightforward. They rotate the eye through the vertical axis. The **medial rectus** is an **adductor** and the **lateral rectus** is an **abductor**. The superior and inferior recti are more complex in their movement because they parallel the orbital axis of the eye socket and not the optic axis of the eyeball. These two muscles project in an anterior and lateral direction

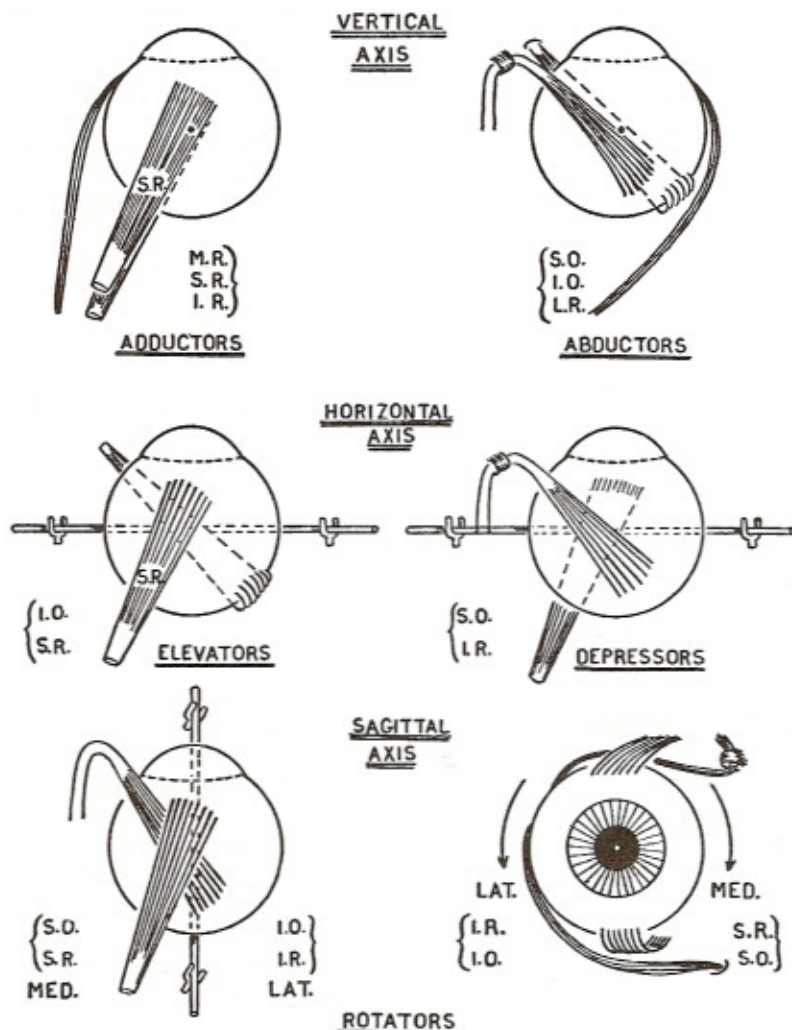


Figure 41.7. The actions of the 6 muscles of the right eyeball represented graphically. MR, medial rectus; SR, superior rectus; IR, inferior rectus; SO, superior oblique; IO, inferior oblique.

as they cross their respective surface of the eyeball. The major function of these muscles are through the horizontal axis. The **superior rectus** is an **elevator** and the **inferior rectus** is a **depressor**. Since both muscles lie medial to the center of the vertical axis, they are **both adductors** of the eyeball as well. The superior rectus and inferior rectus also approach the sagittal axis from the medial side and will therefore produce a "torque" through the sagittal axis. The **superior rectus** will effect a **clockwise medial rotation** (intortion) and the **inferior rectus** will produce a **counterclockwise lateral rotation** (extortion) of the eye.

The oblique muscles are also complex movers of the eye. Their effective direction of force is from medial to lateral in a posterior direction. These forces are nearly perpendicular to those of the superior and inferior recti muscles. The **superior and inferior oblique** muscles pass posterior to the center of the vertical axis and therefore act as **abductors** of the eye. In the horizontal axis, the **inferior oblique** acts as an **elevator** by pulling the postero-inferior surface forward. The **superior oblique** acts as a **depressor** by pulling the posterosuperior surface of the eye forward. The oblique muscles also cross the sagittal axis and therefore produce torque through the optic axis. The **superior oblique** produces a **clockwise medial rotation**, while the **inferior oblique** induces a **counterclockwise lateral rotation** of the eye. Movements of the eye are very important in clinical diagnosis. A test for examining the movement of each individual muscle will be described after the description of the nerve supply to these muscles.

The brain coordinates these complex movements to create smooth bilateral pursuit movements of the eyes. Dysfunction in these movements usually causes the symptom of "double vision" or **diplopia**. This symptom reflects a problem in the motor supply to the eye muscles and not the sensory supply to the retina, which would produce the symptom of blindness.

Nerves in the Orbital Cavity

Four major nerve groups enter the orbital cavity: (a) motor nerves to skeletal muscles; (b) special sensory nerves to the retina (II); (c) general sensory nerves for pain and temperature sensation; and (d) autonomic nerves from the sympathetic and parasympathetic divisions that will supply smooth muscle and glands.

THE THREE MOTOR NERVES TO SKELETAL MUSCLES OF THE ORBIT (fig. 41.6)

The **abducens nerve (VI)** enters the orbit through the superior orbital fissure. It is enclosed by the annular ring

that serves as a point of origin for the recti and it **innervates the lateral rectus** on the surface within the muscular cone. **Nerve VI only** innervates this one eye muscle and therefore influences **abduction** of the eye.

The **trochlear nerve (IV)** also enters the orbit through the superior orbital fissure, but is outside of the fibrous annular ring. Nerve IV courses superiorly across the upper surface of the origins of the superior rectus and levator palpebrae superioris muscles to reach the superior border of the superior oblique muscle. **Nerve IV innervates only the superior oblique muscle.**

The **oculomotor nerve (III)** innervates the superior rectus and levator palpebrae superioris by a superior division and the medial rectus, inferior rectus and inferior oblique muscles through an inferior division (fig. 41.6). Both divisions of III enter the orbit through the superior orbital fissure and are contained within the fibrous annular ring. The muscles are therefore supplied from the surface that is within the muscular cone of the orbit. The inferior division of III also carries preganglionic parasympathetic fibers to the ciliary ganglion.

A convenient memory aid for remembering the innervation of the eye muscles is $LR_6(SO_4)_3$ —the **lateral rectus** by VI, **superior oblique** by IV, and all the rest by III.

A convenient memory aid for remembering how to test the individual muscles of the eye and their nerve supply is the letter H (fig. 41.8). Please note that the test is not the action of the muscle but a trick to isolate each muscle and test it in isolation! Therefore, to test the superior oblique muscle, ask the patient to look medially and down. The inferior movement of the eyeball from the medially adducted position is solely affected by the superior oblique. This tests IV. The abducens nerve (VI) is tested by contracting the lateral rectus muscle and observing the eye in abduction. All of the other eye muscles are innervated by the oculomotor nerve (III). Each muscle that is innervated by nerve III can be isolated from the others: the

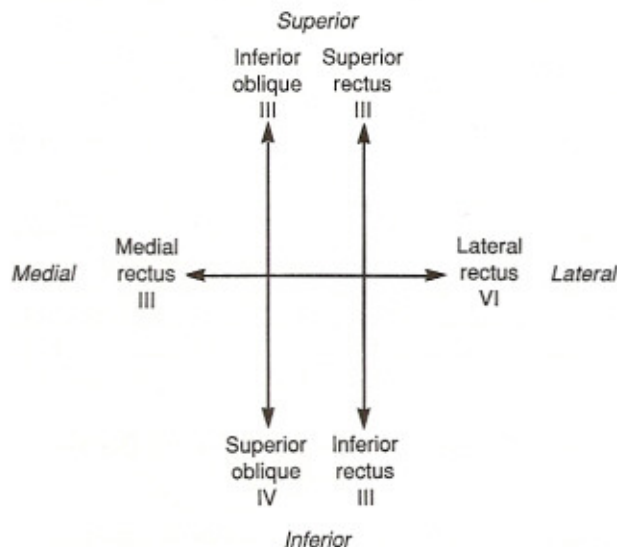


Figure 41.8. Diagram of the test movements for examining individual muscles that control eye movements.

medial rectus by adducting the eye, the inferior oblique by elevating the *adducted* eye, the inferior rectus by depressing the *abducted* eye, and the superior rectus by elevating the *abducted* eye.

SENSORY NERVES IN THE ORBIT (V¹)

The **frontal nerve** passes above the lateral rectus to lie between the levator palpebrae superioris muscle and the periorbita on the inferior surface of the orbital plates of the frontal bone. It divides into supraorbital and supratrochlear branches, which supply sensation to the skin of the upper eyelid, forehead, and scalp (fig. 38.11).

The **lacrimal nerve** follows the upper border of the lateral rectus muscle and ends in the lacrimal gland and the upper eyelid (fig. 41.5). It is *only* sensory to the lacrimal gland. The secretomotor supply to the gland is via the parasympathetic fibers from nerve VII through the pterygopalatine ganglion and branches of V².

The **nasociliary nerve** (fig. 41.5) is of utmost clinical importance. It enters the muscular cone of the orbit between the two heads of the lateral rectus within the fibrous annular ring. It courses over the optic nerve to the medial wall of the orbit and proceeds anteriorly between the superior oblique and medial rectus muscles.

Long ciliary nerves arise from the nasociliary nerve, as it crosses nerve II. The long ciliary nerves pass forward to enter the sclera on the anterior half of the eye. They will carry the clinically important sensory fibers required for the "corneal reflex."

Short ciliary nerves also arise from the nasociliary nerves and then pass forward to the sclera of the posterior half of the eye. Although these are sensory nerves to the eye, they also carry postganglionic parasympathetic fibers from the ciliary ganglion associated with nerve III to two **smooth muscles** in the eye: **pupillary constrictor** and **ciliary body** muscles.

On the medial wall of the orbit, the **posterior** and **anterior ethmoidal branches** arise from the nasociliary nerve to innervate the mucosa of the ethmoid air sinuses. Figure 41.5 shows how the anterior ethmoid also continues onto the cribriform plate of the ethmoid and enters the nose through an opening beside the crista galli. The anterior ethmoid nerve gives V¹ branches to the mucosa of the superior part of the nasal cavity and then continues between the nasal bones and cartilages to supply the skin on the tip of the nose. This results in an isolated "island" of V¹ innervation in the V² dermatome area of the face (fig. 38.11).

The termination of the nasociliary nerve is the **infra-trochlear nerve**. It passes below the trochlea and is sensory to the lacrimal sac and the mucosa surrounding it.

AUTONOMIC NERVES OF THE ORBIT (fig. 41.9)

Both parasympathetic and sympathetic nerves are required to innervate the smooth muscles and glands within

the eye and orbit. The parasympathetic preganglionic fibers are contained in the **oculomotor nerve (III)**. They enter the orbit with III and proceed through the inferior division of nerve III to synapse in the **ciliary ganglion** on the cell bodies (neurons) of the postganglionic parasympathetic neurons. These join the short ciliary branches of the nasociliary nerve and enter the posterior aspect of the eye and pass anteriorly between the scleral and choroid coats of the eye to innervate two intrinsic smooth muscles: the **pupillary constrictor muscle** and the **ciliary body muscle**. The parasympathetic innervation of the pupil can be tested by shining a light in the eye and observing a pupillary constriction (**pupillary light reflex**). The parasympathetic innervation of the ciliary body is tested by asking the patient to read fine print. This is the **accommodation reflex**, which also requires pupillary constriction and medial convergence of both eyes by the medial rectus muscles. All of these functions are controlled by nerve III, even though the accommodation reflex involves both smooth and skeletal muscle action.

The parasympathetic innervation of the lacrimal gland will be described with the pterygopalatine ganglion (page 486).

The **preganglionic sympathetic fibers** of the orbit arise in the upper thoracic region of the spinal cord. They ascend in the sympathetic trunk to the superior cervical ganglion (fig. 41.9) to synapse on the cell bodies of the postganglionic neurons. The **postganglionic sympathetic neurons** then travel to the orbit on the plexuses of the internal carotid and ophthalmic arteries. They enter the orbit with the ophthalmic artery in the optic canal and proceed to the anterior half of the eye on either the long ciliary nerves or arteries. Within the eye, the sympathetics innervate the **dilator pupillae muscle**. These radial fibers of the iris cause pupillary dilatation when they contract. Pupillary dilatation can be tested when the lights

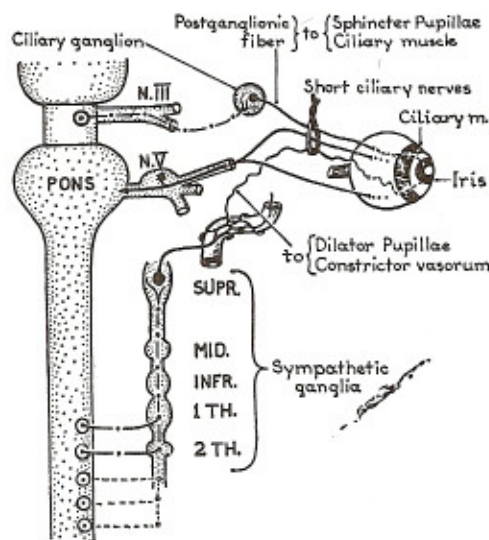


Figure 41.9. The autonomic nerve supply to the eyeball.

in a room are dimmed. Sympathetic fibers also innervate the blood vessels of the orbit to control the vasomotor tone of the blood vessels by active constriction of the vascular smooth muscle. Damage to the sympathetic system that supplies the orbit produces a **Horner's Syndrome**, which is characterized by 4 signs: (a) pupillary constriction (miosis) due to unopposed parasympathetic influence on the iris musculature; (b) partial drooping of the eyelid (ptosis) due to denervation of the smooth muscle component of levator palpebrae superioris; (c) lack of sweating on the skin around the orbit (anhidrosis); and (d) vasodilatation of the blood vessels of the skin around the orbit causing a "flushing" of the skin. A fifth sign of enophthalmos (retraction of the eye into the orbit) is described but not well explained.

VESSELS OF THE ORBITAL CAVITY

The **ophthalmic artery** (fig. 41.10) is the major blood supply to the orbit and its contents. It arises in the middle cranial fossa from the internal carotid artery within the cavernous sinus. The ophthalmic artery enters the orbit on the inferior surface of the optic nerve in the optic canal. Its initial branch, the **central artery of the retina**, is given off in the optic canal, and it enters the optic nerve to reach the retina through the optic disc. The central artery can be examined *in situ* with an ophthalmoscope and is a valuable clinical observation for many vascular and neurologic disorders. It is also the major blood supply to the sensory retina and occlusion of the vessel causes instantaneous blindness.

The ophthalmic artery enters the muscular cone of the orbit on the lateral aspect of nerve II. It ascends and crosses the superior aspect of the optic nerve and courses toward the medial wall of the orbit. The individual branches of the ophthalmic artery are complementary to the branches of V¹. If one knows the branches of the frontal, lacrimal, and nasociliary nerves, one can name the complementary branches of the ophthalmic artery. An important anastomosis between the ophthalmic artery and the facial artery occurs on the medial orbital margin. This provides a potential connection between the external and internal carotid arterial systems.

OPHTHALMIC VEINS

The **superior ophthalmic vein** anastomoses with the facial vein at the medial angle of the eye. Since there are no valves in these veins, blood can flow in either direction (fig. 39.3). This relation has the potential of having blood from infected areas of the face flowing in the reverse direction through the orbit, through the superior orbital fissure, and into the cavernous sinus. The danger of a facial infection causing a severe meningitis is possible by this anatomical route.

The **inferior ophthalmic veins** on the floor of the orbit communicate with the pterygoid plexus of veins in the

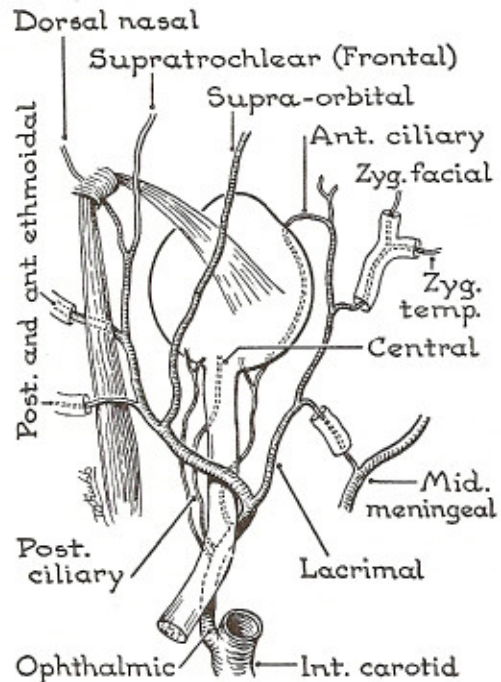


Figure 41.10. Ophthalmic artery and its branches.

deep face. The inferior ophthalmic vein drains through the inferior orbital fissure to reach the cavernous sinus. These venous channels also lack valves and can permit deep facial infections to "spread" to the meningeal sinuses.

THE LACRIMAL GLAND

This serous gland (fig. 41.11) lies behind the superolateral angle of the orbital margin, between the orbital plate of the frontal bone and the conjunctiva. It surrounds the lateral margin of the levator palpebrae muscle. A series of ducts leave the gland and pierce the conjunctiva, so that tears may spread over the conjunctiva and cornea

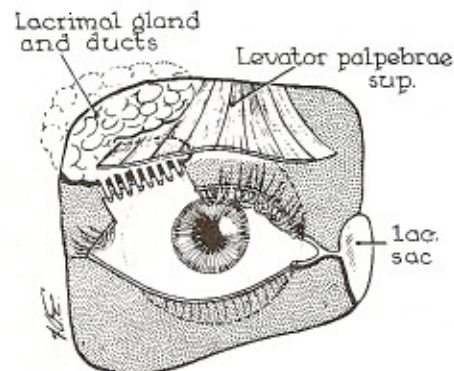


Figure 41.11. The lacrimal gland of the right orbit (schematic).

from the superolateral region to the inferomedial area of the anterior surface of the eye. The tears are then collected through a duct system in the medial aspect of the upper and lower eyelids and drained into the lacrimal sac, lacrimal duct, and nasal cavity. Loss of tear secretion by the **single** lacrimal gland of each eye is a serious condition. Rapid desiccation of the conjunctiva and cornea will cause severe pain (via V^1 fibers) and may lead to ulceration of the cornea and significant visual loss if not treated.

Lacrimation (tearing) is controlled by the **nervus intermedius branch of the facial nerve VII**. These preganglionic parasympathetic fibers are given off the main trunk of the facial nerve in the middle ear and course through a hiatus in the petrous bone to enter the middle cranial fossa. These fibers constitute the **greater superficial petrosal nerve**, which runs through the pterygoid canal to reach the pterygopalatine fossa posterolateral to the nasal cavity and inferior to the orbit. The **pterygopalatine ganglion** is contained within the fossa as well as the **maxillary division of the trigeminal nerve (V^2)**. The preganglionic parasympathetic fibers for the lacrimal gland synapse in the pterygopalatine ganglion and the postganglionic parasympathetic fibers proceed to the lacrimal gland on branches of V^2 . The **infraorbital nerve** carries the postganglionic fibers into the orbit and passes them to the lateral wall of the orbit with its **zygomatic branch**. The zygomatic nerve enters the zygomatic foramen below the lacrimal gland, and the parasympathetic fibers ascend the short distance along the lateral orbital wall to enter the gland and innervate the secretomotor function of the gland. These terminal parasympathetic fibers may join the lacrimal nerve. The lacrimal nerve is a branch of V^1 that carries pain stimuli from the gland and adjacent areas of skin.

The Eyeball

The **three concentric coats** and their individual components are shown in Figure 41.12:

- Outer or fibrous coat (sclera and cornea)
- Middle or vascular coat (choroid, ciliary body & iris)
- Inner or retinal coat (outer pigmented epithelium and inner nervous layer)

Enclosed within these 3 coats are the chambers of the eye, containing the refractive media: aqueous humor, lens, and vitreous body.

The cornea forms the transparent anterior one-sixth of the outer coat of the eye. It is more convex than the scleral portion. The cornea is 0.5 mm–1.0 mm thick and is responsible for most of the refraction by the eye. It is avas-

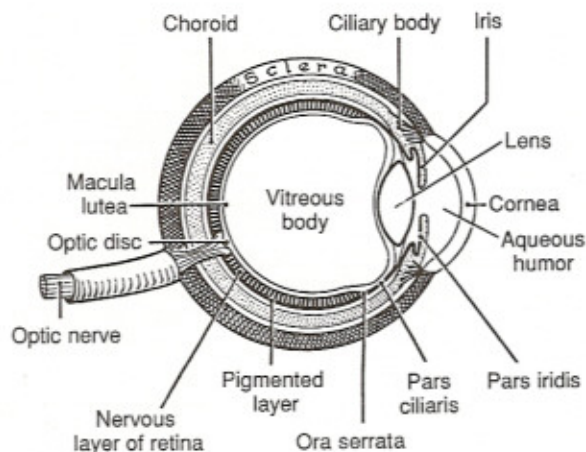


Figure 41.12. Scheme of an eyeball (sagittal section). V, vitreous body; L, lens; A, aqueous humor.

cular and can be readily transplanted due to its lack of blood supply and lymphatics. The cornea is supplied by sensory branches of V^1 and V^2 . When the cornea is touched lightly, the afferent (sensory) fibers induce a corneal reflex, which is expressed by blinking the eyelids through the motor supply to the orbicularis oculi muscle via nerve VII.

The **sclera** forms the posterior five-sixths of the outer coat of the eyeball. It is seen through the conjunctiva as the “white of the eye” and it is not transparent. The sclera serves as the insertion site for the extrinsic recti and oblique muscles of the eye. It is continuous with the dura mater of the optic nerve and is penetrated posteriorly by the neuronal fibers of nerve II. The **sclerocorneal junction** marks the union of the two portions of the outer coat of the eye. A pinpoint size canal, the **scleral sinus** (Canal of Schlemm) runs in a circular fashion adjacent to this sclerocorneal junction (fig. 41.13).

The space behind the cornea is the **anterior chamber**. It is continuous through the pupil with the **posterior chamber**. Both chambers contain aqueous humor. The **ciliary processes** of the ciliary body project into the posterior chamber and secrete the aqueous humor into the posterior chamber. The aqueous humor “circulates” through the pupil into the anterior chamber where it drains at the angle of the anterior chamber between the iris and the cornea (**iridocorneal angle**) through channels into the scleral sinus. The aqueous humor is then transported to the venous plexus within the sclera. Disruptions in the absorption of aqueous humor from the anterior chamber cause **glaucoma**.

The **ciliary body** is the anterior component of the middle or vascular coat of the eye. It is attached firmly to the outer coat at the sclerocorneal junction, and it also projects the **iris** and **ciliary processes** into the anterior and posterior chambers of the eye, respectively. The ciliary body is continuous posteriorly with the pigmented cho-

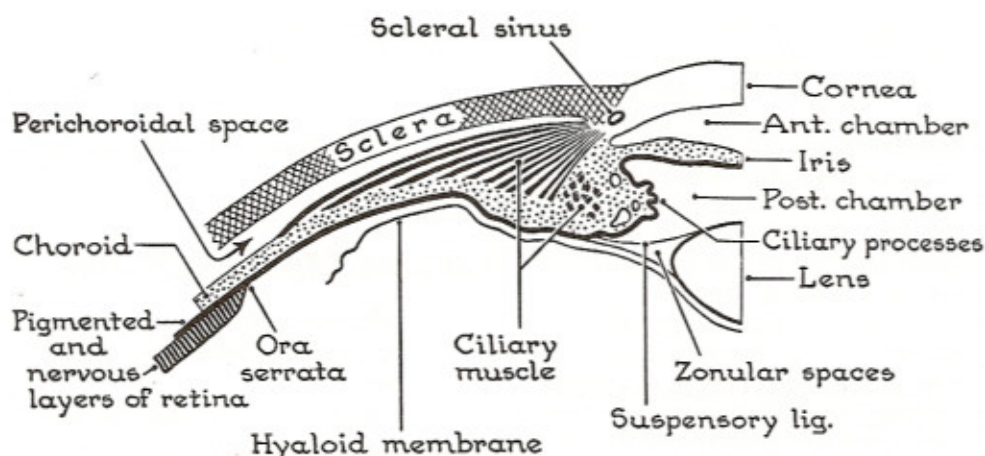


Figure 41.13. The ciliary region, enlarged. (After Cunningham's Anatomy.)

roid. The **ciliary muscle** is contained within the ciliary body. It is a smooth muscle that is innervated by parasympathetic fibers of the oculomotor nerve (III).

Contraction of this circular muscle decreases its diameter and relaxes the **suspensory ligaments** that extend from the ciliary body to the **lens**. The elastic nature of the lens allows it to "thicken" (become more rounded) when the suspensory ligaments are relaxed. The thicker lens is necessary for focusing the light rays on the retina in near vision. It therefore requires muscular energy to focus and do visual work at close range. Far vision is performed through a "thinner" lens, which occurs when the ciliary muscle relaxes and the diameter of the ciliary body expands. The tension on the suspensory ligaments pulls on the perimeter of the lens and makes it thinner and less refractive to the light rays entering the eye. The lens is therefore adjustable to some degree, while the cornea is a fixed refractive structure.

The colored **iris** is a circular diaphragm that lies anterior to the lens and has a central aperture, the **pupil**. The **pupillary constrictor muscle** (**sphincter pupillae**) is on the posterior aspect of the iris near the pupil. It is in-

nervated by parasympathetic neurons in nerve III, which reach the eye via the short ciliary branches of V¹. The **pupillary dilator muscle** (**dilator pupillae**) is a radial array of smooth muscle fibers that extend like spokes of a wheel from the pupillary margin. The **pupillary dilator muscle** is innervated by **sympathetic fibers**.

The **retina** consists of pigmented and nervous layers on the posterior inner surface of the eyeball. The pigmented layer extends anteriorly on the inner surface of the choroid, ciliary body, and iris. The nervous portion, which contains the receptive rods and cones, is limited in its anterior extension and forms the **ora serrata** at its anterior limit in the eye. The retina, optic disc, macula lutea (yellow spot), and the central arteries and veins can

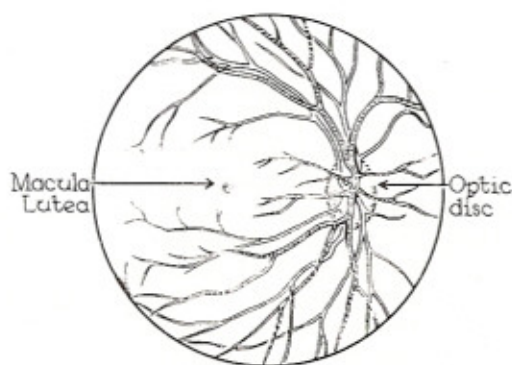


Figure 41.14. The retina and its arteries and veins as seen in the right eye through an ophthalmoscope.

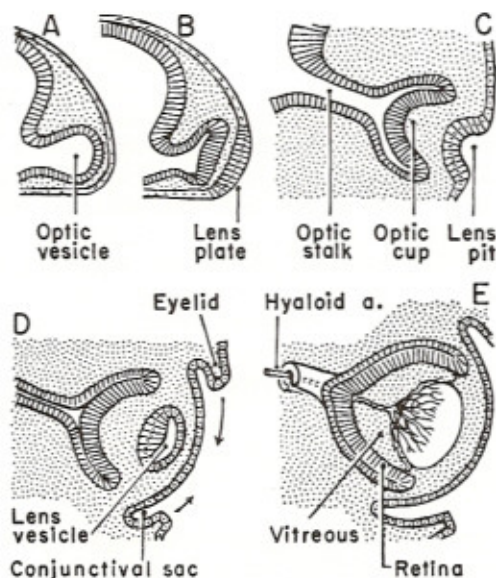


Figure 41.15. Stages in the development of retina, lens, and conjunctival sac. (After Mann.)

be visualized directly **in situ** with an ophthalmoscope. Figure 41.14 is a diagram showing the gross relationships of these important ocular structures. The optic disc lies medial to the macula lutea at the posterior pole of the retina. The macula lutea is an area of high visual acuity. Its central region, the **fovea centralis**, is composed entirely of cones and is where most of the light rays strike the retina when the eye is accommodated for near vision. The retinal blood vessels circumscribe this area to provide the maximal sensitivity to visual stimuli.

The **refractive media** of the eye includes the very refractive but nonadjustable cornea, the serous aqueous humor, the adjustable lens, and the transparent, gelatinous **vitreous body**. The vitreous body fills the space within the globe internal to the retina and posterior to the lens (fig. 41.13). Its limiting membrane, the **hyaloid membrane**, abuts the inner surfaces of the ciliary body and lens (fig. 41.13).

DEVELOPMENT

The retina develops as an outgrowth of the brain (fig. 41.15) and is of ectodermal origin. In its initial stages, it resembles an inflated rubber balloon with a hollow stalk that is continuous with the cavity of the 3rd ventricle. At the same time, the lens is developing from the overlying skin ectoderm. The balloon-like **optic vesicle** collapses under the influence of the developing lens and the ensuing invaginated vesicle becomes cup-shaped. A two-layered retina is therefore formed.

The central artery originally passed through the hyaloid canal in the vitreous body and anastomosed with the capsule of the lens, which is highly vascular in the fetus. Before birth, the lens capsule atrophies and the

artery degenerates back to the retina. The lens will harden and cornify with advancing age. The hardening begins at the lens center, and this loss of elasticity can gradually interfere with accommodation. When hardened, the lens may split into layers somewhat like those of an onion.

Clinical Mini-Problems

1. Blindness results in damage to the visual receptors and sensory pathways contained in which cranial nerve?
2. Diplopia does not affect the visual pathway but is due to the optokinetic dysfunction resulting in paralyzed or weakened eye muscles. Which cranial nerves when damaged could cause diplopia?
3. Which cranial nerve would be damaged in a patient with a drooping upper right eyelid and an unresponsive dilated right pupil when exposed to bright light?
4. Which cranial nerve would be damaged in a patient with a drooping lower eyelid on the right side?
5. How would damage to the two structures in the optic canal cause blindness?
6. How would damage of cranial nerve VII cause pain in the eye?
7. Is the optic disc in the center of the posterior pole of the eyeball? When the blood vessels in the center of the optic disc radiate onto the retina are they medial or lateral to the macula lutea?

(Answers to these questions can be found on p. 000.)

Posterior Triangle of the Neck

Clinical Case 42.1

Patient Mildred Y. This woman with chronic gallbladder disease now comes to the University Clinic complaining of pain over her right shoulder with each breath. You are able to explain that this peculiar symptom may be due to "referred pain" because the sensory nerves from the right dome of the diaphragm and the skin over the right shoulder enter the same level of the spinal cord.

The posterior triangle of the neck contains a number of important structures that enter the upper extremity. This region is therefore important in understanding the basis for signs and symptoms that occur in the upper extremity as well as the neck.

Boundaries

The posterior triangle is illustrated in Figure 42.1. The base of the triangle is formed by the middle one-third of the clavicle. The anterior side is formed by the posterior margin of the **sternomastoid muscle**, while the posterior side is formed by the anterior margin of the **trapezius muscle**. The apex of the triangle projects superiorly behind the ear to the level of the **superior nuchal line** of the **occipital bone**, where the sternomastoid and trapezius muscle meet.

STERNOMASTOID (STERNOCLEIDOMASTOID) AND TRAPEZIUS

These muscles arise from a single sheet of embryonic musculature that extended from the skull and neck to the shoulder girdle and sternum. They have a continuous superior attachment from the **mastoid process** to the **external occipital protuberance (inion)** along the superior nuchal line (fig. 42.2).

Inferiorly, their insertions are discontinuous across the clavicle. The sternomastoid muscle inserts into the medial third of the clavicle and the sternum, while the trapezius inserts into the lateral third of the clavicle, the acromion, and the spine of the scapula. The intervening separation of these muscles above the middle third of the clavicle forms the base of the posterior triangle.

Both muscles are innervated by a single motor nerve, the **accessory nerve**, cranial nerve XI. It lies on the deep surface of the sternomastoid muscle and traverses across the posterior triangle of the neck to reach the deep surface of the trapezius (fig. 42.1). It terminates in the trapezius musculature that arises from the spines of the thoracic vertebrae on the back.

Action

The sternomastoid muscles flex the head when they contract bilaterally. Individually, they rotate the head toward the opposite side of the body. They can also be used as accessory muscles of respiration in forced inspiration during exertion or certain diseased states.

The trapezius elevates the shoulder girdle and helps to support the weight of the upper limb. Its lower fibers draw the scapula toward the vertebral column. All of its movements can alter the position of the glenoid fossa of the scapula and permit a greater degree of circumduction in the shoulder joint.

Investment

The sternomastoid and trapezius muscles are invested by a tough dense cervical fascia. This deep **investing fascia** encircles the neck and covers the posterior triangle.

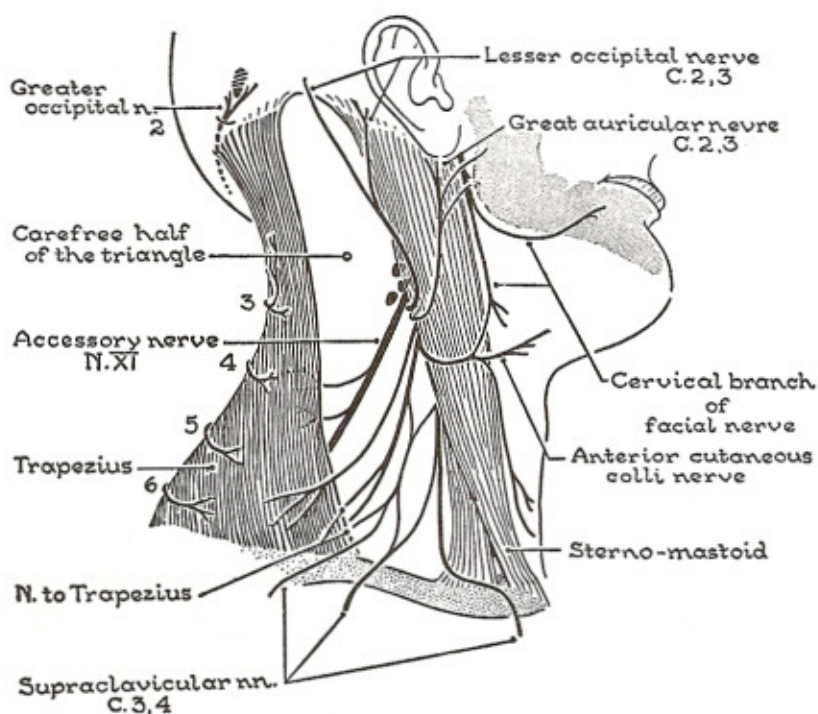


Figure 42.1. The superficial nerves of the neck. Of these, the facial and accessory are motor. (Nerves of neck: anterior cutaneous = transverse.)

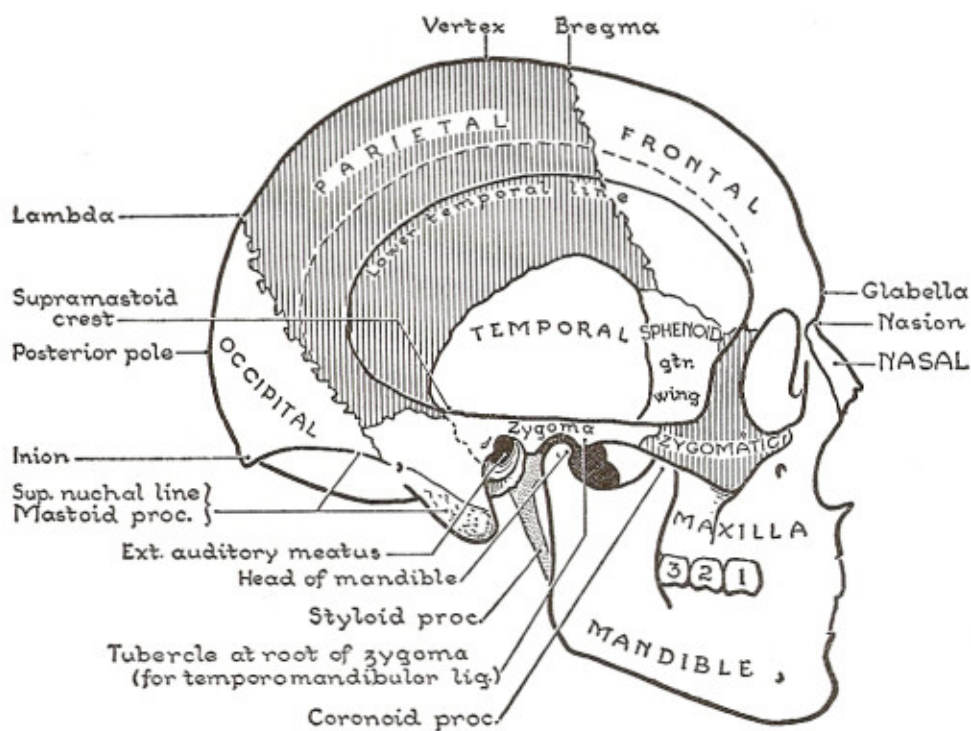


Figure 42.2. The skull, on side view (norma lateralis).

The accessory nerve is located in this fascial roof as it passes posteriorly and inferiorly from the sternomastoid muscle to the trapezius. The accessory nerve is vulnerable to damage in the roof of the posterior triangle. It lies deep to the skin and thin subcutaneous platysma muscle within the deep investing fascia.

CONTENTS OF THE POSTERIOR TRIANGLE

The roof of the posterior triangle contains the **accessory nerve (XI)**. The accessory nerve divides the fascial roof into a superior portion that contains no important structure (**the carefree part**) and a lower fascial roof, which contains the cutaneous branches of the cervical plexus where one must proceed with care not to injure or damage these structures (fig. 42.1). (Nerve XI is the most important structure to protect from injury.)

The cutaneous cervical nerves arise from the posterior border of the sternomastoid and penetrate the investing fascia over the posterior triangle. They then course through the overlying subcutaneous fascia and platysma to innervate the skin of the neck and shoulder region. These nerves are derived from the anterior rami of cervical nerves 2, 3, and 4. The **lesser occipital nerve** supplies the skin posterior to the ear and superficial to the mastoid process. The **greater auricular nerve** supplies the skin overlying the upper aspect of the sternomastoid, the earlobe, and the parotid gland. A small **transverse cervical nerve** of the neck crosses the sternomastoid in a horizontal plane to supply the skin of the neck overlying the "Adam's Apple" (laryngeal prominence). These three cutaneous nerves are derived from C2, 3 ventral rami. A very important group of cutaneous nerves are derived from the ventral rami of C3, 4 to exit from the posterior triangle through its roof and penetrate the subcutaneous fascia and platysma to innervate the skin that is superficial to the clavicle and scapula. These are the **supraclavicular nerves**. They overlap with cutaneous branches of the upper thoracic intercostal nerves on the chest wall above the 1st intercostal space. This is why the C4 dermatome approximates the T1 dermatome on the anterior chest wall. One must be sure to test the C5, C6, C7, and C8 dermatomes on the upper extremity in patients with suspected neurologic damage or you will be misled by this peculiar arrangement of overlapping high thoracic and midcervical dermatomes. The **supraclavicular nerves** also show a common neurologic origin with the **phrenic nerves** (C3, 4, 5). Sensations from pleura and peritoneum adhering to certain areas of the diaphragm are carried in the phrenic nerves and may be interpreted as pain from the skin supplied by the supraclavicular nerves, C3, 4 (a form of referred pain).

The posterior triangle also contains nerve fibers from the cervical plexus that enter the undersurface of the **trapezius muscle**. These are C3, 4 fibers that are thought to carry mainly sensory impulses from the muscle spindles of the trapezius back to the cervical regions of the

cord. The sternomastoid has similar cervical branches from C2, 3, on its posterior surface. The unique way in which nerve XI arises from the cervical region of the cord and ascends into the foramen magnum and then exits the cranium via the jugular foramen is shown in Figure 42.3. Clinicians assess nerve XI as a peripheral nerve after it leaves the jugular foramen. Damage to XI will affect the motor function of the sternomastoid and trapezius muscle. Spinal cord damage to C2, 3, and 4 levels are frequently fatal due to the loss of phrenic nerve function. Patients on respiratory support units due to damage of the C3, 4, and 5 regions of the spinal cord may show weakness in the trapezius and sternomastoid muscles because of damage to some of the motor neurons that form nerve XI.

OMOHYOID (fig. 42.4)

The inferior belly of this neck strap muscle passes through the lower aspect of the posterior triangle as it inserts into the upper margin of the scapula. It runs one or two fingerbreadths above the clavicle. The inferior belly of the omohyoid is separated from its superior belly in the anterior triangle of the neck. The intervening tendon is bound to the clavicle by a fascial sling.

EXTERNAL JUGULAR VEIN (fig. 42.4)

This large vein descends subcutaneously across the sternomastoid muscle and pierces the deep fascia that

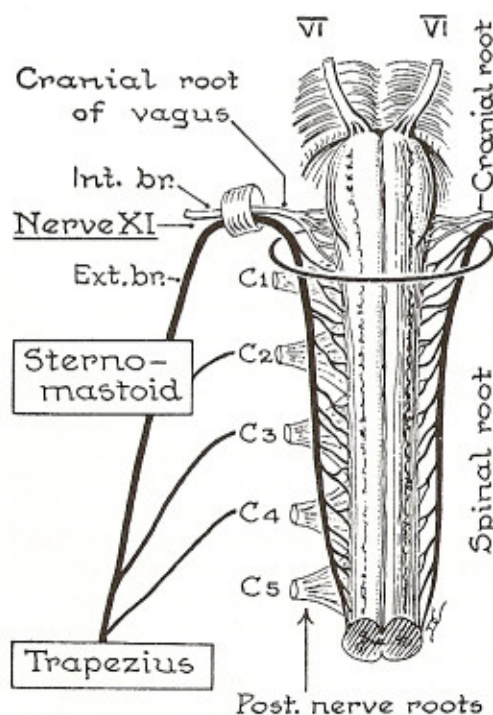


Figure 42.3. Origin and distribution of the accessory (XI) nerve. (Ventral nerve roots have been cut away.)

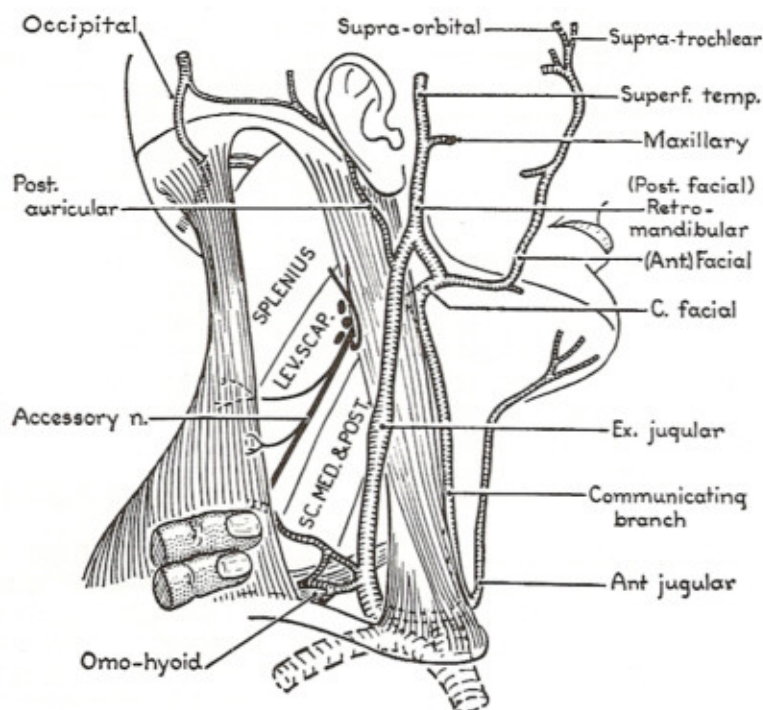


Figure 42.4. The superficial veins of the face and neck.

forms the roof of the posterior triangle. The vein terminates in the subclavian vein or the internal jugular vein at the base of the posterior triangle. The **transverse colli**, **suprascapular**, and **anterior jugular veins** communicate with each other and drain into the external jugular vein after it enters the posterior triangle.

FLOOR OF THE TRIANGLE

The "floor" is formed by several muscles whose fibers run obliquely in an inferior and posterior direction (figs. 42.4 and 42.5). **Levator scapulae** occupies a middle position underlying the accessory nerve and paralleling it.

Superior to the levator scapulae lies the **splenius**, while inferior to the levator scapulae are the three **scalene muscles**.

Levator scapulae arises from the posterior tubercles of the transverse processes of C1–4 vertebrae. It inserts into the medial border of the scapula at its superior angle.

The **scalenus posterior** and **scalenus medius** muscles are collectively termed the **scalene mass**. They arise from the posterior tubercles of cervical vertebrae and insert into the 1st and 2nd ribs posterior to the position of the subclavian artery.

The **scalenus anterior** is difficult to see from the posterior triangle. It lies deep to the sternomastoid muscle and is a key structure in understanding the visceral relationships in the neck. **Knowledge of the origin and**

insertion of this muscle and its key relationship is very important to easy understanding of the root of the neck. The scalenus anterior arises from the **anterior** tubercles of the transverse processes of the cervical vertebrae C3–6. It inserts into the **scalene** tubercle of the 1st rib and separates the subclavian artery and vein at its insertion.

A small part of **semispinalis capitis** may appear at the apex of the posterior triangle, superior to the splenius (fig. 42.5).

FASCIAL CARPET (fig. 42.6)

The muscular floor of the posterior triangle is covered by a layer of deep fascia (**prevertebral fascia**). This fascia is part of the fascia that envelops the vertebral column and the prevertebral and postvertebral muscles of the neck.

This prevertebral fascia covers the subclavian vessels and the roots of the brachial plexus as they emerge between the **scalenus anterior** and **scalene mass** in the floor of the posterior triangle. The fascia of the prevertebral muscle is then drawn into the axilla on the brachial plexus and subclavian artery as the **axillary sheath** (fig. 42.6). This provides an anatomical course for infections within the posterior compartment of the neck to "track" into the axilla and produce upper extremity signs and symptoms. The space that lies between the investing fascia (roof of triangle) and the prevertebral fascia (floor of triangle) is a common site for head and neck fascial infections.

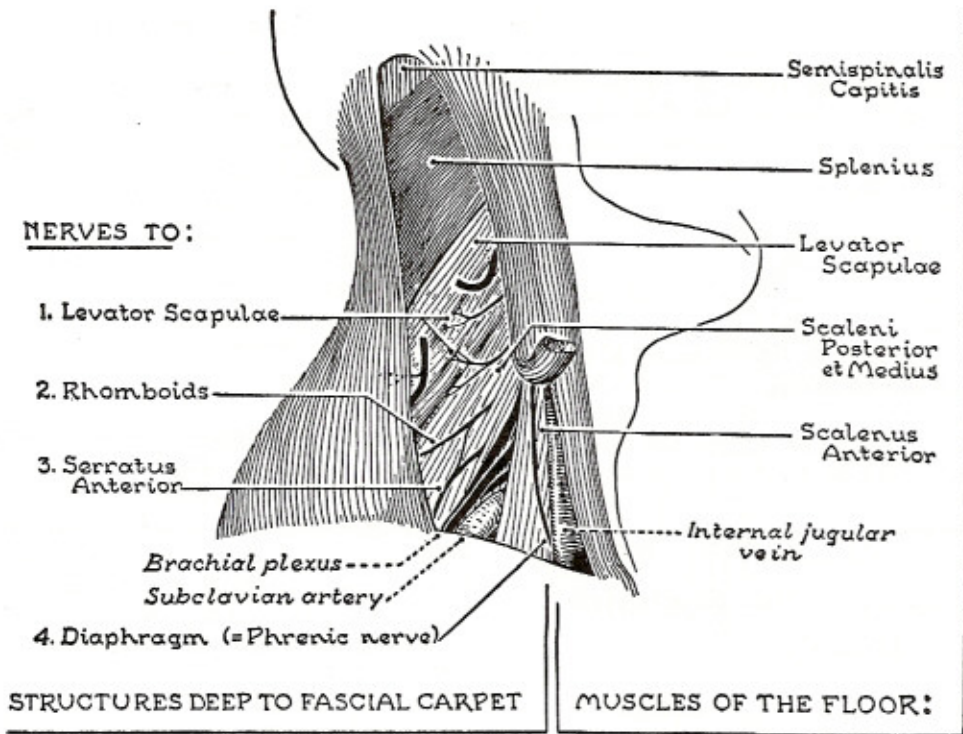


Figure 42.5. Floor of the posterior triangle and nerves that have no occasion to pierce its fascial carpet.

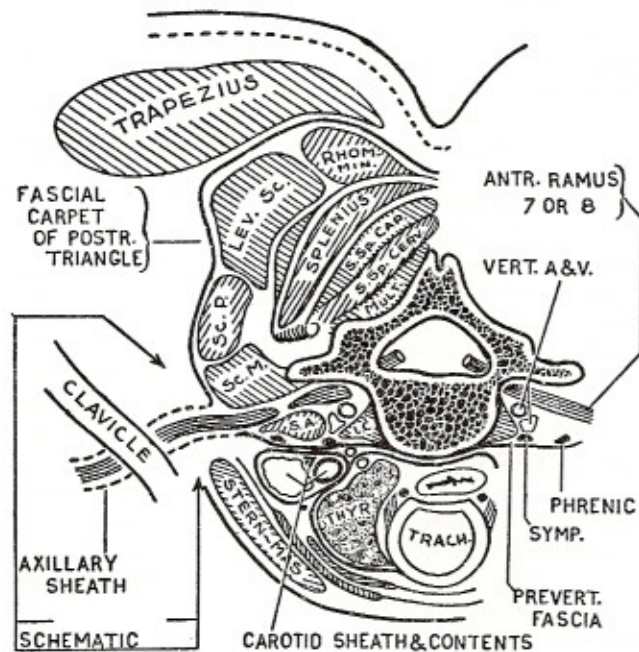


Figure 42.6. Transverse section of the neck showing the pre- and postvertebral fasciae prolonged into the axilla as a tubular covering

(axillary sheath) for the brachial plexus and subclavian vessels. The nerves shown in Figure 36.4 remain deep to this fascia.

The prevertebral muscles, which underlie the prevertebral fascia, also have important motor nerves which are deep and protected by the fascia. These include the nerves to levator scapulae and rhomboids, the **long thoracic nerve** (C5, 6, 7) to serratus anterior and the **phrenic nerve** (C3, 4, 5) to the diaphragm.

LYMPH NODES

Some lymph nodes may be evident on the posterior margin of the sternomastoid at the level of the accessory nerve (fig. 42.4). These are the **lateral group of the inferior deep cervical lymph nodes**. They drain the back of the scalp and neck and drain into the jugular lymphatic trunks. Most of the cervical lymph nodes are associated with the jugular vein deep to the sternomastoid.

Blood Vessels in the Posterior Triangle

THE SUBCLAVIAN VEIN

The subclavian vein is a continuation of the axillary vein. It begins at the lateral border of the first rib and ends medial to the scalenus anterior muscle where it joins the internal jugular to form the brachiocephalic vein. The subclavian vein is separated from the subclavian artery superior to the 1st rib by the insertion of the scalenus anterior muscle. Both vessels groove the upper surface of the 1st rib next to the **scalenus tubercle**. Since the subclavian vein is anterior to the scalenus anterior (prevertebral muscle), less prevertebral fascia covers the vein in the axillary sheath. Sometimes the vein appears to be separate from the densely wrapped subclavian artery and brachial plexus with the axilla. Because of the obliqueness of the 1st rib, the subclavian vein is more inferior in its position than the subclavian artery. It actually lies posterior and inferior to the clavicle and can be catheterized at this point to gain access to the great veins and right side of the heart via the superior vena cava (fig. 42.4).

THE SUBCLAVIAN ARTERY

The subclavian artery enters the posterior triangle posterior to the insertion of scalenus anterior. It traverses the triangle and becomes the axillary artery at the lateral aspect of the 1st rib. The pulsations of the subclavian are easily felt here. It can be compressed on the 1st rib at this point to control hemorrhage in the axilla and upper extremity. The portion of the subclavian artery that is in the posterior triangle may give off a **dorsal scapular ar-**

tery. This branch traverses through the **trunks** of the brachial plexus to supply the medial border of the scapula and the rhomboid muscles. This is more commonly supplied by the deep branch of the **transverse cervical artery**, which arises in the anterior triangle from the first part of the subclavian artery.

Important relationships around the subclavian artery are as follows (fig. 42.5):

Inferiorly—1st rib and pleura of apex of lung

Posteriorly—scalenus medius and lower trunk of brachial plexus

Anteriorly—scalenus anterior.

OTHER ARTERIES IN THE POSTERIOR TRIANGLE

The **suprascapular** and **transverse cervical (transverse colli) arteries**, which arise from the first part of the subclavian artery medial to the scalene anterior muscle, appear in the posterior triangle. They pass anterior to the scapula anterior and the phrenic nerve, as they course laterally and posteriorly through the posterior triangle.

The **suprascapular** artery crosses the superior border of the scapula to supply the supraspinatus and infraspinatus fossae structures of the scapula.

The **transverse cervical artery** supplies the posterior surface of the trapezius through a superficial branch. Its deep branches, if present, would supply the rhomboids and medial border of the scapula. If the deep branch is absent then a **dorsal scapular artery** frequently arises from the 3rd part of the subclavian artery in the posterior triangle.

Nerves in the Posterior Triangle

TERMINOLOGY

In the thoracic, lumbar, and sacral regions, the spinal nerves are named numerically after the vertebrae that lie above them. In the cervical region, however, they are named for the vertebrae that lie inferior to the nerves. C1 passes above the 1st cervical vertebrae and sets the pattern for each subsequent cervical nerve. Since there are 8 cervical nerves and only 7 cervical vertebrae, C8 exits the vertebral canal below the 7th cervical vertebrae, and the pattern for the thoracic, lumbar, and sacral nerves persists.

The **transverse process** of the cervical vertebrae have a cup-shaped groove for the ventral rami of the cervical nerves. Each process has a posterior tubercle but only C3, 4, 5, and 6 vertebrae have anterior tubercles.

BRACHIAL PLEXUS

This plexus (fig. 42.7) is formed by the ventral rami of nerves C5, 6, 7, 8, and T1. The ventral ramus of C4 or the ventral ramus of T2 may also be included in some brachial plexuses. As illustrated, the ventral rami of C5 and C6 fuse in the posterior triangle to create the **upper trunk** of the brachial plexus. The ventral rami C7 continues into the posterior triangle as the **middle trunk** of the brachial plexus. C8 and T1 ventral rami combine to form the **lower trunk** of the brachial plexus. The lower trunk passes over the apex of the lung behind the subclavian artery to cross the superior aspect of the 1st rib in the posterior triangle.

Each of the three trunks divide into an **anterior** and a **posterior division** over the 1st rib. The three posterior divisions unite to form the **posterior cord** of the brachial plexus in the axilla. The anterior divisions of the upper and middle trunks unite to form the **lateral cord** and the anterior division of the lower trunk continues into the axilla in the **medial cord**.

Branches from the **roots** of the brachial plexus innervate the rhomboids (dorsal scapular nerve, C5), serratus anterior (long thoracic nerve C5, 6, 7) and diaphragm (phrenic nerve C3, 4, 5) (fig. 42.5). They also supply the adjacent prevertebral muscles. The roots of the brachial plexus also receive gray rami from the cervical sympathetic trunk that provides the sympathetic innervation of the skin supplied by the cutaneous branches of the brachial plexus.

The major nerve that arises from the **upper trunk** of brachial plexus in the posterior triangle is the **suprascapular nerve**. It arises from the upper trunk (C5, 6) and passes through the suprascapular notch of the scapula to innervate the supraspinatus and infraspinatus muscles. This branch can be tested by asking a patient to externally rotate their shoulder while palpating the infraspinatus.

A branch to the **subclavius** muscle also arises from the upper trunk in the posterior triangle. The nerve to the levator scapulae comes out of the cervical nerves C3 and 4 above the brachial plexus.

Suboccipital Region

The back of the neck contains a large number of muscles that overlie the posterior aspects of the cervical vertebrae. The muscles of the suboccipital region are principally related to the 1st two cervical vertebrae, the **atlas** (C1) and **axis** (C2), and the occipital bone. Figure 42.5 illustrates the superficial muscles in the apex of the posterior triangle, the **trapezius** and the **splenius**. Deep to the splenius are the true back muscles represented in the

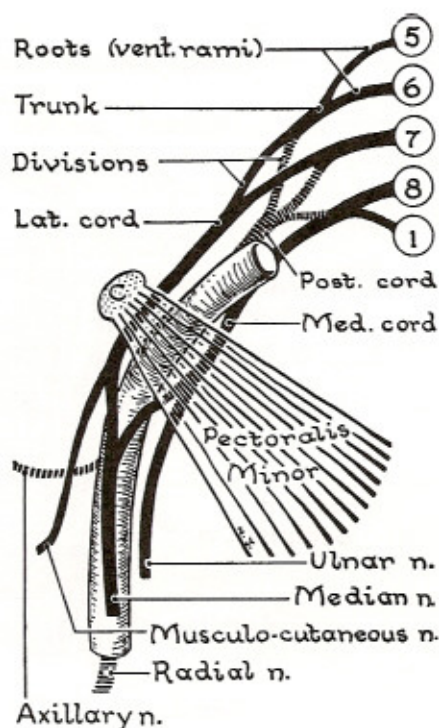


Figure 42.7. The brachial plexus.

suboccipital region by the **semispinalis capitis**. This muscle overlies muscles that relate specifically to the atlas and the axis. The relation of the vertebral artery and the 1st and 2nd cervical nerves are of major importance in this region.

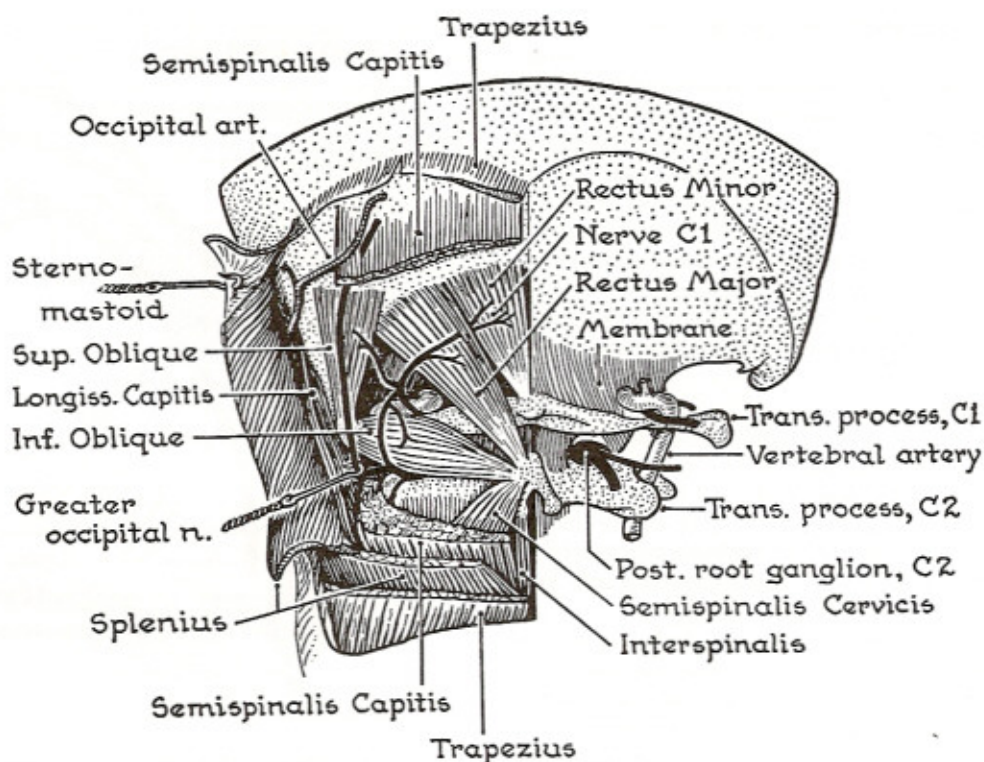
Contents of the Region

Four Muscles	—Two oblique muscles —Two straight (rectus) muscles
Two Nerves	—Greater occipital C2 —Suboccipital C1
Two Arteries	—Vertebral —Occipital

MUSCLES (fig. 42.8)

The **obliquus capitis inferior** (inferior oblique) passes from the spine of the axis (C2) in an oblique fashion to attach to the transverse process of the atlas (C1). The **greater occipital nerve** (C2) is inferior to this muscle and the **suboccipital nerve** (C1) is superior. The obliquus capitis inferior forms the inferior border of the suboccipital triangle.

The **obliquus capitis superior** (superior oblique) passes from the tip of the transverse process of the atlas (C1) in



Figures 42.8. The suboccipital region, containing the suboccipital triangle.

an oblique fashion to attach to the occipital bone between the superior and inferior nuchal lines. It forms the lateral margin of the suboccipital triangle.

The **rectus posterior minor** attaches to the posterior tubercle of the atlas (C1) and the **rectus capitis posterior major** attaches to the spine of the axis (C2). These two muscles attach superiorly in an adjacent manner on the inferior nuchal line of the occipital bone just posterior to the foramen magnum. The lateral border of the **rectus capitis posterior major** forms the medial border of the suboccipital triangle.

Within the suboccipital triangle is the vertebral artery as it traverses medially above the arch of the atlas.

VERTEBRAL ARTERY

The vertebral artery arises from the first part of the subclavian artery in the root of the neck. Occasionally, the left vertebral arises directly from the arch of the aorta. The artery enters the foramen transversarium of the 6th cervical vertebra and ascends through the successive foramina transversarii of vertebrae C5–C1. The artery assumes a near horizontal course above the posterior arch of the atlas and penetrates the posterior atlanto-occipital membrane and the dura mater to enter the subarachnoid space as it passes through the foramen magnum. The vertebral artery lies above the **suboccipital nerve** (C1), as

it passes above the posterior arch of the atlas and posterior to its articulation with the occipital condyles.

SUBOCCIPITAL NERVE (C1 DORSAL RAMUS)

Supplies all four muscles of the suboccipital triangle. The C1 nerve is purely motor. There is no C1 dermatome.

GREATER OCCIPITAL NERVE (C2)

The dorsal rami of C2 exits the suboccipital triangle below the obliquus capitis inferior muscle. It is sensory to the scalp over the parietal and occipital bones, posterior to the vertex. The C2 dermatome overlaps with the V¹ dermatome on the back of the scalp. The greater occipital nerve accompanies the **occipital** artery in the scalp over the occipital bone.

DEEP CERVICAL ARTERY

A branch of the first part of the subclavian artery gives access to the dorsal aspect of the neck by passing between the 1st rib and the transverse process of the 7th cervical vertebra. It supplies blood to the postvertebral musculature and anastomoses with branches of the occipital and vertebral artery. This may augment supply to the brain when the carotid artery is occluded.

Clinical Mini-Problems

1. How would one test the integrity of the accessory nerve (XI) at the base of the skull?
2. Which motor nerve(s) must be avoided when incising the investing fascia that forms the roof of the posterior triangle?
3. The axillary sheath is derived from prevertebral fascia of the neck. The structures that leave the neck between the anterior scalene muscles and scalene mass are tightly enclosed in the axillary fascia. Which structures would you expect to be enclosed securely in the axillary sheath?
4. When an anesthetist injects a local anesthetic into

the brachial plexus in the neck, he palpates the subclavian artery over the 1st rib and injects the solution superior to the artery. This avoids traumatizing the artery and also prevents the chances of causing a pneumothorax by penetrating the apex of the lung. What relationship does the 1st rib have to the brachial plexus and the apex of the lung in the neck?

5. Which cervical spinal nerve lies inferior to the body of the 5th cervical vertebra?
6. How would one test the integrity of the upper trunk of the right brachial plexus in a patient with an injury to their right shoulder and neck?

(Answers to these questions can be found on p. 587.)
