

"Brain Meninges"

- The brain in the skull is surrounded by three protective membranes:

- Dura Mater
- Arachnoid Mater
- Pia Mater

» Dura Mater

> Layers:

1) Endosteal Layer:

- Acts as the periosteum covering the inner surface of skull bones.
- Does not continue with the dura mater of the spinal cord at the foramen magnum.
- Around all foramina in the skull, it connects with the periosteum on the outside of the skull bones.
- At sutures, it becomes continuous with sutural ligaments.
- Most strongly adheres to bones over the base of the skull.

2) Meningeal Layer:

- Known as the dura mater proper; a dense, strong, fibrous membrane covering the brain.
 - Continuous with the dura mater of the spinal cord through the foramen magnum.
 - Provides tubular sheaths for cranial nerves as they pass through skull foramina, fusing with the epineurium of the nerves outside the skull.
- > Inward Septa: The meningeal layer projects inward to form four septa:
- Falx Cerebri
 - Falx Cerebelli
 - Tentorium Cerebelli
 - Diaphragma Sellae
- Function:
- Divide the cranial cavity into spaces that house subdivisions of the brain
 - Limit brain displacement during head acceleration and deceleration.

"Falx Cerebri"

» Structure:

- Sickle-shaped fold of dura mater lying in the midline between the cerebral hemispheres.

- Anterior end:

- Narrow, attached to the internal frontal crest and crista galli.

- Posterior part:

- Broad, merging with the upper surface of the tentorium cerebelli.

» Sinuses:

- Superior sagittal sinus: Runs along the upper fixed margin.

- Inferior sagittal sinus: Runs along the lower concave free margin.

- Straight sinus: Runs along the attachment to the tentorium cerebelli.

"Tentorium Cerebelli"

» Structure:

- Crescent-shaped fold of dura mater forming a roof over the posterior cranial fossa.
- Covers the cerebellum's upper surface and supports occipital lobes of the cerebral hemispheres.

• Tentorial Notch:

- Gap in the anterior edge for the midbrain passage, creating:

• Free border:

- Runs forward, attaching to the anterior clinoid process on each side.

• Fixed border:

- Attached to posterior clinoid processes, superior borders of petrous bones, and occipital bone grooves for transverse sinuses.

» Nerve Passage:

- At the crossing of free and fixed borders, the third and fourth cranial nerves pass forward to the lateral wall of the cavernous sinus.

• Recess for Trigeminal Nerve:

- Lower layer of the tentorium forms a pouch near the petrous part of the temporal bone apex, providing a recess for the trigeminal nerve and ganglion.

» Attachments:

- Falx cerebri (upper surface) and falx cerebelli (lower surface).

» Sinuses:

- Straight sinus: Runs along falx cerebri attachment.
- Superior petrosal sinus: Runs along attachment to petrous bone.

- Transverse sinus: Runs along attachment to occipital bone.

"Falx Cerebelli"

» Structure:

- Small, sickle-shaped fold of dura mater attached to the internal occipital crest.
- Projects forward between the cerebellar hemispheres.

» Sinus:

- Occipital sinus: Runs along the posterior fixed margin.

"Diaphragma Sellae"

» Structure:

- Small, circular fold of dura mater forming the roof of the sella turcica.
- Opening: Small central opening allowing passage of the hypophysis cerebri stalk.

"Dural Nerve Supply"

» Nerve Branches: Supplied by branches from:

- Trigeminal nerve
- Vagus nerve
- First three cervical spinal nerves
- Sympathetic trunk

» Sensory Endings:

- Numerous sensory endings in the dura are sensitive to stretching, producing headache sensations.

> Referred Pain:

- Stimulation above the tentorium cerebelli (via trigeminal nerve) results in pain referred to skin on the same side of the head.
- Stimulation below the tentorium leads to pain referred to the back of the neck and back of the scalp (distributed by the greater occipital nerve).

"Dural Arterial Supply"

» Arterial Sources: Supplied by branches from:

- Internal carotid artery
 - Maxillary artery
- Ascending pharyngeal artery
 - Occipital artery
 - Vertebral artery

» Clinical Significance:

- Middle meningeal artery: Most clinically significant artery, prone to damage in head injuries.

» Middle Meningeal Artery:

- Originates from the maxillary artery in the infratemporal fossa.
- Enters cranial cavity through foramen spinosum and lies between meningeal and endosteal layers.

> Path:

- Runs forward and laterally in a groove on the upper surface of the squamous part of the temporal bone.

- Anterior branch:

- Tunnels the anterior-inferior angle of the parietal bone, roughly aligning with the precentral gyrus.

- Posterior branch:

- Curves backward, supplying the posterior dura.

» Meningeal Veins:

- Located in the endosteal layer of the dura.
 - Veins lie lateral to the arteries.

- Middle meningeal vein: Follows the artery's branches, draining into:

- Pterygoid venous plexus
- Sphenoparietal sinus

"Dural Venous Sinuses"

» Structure & Function:

- Located between the layers of the dura mater.

> Primary function:

- Receive blood from the brain via cerebral veins.
- Receive cerebrospinal fluid (CSF) from the subarachnoid space via arachnoid villi.

» Drainage:

- Blood in dural sinuses drains into the internal jugular veins in the neck.

» Characteristics:

- Lined by endothelium; walls are thick but lack muscular tissue and valves.

» Emissary veins:

Valveless veins connecting dural sinuses with the diploic veins of the skull and veins of the scalp.

1) Superior Sagittal Sinus

» Location:

- Occupies the upper fixed border of the falx cerebri.

» Origin:

- Begins anteriorly at the foramen cecum (may receive a vein from the nasal cavity).

» Path:

- Runs posteriorly, grooving the skull vault, and ends near the internal occipital protuberance.

» Continuation:

- Joins one of the two transverse sinuses at the confluence of sinuses.
- Usually deviates to right side and joins the right transverse sinus

» Connections:

- Communicates with two to three venous lacunae on each side, where arachnoid villi and granulations project.

» Receives:

- Superior cerebral veins during its course.
- Diploic and meningeal veins into the lacunae.

2) Inferior Sagittal Sinus

» Location:

- Occupies the free lower margin of the falx cerebri.

» Path:

- Runs backward along the free lower border.

» Termination:

- Joins with the great cerebral vein at the margin of the tentorium cerebelli, forming the straight sinus.

» Receives:

- Some cerebral veins from the medial surface of the cerebral hemispheres

3) Straight Sinus

» Location:

- Found along the junction between the falx cerebri and the tentorium cerebelli.

» Formation:

- Created by the union of the inferior sagittal sinus and the great cerebral vein.

» Termination:

- Typically continues as the left transverse sinus but may connect to the right in some cases.

4) Transverse Sinuses

» Structure:

- Paired sinuses beginning at the internal occipital protuberance.
- Right Transverse Sinus: Often continuous with the superior sagittal sinus.

- Left Transverse Sinus: Typically continuous with the straight sinus.

» Path:

- Occupy the attached border of the tentorium cerebelli, grooving the occipital and parietal bones.

» Receives:

- Superior petrosal sinuses
- Inferior cerebral and cerebellar veins
- Diploic veins

» Termination:

- Curves downward to continue as the sigmoid sinuses.

S) Sigmoid Sinuses

» Continuation:

- Direct continuation of the transverse sinuses.

» Path:

- Descend medially, grooving the mastoid part of the temporal bone.
- Lie posterior to the mastoid antrum.

» Termination:

- Continue through the jugular foramen, becoming the superior bulb of the internal jugular vein.

6) Occipital Sinus

» Location:

- Occupies the attached margin of the falx cerebelli.

» Commencement:

- Starts near the foramen magnum.

» Connections:

- Communicates with the vertebral veins.

» Termination:

- Drains into the confluence of sinuses.

7) Cavernous Sinuses

» Location:

- Situated in the middle cranial fossa on either side of the sphenoid bone.

» Structure:

- Contains numerous trabeculae, creating a spongy structure.
- Extends from the superior orbital fissure to the apex of the petrous temporal bone.

» Contents:

- Internal Carotid Artery:
 - Runs forward within the sinus, surrounded by the sympathetic plexus.
- Abducens Nerve (CN VI):
 - Passes directly through the sinus.
- Third (Oculomotor) and Fourth (Trochlear) Nerves

- Along with the ophthalmic (V1) and maxillary (V2) branches of the trigeminal nerve, these run in the lateral wall of the sinus, situated between the endothelial lining and dura.

» Tributaries: S-SIC

- Superior and Inferior Ophthalmic Veins
 - Inferior Cerebral Veins
 - Sphenoparietal Sinus
- Central Vein of the Retina

» Drainage:

- Posteriorly drains into the superior and inferior petrosal sinuses.
- Inferiorly drains into the pterygoid venous plexus.

» Connections:

- Intercavernous Sinuses:
 - Connect the left and right cavernous sinuses (anteriorly and posteriorly) in the diaphragma sellae, near the hypophysis cerebri.

- Facial Vein Communication:
 - Connects via the superior ophthalmic vein, allowing potential infection spread from facial skin to the cavernous sinus.

8) Superior and Inferior Petrosal Sinuses

» Location:

- Run along the superior and inferior borders of the petrous part of the temporal bone on each side.

» Drainage Pathways:

- Superior Petrosal Sinus: Drains the cavernous sinus into the transverse sinus.
- Inferior Petrosal Sinus: Drains the cavernous sinus into the internal jugular vein.

"Arachnoid Mater"

» Description:

- A delicate, impermeable membrane covering the brain.
- Positioned between the pia mater (internally) and the dura mater (externally).

» Spaces:

- Subdural Space:
 - A potential space filled with a film of fluid, located between the arachnoid and dura mater.
- Subarachnoid Space:
 - Contains cerebrospinal fluid (CSF) and is situated between the arachnoid and pia mater.

» Surface Characteristics:

- Both outer and inner surfaces are lined with flattened mesothelial cells.

» Cisternae:

- Widened areas where the arachnoid and pia mater are separated, allowing for CSF communication.
- Cisterna Cerebellomedullaris: Located between the inferior surface of the cerebellum and the roof of the fourth ventricle.
- Cisterna Interpeduncularis: Located between the two cerebral peduncles.
- All cisternae communicate freely with each other and the subarachnoid space.

» Arachnoid Villi and Granulations:

- Projects into venous sinuses, forming arachnoid villi.
- Most numerous along the superior sagittal sinus; aggregates are called arachnoid granulations.

» Function:

- Sites for CSF diffusion into the bloodstream.

» Connection to Pia Mater:

- Connected by delicate fibrous tissue strands across the fluid-filled subarachnoid space.

» Nerve and Vessel Pathways:

- Structures passing between the brain and skull must traverse the subarachnoid space.
- Contains all cerebral arteries and veins, as well as cranial nerves.
- The arachnoid fuses with the epineurium of nerves at their skull exit.
- For the optic nerve, the arachnoid forms a sheath extending into the orbital cavity, fusing with the sclera of the eyeball, thus extending the subarachnoid space around the optic nerve to the eyeball.

» Cerebrospinal Fluid (CSF)

> Production:

- Produced by the choroid plexuses within the lateral, third, and fourth ventricles of the brain.

> Circulation:

- Escapes the ventricular system through three foramina in the roof of the fourth ventricle, entering the subarachnoid space.
- Circulates upward over the surfaces of the cerebral hemispheres and downward around the spinal cord.

» Spinal Subarachnoid Space:

- Extends down to the second sacral vertebra.

> Drainage:

- Enters the bloodstream by passing into arachnoid villi and diffusing through their walls.

» Functions:

- Removes waste products associated with neuronal activity.
- Provides a buoyant fluid medium, protecting the brain from trauma.
- Believed to play a role in hormonal transport.

"Pia Mater"

» Description:

- A vascular membrane composed of flattened mesothelial cells.
- Closely adheres to the brain's surface, covering the gyri and descending into the deepest sulci.

» Extensions:

- Extends over cranial nerves and fuses with their epineurium.
- Accompanies cerebral arteries into the brain's substance, forming a sheath.

» Choroid Plexuses:

- Forms the tela choroidea (the choroid tela) of the roofs of the third and fourth ventricles.
- Fuses with the ependymal layer to create the choroid plexuses in the lateral, third, and fourth ventricles.

» Function

- Supports and protects the brain while
- Facilitates the production of cerebrospinal fluid (CSF)

"Spinal Cord Meninges"

- The spinal cord is protected by three layers of meninges, similar to the brain.
- These meninges collectively protect the spinal cord
- Provide structural support within the vertebral column.

1) Dura Mater

» Description:

- A dense, strong, fibrous membrane that encloses the spinal cord and the cauda equina.

continuous with the epineurium surrounding each spinal nerve.

- The inner surface contacts the arachnoid mater.

» Connections:

- Superiorly:
 - Continuous through the foramen magnum with the meningeal layer of the dura mater covering the brain.
- Inferiorly:
 - Ends on the filum terminale at the lower border of the second sacral vertebra.

» Structure:

- Lies loosely in the vertebral canal, separated from its wall by the extradural space, which contains loose areolar tissue and the internal vertebral venous plexus.
- Extends along each nerve root, becoming continuous with the epineurium surrounding each spinal nerve.
- The inner surface contacts the arachnoid mater.

2) Arachnoid Mater

» Description:

- A delicate, impermeable membrane that covers the spinal cord, situated between the pia mater internally and the dura mater externally.

» Spaces:

- Separated from the pia mater by the subarachnoid space, which is filled with cerebrospinal fluid (CSF).
- The subarachnoid space is crossed by fine strands of connective tissue.

» Connections:

- Superiorly:
 - Continuous with the arachnoid covering the brain through the foramen magnum.
- Inferiorly:
 - Ends on the filum terminale at the lower border of the second sacral vertebra.

- Continues along the spinal nerve roots, forming small lateral extensions of the subarachnoid space.

3) Pia Mater

» Description:

- A vascular membrane that closely invests the spinal cord.

» Structures:

- Thickened on either side between the nerve roots to form the ligamentum denticulatum, which adheres laterally to the arachnoid and dura, suspending the spinal cord in the middle of the dural sheath.

» Connections:

- Extends along each nerve root and becomes continuous with the connective tissue surrounding each spinal nerve.

- Continues along the spinal nerve roots, forming small lateral extensions of the subarachnoid space.

"Clinical Notes"

» Functional Significance

- Meninges consist of three concentric coverings:

i) Dura Mater:

- Tough outer covering that protects underlying nervous tissue.
- Forms sheaths covering cranial nerves as they pass through foramina in the skull.
- Provides protective sheaths for spinal nerve roots.
- Falx Cerebri: Vertical sheet of dura between cerebral hemispheres.
 - Tentorium Cerebelli: Horizontal sheet between cerebrum and cerebellum, limits excessive brain movement.

ii) Arachnoid Mater:

- Thinner impermeable membrane loosely covering the brain.
- Subarachnoid space between arachnoid and pia mater filled with CSF.
- CSF provides buoyancy and protects nervous tissue from mechanical forces.

iii) Pia Mater:

- Vascular membrane closely investing and supporting the brain and spinal cord.

"Excessive Brain Movement"

- Sudden head halts cause brain momentum to travel until resisted by the skull or dura mater.

» Lateral movements:

- One hemisphere's lateral surface hits skull; opposite hemisphere's medial surface hits falx cerebri.

» Superior movements:

- Superior surfaces of cerebral hemispheres hit skull; corpus callosum's superior surface hits falx cerebri; cerebellum's superior surface presses against tentorium cerebelli

» Complications

- Relative brain movement can injure cranial nerves passing through foramina.
- Fragile cortical veins draining into dural sinuses may tear, causing subdural or subarachnoid hemorrhage.
- Tortuous arteries rarely damaged due to strong walls.

"Intracranial Hemorrhage"

- Caused by excessive brain movement or cranial trauma, leading to traction on cranial vessels and hemorrhage.
- Classified based on relationship to meninges: epidural, subdural, and subarachnoid.

» Epidural Hemorrhage

- Results from injuries to meningeal arteries or veins.
- Commonly damaged artery: anterior division of middle meningeal artery.
- Minor blow to the head may fracture skull near anterior-inferior parietal bone, severing the artery.
- Bleeding strips meningeal layer of dura from skull's internal surface, raising intracranial pressure.
- Enlarging blood clot exerts pressure on underlying motor area in precentral gyrus.
- Blood passes laterally through fracture line, forming soft swelling under temporalis muscle.

• Treatment:

- Ligation or plugging of torn artery or vein; burr hole placed $1\frac{3}{8}$ in (4 cm) above midpoint of zygomatic arch.

"Subdural Hemorrhage"

- Results from tearing of superior cerebral veins at entry into superior sagittal sinus.
- Usually caused by blow to front or back of head, leading to excessive anteroposterior displacement of the brain.
- Can present as acute or chronic forms.

"Computed Tomography Scans"

» Blood Clot Appearances on CT

> Epidural Hemorrhage:

- Blood strips the meningeal layer of dura from the endosteal layer (periosteum of the skull).
- Results in a lens-shaped hyperdense blood collection.

- Compresses the brain and displaces midline structures to the opposite side.
- Clot shape determined by adherence of meningeal dura to periosteal dura.

> Subdural Hematoma:

- Blood accumulates in potential space between the meningeal layer of dura and the arachnoid.
- Produces a long crescent-shaped hyperdense rim of blood from anterior to posterior along the inner skull surface.
- Large hematomas obliterate brain sulci and displace midline structures to the opposite side.

"Intracranial Hemorrhage in Infants"

- Occurs during birth from excessive head molding.
- Bleeding may originate from cerebral veins or venous sinuses.

- Anteroposterior compression tears anterior attachment of falx cerebri from tentorium cerebelli.
- Bleeding may involve great cerebral veins, straight sinus, or inferior sagittal sinus.

"Headaches"

» General Mechanism

- Brain insensitivity to pain; headaches arise from stimulation of receptors outside the brain.

» Meningeal Headaches

> Dura Mater Innervation:

- Trigeminal and first three cervical nerves supply sensory innervation.
- Above Tentorium: Innervated by trigeminal nerve; headaches referred to forehead and face.

- Below Tentorium: Innervated by cervical nerves; headaches referred to back of head and neck.
- Meningitis: Causes severe headache across the head and neck.

"Headaches Caused by Cerebral Tumors"

- Tumors cause severe, continuous headaches due to irritation and stretching of the dura.
- Tumors above the tentorium refer headaches to the front; tumors below refer headaches to the back.

"Migraine Headaches"

- Common, may be unilateral or bilateral, recurring with prodromal visual disturbances.
- Visual disturbances from sympathetic vasoconstriction of cerebral arteries.
- Headache from dilation and stretching of cerebral arteries and external carotid artery branches.

- Cause unknown; factors include genetic, hormonal, biochemical influences.
- Treatment: β -blockers relieve symptoms by reducing cerebral vasodilation.

"Alcoholic Headaches"

- Caused by the direct toxic effect of alcohol on the meninges.

"Headaches from Other Conditions"

- Dental Infections and Sinusitis:
 - Common headache sources; pain referred to facial skin via trigeminal nerve branches.
- Tonic Spasm of Ciliary Muscle:
 - Can cause severe orbital headaches during prolonged focusing (e.g., reading small print).
 - Common in individuals needing lenses for presbyopia correction.