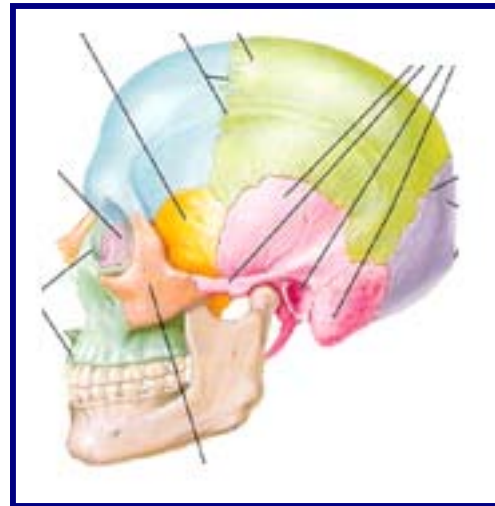


**Objective 1)**

**Identify the bones of the cranium and face and the three intracranial fossae. Identify each on the cranial nerves as it leaves the cranial cavity and the foramen through which it passes.**

A). Bones of the cranium

- i. Neurocranium (brain box) – 8 bones: consists of calvaria (skull-cap) and cranial base
  1. Frontal bone → forehead
  2. Parietal bones (2) → superior side of skull and top of skull
  3. Temporal bones (2) → inferior side of skull around ear
  4. Occipital bone → back of skull
  5. Sphenoid bone
  6. Ethmoid bone → in frontal bone and has crista galli and cribriform plate
- ii. Viscerocranium (facial skeleton) – 14 bones: consists of orbits, nasal cavities, and jaws
  1. Lacrimal bones (2)
  2. Nasal bones (2)
  3. Maxillae (2) → upper jaw
  4. Zygomatic bones (2) → cheek prominences
  5. Palatine bones (2) → palate behind maxilla
  6. Inferior nasal conchae (2)
  7. Mandible → lower jaw
  8. Vomer → flat bone that makes up major contribution to bony nasal septum
- iii. Sutures:
  1. Sagittal suture: separates the parietal bones
  2. Coronal suture: separates the frontal and parietal bones
  3. Lamboid suture: separates the parietal and occipital bones
  4. Lambda: landmark formed by joining of sagittal and lamboid sutures
  5. Bregma: landmark formed by joining of sagittal and coronal sutures



B). Intracranial fossae: form bowl-shaped floor of cranial cavity

- i. Anterior cranial fossa: highest level

1. Formed by the frontal bone anteriorly and laterally, the ethmoid bone centrally, and the body and lesser wings of the sphenoid bone posteriorly.
2. Orbital plates of frontal bone make up the greater part of the anterior cranial fossa and support the frontal lobes and make up the roof of the orbit.
3. Frontal crest and crista galli of ethmoid are in middle of anterior cranial fossa
- ii. Middle cranial fossa: second level and intermediate; butterfly-shaped
  1. Composed of sella turcica, greater wings of the sphenoid bone and squamous part of temporal bone laterally, and petrous parts of temporal bone posteriorly.
    - a. Sella turcica made of tuberculum sellae (saddle horn that is anterior), hypophysial fossa (depression for pituitary), dorsum sellae (back of saddle posteriorly)
  2. Support the temporal lobes of the brain, the pituitary gland.
  3. Contains optic canal, superior orbital fissure, foramen rotundum, foramen ovale, foramen spinosum
- iii. Posterior cranial fossa: largest and deepest cranial fossa
  1. Composed of occipital bone (mostly), parts of sphenoid and temporal bones.
  2. Contains the cerebellum, pons, and medulla oblongata.
  3. Has broad grooves for sigmoid and transverse sinuses in it.
  4. Contains the foramen magnum with the internal occipital protuberance crest posterior to it dividing the posterior part of the posterior cranial fossa into to cerebellar fossae.
  5. Contains the jugular foramen at the base of the petrous crests and hypoglossal canal (for CN XII) b/ the anteriolateral margins of the foramen magnum and jugular foramina

C). Cranial Nerves:

- i. Olfactory – CN I:
  1. Located under frontal lobes on top of ethmoid bone on anterior cranial fossa
  2. Exits the cranium through the foramina of the cribriform plate of the ethmoid bone
- ii. Optic – CN II:
  1. Located in front of the pituitary gland on lesser wing/body of sphenoid bone
  2. Exits the cranium through the optic canal in lesser wing/body of sphenoid
- iii. Oculomotor – CN III:
  1. Located behind pituitary gland and side of sphenoid
  2. Exits the cranium through the superior orbital fissure
- iv. Trochlear – CN IV:
  1. Located in area of cavernous sinus near CN III
  2. Exits the cranium through the superior orbital fissure
- v. Trigeminal – CN V:
  1. Located near greater wing of sphenoid

2. Exits the cranium through the superior orbital fissure for V<sub>1</sub> (ophthalmic nerve), foramen rotundum for V<sub>2</sub> (maxillary nerve), and foramen ovale for V<sub>3</sub> (mandibular nerve)
- vi. Abducent – CN VI:
  1. Located in the area of the cavernous sinus with the internal carotid artery
  2. Exits the cranium through the superior orbital fissure
- vii. Facial – CN VII:
  1. Located on lateral side posterior cranial fossa anterior to foramen magnum
  2. Exits the cranium through the stylomastoid foramen
- viii. Vestibulocochlear – CN VIII:
  1. Located on lateral side posterior cranial fossa anterior to foramen magnum
  2. Exits the cranium through the stylomastoid foramen
- ix. Glossopharyngeal – CN IX:
  1. Located near jugular foramen
  2. Exits the cranium through the jugular foramen
- x. Vagus – CN X:
  1. Located near jugular foramen
  2. Exits the cranium through the jugular foramen
- xi. Accessory – CN XI:
  1. Located near jugular foramen
  2. Exits the cranium through the jugular foramen
- xii. Hypoglossal – CN XII:
  1. Located b/ the foramen magnum and the jugular foramen
  2. Exits the cranium through the hypoglossal canal

### Objective 2)

**Identify the three layers of meninges surrounding the brain and spinal cord and the folds of dura mater that divide cranium. Identify each on the cranial nerves on the brainstem.**

- D). Dura mater: external, thick, dense fibrous membrane; adheres to the internal surface of the cranium and can be described in 2 layers
- i. External periosteal layer: formed by the periosteum covering the internal surface of the calvaria
  - ii. Internal meningeal layer: a strong fibrous membrane that is continuous at the foramen magnum with the spinal dura mater
    1. The internal meningeal layer draws away from the external periosteal layer to form dural infoldings, which separate the regions of the brain from each other. These infoldings divide the cranial cavity into compartments and support parts of the brain.
      - a. Cerebral falx: Largest dural infolding and sickle-shaped partition that lies in the longitudinal cerebral fissure separating the right and left cerebral hemispheres. Runs from frontal crest and crista galli posteriorly to become continuous with the cerebellar tentorium.
      - b. Cerebellar tentorium: Second largest infolding that is a crescentic septum that separates the occipital lobes and temporal lobes from the cerebellum. It attaches to the

- clinoid processes of the sphenoid, petrous part of the temporal, and internal surfaces of the occipital bone and parietal bones grooved by the transverse sinus. Attached to cerebral falx, which pulls up on it to give tent-like appearance.
- c. Cerebellar falx: Vertical dural infolding inferior to the cerebellar tentorium in posterior part of posterior cranial fossa that partially separates the cerebellar hemispheres.
  - d. Sellar diaphragm: Smallest infolding that is circular and suspended b/ the clinoid processes forming a roof over the hypophysial fossa (covers pituitary).
- E). Arachnoid mater: an intermediate, delicate, avascular layer
- i. Have arachnoid granulations that form into the sinuses to drain CSF out of the subarachnoid space and into the venous drainage.
  - ii. Have arachnoid trabeculae that are supporting bundles that pass b/ arachnoid and pia maters. Suspends brain in CSF.
- F). Pia mater: an internal, delicate, vascular membrane
- i. Adheres to brain and follows its contours.
  - ii. Follows arteries that penetrate brain a short distance to form pial coat and a periarterial space.
- G). Meningeal spaces:
- i. Dura-cranium interface (extradural or epidural space): Not normally a space but a potential one b/ the bones and periosteal layer. Only becomes a space when blood gets in pathologically.
  - ii. Dura-arachnoid junction or interface (subdural space): Only a potential space that may develop pathologically if blood enters it.
  - iii. Subarachnoid space: B/ the pia mater and arachnoid mater and contains CSF, trabecular cells, arteries, and veins.
- H). Cranial nerves on brainstem:
- i. Olfactory – CN I: not on brainstem but under frontal lobes
  - ii. Optic – CN II: not on brainstem but pass around both sides of midbrain
  - iii. Oculomotor – CN III: off of midbrain superior to pons but inferior to mammillary bodies
  - iv. Trochlear – CN IV: off of dorsal surface of midbrain and winds around brainstem
  - v. Trigeminal – CN V: emerges for the side of the pons by small motor root and large sensory root
  - vi. Abducent – CN VI: emerges from the anterior brainstem b/ the pons and medulla
  - vii. Facial – CN VII: emerges from the lateral brainstem b/ the pons and medulla
  - viii. Vestibulocochlear – CN VIII: emerges from the lateral brainstem b/ the pons and medulla
  - ix. Glossopharyngeal – CN IX: emerges from the lateral medulla
  - x. Vagus – CN X: emerges from the lateral medulla inferior to CN IX as rootlets
  - xi. Accessory – CN XI:
    1. Cranial root off of medulla as rootlets and joins CN X
    2. Spinal root off of 1<sup>st</sup> 5 segments of cervical spinal cord
  - xii. Hypoglossal – CN XII: emerges from the anterior medulla as rootlets

### Objective 3)

Identify the facial muscles surrounding the eyes, and mouth, and the muscles contributing to the scalp. Trace the flow of blood, arterial and venous, of the face and scalp. Indicate the major supply and drainage of this vascular network, and identify known vascular interconnections.

I). Facial muscles: all innervated by the facial nerve (CN VII)

i. Orbicularis oculi:

1. From medial orbital margin, medial palpebral ligament, and lacrimal bone to skin around margin of orbit
2. Closes eyelids and helps flow of lacrimal fluid

ii. Orbicularis oris:

1. From median plane of maxilla and mandible and deep surface of skin to mucous membrane of lips
2. Sphincter of oral opening that compresses and protrudes lips

iii. Buccinator:

1. From mandible, pterygomandibular raphe, and alveolar processes of maxilla and mandible to angle of mouth
2. Presses cheek against molars (aids chewing), expels air through oral cavity

iv. Platysma:

1. From superficial fascia of deltoid and pectoral regions to mandible, skin of cheek, angle of mouth, and orbicularis oris
2. Depresses mandible and tenses skin of lower face and neck

v. Zygomaticus major:

1. From zygomatic bone to angle of mouth
2. Raises angle of mouth superolaterally (smiling)

vi. Zygomaticus minor:

1. From zygomatic bone to orbicularis oris
2. Helps raise upper lip

vii. Levator anguli oris:

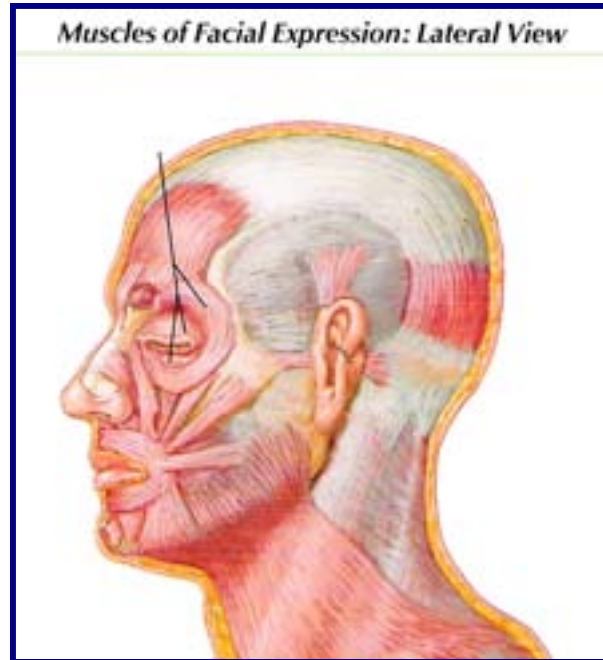
1. From infraorbital margin to angle of mouth
2. Elevates corners of mouth

viii. Depressor labii inferioris:

1. From mandible lateral to mentalis to orbicularis oris
2. Draws lower lip inferior and slightly lateral

ix. Depressor anguli oris:

1. From platysma to orbicularis oris



2. Depresses angles of the mouth
- x. Mentalis:
  1. From mandible centrally to skin over chin
  2. Raises skin over chin
- J). Muscle of scalp:
  - i. Epicranii muscle:
    1. Frontalis (or frontal belly of occipitofrontal):
      - a. Over frontal bone and pulls scalp anteriorly, wrinkles forehead, and elevates eyebrows
    2. Occipitalis (or occipital belly of occipitofrontal):
      - a. Over occipital bone and pulls scalp posteriorly and wrinkles skin at back of neck
    3. Superior auricular muscle
  - ii. Epicranial aponeurosis: strong tendon sheet that covers calvaria made for above three muscles
- K). Facial arterial supply: external carotid artery →
  - i. Facial artery: Branches from external carotid artery, ascends deep to the submandibular gland, winds around inferior border of mandible and enters face going towards medial corner of eye to supply the muscles of the face and facial expression
    1. Inferior labial artery: First branch of facial artery and runs medially in lower lip to supply the lower lip and chin
    2. Superior labial artery: Second branch of the facial artery and runs medially in upper lip to supply upper lip and ala (side) of septum and nose
    3. Lateral nasal artery: Third branch of facial artery that passes to ala of nose to supply skin on ala and dorsum of nose
    4. Angular artery: Terminal branch of facial artery that passes to medial angle of eye to supply superior part of cheek and lower eyelid
  - ii. Superficial temporal artery: Smaller terminal branch of external carotid artery that ascends anterior to ear to temporal region and ends in scalp to supply facial muscles and skin of frontal and temporal regions.
    1. Frontal and parietal branches: terminal branches of superficial temporal artery that supply the scalp.
    2. Transverse facial artery: Branch of superficial temporal artery w/in the parotid gland that crosses face superficial to masseter and inferior to zygomatic arch to supply the parotid gland and duct and muscles and skin of the face.
- L). Facial venous drainage:
  - i. The supratrochlear vein and supraorbital vein combine to form angular vein, which becomes the facial vein. The facial vein runs inferoposteriorly through the face posterior to the facial artery. As it runs, it receives blood from the deep facial vein (drains pterygoid venous plexus), and then, the anterior branch of the retromandibular vein inferior to the mandible joins it. It ends by flowing into the internal jugular vein.
  - ii. The superficial temporal vein drains the forehead and scalp and receives tributaries from the veins of the temple and face. Near the auricle, the superficial temporal vein enters the parotid gland to join the maxillary vein to make the retromandibular vein, which descends in the parotid gland superficial to the external carotid artery and deep to the facial nerve. The

retromandibular vein divides into anterior and posterior branches. The anterior joins the facial vein, and the posterior branch of the retromandibular vein joins the posterior auricle vein to form the external jugular vein.

M). Scalp arterial supply: run in 2<sup>nd</sup> layer of scalp

- i. Internal carotid artery → ophthalmic artery →
  1. Supraorbital artery: A terminal branch of the ophthalmic artery of internal carotid artery that passes superiorly from supraorbital foramen to supply muscles and skin of the forehead and scalp.
  2. Supratrochlear artery: A terminal branch of the ophthalmic artery of internal carotid artery that passes superiorly from supratrochlear notch to supply muscles and skin of the scalp.
- ii. External carotid artery →
  1. Occipital artery: runs over occipital area
  2. Posterior auricular artery: runs behind ear
  3. Superficial temporal artery with its frontal and parietal branches

N). Scalp venous drainage:

- i. Superficial: Supratrochlear vein, supraorbital vein, superficial temporal vein, and posterior auricular vein (see veins of face). The occipital veins drain the occipital region of the scalp into internal jugular vein.
- ii. Deep venous drainage occurs through emissary veins from the scalp into the dural sinuses, and in the temporal region through deep temporal veins to the pterygoid venous plexus.

O). Known vascular interconnections:

- i. Both sides of inferior and superior labial arteries anastomose.
- ii. Inferior labial and mental arteries interconnect.
- iii. Supratrochlear and lateral nasal arteries anastomose.
- iv. Transverse facial and fascial arteries anastomose.
- v. All arteries of scalp interconnect.

#### Objective 4)

**Follow the course of the major sensory and motor nerves and their branches to the face and scalp. Indicate the source of each and predict the deficit that would be expected to follow injury to one of these nerves.**

P). Sensory:

- i. From ophthalmic nerve (CN V<sub>1</sub>): Forehead, nose, upper eye, front of scalp
  1. Frontal nerve: Crosses orbit on superior aspect of levator palpebrae superioris; divides into supraorbital and supratrochlear branches to innervate skin of forehead, scalp, upper eyelid and nose, conjunctiva of upper lid and mucosa of frontal sinus.
    - a. Supraorbital nerve: Continuation of frontal nerve that emerges through supraorbital notch and breaks up into small branches to innervate mucous membranes of frontal sinus and conjunctiva of upper eyelid, skin of forehead as far as vertex.
    - b. Supratrochlear nerve: From frontal nerve and passes superiorly on medial side of supraorbital nerve and divides into two or more branches to innervate skin in middle of forehead to hairline.

2. Infratrochlear nerve: Follows medial wall of orbit to upper eyelid to innervate skin and conjunctiva of upper eyelid
  3. Lacrimal nerve: Passes through palpebral fascia of upper eyelid near lateral angle of eye to innervate lacrimal gland and small area of skin and conjunctiva of lateral part of upper eye.
  4. External nasal nerve: Runs in nasal cavity and emerges on face b/ nasal bone and lateral nasal cartilage to innervate skin on dorsum of nose including tip.
- ii. From maxillary nerve (CN V<sub>2</sub>): Cheek, lower eye, upper lip, anterior temporal region, lateral nose
    1. Zygomatic nerve: Arises in floor of orbit, divides into zygomaticofacial nerve and zygomaticotemporal nerve, which transverse foramina of same names to innervate skin over zygomatic arch and anterior temporal region. They carry postsynaptic parasympathetic fibers from pterygopalatine ganglion to lacrimal nerve.
    2. Infraorbital nerve: Terminal branch that runs in floor of orbit and emerges at infraorbital foramen to innervate skin of cheek, lower eyelid, lateral side of nose and inferior septum and upper lip, upper premolar incisors and canine teeth, and mucosa of maxillary sinus and upper lip.
  - iii. From mandibular nerve (CN V<sub>3</sub>): anterior ear, posterior temporal region, exterior acoustic meatus, lower cheek, molars, lower lip, chin
    1. Auriculotemporal nerve: From posterior division of CN V<sub>3</sub>, it passes b/ neck of mandible and external acoustic meatus to accompany superficial temporal artery to innervate skin anterior to ear and posterior temporal region, tragus and part of helix of auricle, and roof of exterior acoustic meatus and upper tympanic membrane.
    2. Buccal nerve: From anterior division of CN V<sub>3</sub> in infratemporal fossa, it passes anteriorly to meet cheek to innervate skin and mucosa of cheek, buccal gingival adjacent to 2<sup>nd</sup> and 3<sup>rd</sup> molar teeth.
    3. Mental nerve: Terminal branch that emerges from mandibular canal at mental foramen to innervate skin on chin and lower lip and mucosa of lower lip.
  - iv. From spinal nerves:
    1. Greater occipital nerve: From C2 to innervate posterior occipital area of scalp including back of skull up to vertex.
    2. Lesser occipital nerve: From C3 to innervate area of scalp behind ear and part of posterior helix of ear.

Q). Motor:

- i. From facial nerve (CN VII):
  1. Extracranial branches: temporal, zygomatic, buccal, mandibular, cervical, and posterior auricle
    - a. Innervate superficial muscles of neck and chin (platysma), muscles of fascial expression, muscles of cheek (buccinator), muscles of ear (auricular), and muscles of scalp (occipitalis, frontalis, or occipital and frontal bellies of occipitofrontal muscle)
- ii. From mandibular nerve (CN V<sub>3</sub>):

1. Innervates muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatine, and tensor tympani

R). Deficits:

- i. Lesions of the trigeminal nerve can cause widespread anesthesia involving the: corresponding anterior half of the scalp, face, except for an area around the angle of the mandible, cornea and conjunctiva, mucous membranes of the nose and paranasal sinuses, mouth, and anterior tongue, and paralysis of the muscle of mastication.
- ii. **Bell Palsy**: From paralysis or inflammation of the facial nerve at stylomastoid foramen or trauma to it. It causes the loss of tonus of the orbicularis oculi, so lower eyelid everts, and cornea dries out. The buccinator and orbicularis oris are paralyzed, so wind cannot be blown out and food accumulates in b/ teeth and cheek. Side of face is paralyzed and mouth on that side droops. Saliva and tears dribble out paralyzed side.

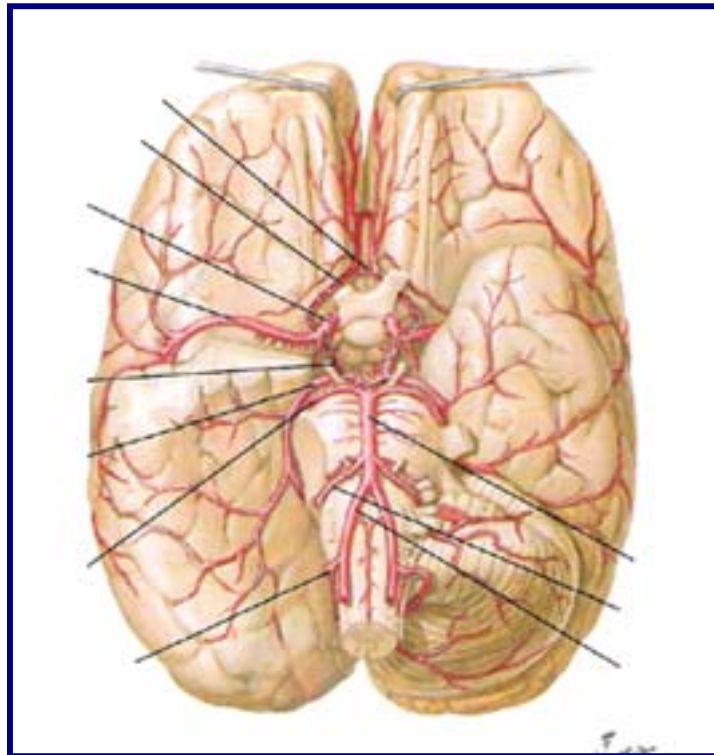
**Objective 5)**

**Trace the flow of blood into the cranial cavity. Follow the flow of blood through the cerebral arterial circle indicating the region of brain supplied by each major branch and known vascular interconnections.**

- S). From the internal carotid arteries: The internal carotid arteries start in the neck off of the common carotid arteries and enter the skull via the carotid canal. It then snakes up past the petrous part of the temporal bone, deep to the trigeminal nerve, and pass through the cavernous sinuses giving off branches there, and they terminate as the anterior and middle cerebral arteries, which are the main blood supply to the brain.

- i. Anterior cerebral arteries: Comes

from the termination of the internal carotid arteries and supplies most of the medial and superior surfaces and the frontal pole (cerebral hemispheres, except for occipital lobes).

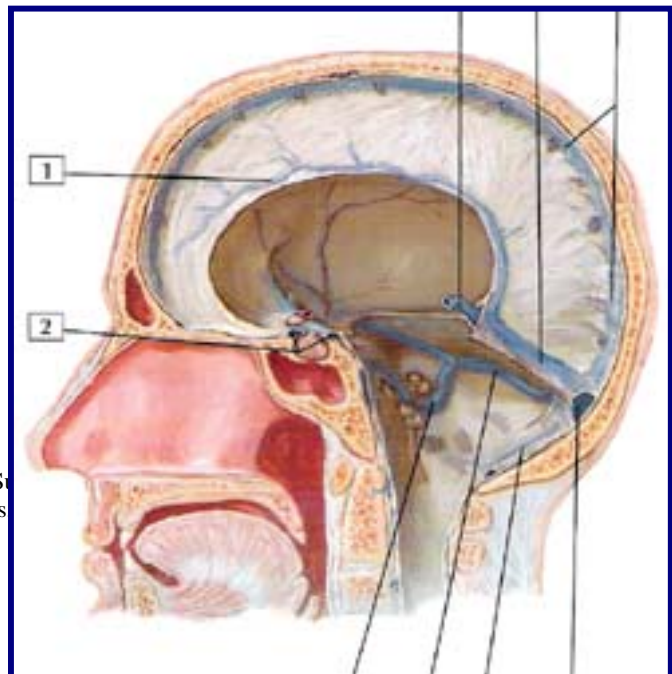


1. Anterior communicating branch: Branch off of the anterior cerebral arteries and connects the two.
  - ii. Middle cerebral arteries: Comes from the termination of the internal carotid arteries and supplies the lateral surface and temporal lobes (most of lateral surface of cerebral hemispheres).
- T). From the vertebral artery: The vertebral artery begins at the root of the neck as branches of the 1<sup>st</sup> part of the subclavian arteries and run in the foramina transversarium of the cervical vertebrae and enter the skull through the foramen magnum. The two vertebral arteries unite at the caudal border of the pons to form the basilar artery. They supply the cranial meninges and cerebellum.
- i. Basilar artery: The basilar artery starts as the joining of the two vertebral arteries and runs up the pons through the pontocerebellar cistern to the superior border of the pons where it gives off two posterior cerebral arteries. It supplies the brainstem, cerebellum, and cerebrum.
    1. Posterior cerebral arteries: Come from termination of basilar artery and supplies the inferior surface and occipital pole (inferior aspect of the cerebral hemispheres and occipital lobes).
      - a. Posterior communicating arteries: Come off the posterior cerebral arteries to connect them to the internal carotid arteries.
    2. Superior cerebral arteries: Come off basilar artery and supply the superior aspect of cerebellum.
    3. Pontine arteries: Numerous branches off basilar artery.
- U). Known vascular interconnections: Cerebral arterial circle (of Willis):
- i. Located at the base of the brain, it is an important anastomosis between four arteries: two vertebral arteries, two internal carotid arteries.
  - ii. The posterior cerebral, posterior communicating, internal carotid, anterior cerebral, and anterior communicating arteries form the circle.
  - iii. Variations in the origins and size of the vessels forming the circle are common.

### Objective 6)

**Trace the flow of blood out of the cranial cavity. Identify the interconnections of the dural venous sinuses and known connections between them and the venous system of the head and neck. Identify the cranial nerves passing through the cavernous sinus and indicate their relationship within the sinus.**

- V). Dural sinuses and their connections:
- i. Superior sagittal sinus: Lies in the convex attached (superior) border of the cerebral falx. It begins at the crista galli and ends near the internal occipital protuberance at the confluence of sinuses. Receives blood form superior cerebral veins.



- ii. Inferior sagittal sinus: Much smaller and runs in the inferior, free concave border of the cerebral falx and merges with the great cerebral vein to form the straight sinus.
  - iii. Straight sinus: Runs inferoposteriorly along line of attachment of cerebral falx to cerebellar tentorium to the confluences of sinuses.
  - iv. Transverse sinuses: Passes laterally from confluence of sinuses in posterior attached margin of the cerebellar tentorium, grooving the occipital bones and the posteroinferior angles of the parietal bones. They leave the cerebellar tentorium at the posterior aspect of the petrous temporal bone and become the sigmoid sinuses.
  - v. Sigmoid sinuses: Follow S-shaped courses in posterior cranial fossa, forming deep grooves in the temporal and occipital bones. Each turns anteriorly and continues as the internal jugular veins.
  - vi. Occipital sinus: Lies in attached border of the cerebellar falx and ends superiorly in confluences of sinuses. Also communicates inferiorly with internal vertebral venous plexus.
  - vii. Cavernous sinus: Situated bilaterally on each side of the sella turcica on upper body of sphenoid. Each extends from superior orbital fissure to apex of petrous part of temporal bone posteriorly. Receive blood from superior and inferior ophthalmic veins, superficial middle cerebral vein, and the sphenoparietal sinus. Cavernous sinuses communicate with each other through intercavernous sinuses. Drains via superior and inferior petrosal sinuses and emissary veins to the pterygoid plexuses.
  - viii. Superior petrosal sinuses: Runs from posterior ends of the cavernous sinuses to join the transverse sinuses where they become sigmoid sinuses. Each superior petrosal sinus lies in the anteriolateral-attached margin of the cerebellar tentorium, which attaches to the superior border of the petrous part of the temporal bone.
  - ix. Inferior petrosal sinuses: Also commence at the posterior end of the cavernous sinuses inferiorly. Drain directly to the internal jugular vein. Basilar plexus (sinus) connects the inferior petrosal sinuses and communicates inferiorly with the internal vertebral venous plexus.
  - x. Emissary veins drain blood from scalp into dural venous sinuses.
- W). Cranial nerves in the cavernous sinus:
- i. Cranial nerves pass through the cavernous sinus in this order from superior to inferior: oculomotor nerve (CN III), trochlear nerve (CN IV), ophthalmic nerve (CN V<sub>1</sub>), and maxillary nerve (CN V<sub>2</sub>).