Systemic Module
CNS

“Anatomy”

Blood Supply of CNS

Dr. Ayman Alzubi

Faculty of Medicine, Yarmouk University

Blood Supply of Brain

- The brain is particularly very sensitive to oxygen starvation.
  - The **consciousness is lost** if blood supply stops for 10 sec
  - If the state continues – **irreversible brain damage**
    - starts at 4 min – completes in 10 min
- Brain consists of 2% of total body but
  - Receives 20% cardiac output
  - 20% total O2
- Stroke - Also Known as "Cerebrovascular Accident (CVA)" - A medical condition in which poor blood flow to the brain causes cell death.

Blood Supply of Brain

- Brain is supplied by 2 sets of arteries:

  1. **A pair of Vertebral arteries (vertebral system)**

  2. **A pair of Internal carotid arteries (carotid system)**

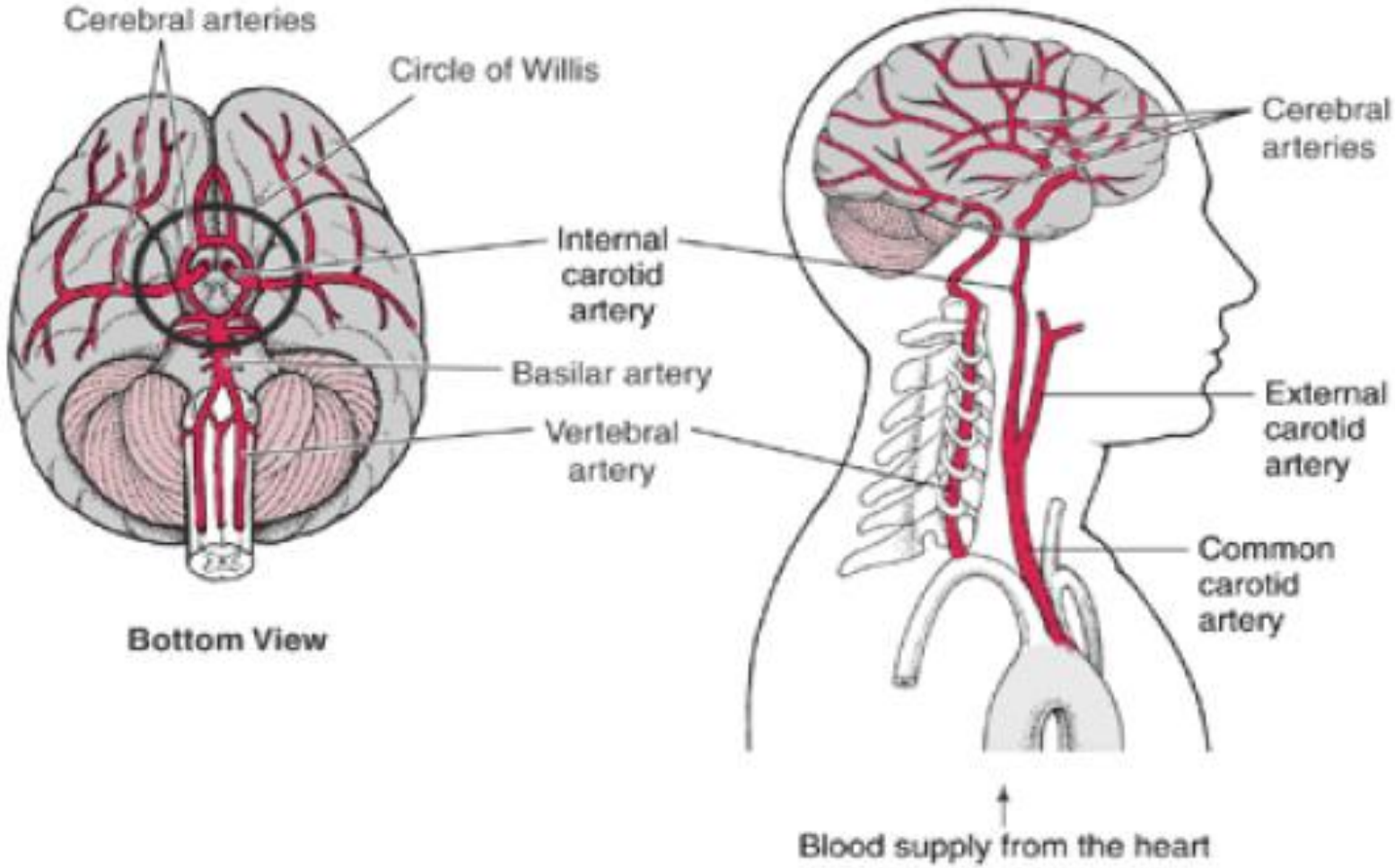
- These arteries arise in the neck and ascend to the cranium.

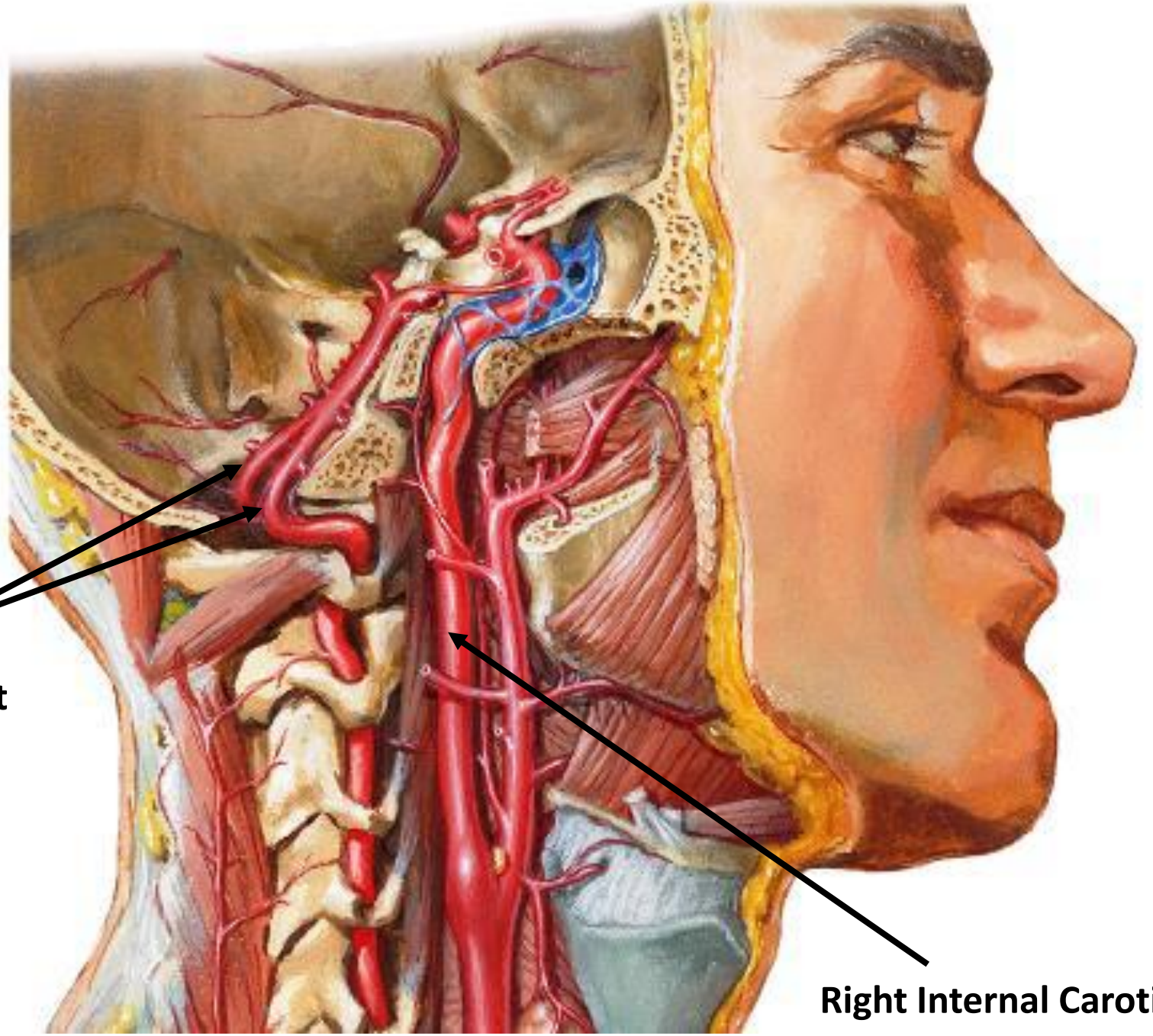
- Within the cranial cavity, the terminal branches of these arteries form an **anastomotic circle**, called the **Circle of Willis**. From this circle, branches arise which supply most of the cerebrum.

Two Systems:

- Carotid System (80%)
- Vertebrobasilar System (20%)

  Polygonal anastomosis at the base of brain-circle of willis





Right and left Vertebral Arteries

Right Internal Carotid Artery

Internal Carotid Artery (ICA)

- **Begins:** at bifurcation of common carotid A. (at upper border of thyroid cartilage).

- Its course is divided into 4 parts:

  - The **1st part** is the **cervical part**.

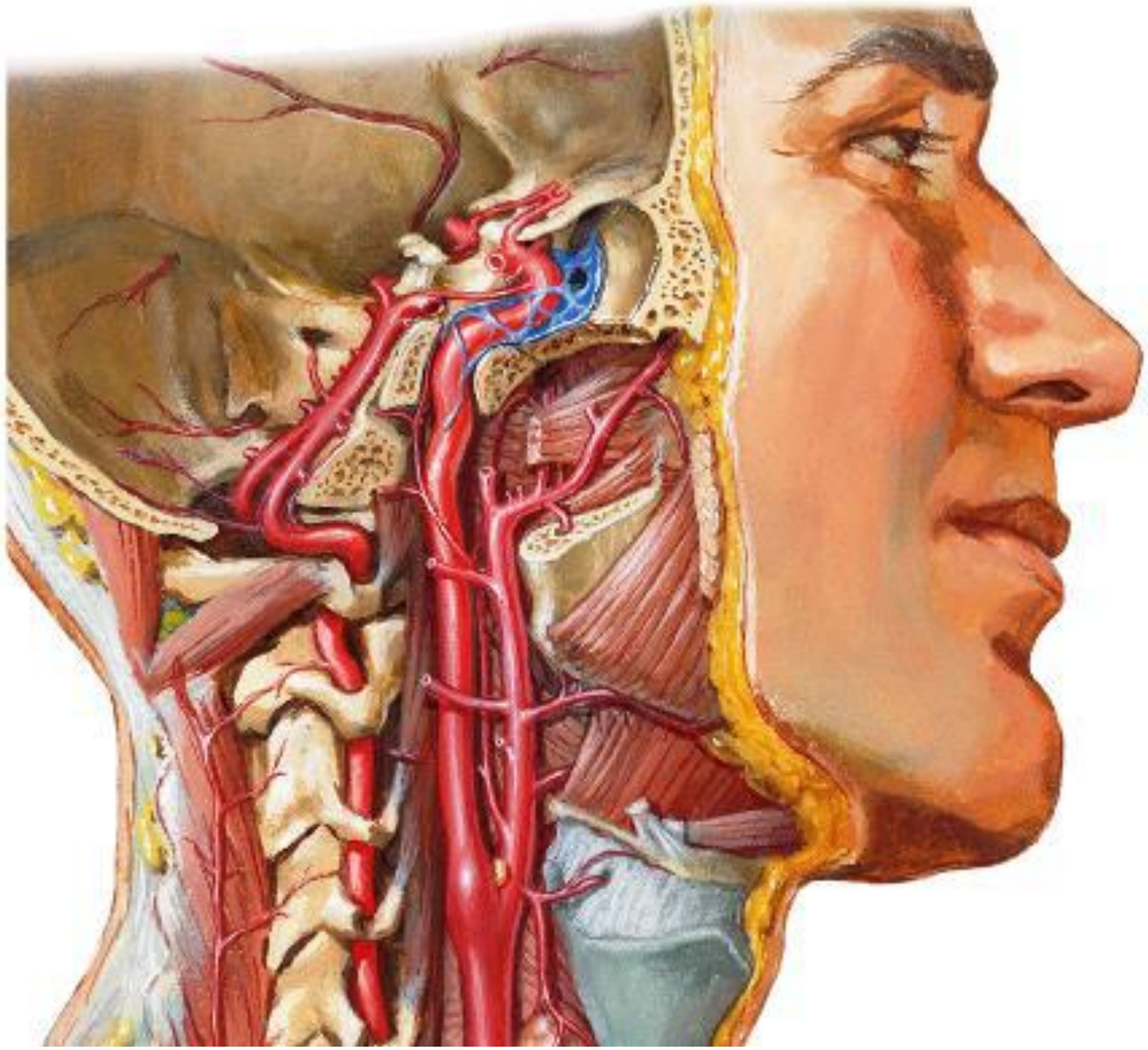
  - The **2nd part** (**petrous part**) passes through carotid canal of skull to enter cranial cavity via foramen lacerum.

Contd..

- The **3rd part** (**cavernous part**) runs in cavernous sinus; giving branches to pituitary, trigeminal ganglion and meninges.

- Its **4th part** (**cerebral part**) emerges through roof of cavernous sinus medial to anterior clinoid process.

- **Terminates**: opposite anterior perforated substance by dividing into **anterior** and **middle cerebral arteries (ACA & MCA).**



Branches of cerebral part of ICA

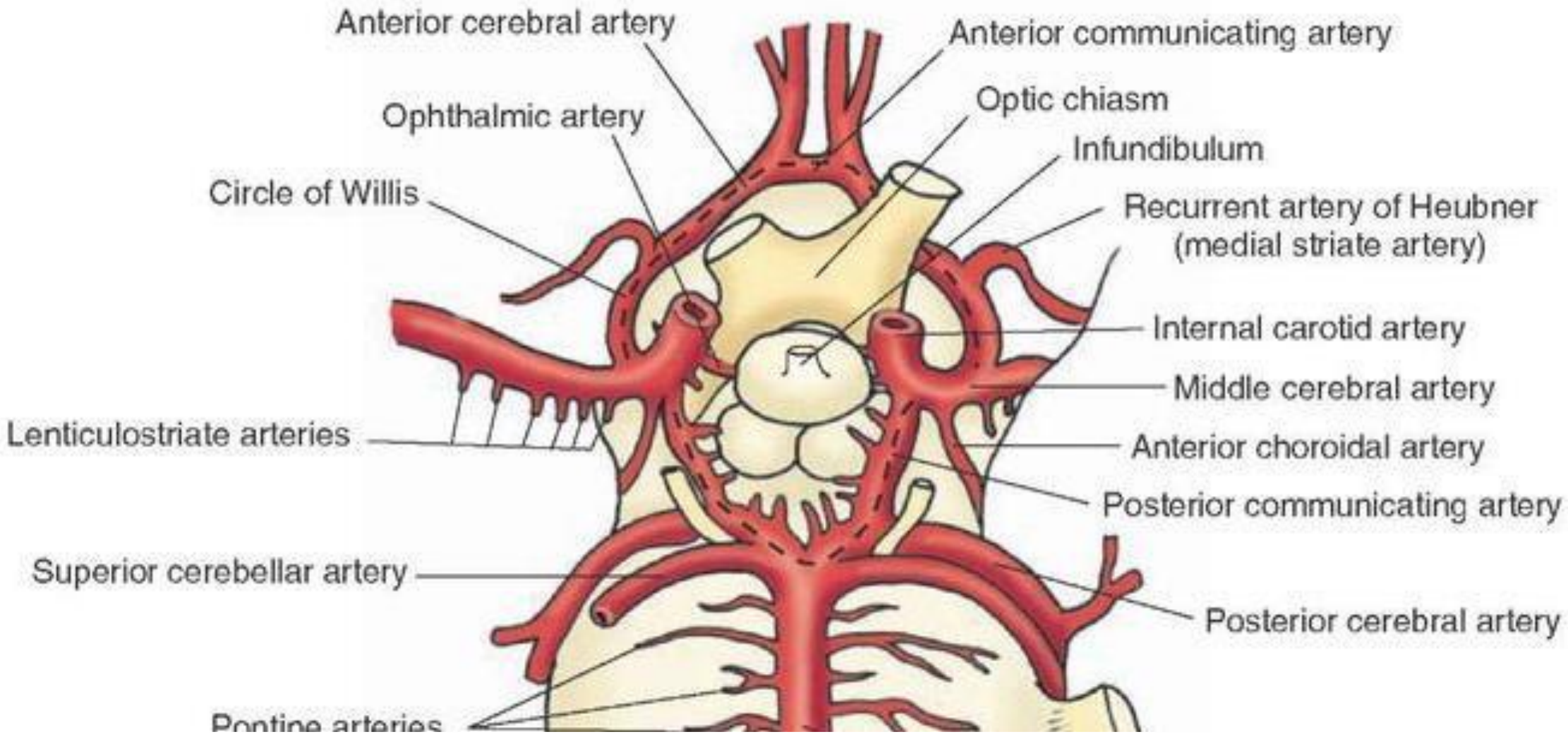
1. **Ophthalmic artery**: supplies the structures of the orbit, frontal and ethmoidal sinuses, frontal part of the scalp and dorsum of the nose.

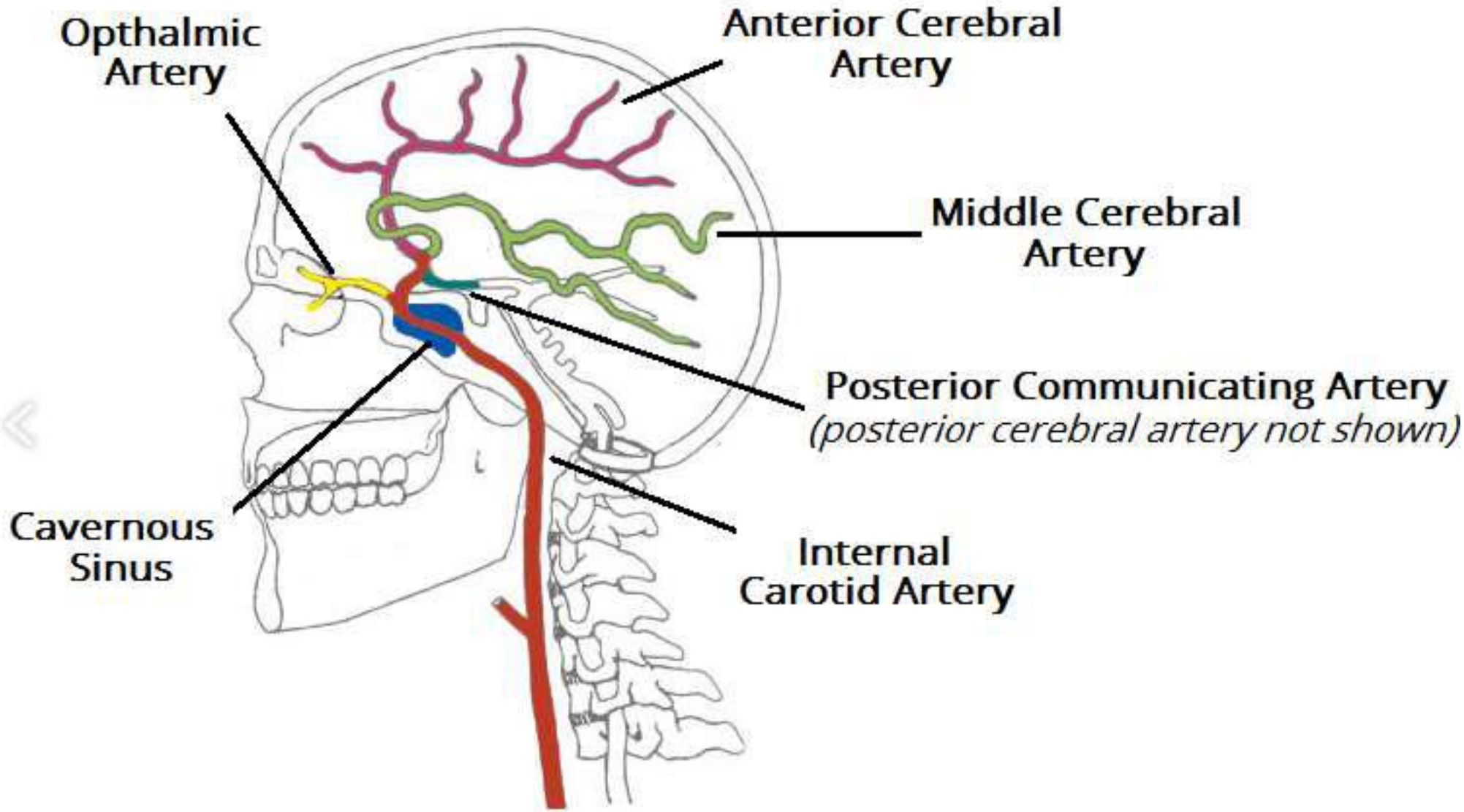
2. **Posterior communicating artery**: runs backward to join the posterior cerebral artery.

3. **Anterior choroidal artery:** supplies the optic tract, choroid plexus of the lateral ventricle, hippocampus and some of the deep structures of the hemisphere, including the internal capsule and globus pallidus.

4. **Anterior cerebral artery** (terminal): supplies parts of the cerebrum.

5. **Middle cerebral artery** (terminal): supplies the lateral portions of the cerebrum.


Anterior cerebral artery
Anterior communicating artery
Ophthalmic artery
Optic chiasm
Infundibulum
Circle of Willis
Recurrent artery of Heubner
(medial striate artery)
Internal carotid artery
Middle cerebral artery
Lenticulostriate arteries
Anterior choroidal artery
Posterior communicating artery
Superior cerebellar artery
Posterior cerebral artery
Pontine arteries

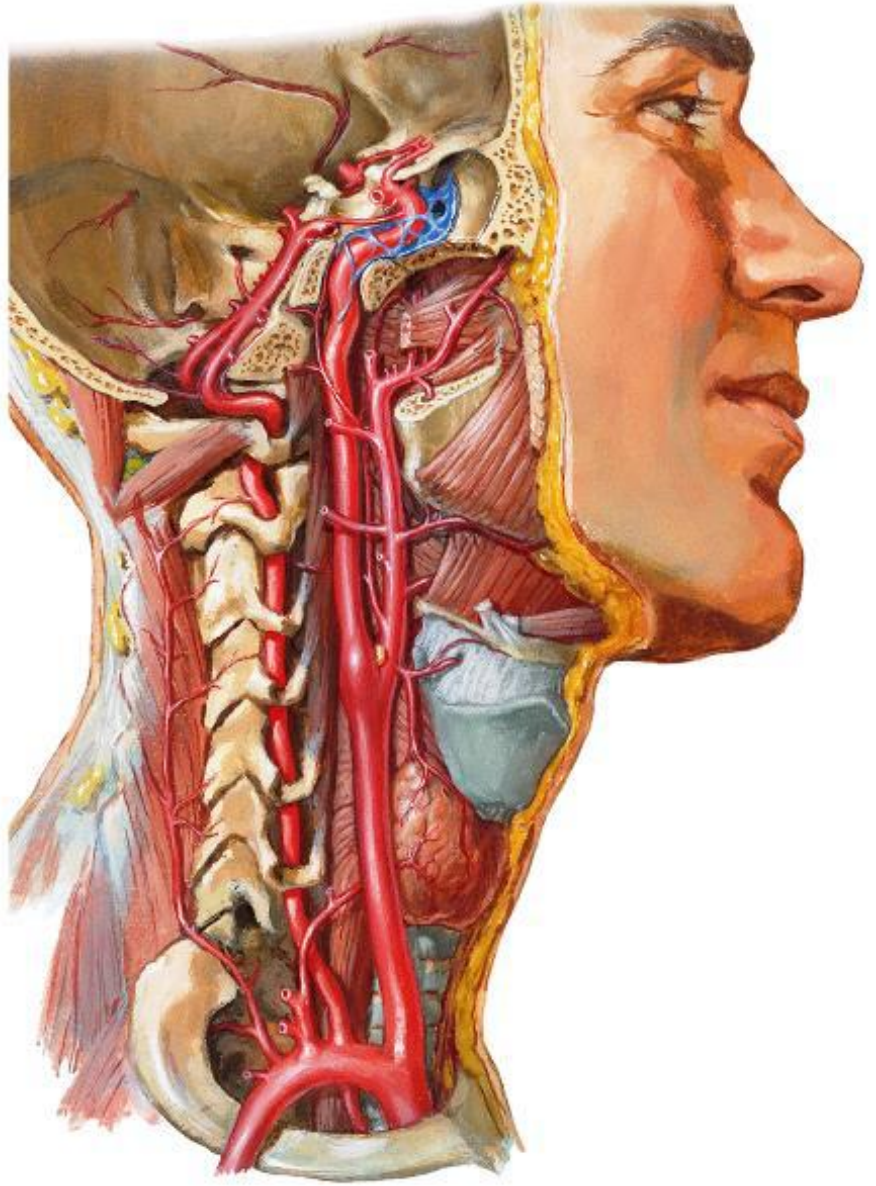


Branches of the internal carotid artery.

Vertebral Artery

- **Begins:** as branch of first part of subclavian artery.
- Its course is divided into 4 parts:

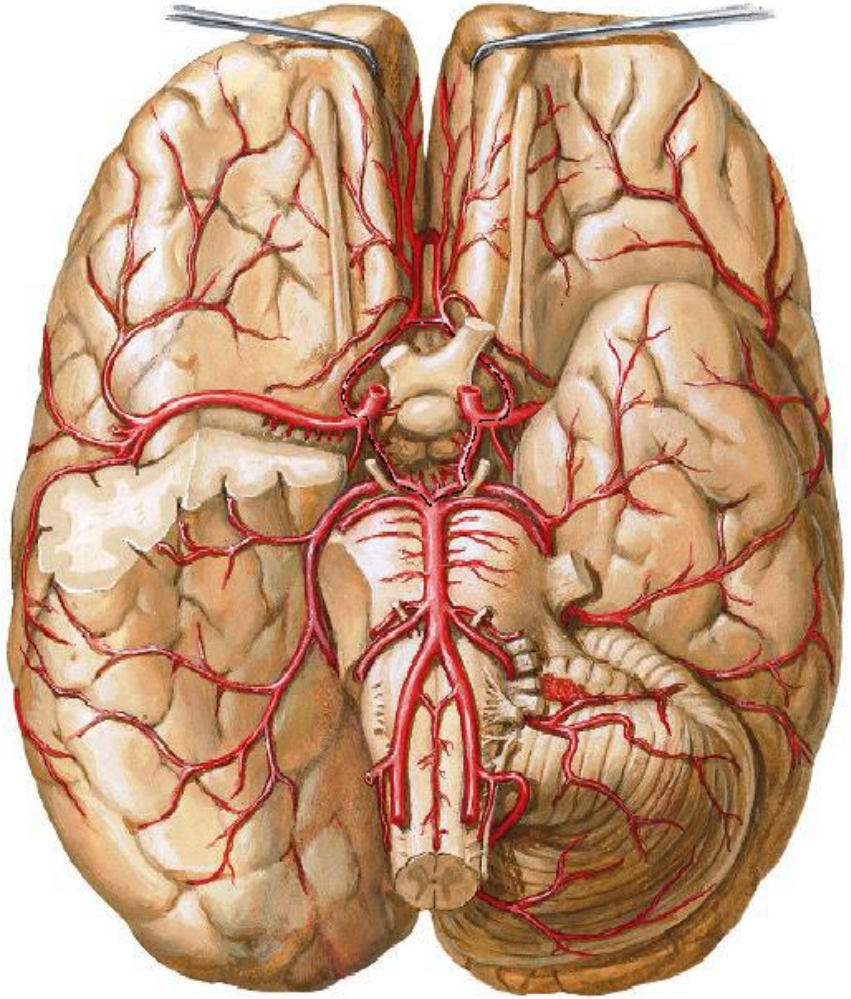
1. The 1st part → before the foramen transversarium of C6.
2. The 2nd part → passes through the foramina transversaria of upper six cervical vertebrae.
3. The 3rd part passes in the suboccipital triangle then enters cranial cavity through foramen magnum.
4. The 4th part passes on ventral surface of medulla oblongata.

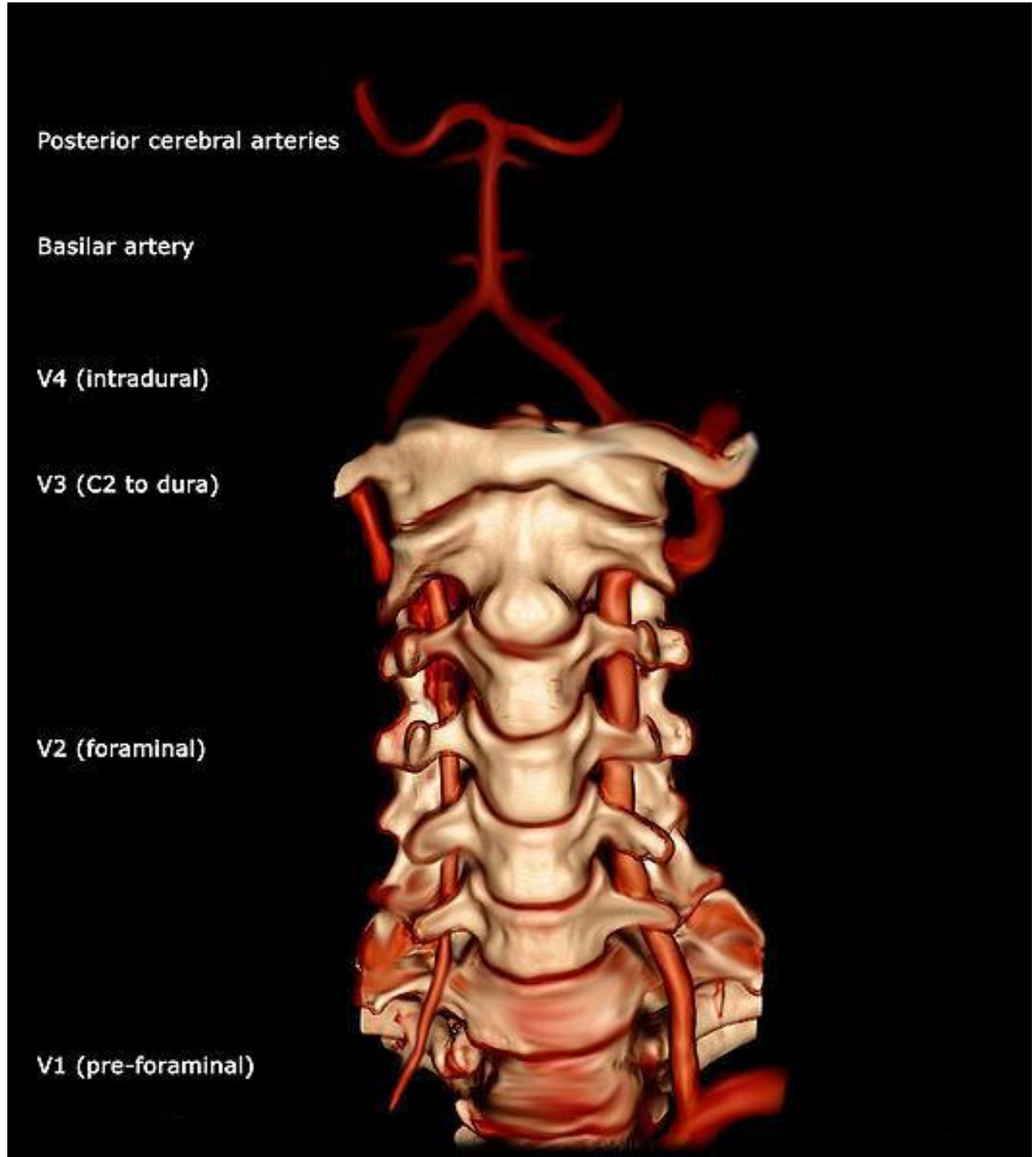


Vertebral Artery

- **Ends:** at lower border of pons by joining the other vertebral to form **basilar artery**.

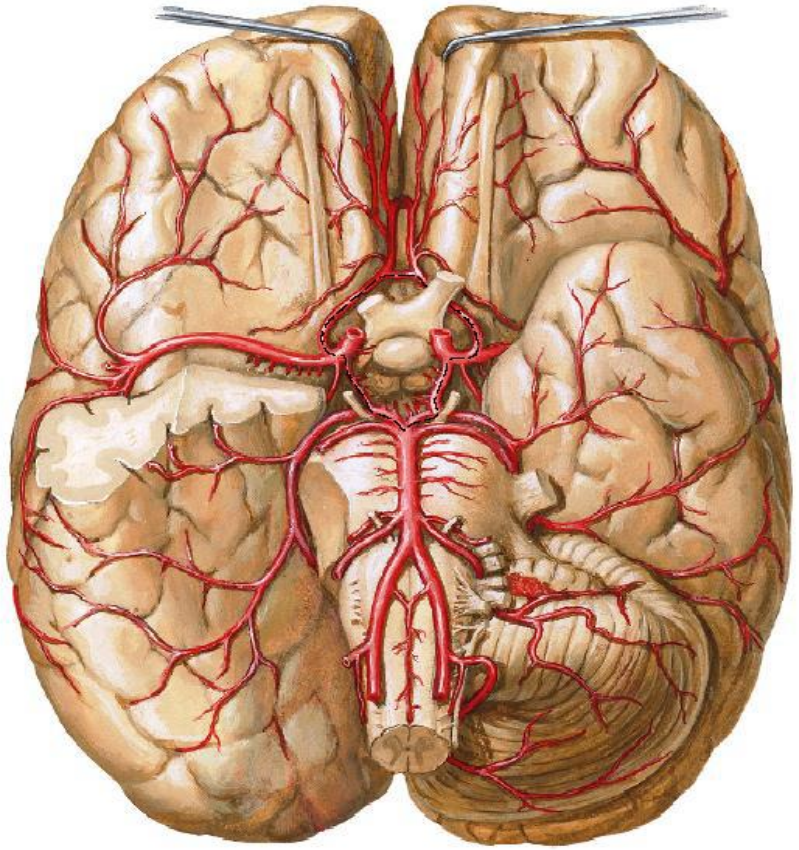
- Branches of vertebral artery in cranial cavity:
  1. Meningeal.
  2. Posterior inferior cerebellar.
  3. Posterior spinal (2).
  4. Anterior spinal (1).
  5. Medullary branches.




Posterior cerebral arteries
Basilar artery
V4 (intradural)
V3 (C2 to dura)
V2 (foraminal)
V1 (pre-foraminal)

Basilar Artery

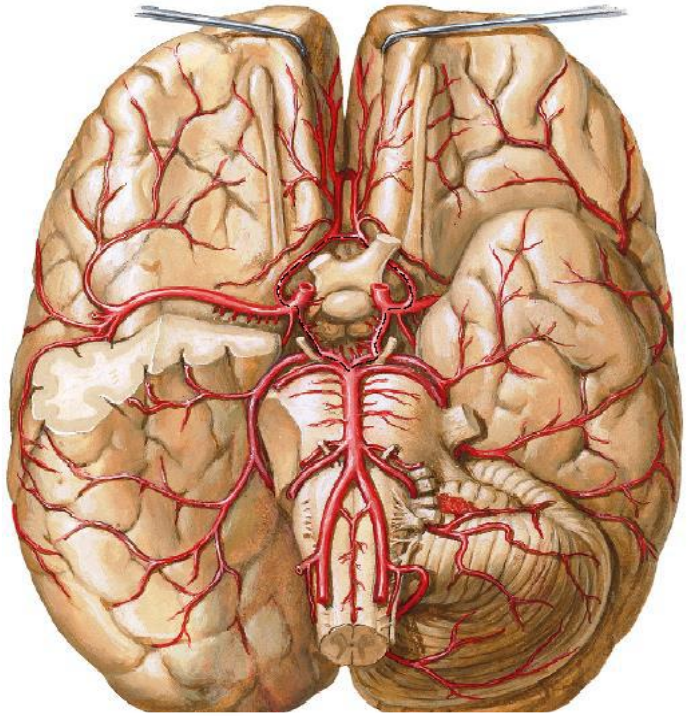
- **Origin: formed by the** union of right and left vertebral arteries at lower border of pons.
- It runs in a shallow groove along the ventral surface of pons.
- **End:**, it ends by giving its two terminal branches "**right and left posterior cerebral arteries**" at the upper border of pons.

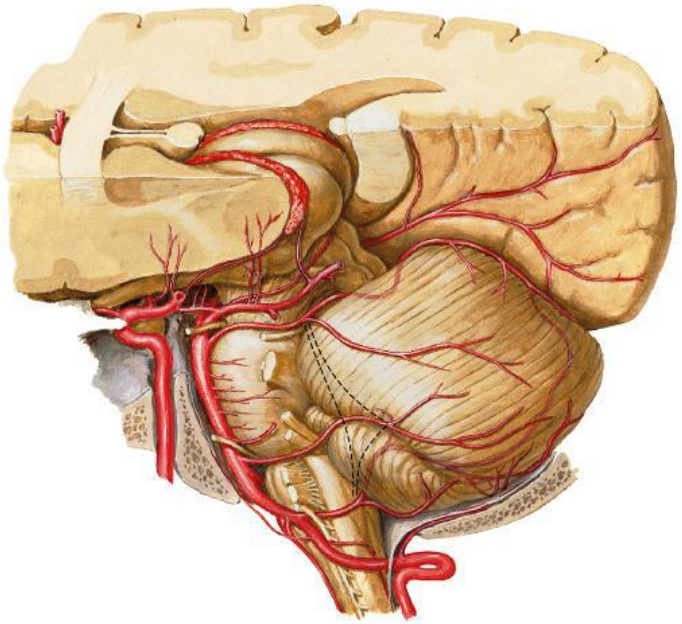


Basilar Artery

- Branches of Basilar Artery:

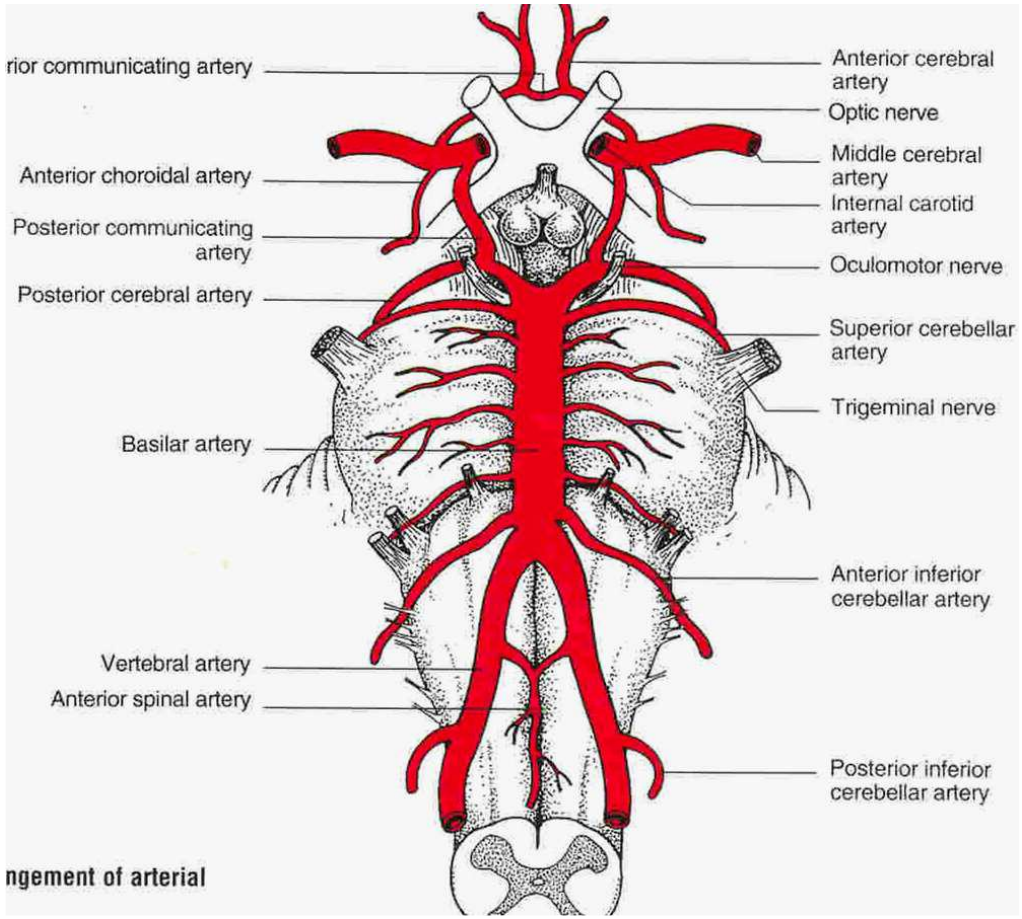
1. Pontine branches.
2. Labyrinthine
3. Anterior inferior cerebellar.
4. Superior cerebellar.
5. Posterior cerebral.





Circle of Willis

- It a large arterial anastomotic circle between the carotid and vertebrobasilar systems (terminal branches of the vertebral and internal carotid arteries).
- It provides alternative route if one of the artery in occluded.
- **Site:** at the base of the brain, in the interpeduncular cistern.



Circle of Willis

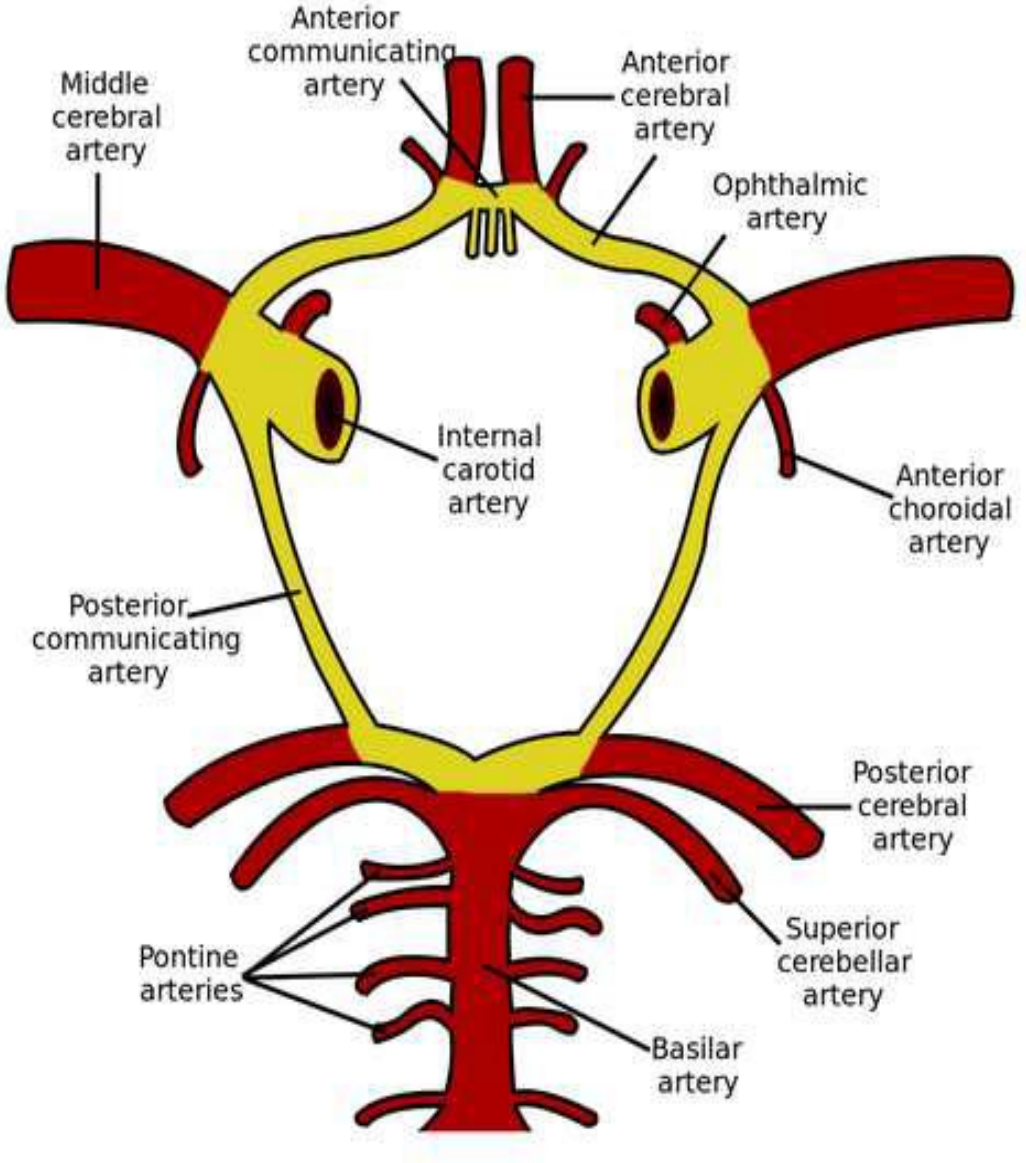
- **It is formed by:**

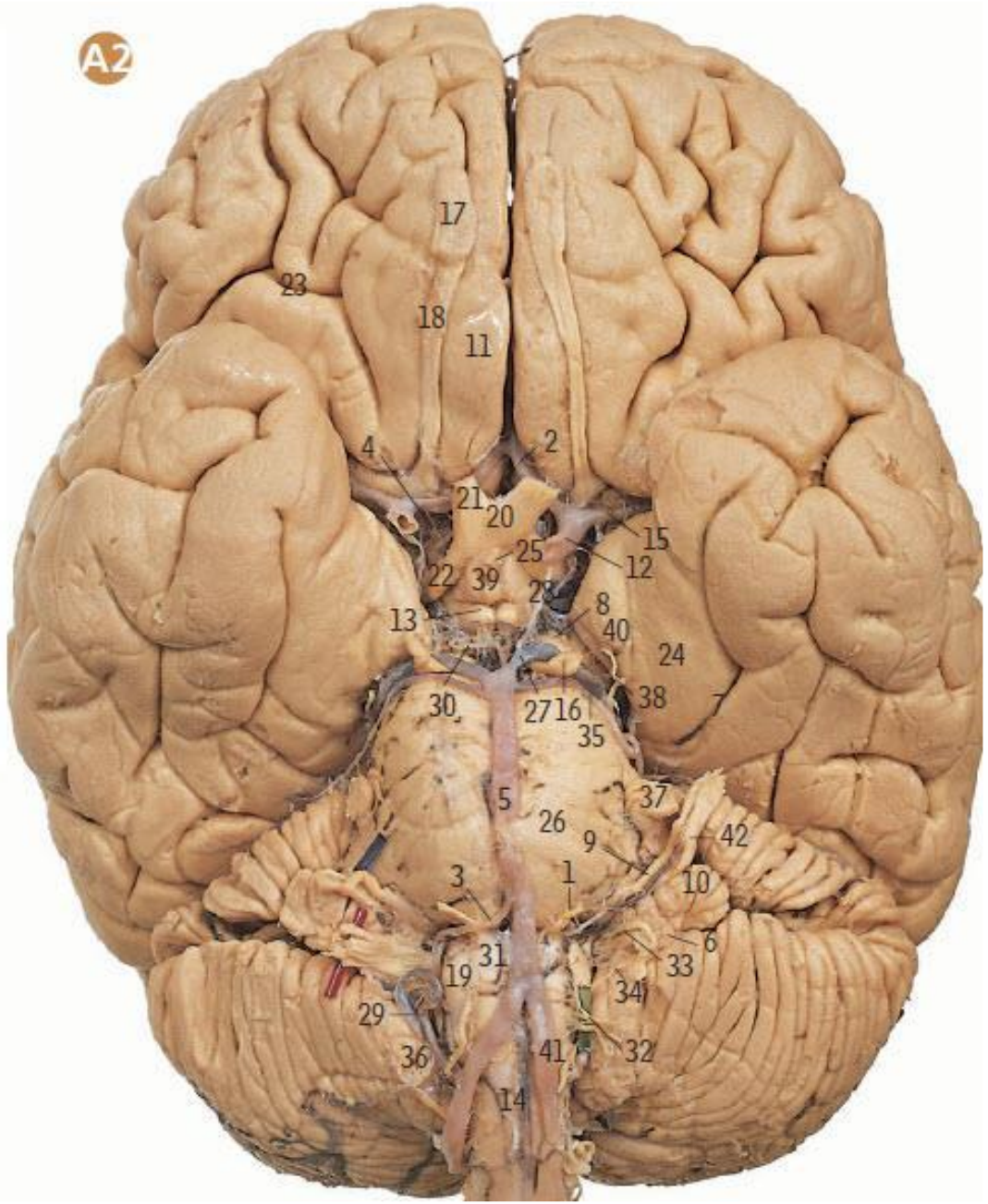
1. Right and left anterior cerebral arteries. with the anterior communicating artery connecting them.

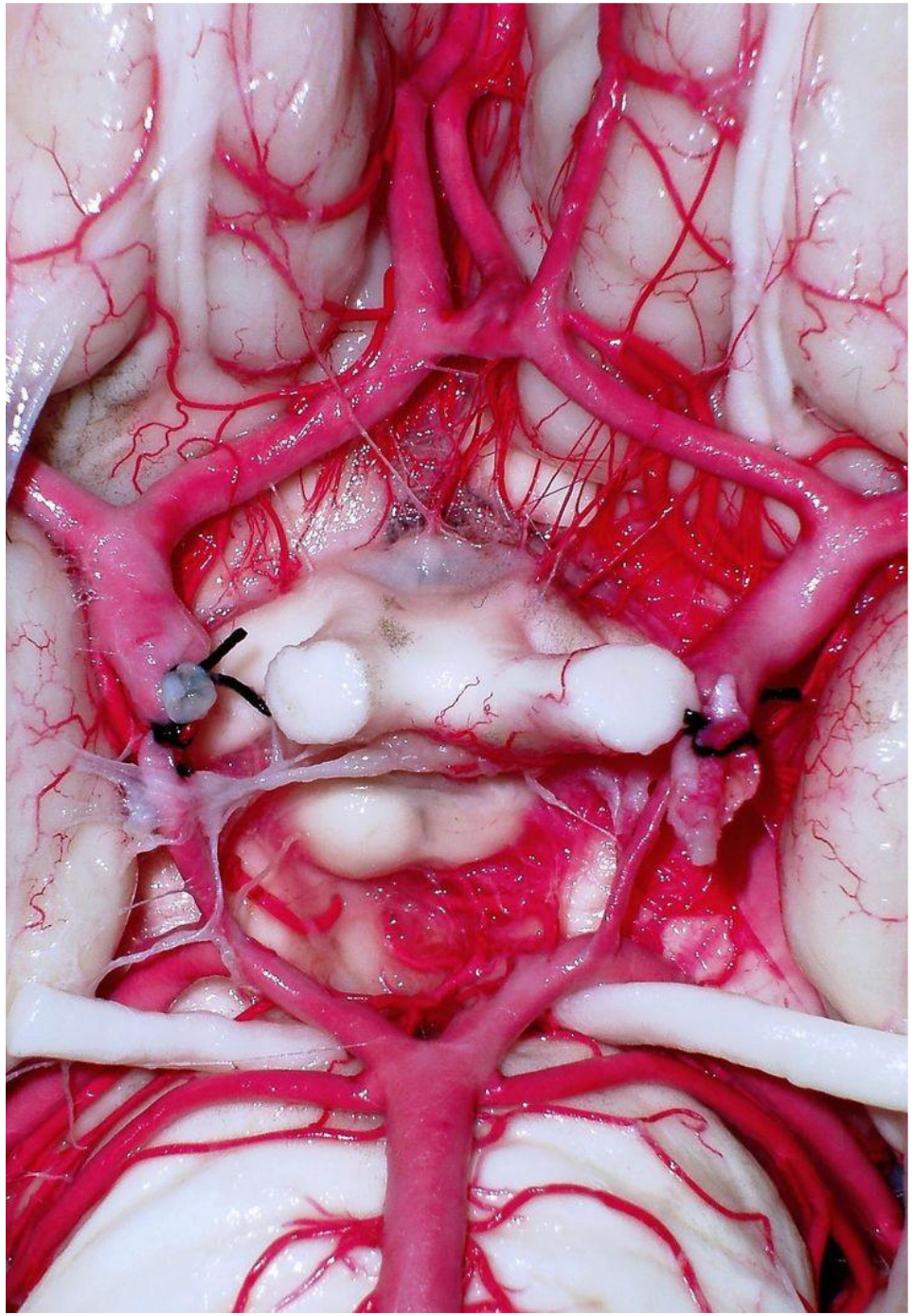
2. Right and left internal carotid arteries (ICA).

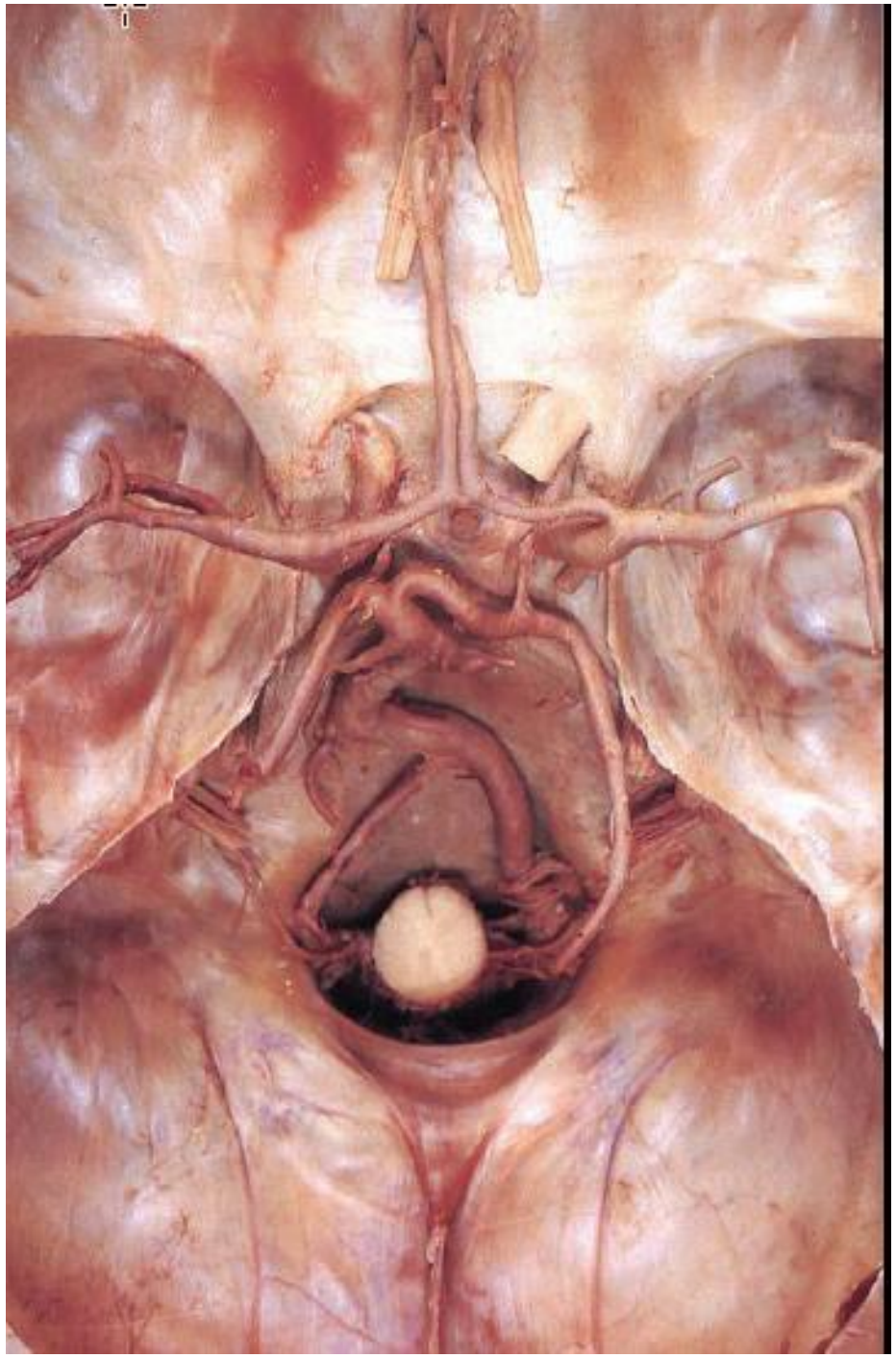
3. Right and left posterior cerebral arteries.

4. Posterior communicating artery connects the ICA to the posterior cerebral artery on either side



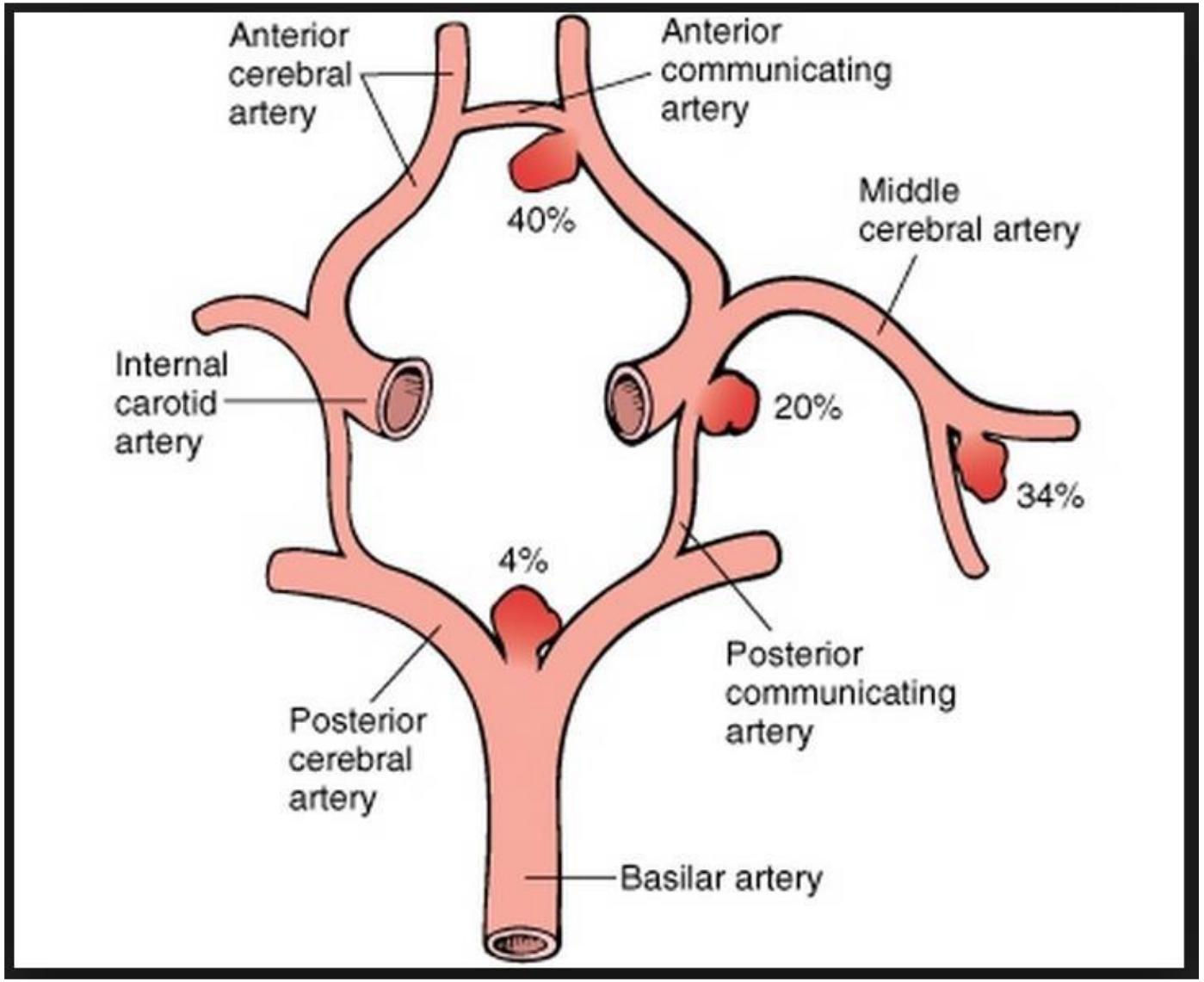

A2
17
23
18
11
4
2
21
20
15
25
12
22
39
28
8
13
40
24
30
27
16
38
35
5
37
26
42
9
3
1
10
6
31
33
19
34
29
36
41
32
14

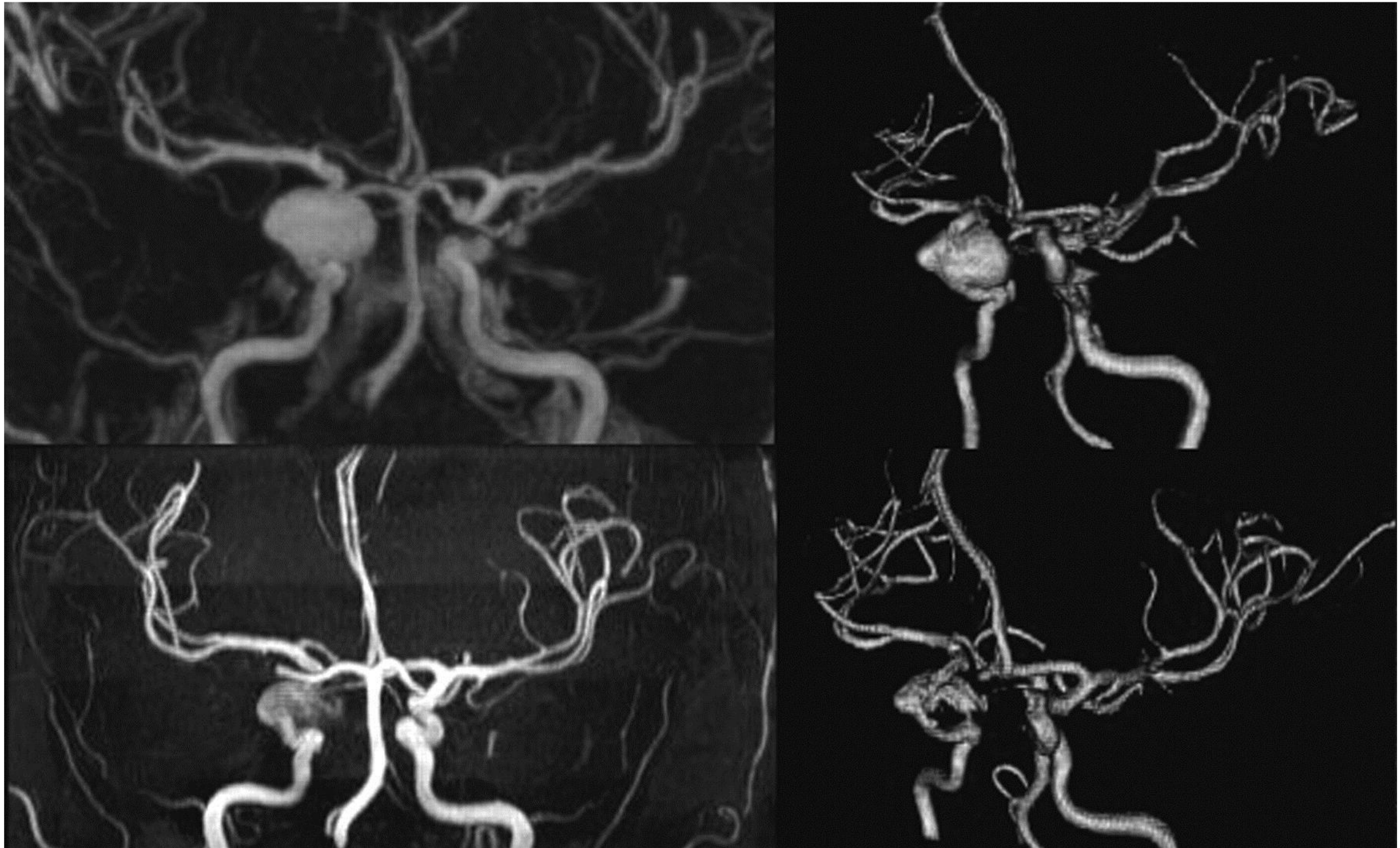





R
L
Z: 100%
1/1 1/1
B5-3: 2.0(0.1P)
16.0x16.0cm

Berry Aneurysm





Circle of Willis

Central Branches

- Arise from the circle of Willis or very close to it to supply nearby structures.
- Divided into four groups:

1- Anteromedial group:

- Branches from anterior cerebral and communicating artery
- Pierce ant. perforated substance to supply ant. part of caudate & lentiform + internal capsule (genu and lower ½ of ant. limb).

2- Anterolateral group

- Branches from middle cerebral artery
- Pierce anterior perforated substance to supply post part of caudate & lentiform + internal capsule (upper ½ of ant. & post. limbs).

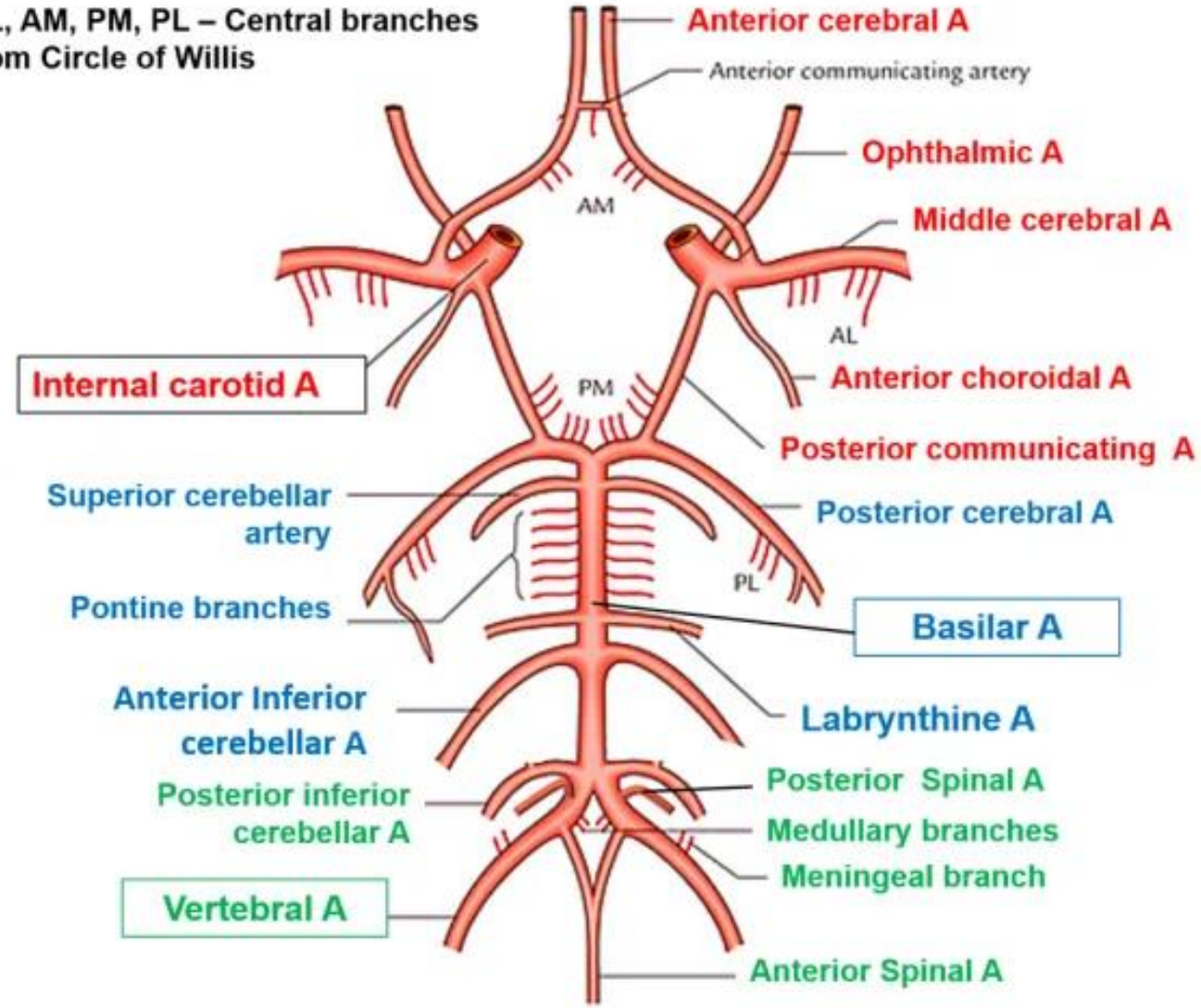
3- Posteromedial group:

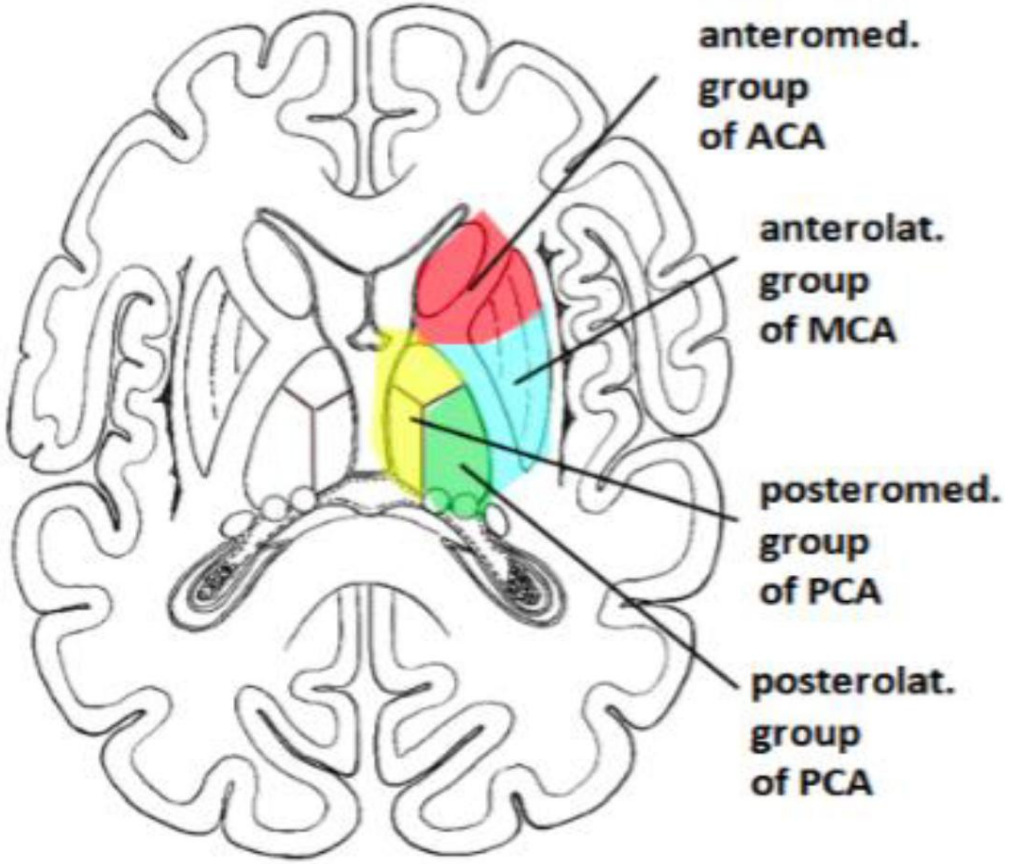
- Branches from posterior cerebral and posterior communicating arteries.
- Pierces posterior perforated substance to supply ant. & med. nuclei of thalamus + hypothalamus

4- Posteromedial group:

- Branches from posterior cerebral artery.
- Passes directly to supply lat. & post. parts of thalamus + metathalamus (MGB & LGB).

AL, AM, PM, PL – Central branches from Circle of Willis

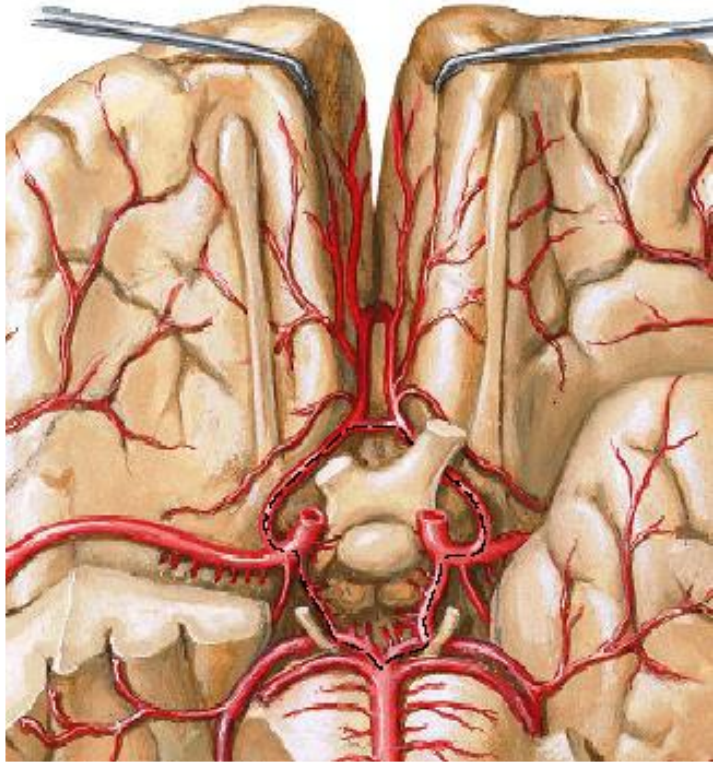


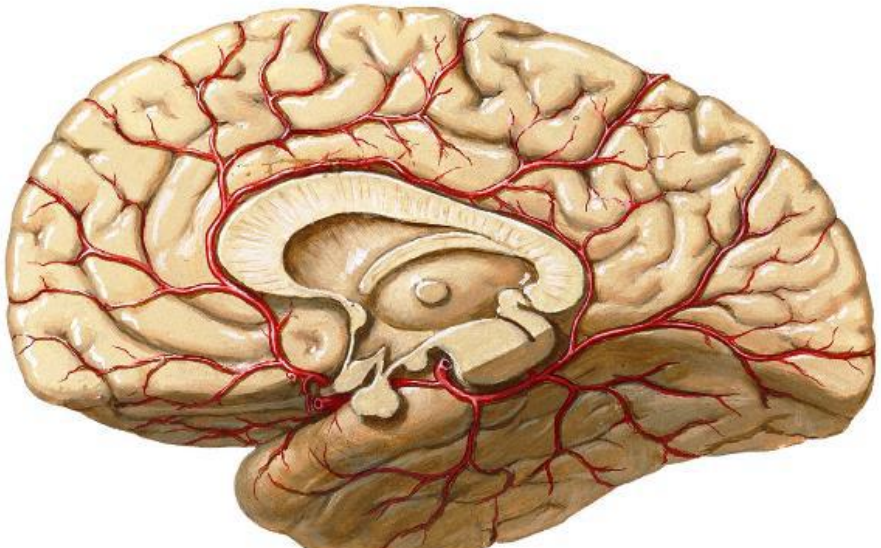


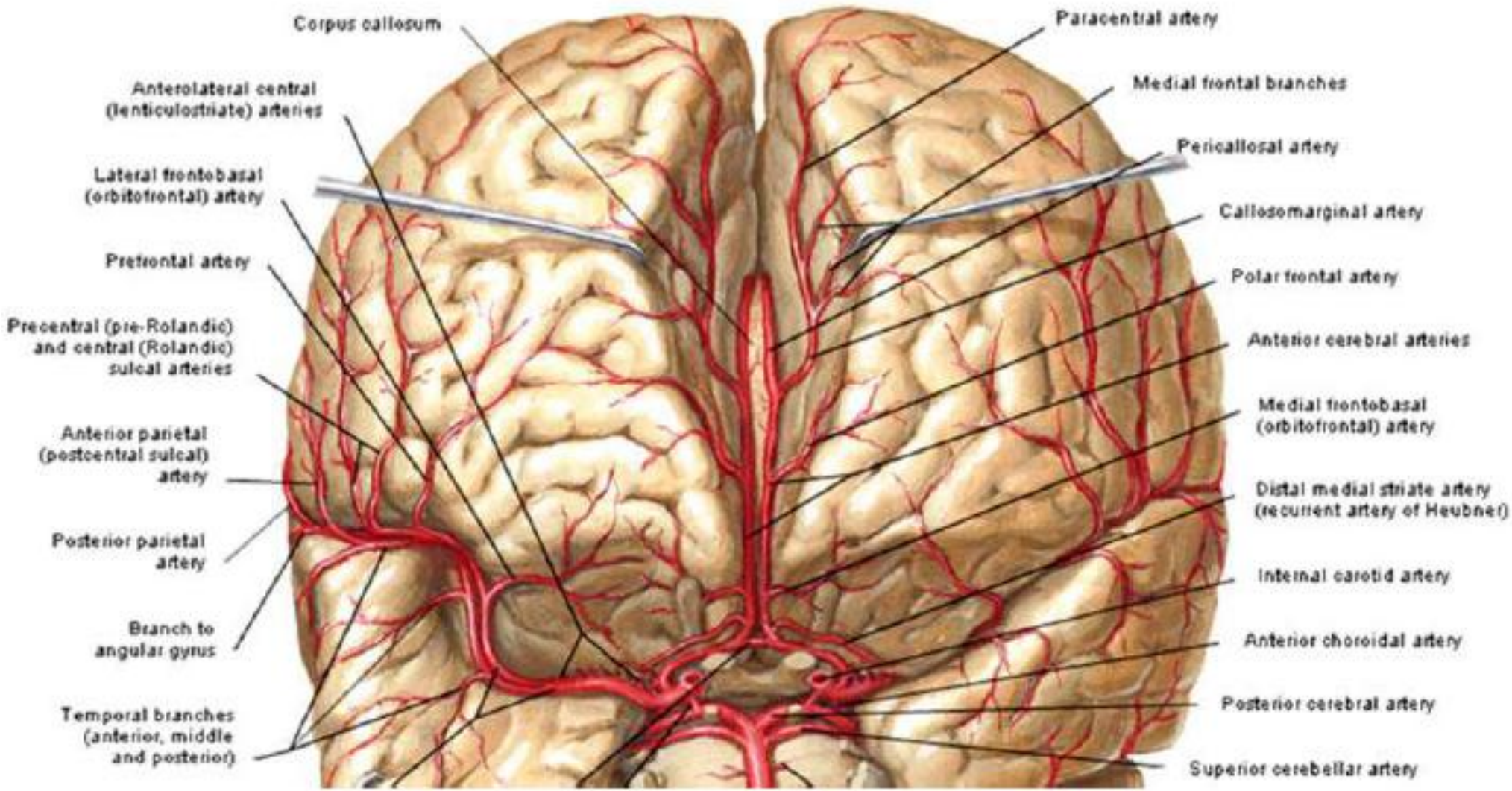
Anterior Cerebral Artery

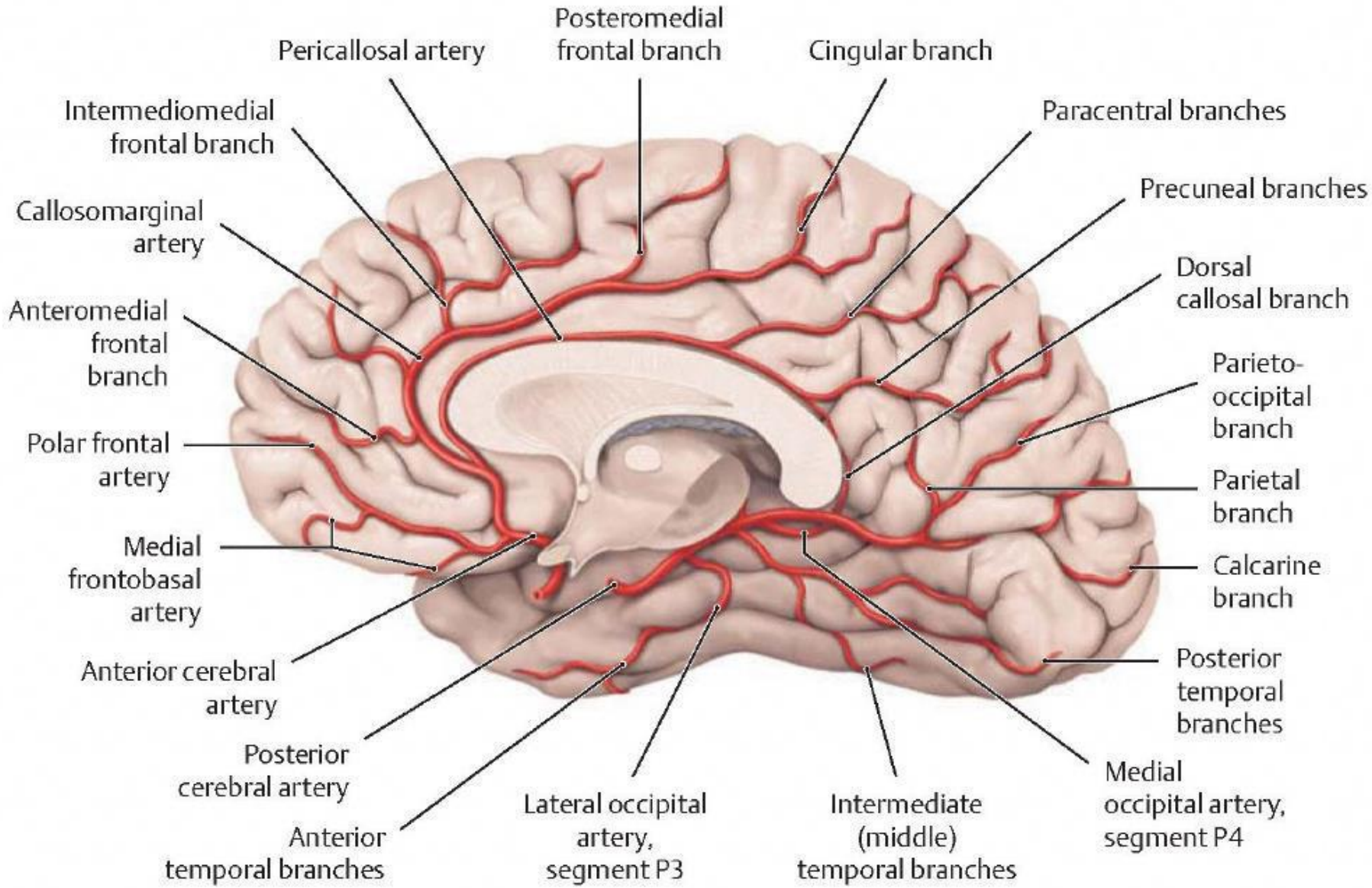
- **Origin:** It is a terminal branch of internal carotid artery.

- **Course:** It runs towards the longitudinal fissure where it communicates with the other anterior cerebral artery through the anterior communicating artery. It runs backwards over corpus callosum. It ends at parieto-occipital sulcus (P.O.S.) by anastomosing with the posterior cerebral artery.






Corpus callosum
Anterolateral central (lenticulostriate) arteries
Lateral frontobasal (orbitofrontal) artery
Prefrontal artery
Precentral (pre-Rolandic) and central (Rolandic) sulcal arteries
Anterior parietal (postcentral sulcal) artery
Posterior parietal artery
Branch to angular gyrus
Temporal branches (anterior, middle and posterior)
Paracentral artery
Medial frontal branches
Pericallosal artery
Callosomarginal artery
Polar frontal artery
Anterior cerebral arteries
Medial frontobasal (orbitofrontal) artery
Distal medial striate artery (recurrent artery of Heubner)
Internal carotid artery
Anterior choroidal artery
Posterior cerebral artery
Superior cerebellar artery


Posteromedial frontal branch
Pericallosal artery
Cingular branch
Intermediomedial frontal branch
Paracentral branches
Precuneal branches
Callosomarginal artery
Dorsal callosal branch
Anteromedial frontal branch
Parieto-occipital branch
Polar frontal artery
Parietal branch
Medial frontobasal artery
Calcarine branch
Posterior temporal branches
Anterior cerebral artery
Posterior cerebral artery
Medial occipital artery, segment P4
Anterior temporal branches
Lateral occipital artery, segment P3
Intermediate (middle) temporal branches

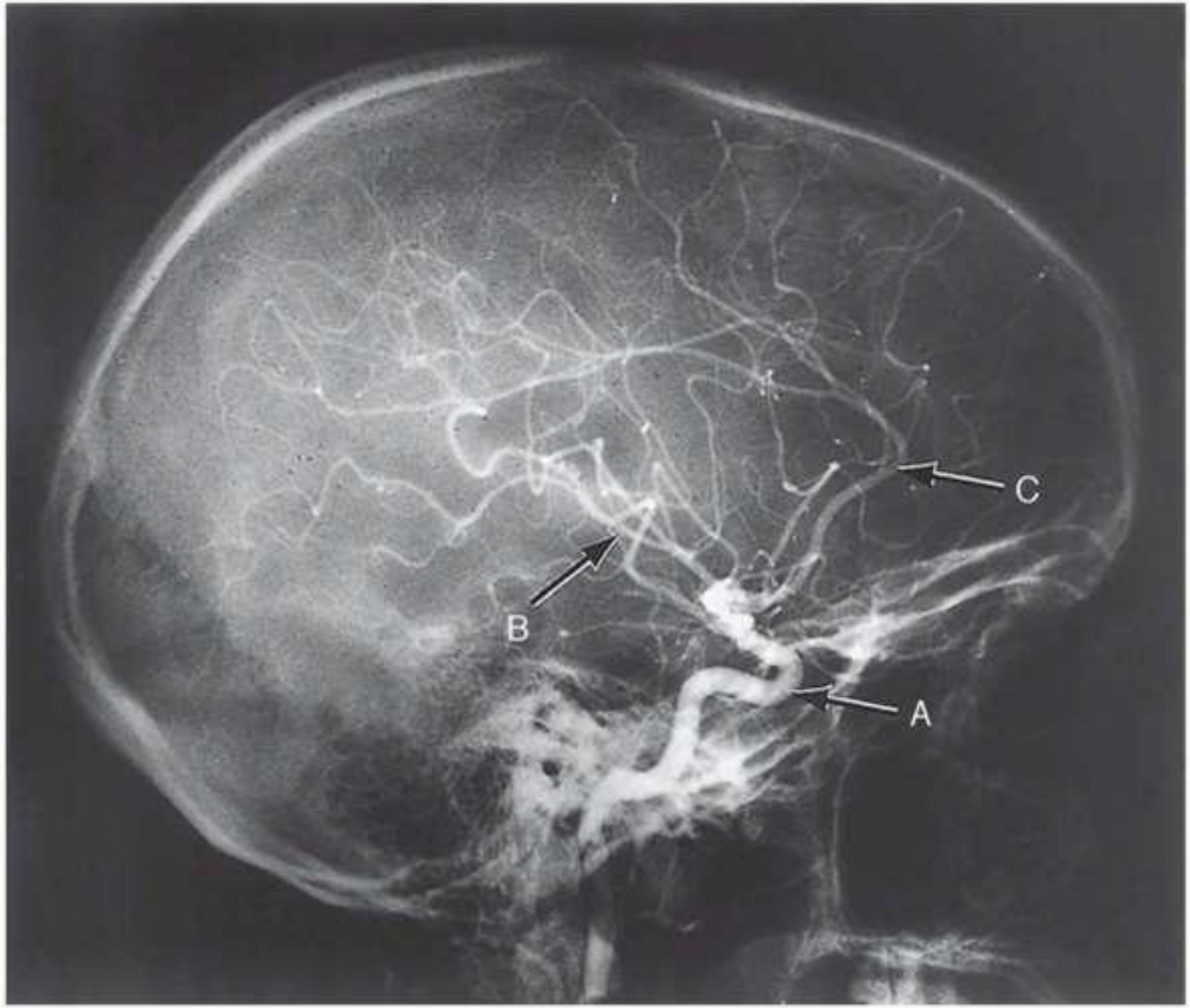


FIGURE 25-1 Carotid an giogram (lateral view). A, carotid siphon; B, branches of the middle cerebral artery; C, anterior cerebral artery. (Courtesy of Dr. J. M. Allcock.)

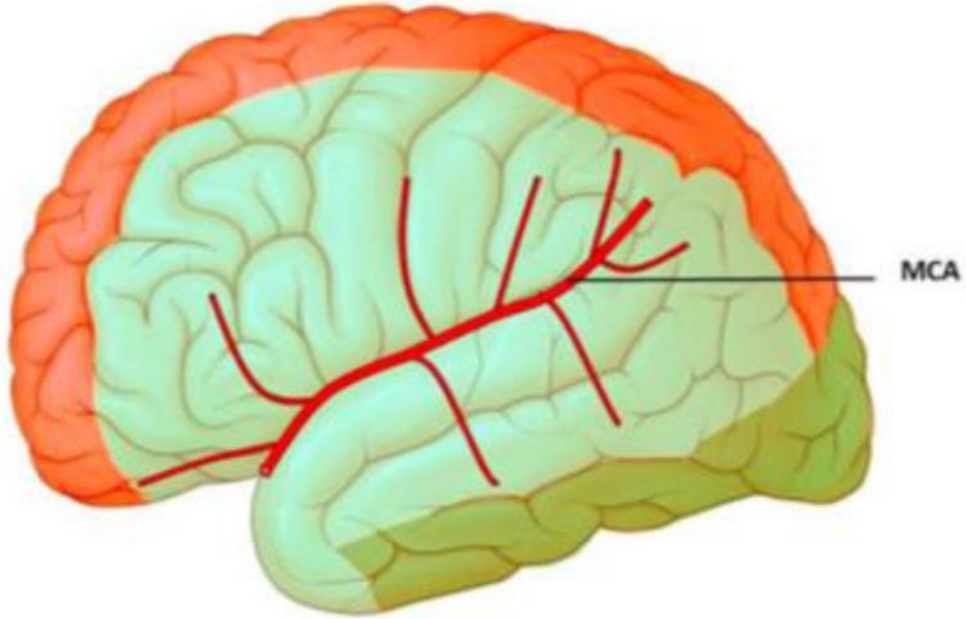
Anterior Cerebral Artery

- **The cortical branches**
  - Supply:

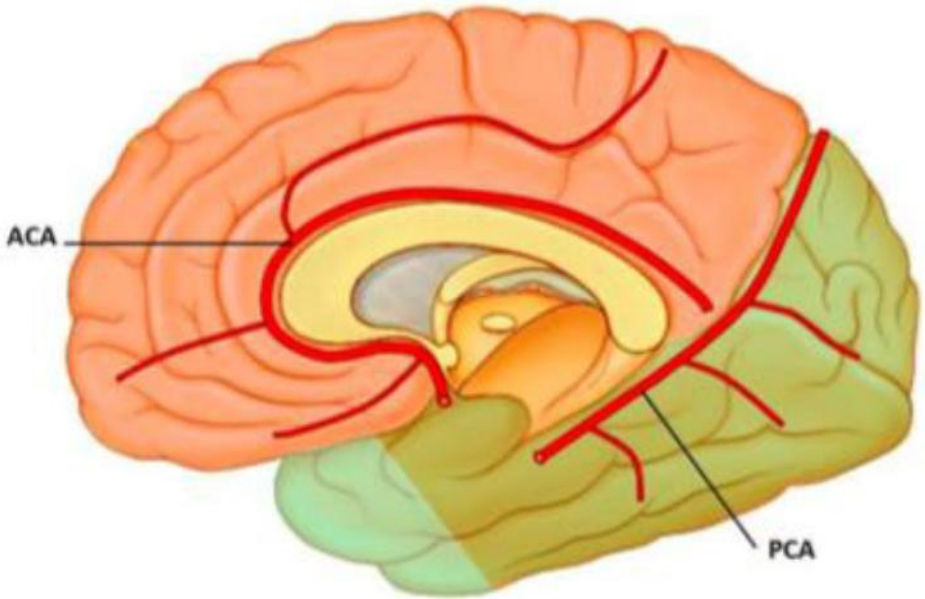
    1. Medial surface → All except occipital lobe.
    2. Lateral surface → One inch strip superiorly.
    3. Inferior surface → medial part of orbital surface.

- **The central branches**
  - Anteromedial group

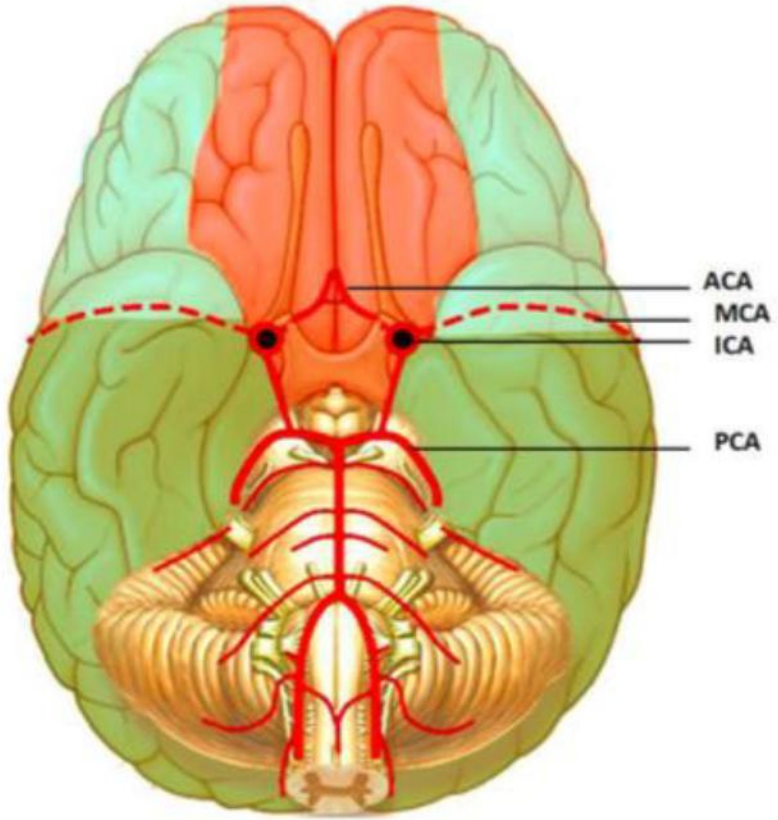
Cortical branches



Lateral surface

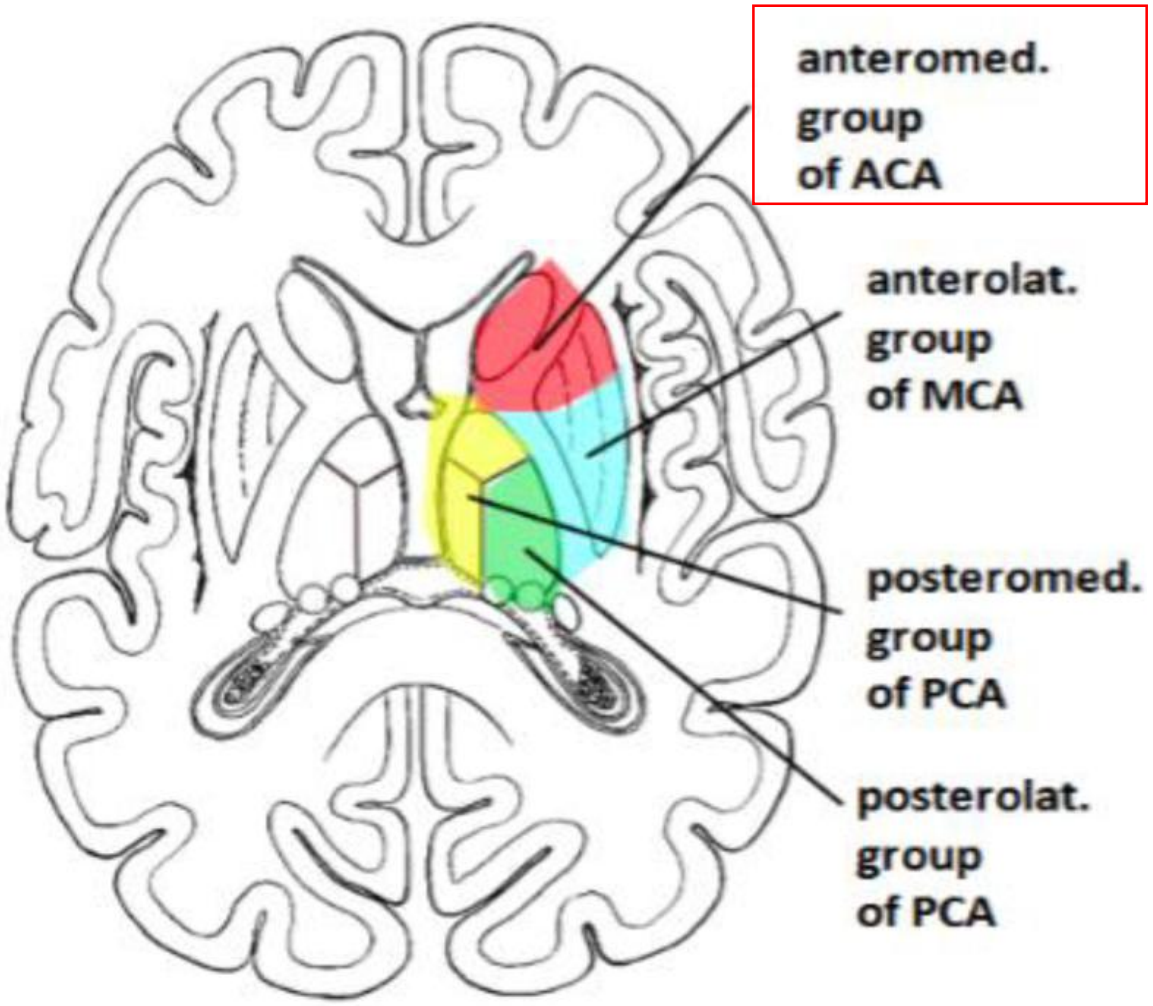


Medial surface



Inferior surface

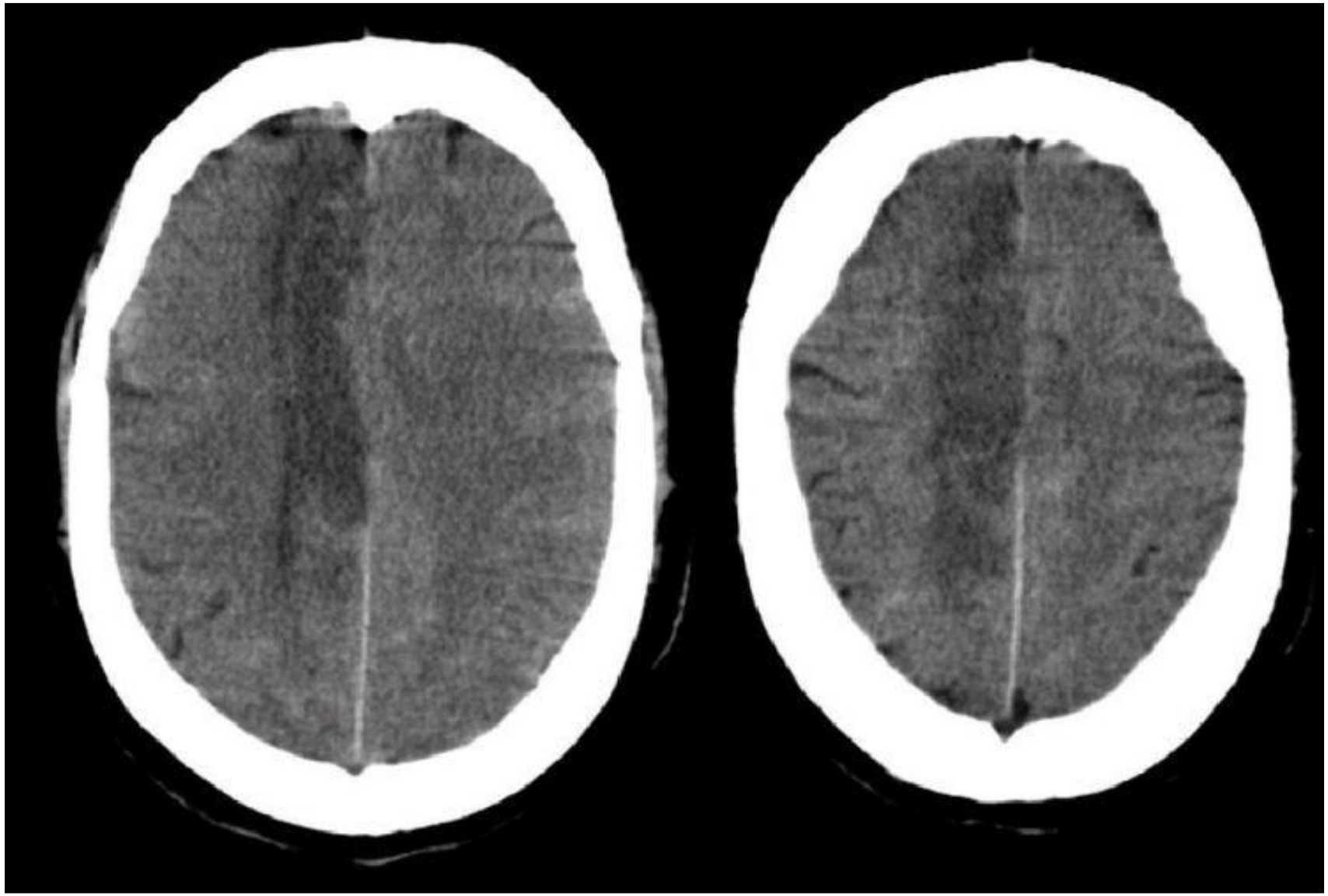
Central branches



Anterior cerebral artery stroke

- **Occlusion of anterior cerebral artery led to:**
  - **Contralateral hemiplegia** (paralysis or weakness) mainly leg & foot - Due to involvement of upper part of primary motor area.
  - **Contralateral hemianaesthia** (sensory loss) mainly leg & foot- Due to involvement of upper part of primary sensory area.
  - **Apathy and personality changes** – Due to involvement of part of frontal lobe.

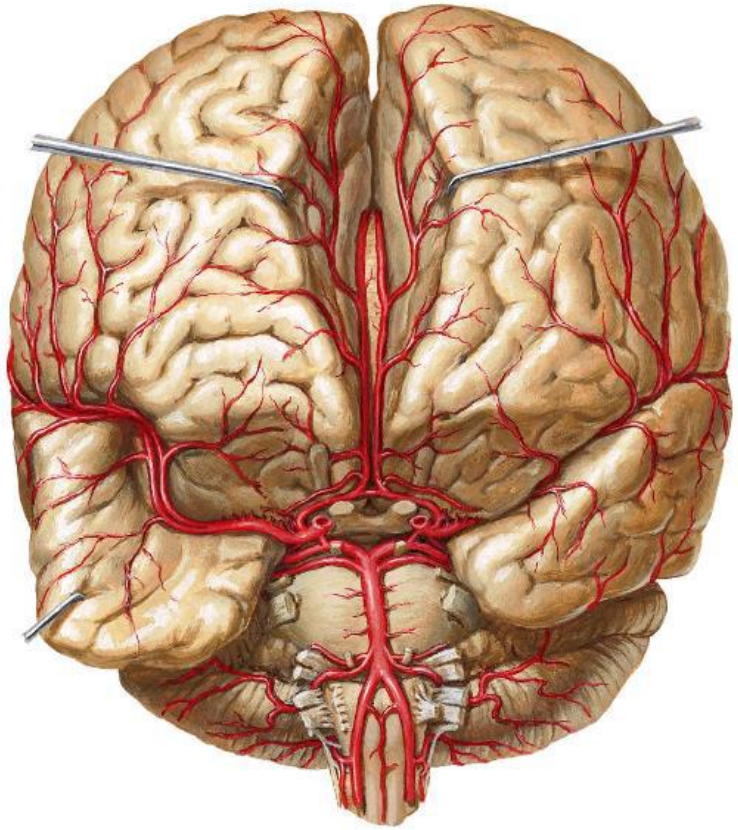
ACA Infarct

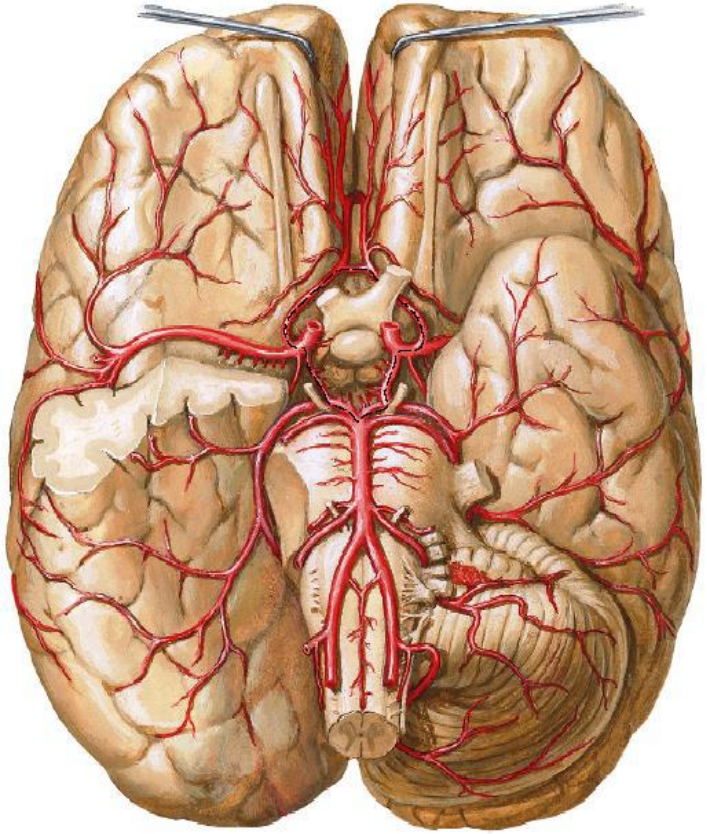


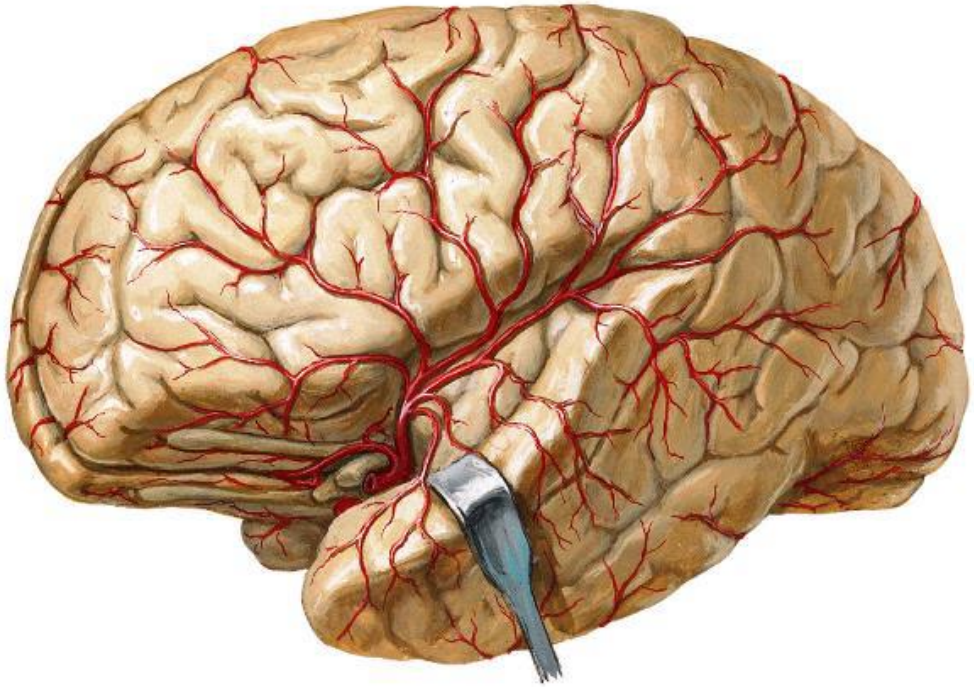
Stroke occur only if the blockage after the branchpoint of anterior communicating artery !! Why ??

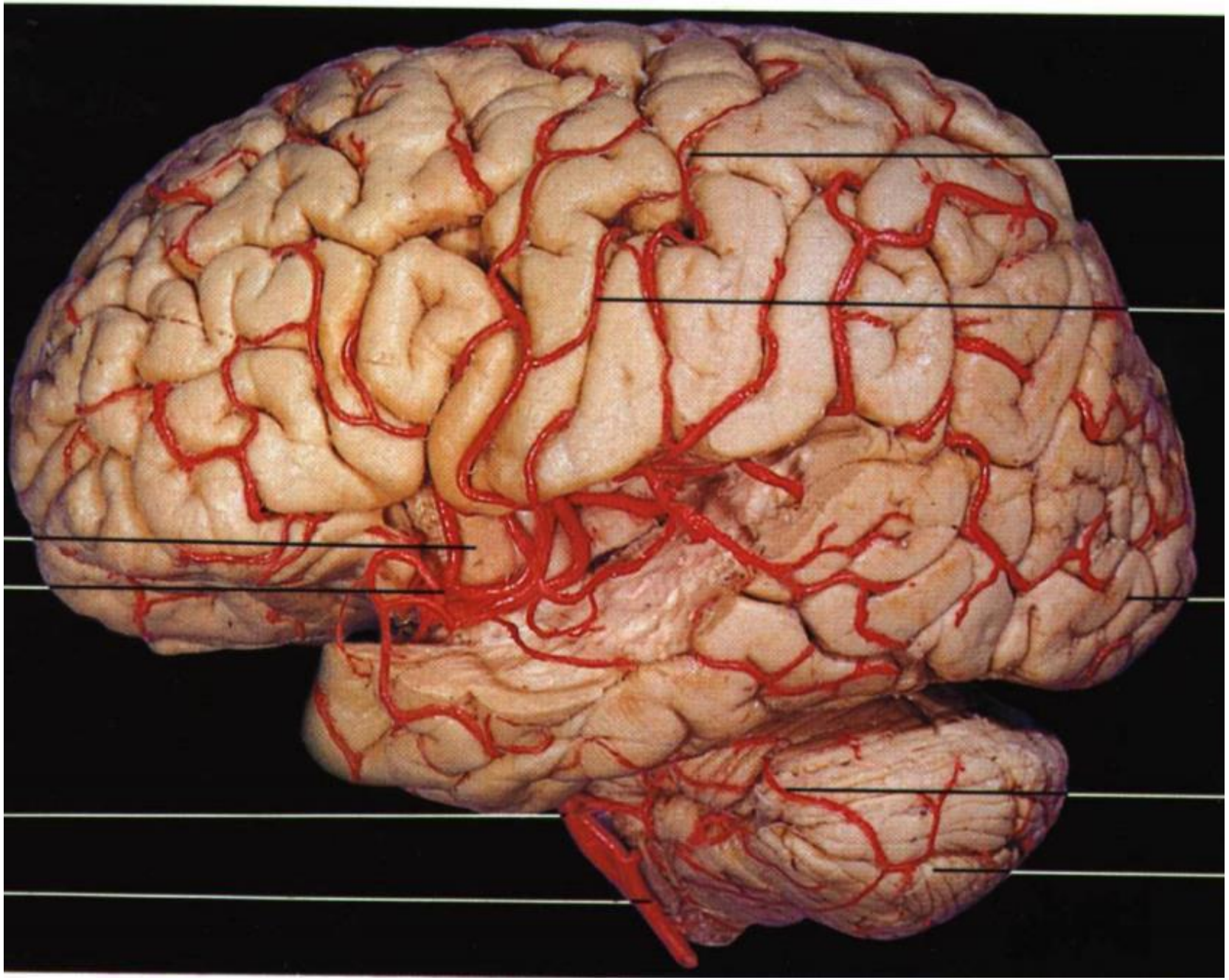
Middle Cerebral Artery

- **Origin:** It is the larger terminal branch of internal carotid artery.
- **Course:** It runs in the lateral sulcus to reach the superolateral surface.









Middle Cerebral Artery

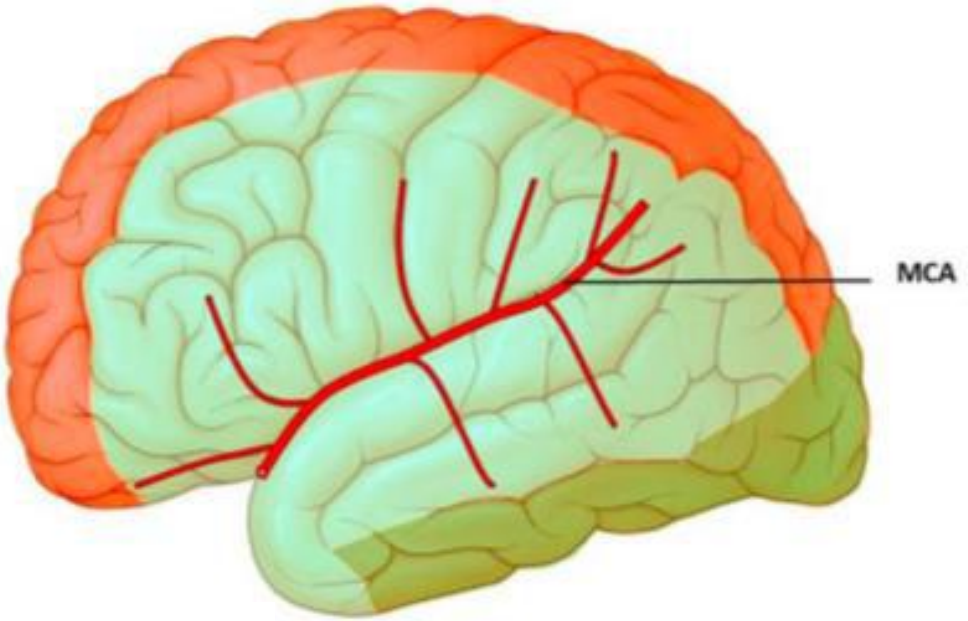
- **The cortical branches**
  - Supply:

    1. Lateral surface → large area except occipital lobe + a strip along superior border + a strip along inferior border.

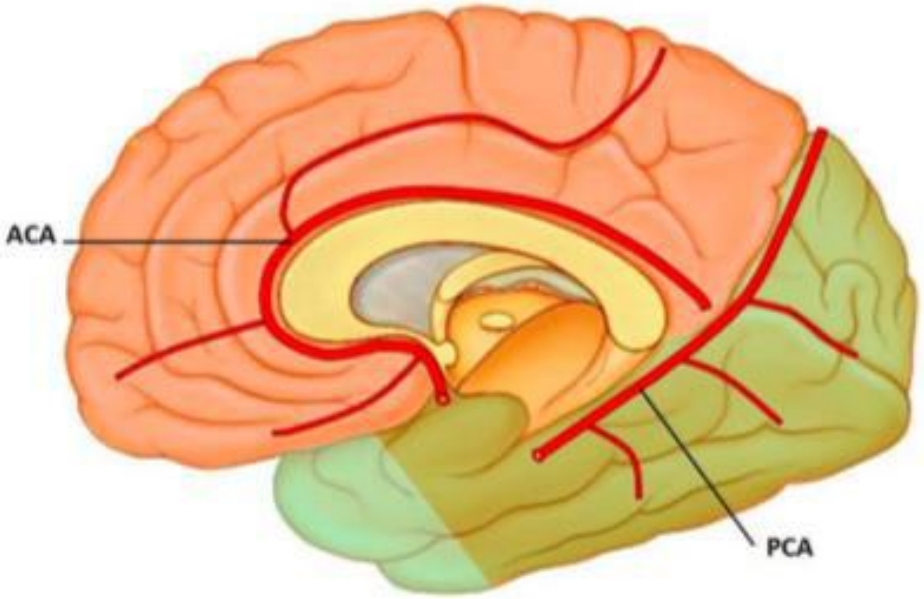
    2. Inferior surface → lateral part of orbital surface + temporal pole.

- **The central branches**
  - Anterolateral group

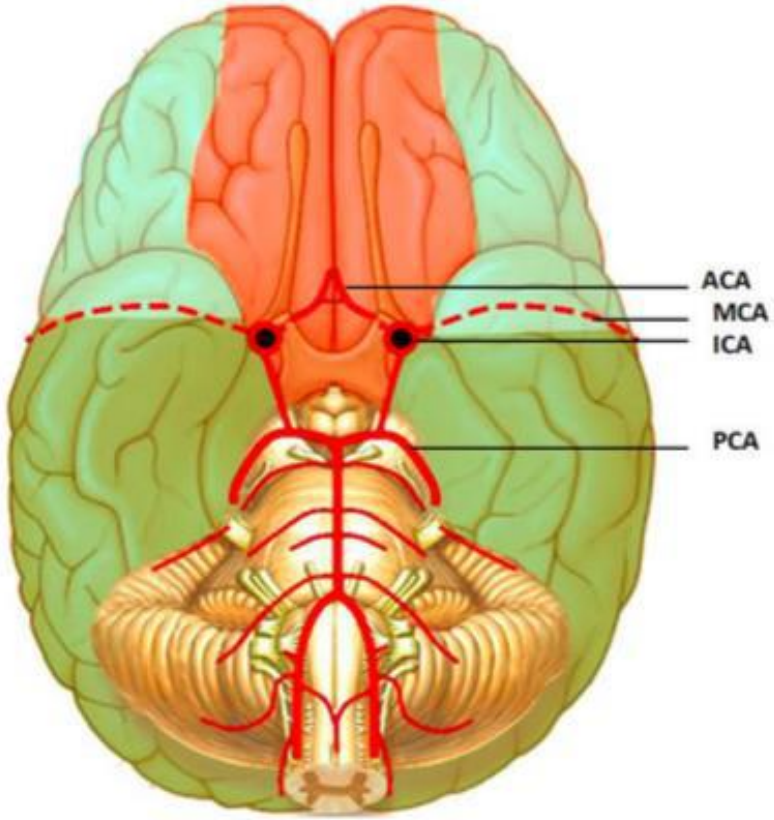
Cortical branches



Lateral surface

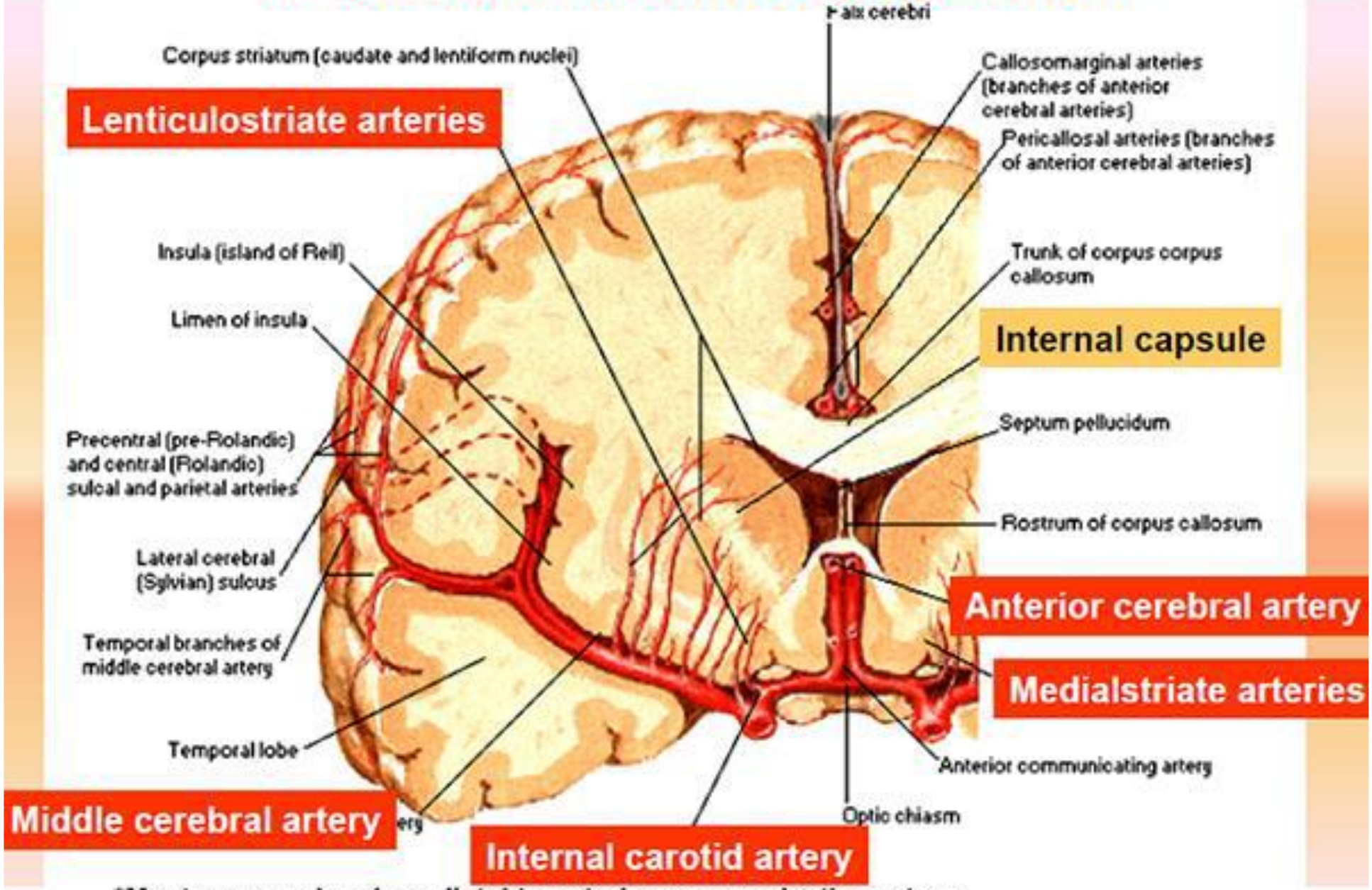


Medial surface



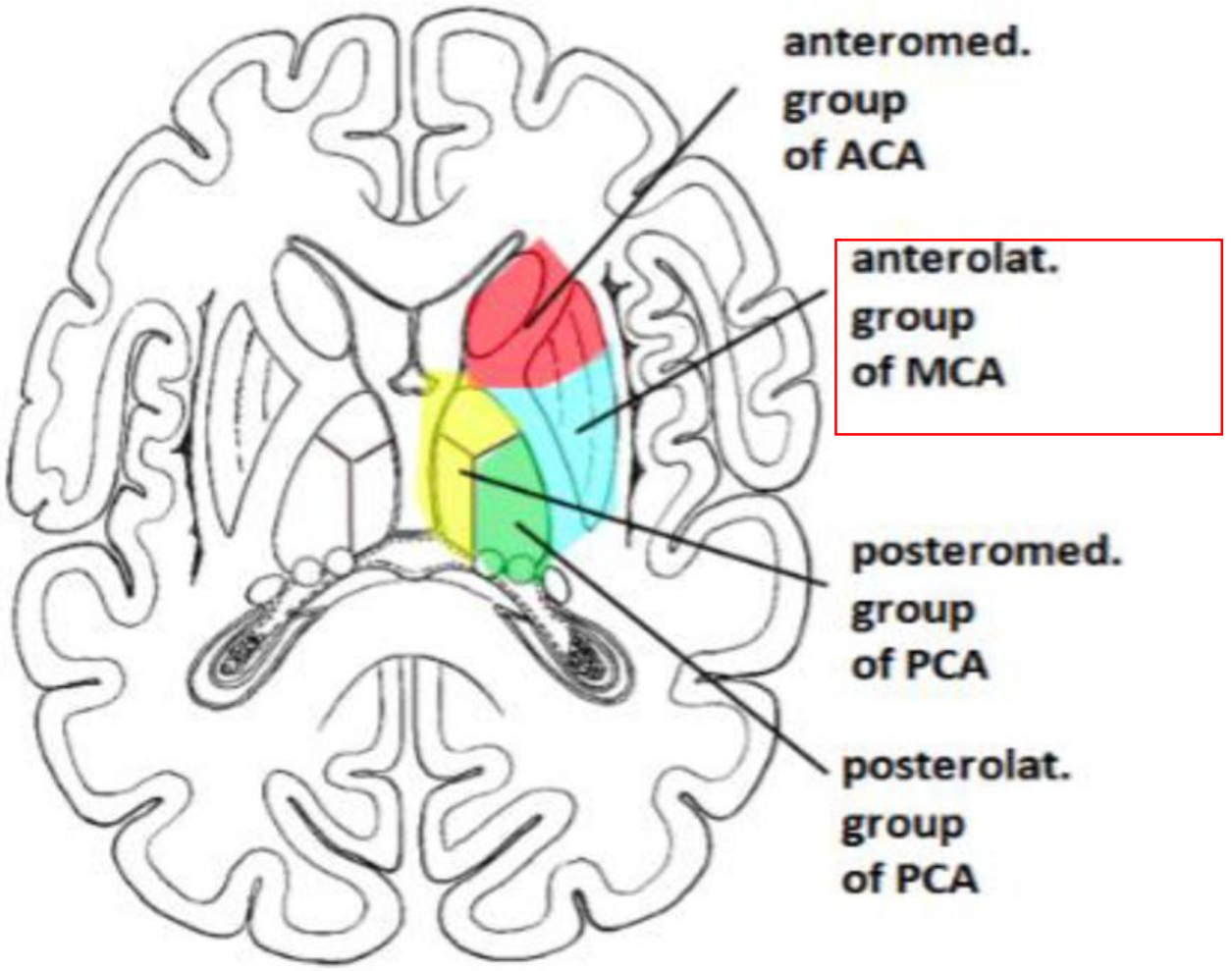
Inferior surface

Arteries of Brain - CORONAL SECTION

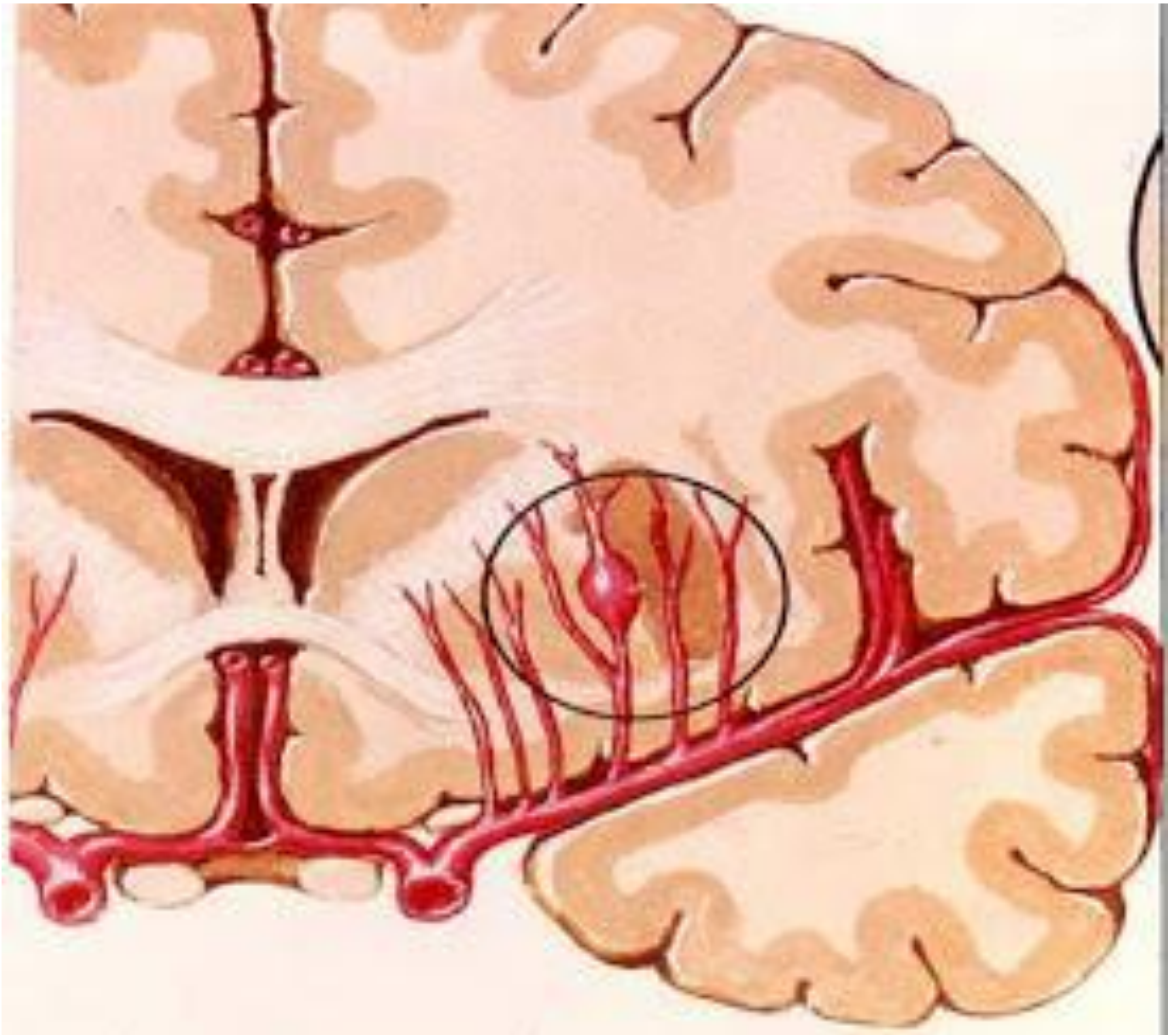


*Most commonly arises distal to anterior communication artery

Central branches



Lenticulostriate (CHARCOT ARTERY)

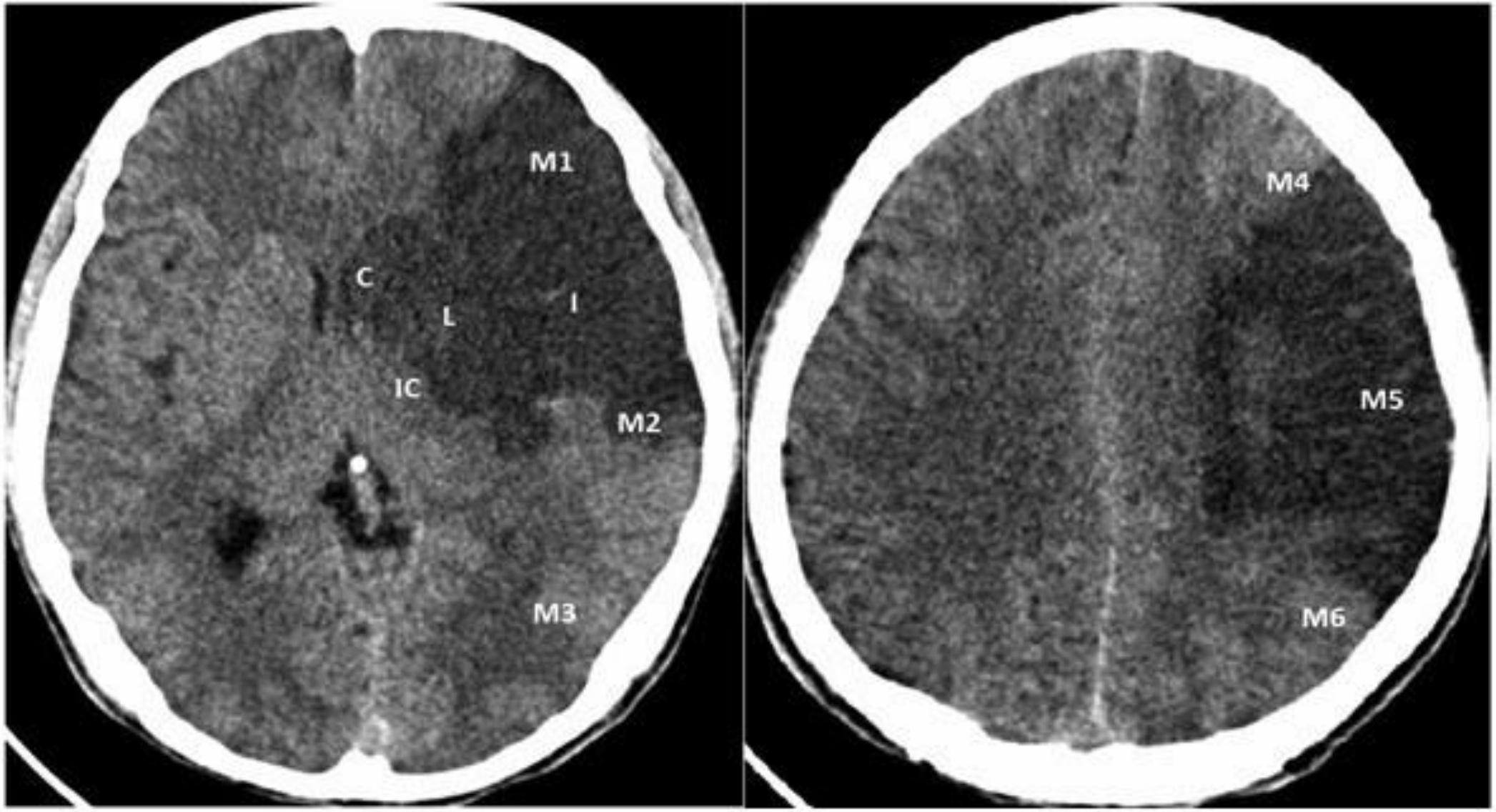


A. Microaneurysm formed in parenchymal artery of brain as result of hypertension. Lenticulostriate vessels (shown) most commonly involved, but similar process may occur in other parts of brain, especially lobar white matter, thalamus, pons and cerebellum

Middle cerebral artery stroke

- **Occlusion of middle cerebral artery led to:**
  - **Contralateral hemiplegia, hemianaesthesia** (mainly face & arm) – due to involvement of most of primary motor and sensory areas.
  - **Aphasia** – if dominant hemisphere involved- Due to involvement of motor & sensory speech area.
  - **Contralateral homonymous hemianopia** (right or left half of vision both sides lost) – Due to involvement of optic radiation.

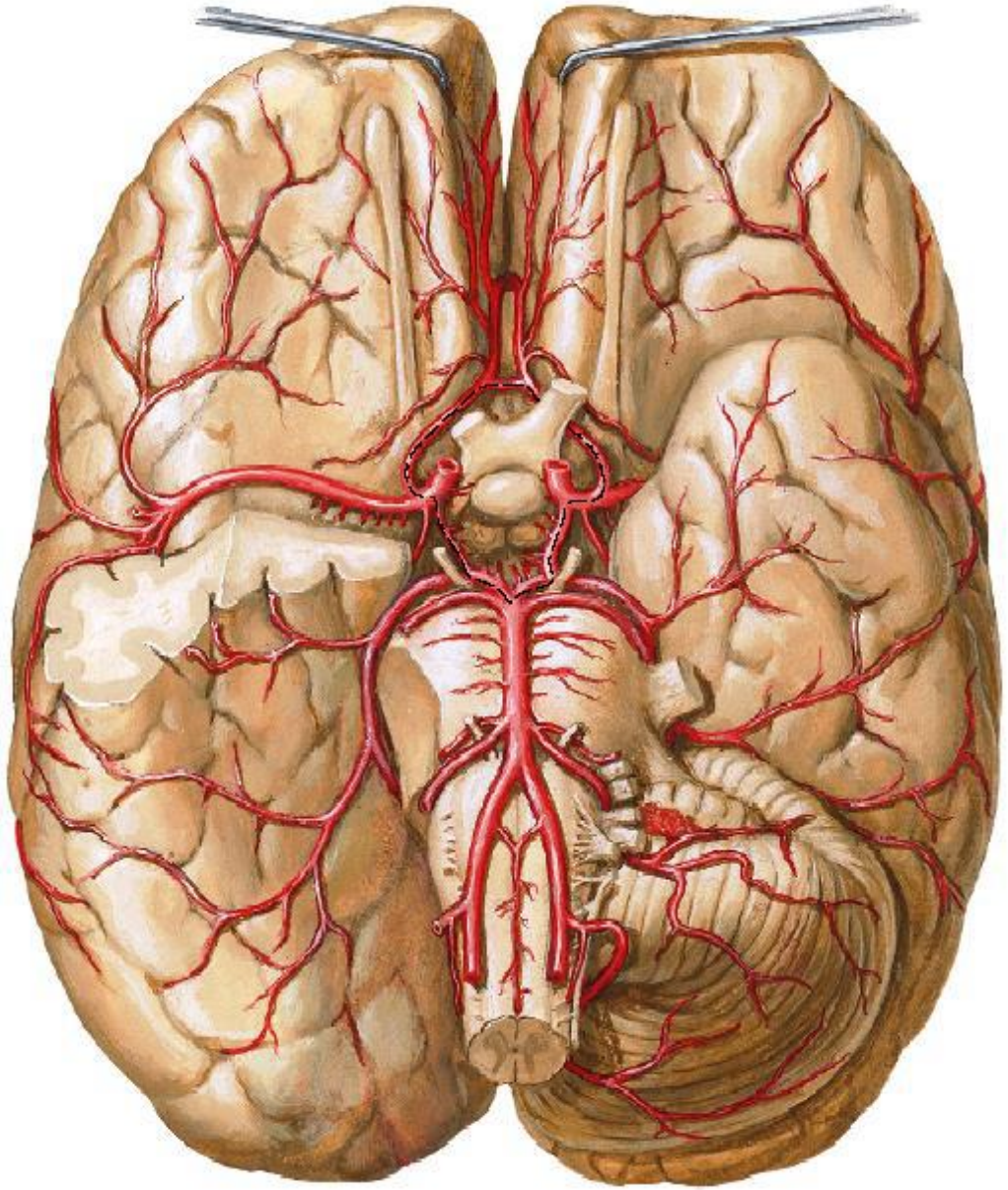
MCA Infarct



Posterior Cerebral Artery

- **Origin:** The terminal branch of basilar artery.

- **Course:** It receives the posterior communicating artery and turns around the cerebral peduncle to reach tentorial surface of brain



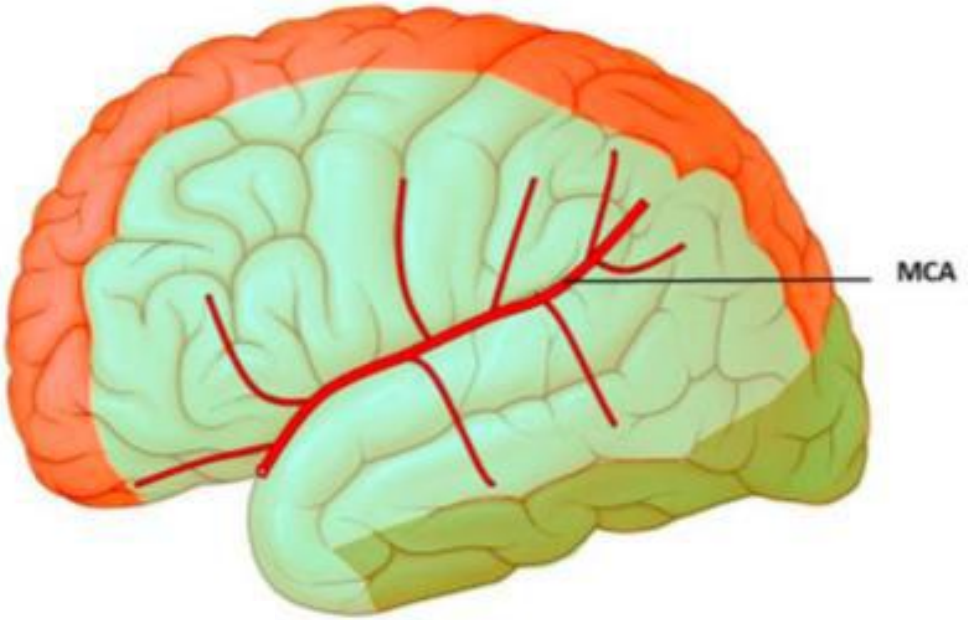
Posterior Cerebral Artery

- **The cortical branches**
  - Supply:

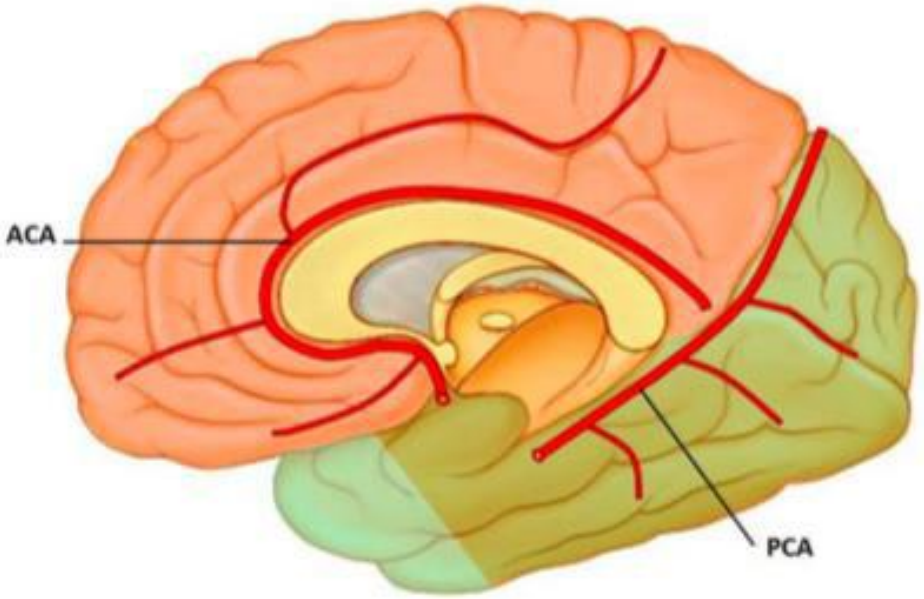
    1. Medial surface → occipital lobe.
    2. Lateral surface → occipital lobe + strip along lower border of hemisphere.
    3. Inferior surface → tentorial part except temporal pole.

- **The central branches**
  - Posteromedial group
  - Posterolateral group
  - Anterior choroidal artery: to choroid plexuses of lateral & third ventricles

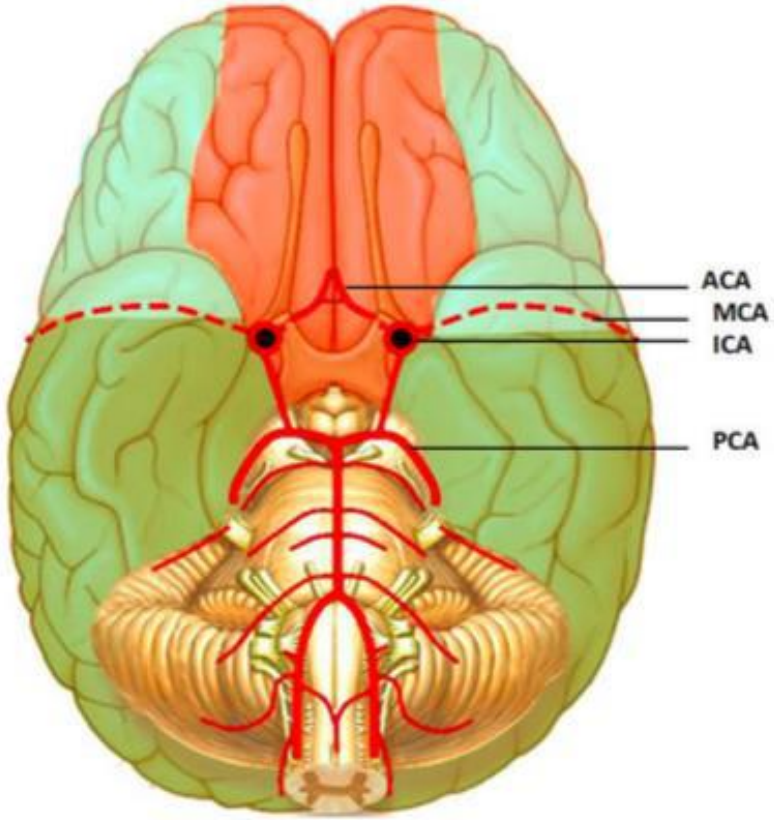
Cortical branches



Lateral surface

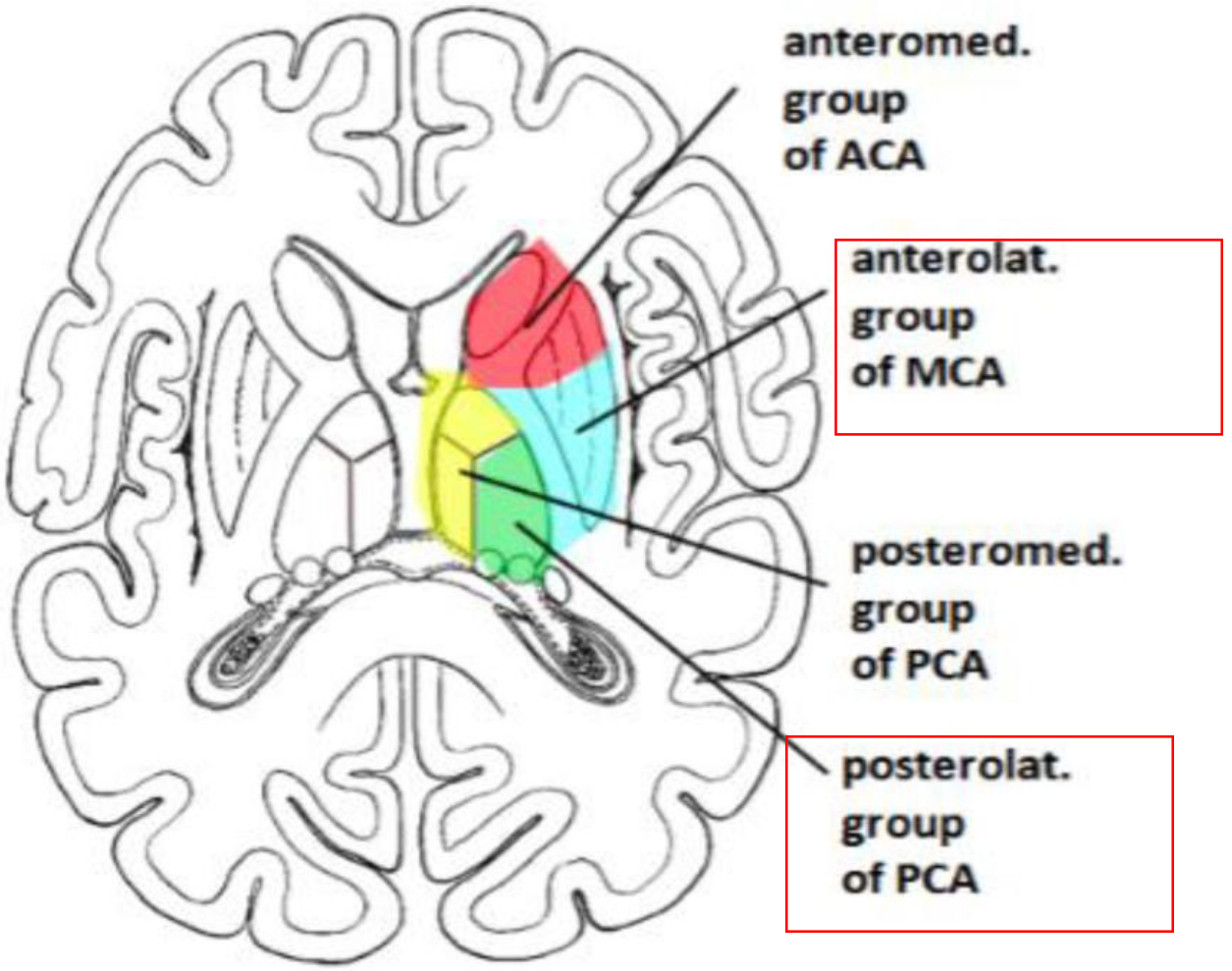


Medial surface



Inferior surface

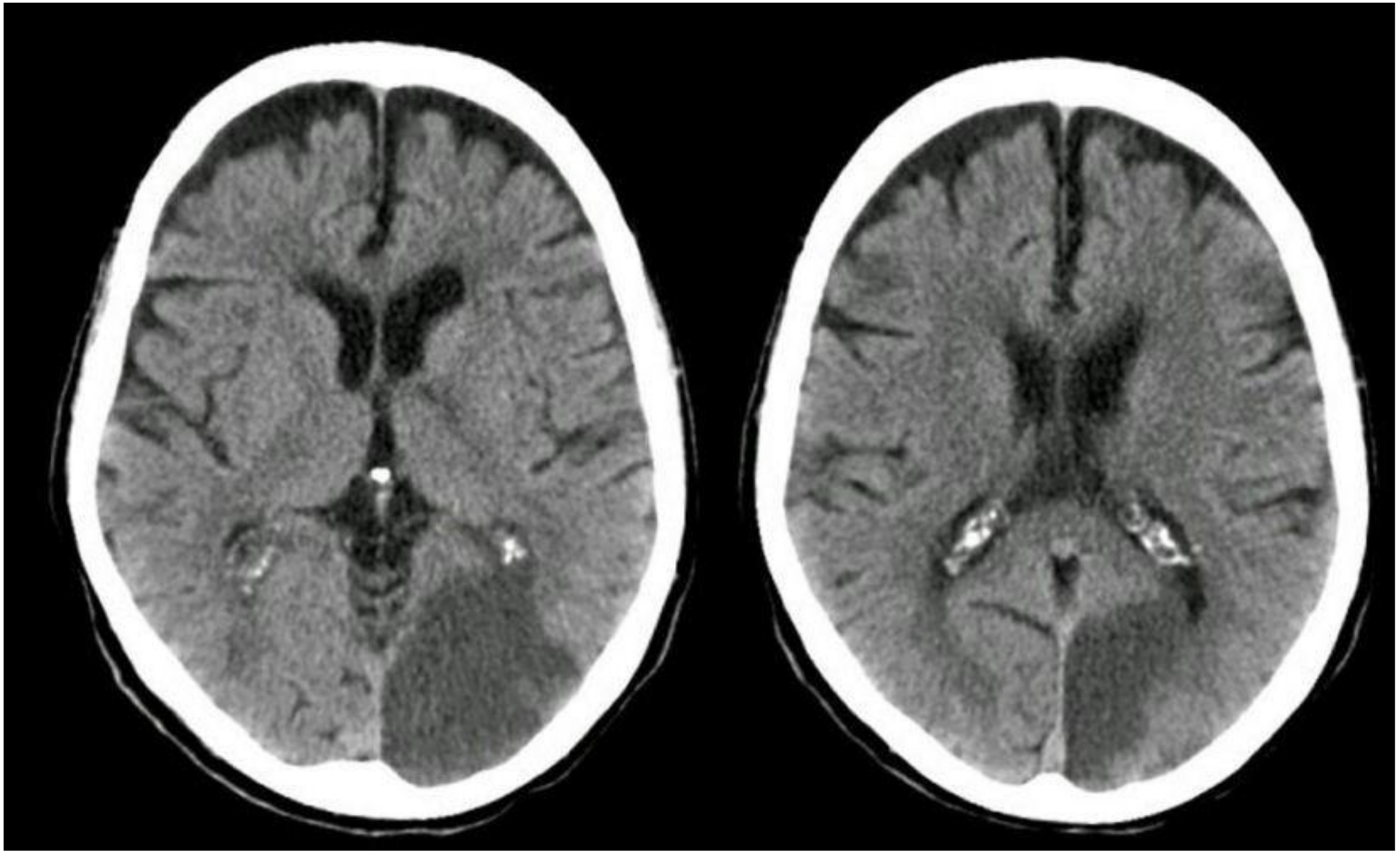
Central branches



Posterior cerebral artery stroke

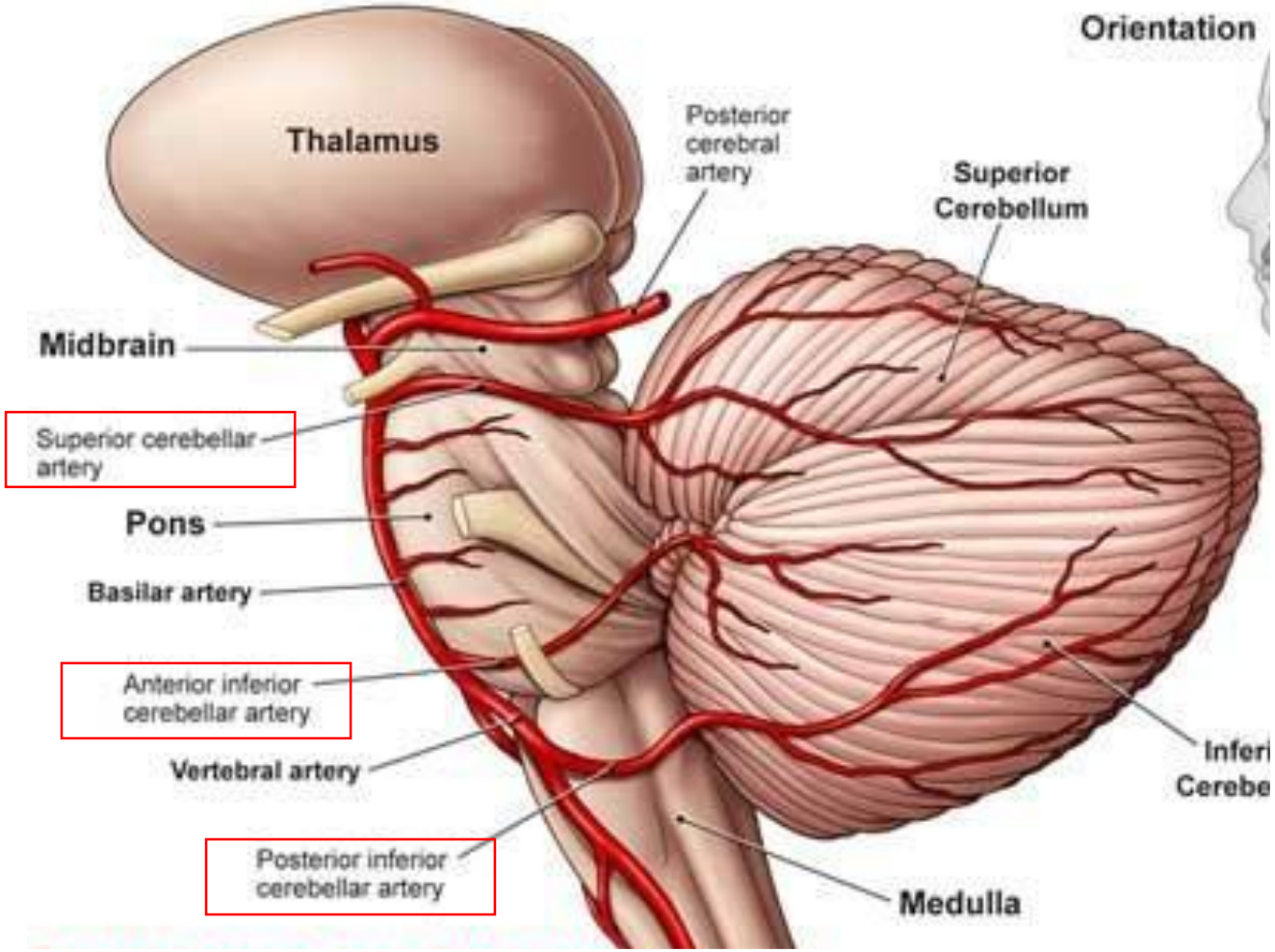
- **Occlusion of posterior cerebral artery led to:**
  - **Contralateral homonymous hemianopia** – Due to involvement of visual cortex with some degree of **macular sparing** (Since occipital pole also has alternative supply from middle cerebral artery)

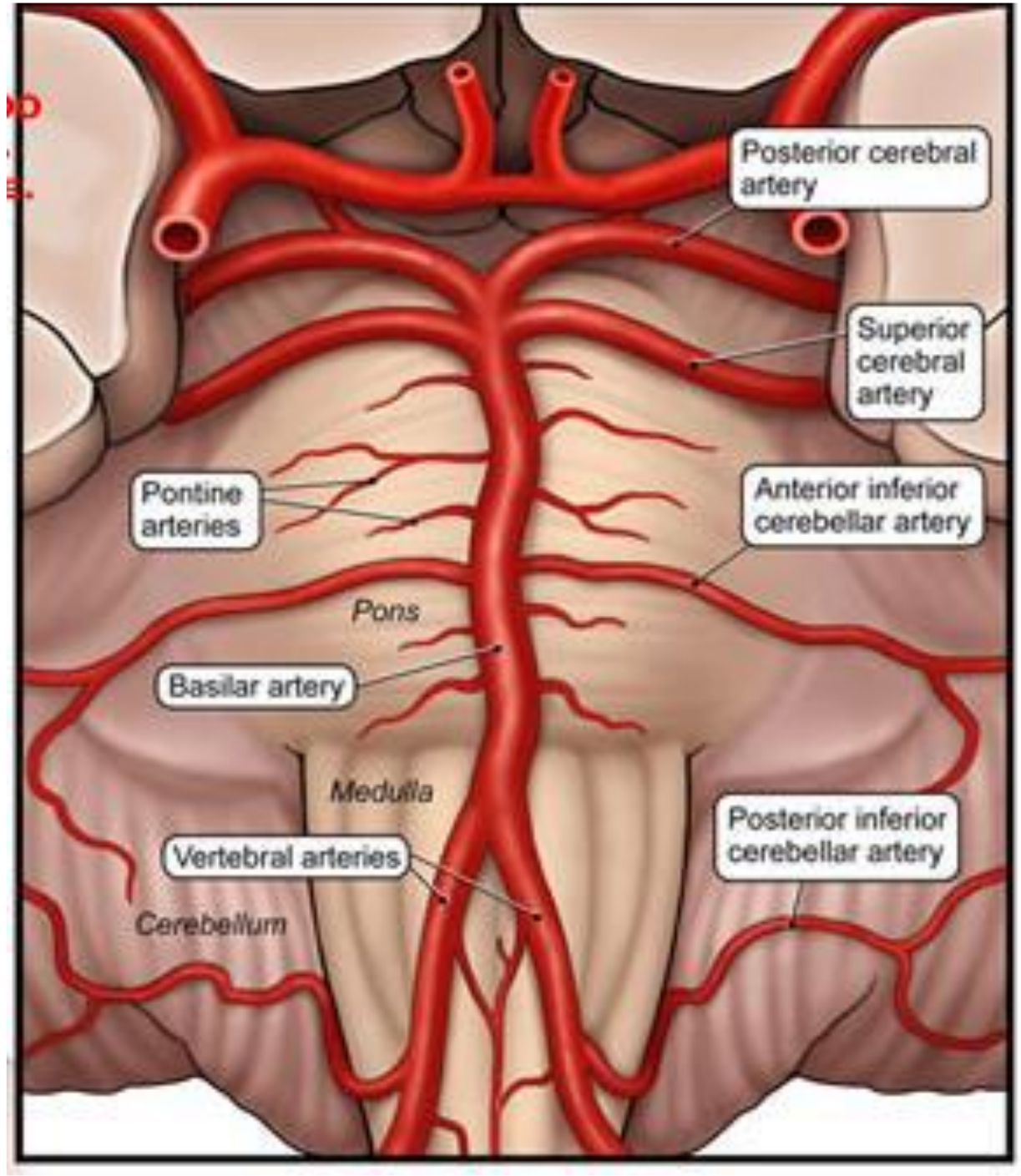
PCA Infarct



Blood Supply to Cerebellum

1. **Superior cerebellar artery** from basilar artery.
2. **Anterior inferior cerebellar artery** from basilar artery.
3. **Posterior inferior cerebellar artery** from vertebral artery.




Posterior cerebral artery
Superior cerebral artery
Pontine arteries
Anterior inferior cerebellar artery
Pons
Basilar artery
Medulla
Posterior inferior cerebellar artery
Vertebral arteries
Cerebellum

Blood Supply to Spinal Cord

- The spinal cord is supplied with blood by:

1. **Three arteries** that run along its length starting in the brain
    - **Anterior spinal artery.**
    - **Right and left posterior spinal arteries.**
2. **Many arteries** that approach it through the sides of the spinal column.
    - **Radicular or segmental arteries.**

Blood Supply to Spinal Cord

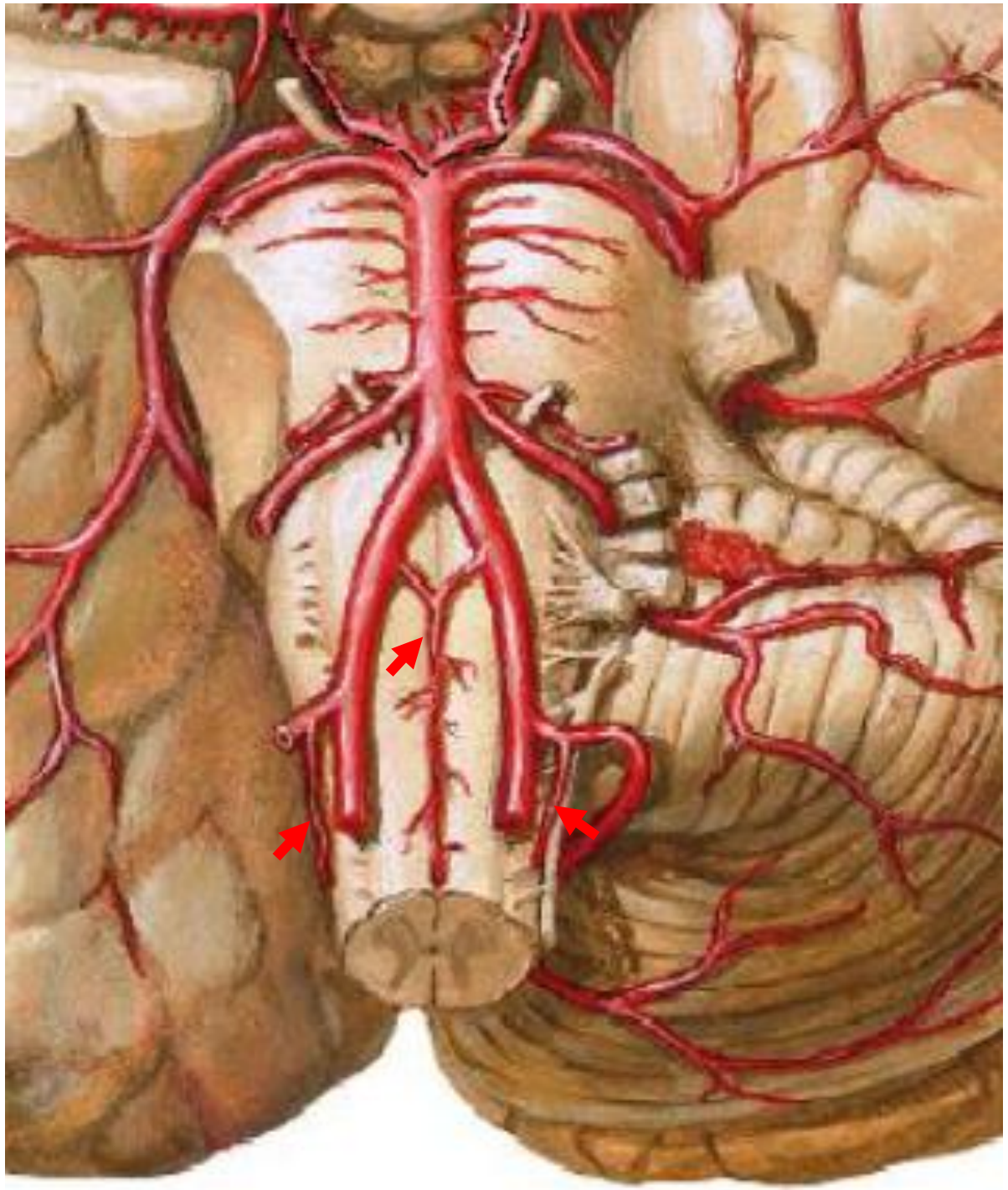
Anterior Spinal artery

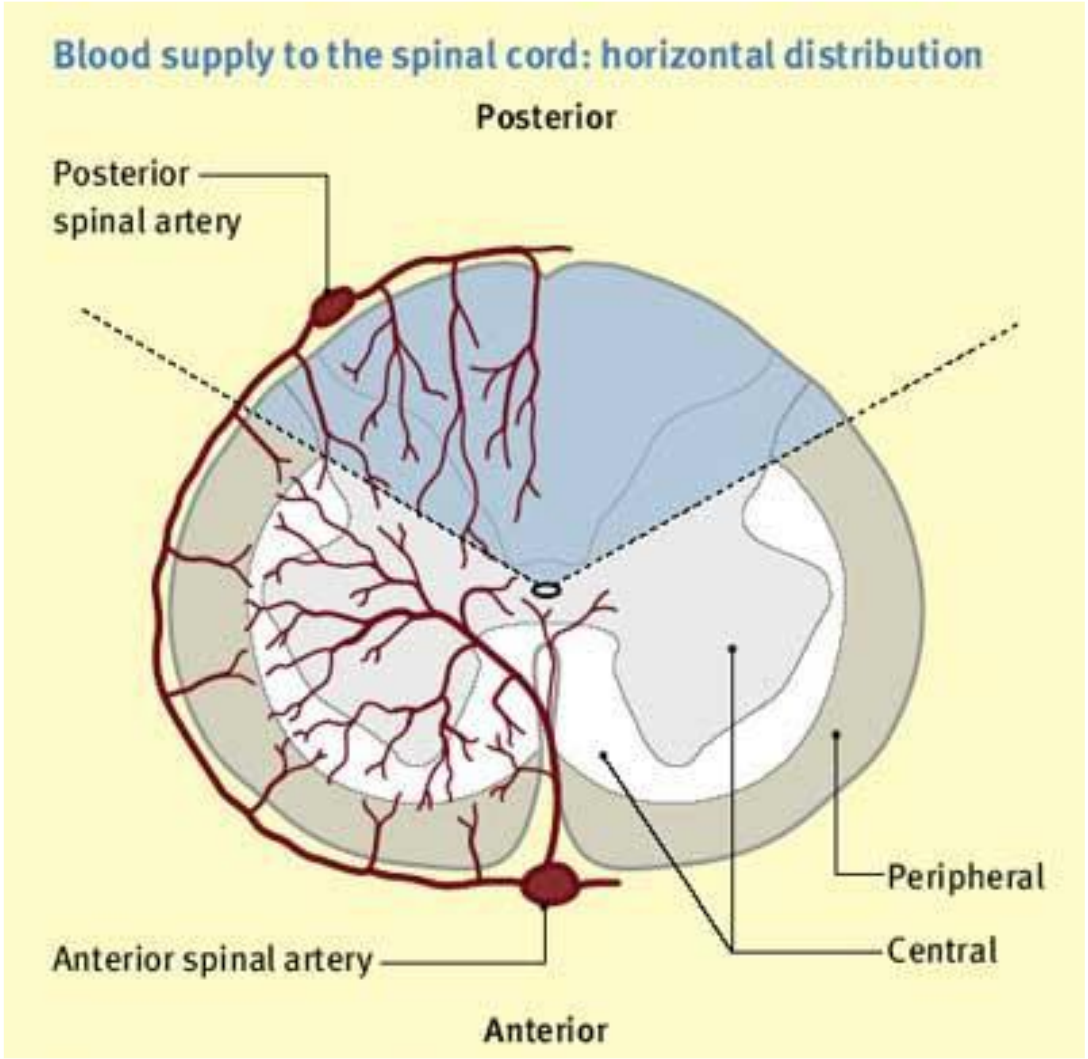
- A single Y - shaped artery.
- Arises from :Vertebral artery at the level of the medulla.

Posterior spinal arteries

- Two arteries (right and left).
- Arise from Vertebral or Posterior Inferior Cerebellar arteries.

Spinal Arteries (Anterior &Posterior) are insufficient alone to supply the cord Below the Cervical Level.




Blood supply to the spinal cord: horizontal distribution
Posterior
Posterior spinal artery
Peripheral
Central
Anterior spinal artery
Anterior

Blood Supply to Spinal Cord

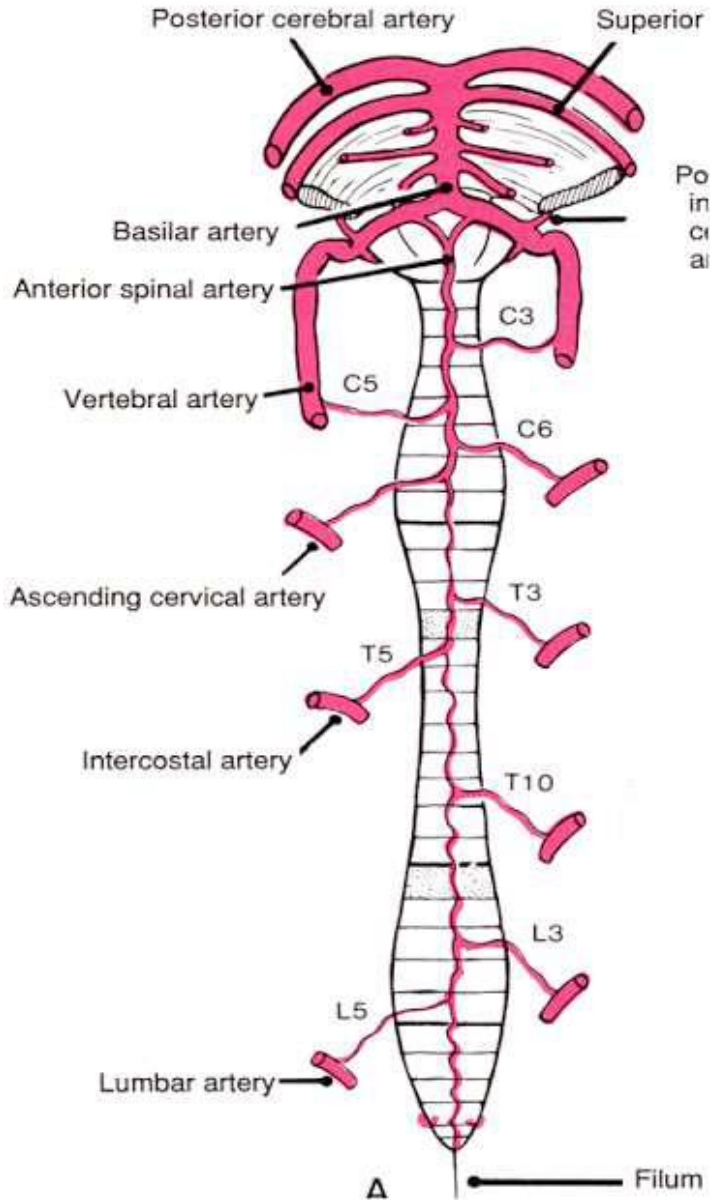
Radicular arteries

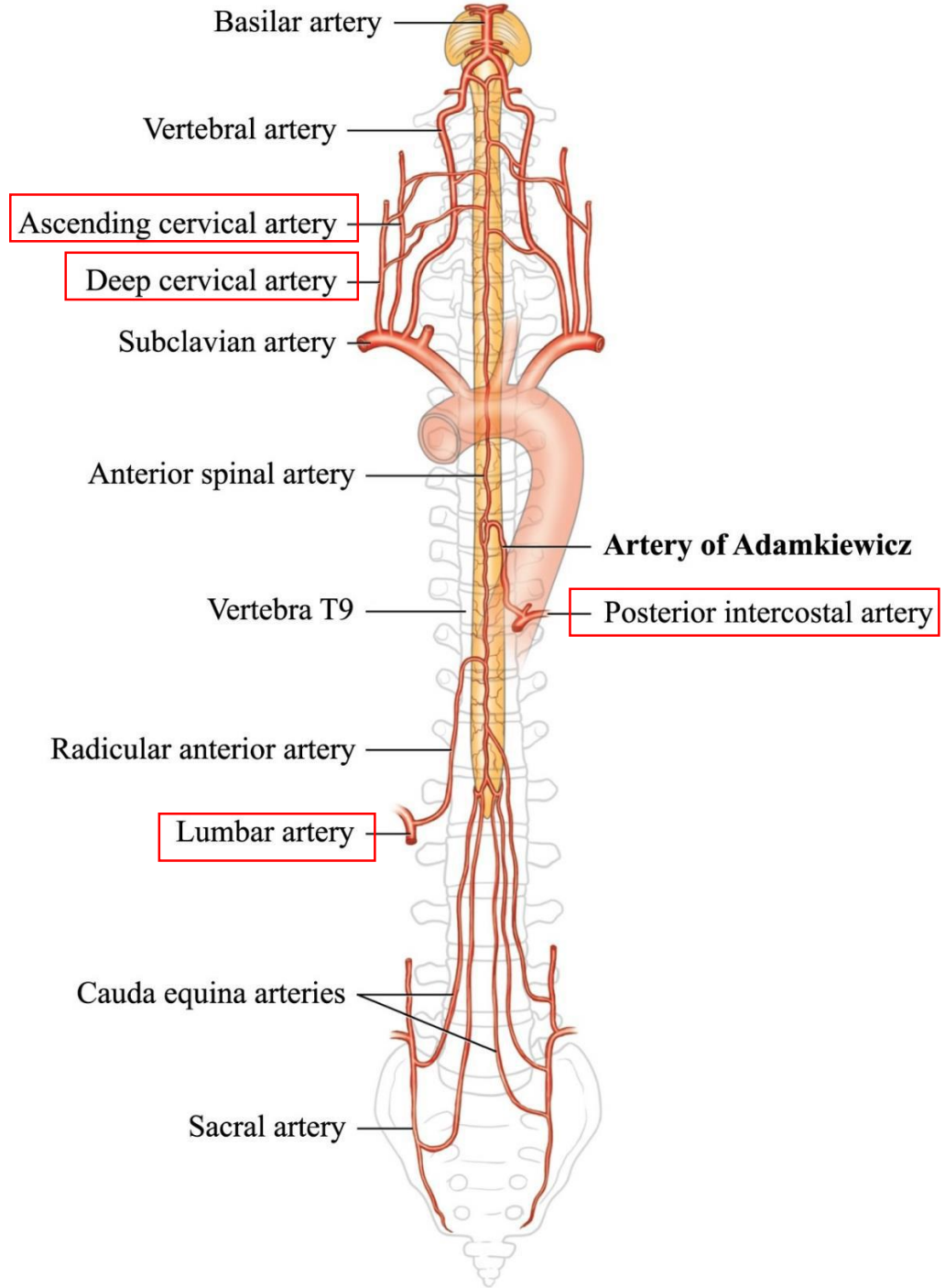
- Posterior and anterior radicular arteries run into spinal cord alongside the dorsal and ventral nerve roots.

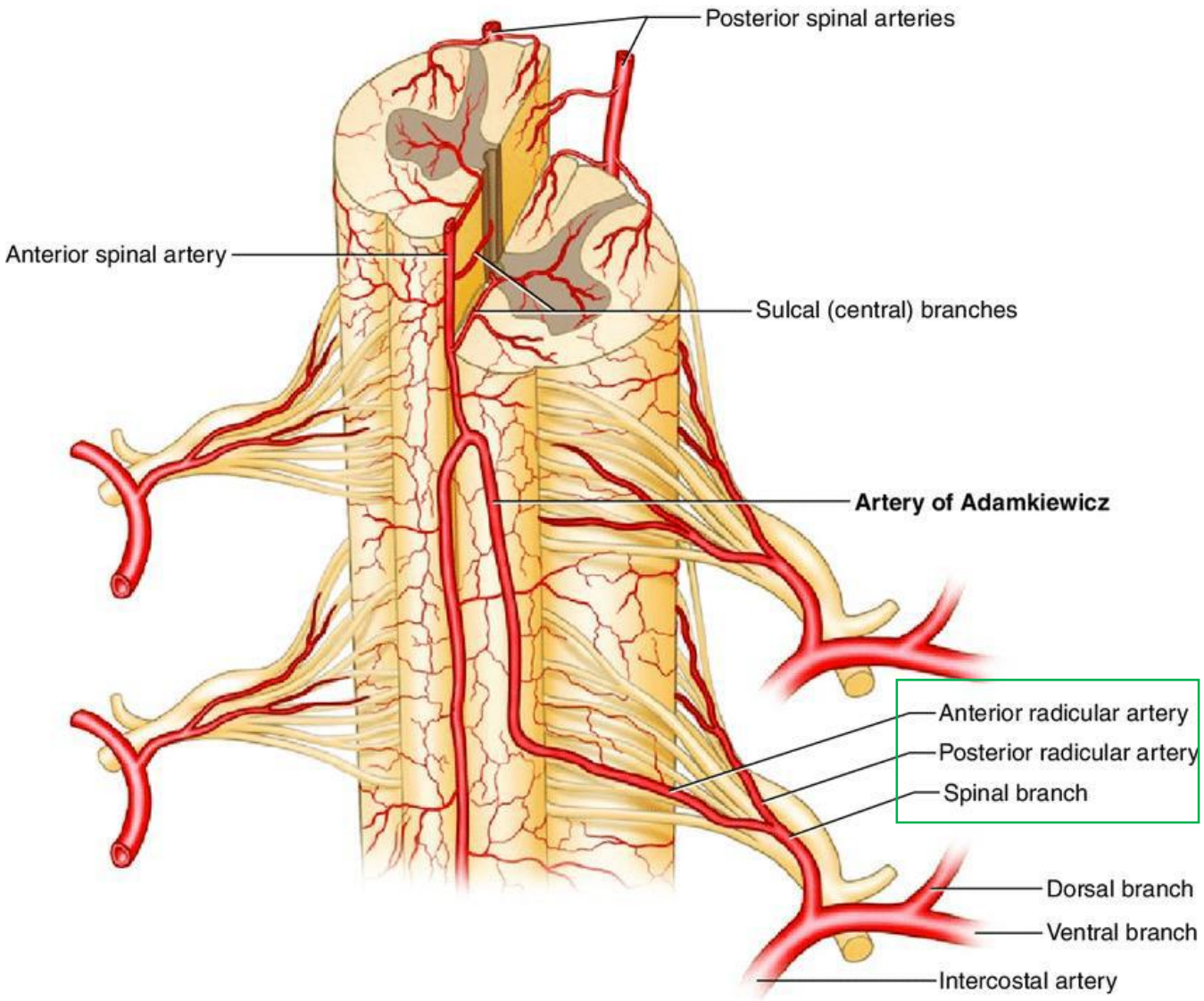
- Origin from following arteries :
  1. Deep cervical
  2. Ascending cervical
  3. Posterior Intercostal arteries
  4. Lumbar arteries

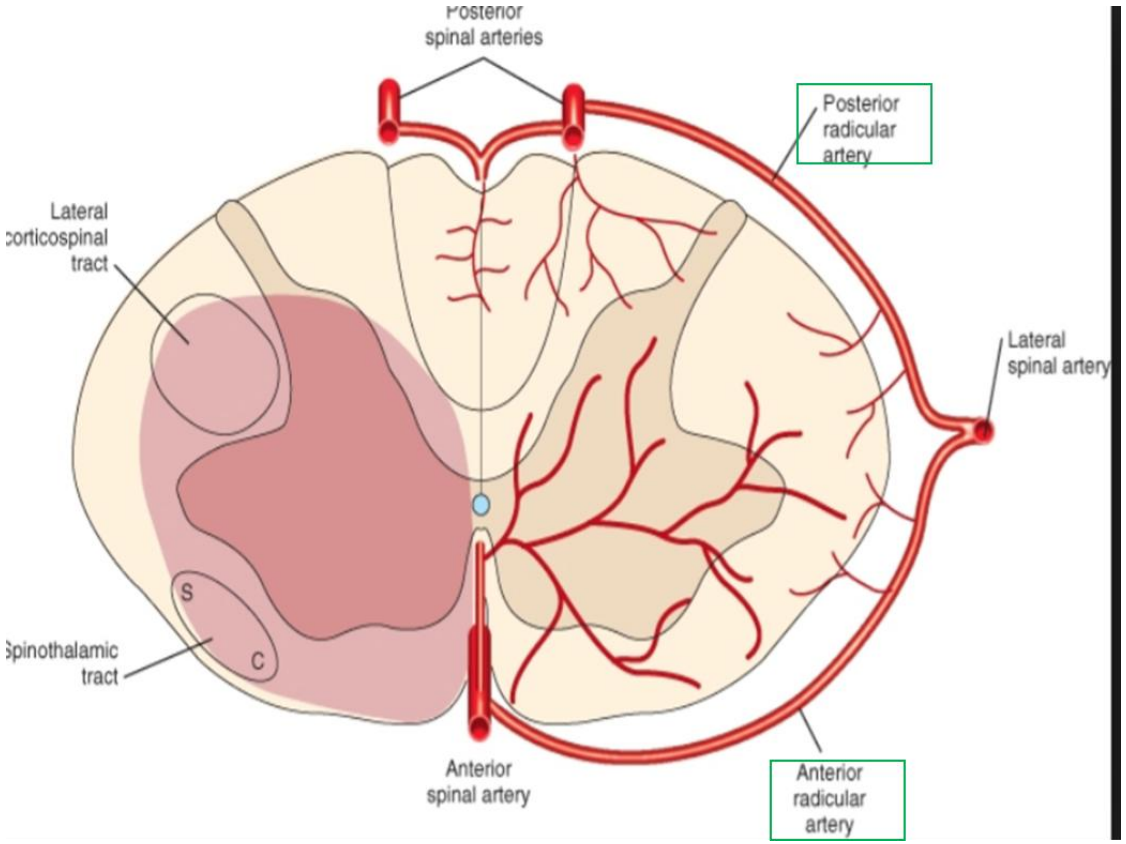
- They share in the arterial supply of the cord **Below the Cervical Level.**

- They Anastomose freely with the Spinal Arteries.




Basilar artery
Vertebral artery
Ascending cervical artery
Deep cervical artery
Subclavian artery
Anterior spinal artery
Artery of Adamkiewicz
Vertebra T9
Posterior intercostal artery
Radicular anterior artery
Lumbar artery
Cauda equina arteries
Sacral artery

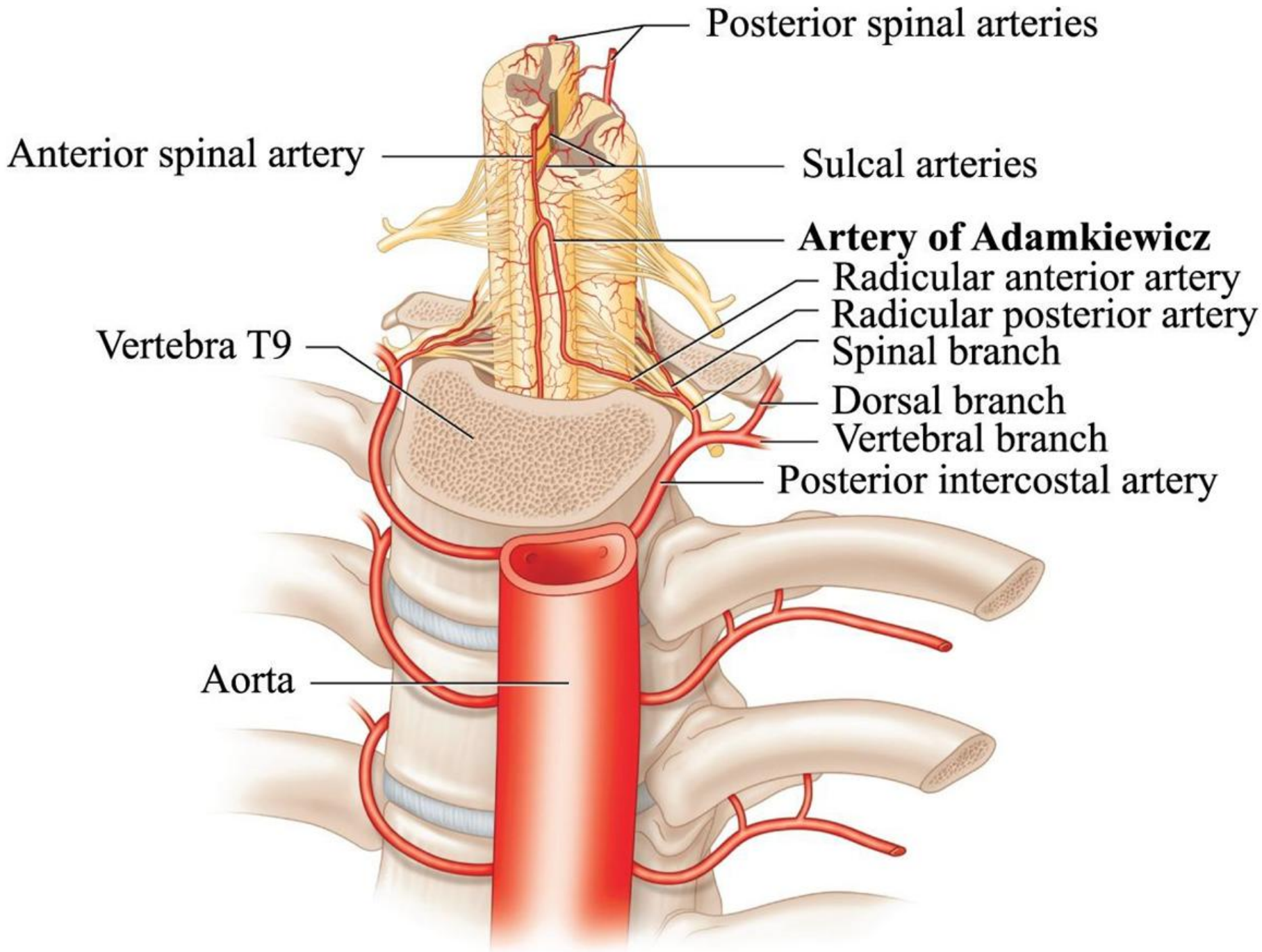

Posterior spinal arteries
Anterior spinal artery
Sulcal (central) branches
Artery of Adamkiewicz
Anterior radicular artery
Posterior radicular artery
Spinal branch
Dorsal branch
Ventral branch
Intercostal artery


Posterior spinal arteries
Posterior radicular artery
Lateral corticospinal tract
Lateral spinal artery
S
C
Spinothalamic tract
Anterior spinal artery
Anterior radicular artery

Blood Supply to Spinal Cord

GREAT RADICULAR ARTERY

- Artery of **Adamkiewicz**.
- Largest of the anterior radicular arteries.
- It may arise from: Intercostal or Lumbar arteries (usually T1 or T11).
- Provides the major blood supply to the **lumbar and sacral cord.**


Posterior spinal arteries
Anterior spinal artery
Sulcal arteries
Artery of Adamkiewicz
Radicular anterior artery
Radicular posterior artery
Vertebra T9
Spinal branch
Dorsal branch
Vertebral branch
Posterior intercostal artery
Aorta

Blood Supply to Spinal Cord

- Impaired blood flow through these critical radicular arteries, especially during surgical procedures that involve abrupt disruption of blood flow through the aorta, for example during aortic aneurysm repair, can result in spinal cord infarction and paraplegia

Venous drainage of Brain

The route of venous blood of brain:

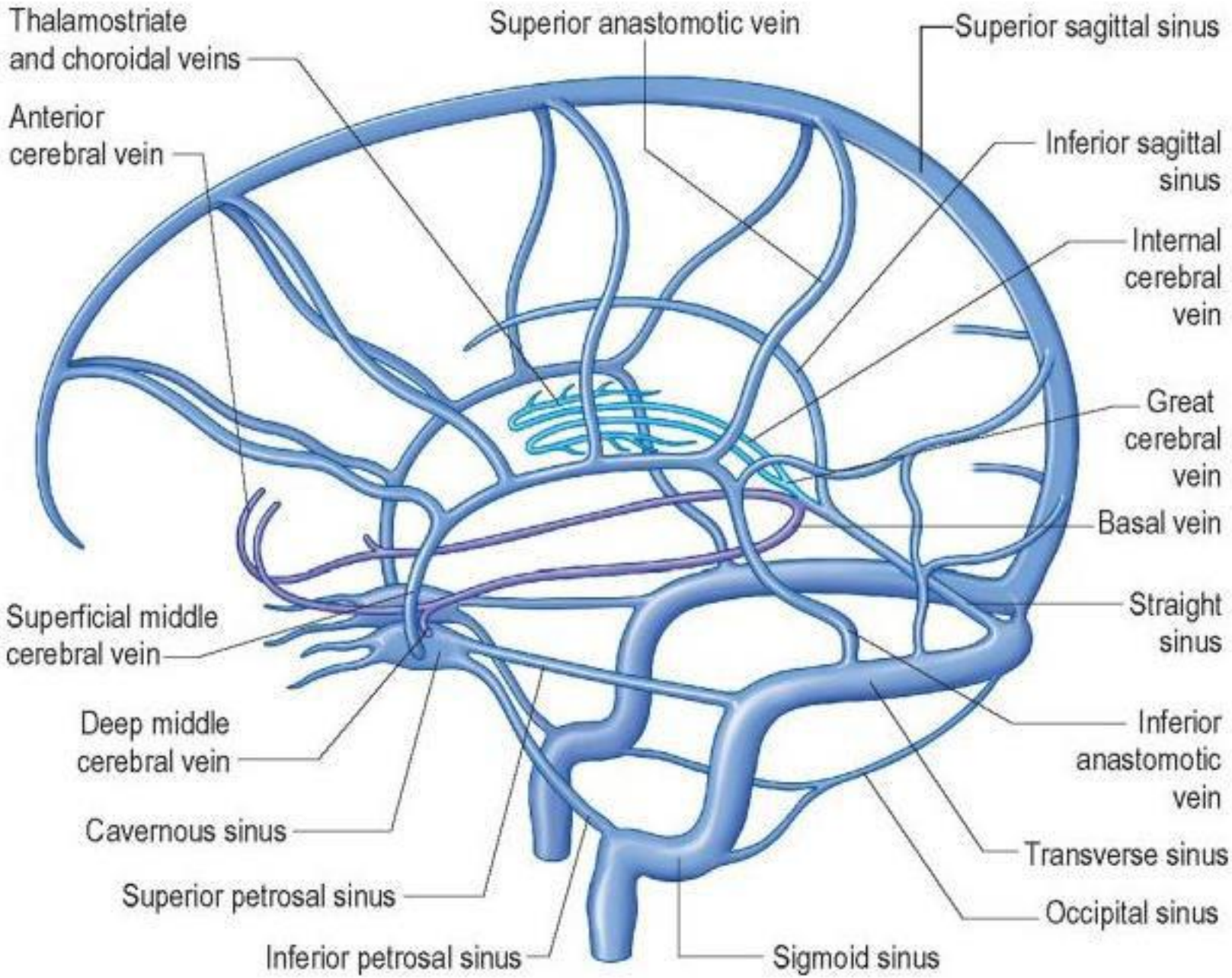
Cerebral veins

↓

Dural venous sinuses

↓

Internal jugular veins


Thalamostriate and choroidal veins
Anterior cerebral vein
Superior anastomotic vein
Superior sagittal sinus
Inferior sagittal sinus
Internal cerebral vein
Great cerebral vein
Basal vein
Straight sinus
Inferior anastomotic vein
Transverse sinus
Occipital sinus
Sigmoid sinus
Superficial middle cerebral vein
Deep middle cerebral vein
Cavernous sinus
Superior petrosal sinus
Inferior petrosal sinus

Dural Venous Sinuses

- They are venous channels situated between the 2 dural layers (outer endosteal and inner meningeal).

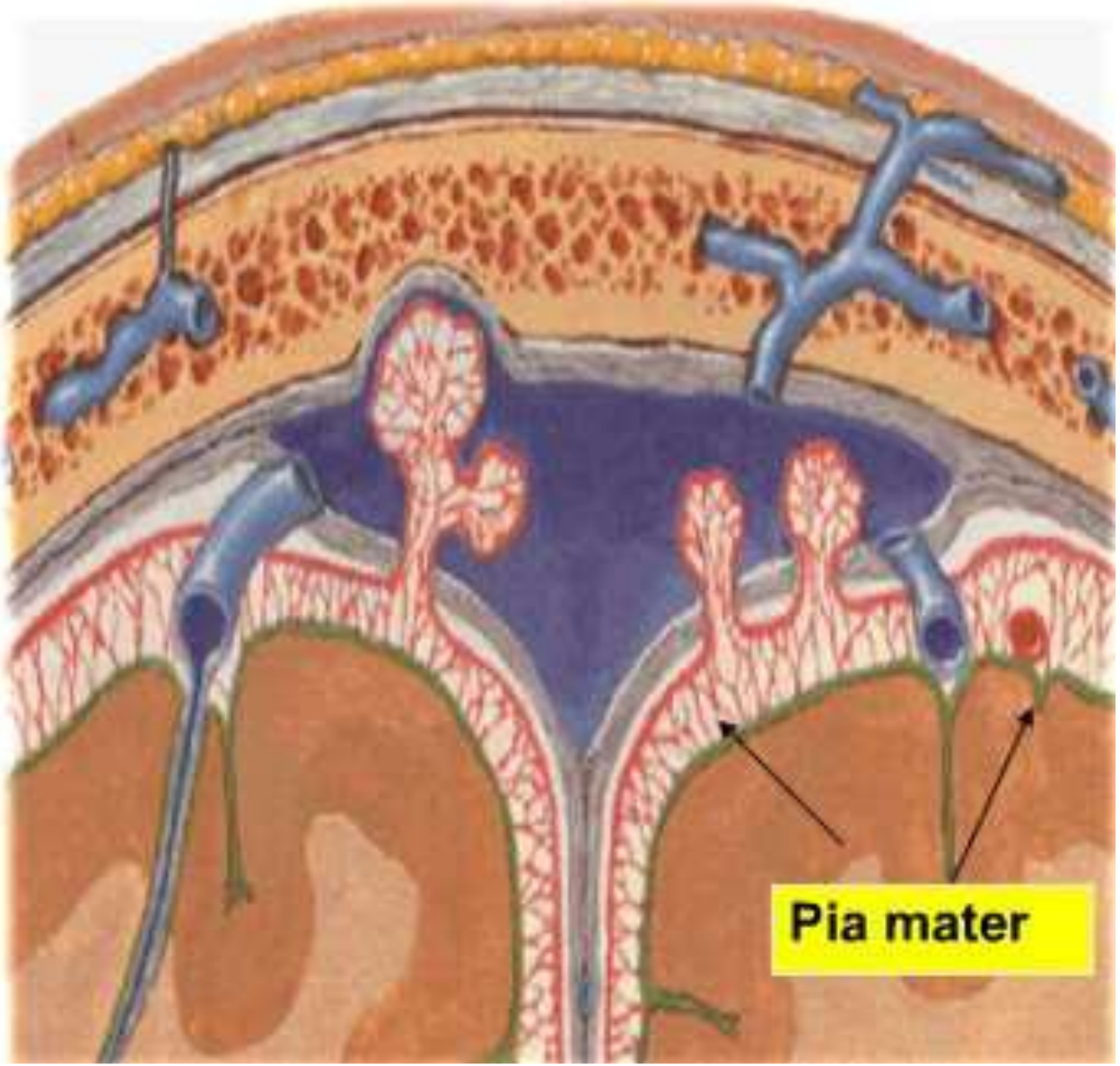
- **Characteristic features:**

  - Lined by endothelium, no muscular coat and valveless.

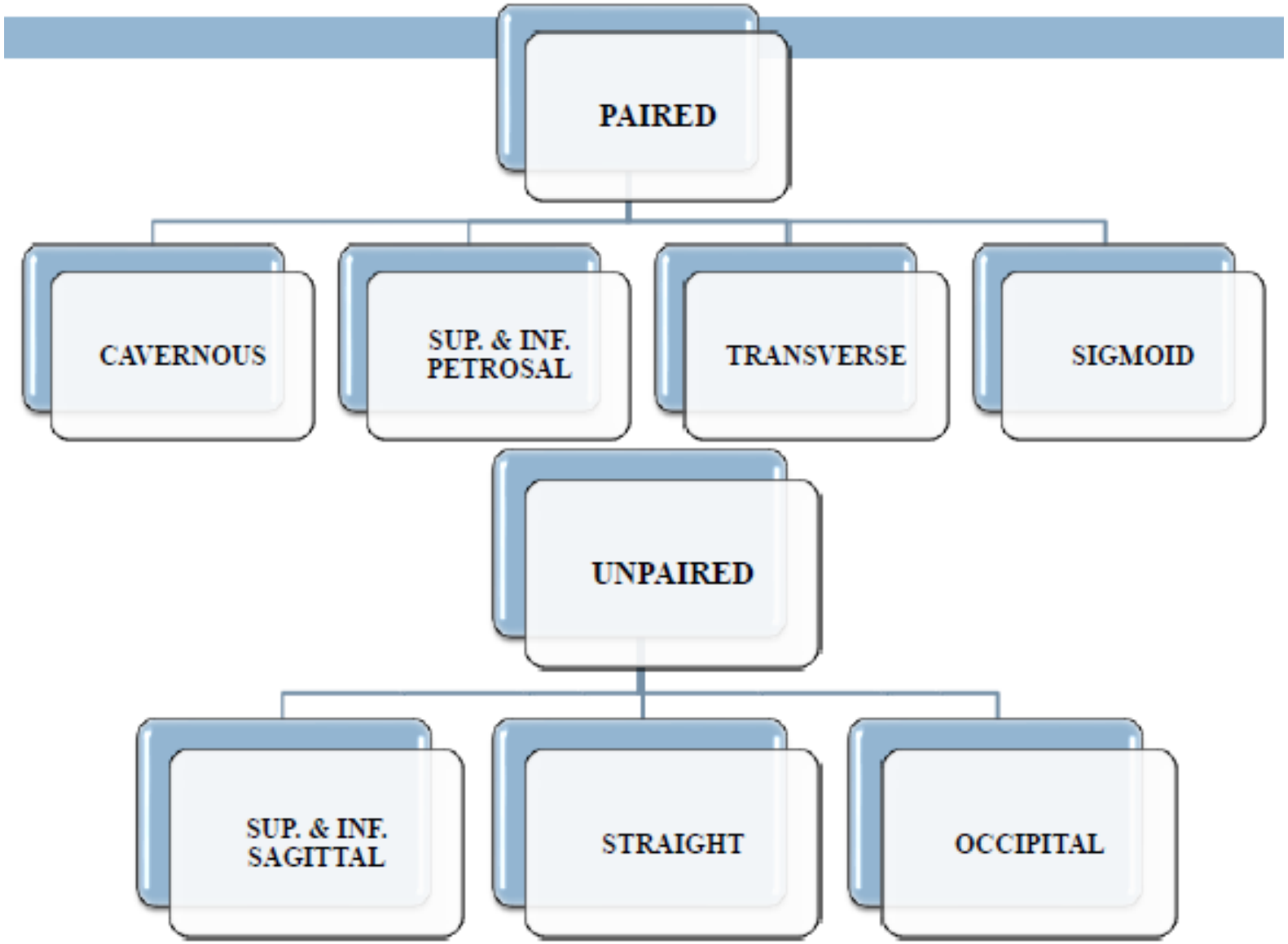
  - Collect blood from brain, meninges, orbit, internal ear & diploe.

  - Have projections of arachnoid granulation into it for CSF absorption.

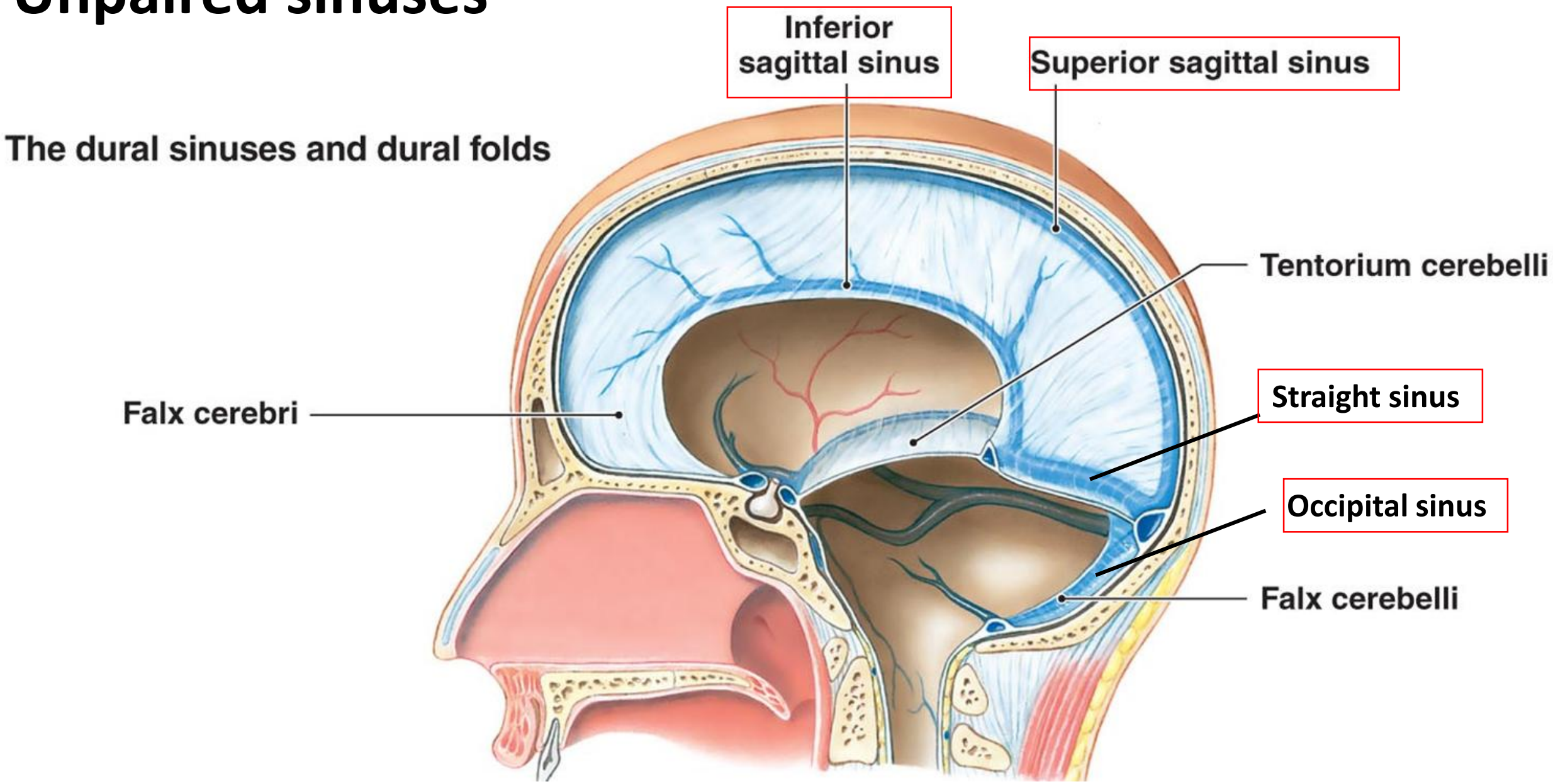
  - They are connected to extracranial veins via valveless emissary veins to maintain the internal and external venous pressure.

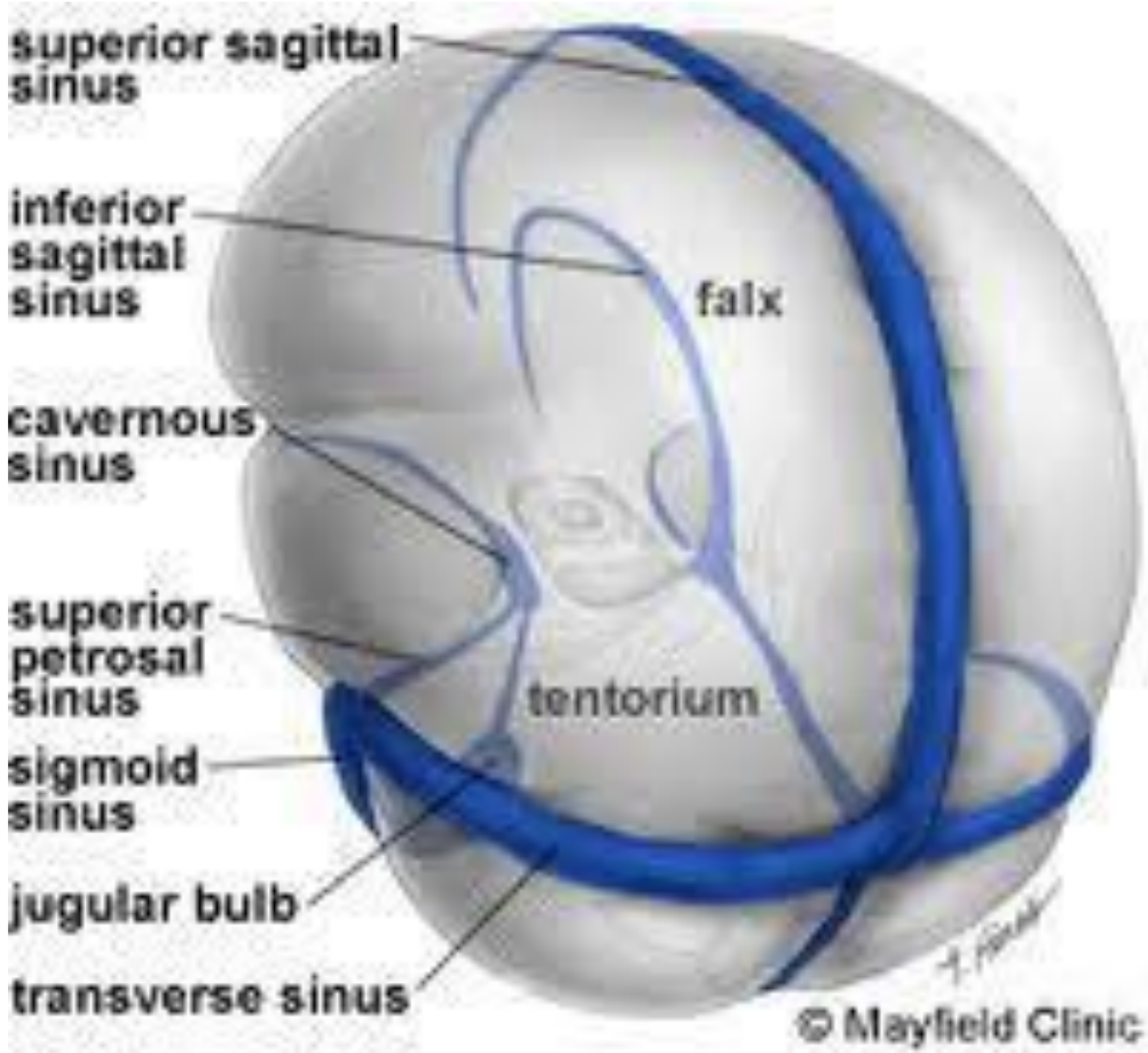

Pia mater

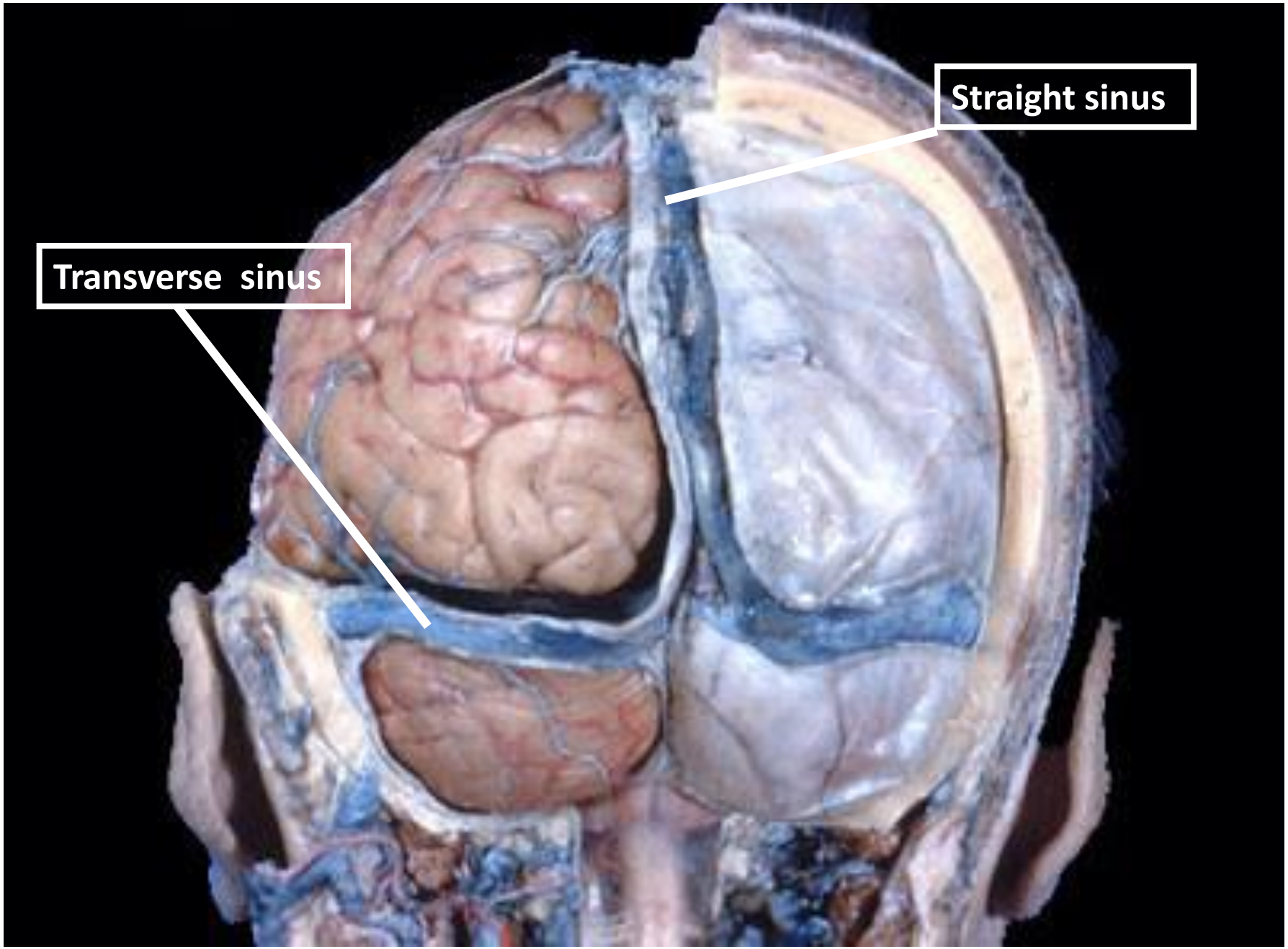
Classification of Dural Sinuses



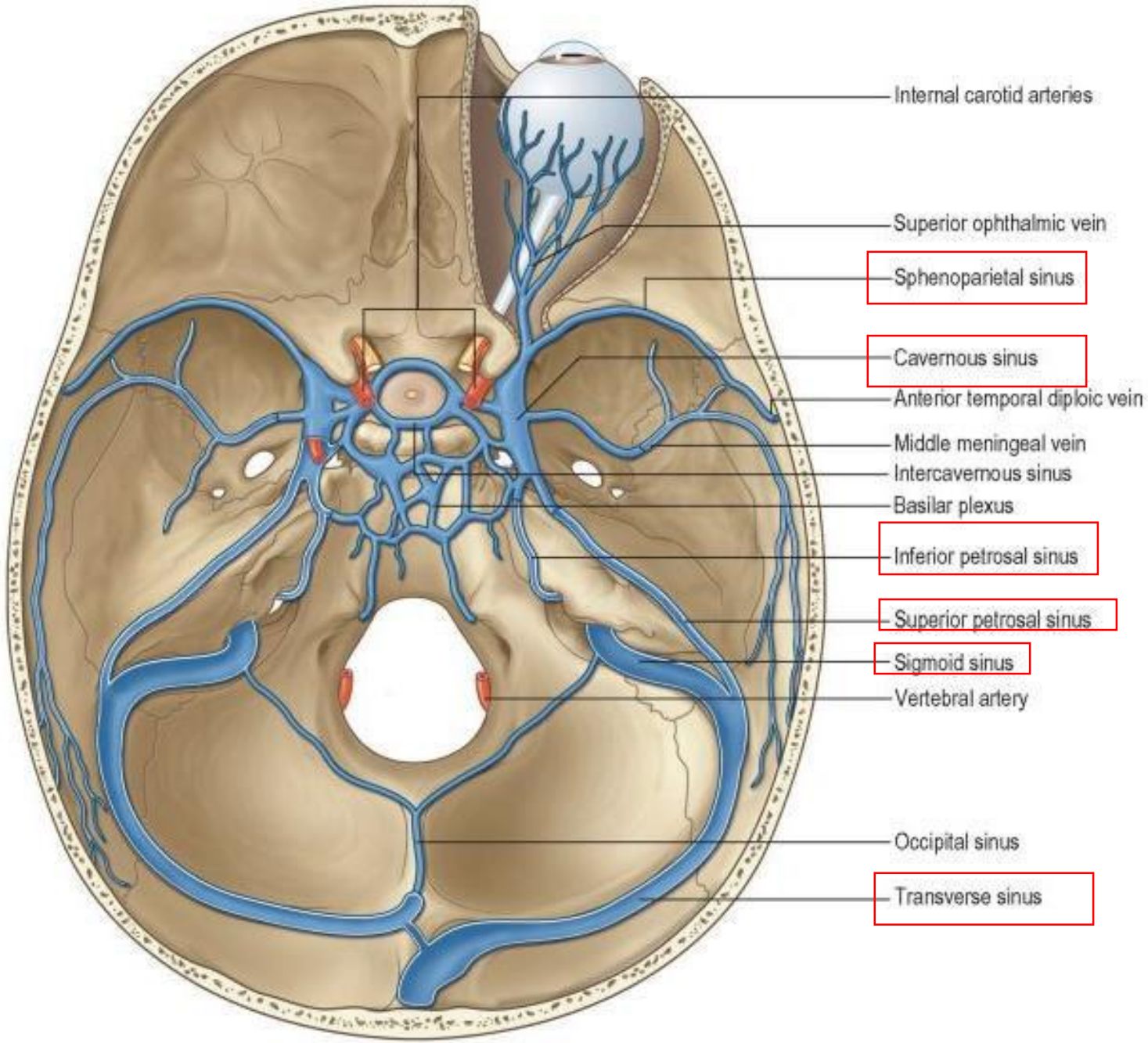
Unpaired sinuses




superior sagittal sinus
inferior sagittal sinus
falx
cavernous sinus
superior petrosal sinus
tentorium
sigmoid sinus
jugular bulb
transverse sinus
© Mayfield Clinic


Straight sinus
Transverse sinus

Paired sinuses

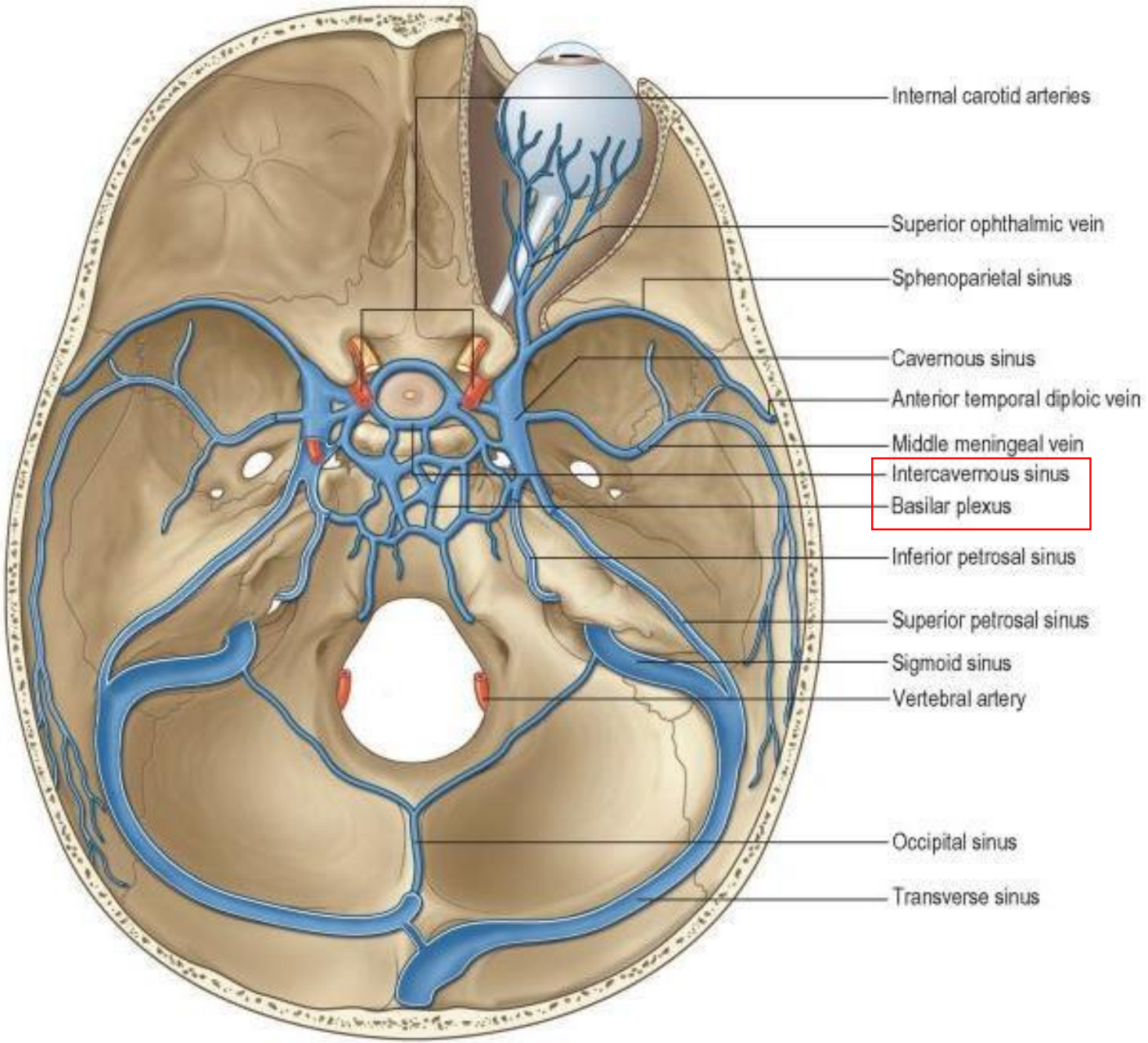


Multiple sinuses

- Two Multiple, usually connect dural sinuses on both sides of the body

  1. Intercavernous connect the 2 cavernous sinuses together.

  2. Basillar plexus of veins connect the 2 inferior petrosal sinuses together.



Cavernous sinuses

- The paired cavernous sinuses are against the lateral aspect of the body of the sphenoid bone on either side of the sella turcica.

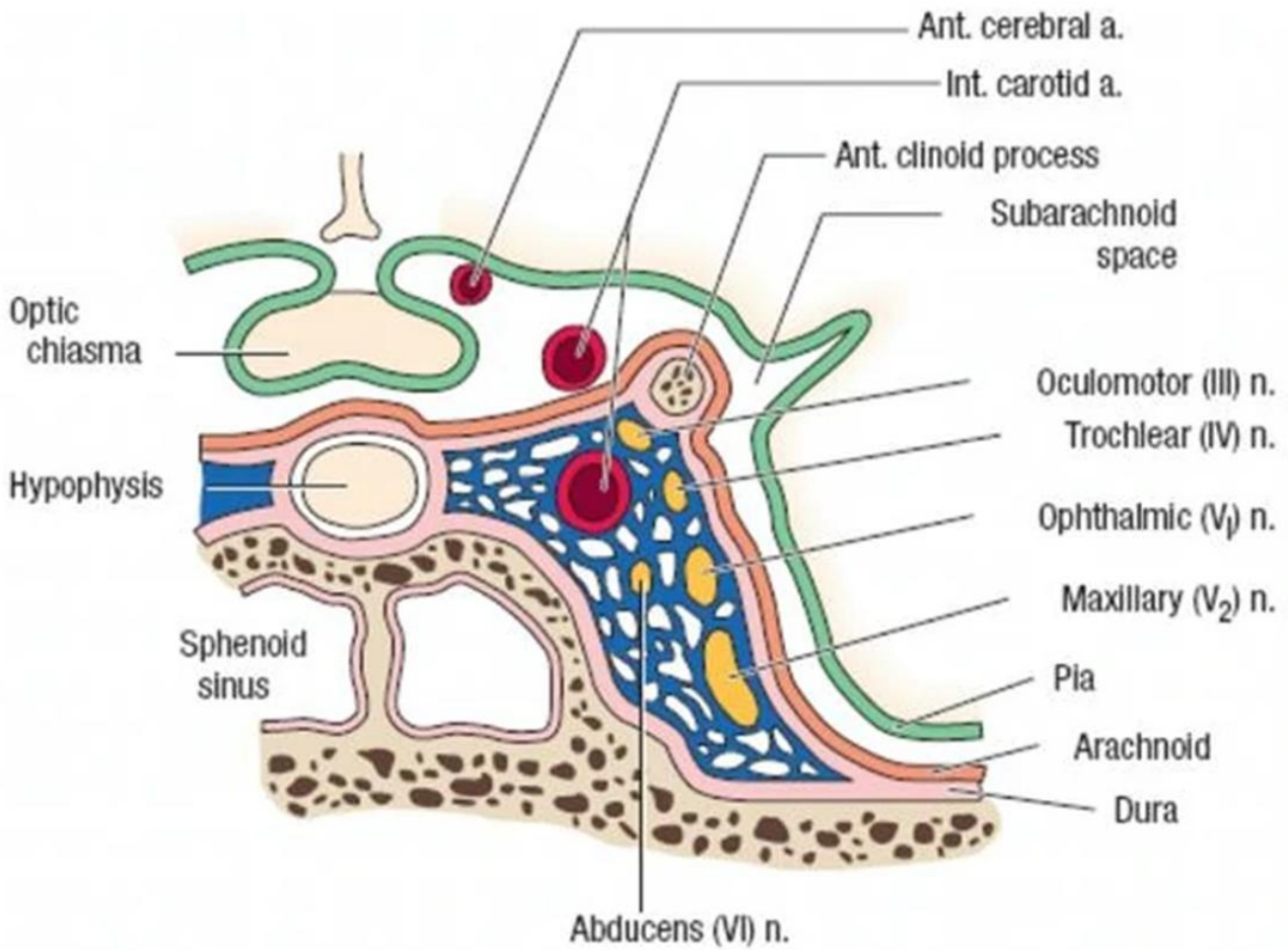
- They are of great clinical importance because of **their connections** and **the structures that pass through them**.

Contd..

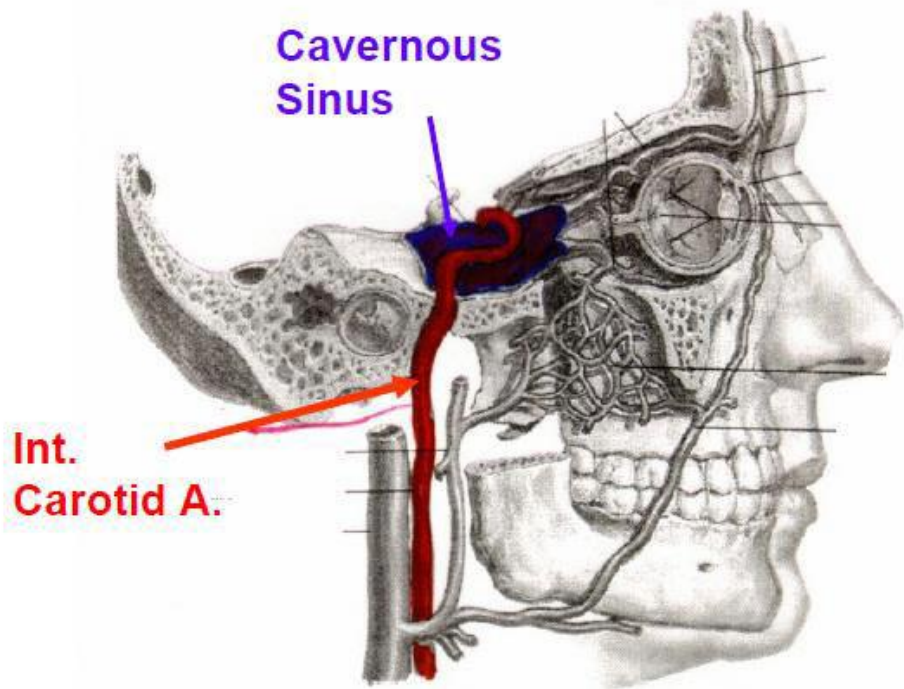
- Structures passing **through** each cavernous sinus are the **internal carotid artery** and the **abducent nerve** (VI).

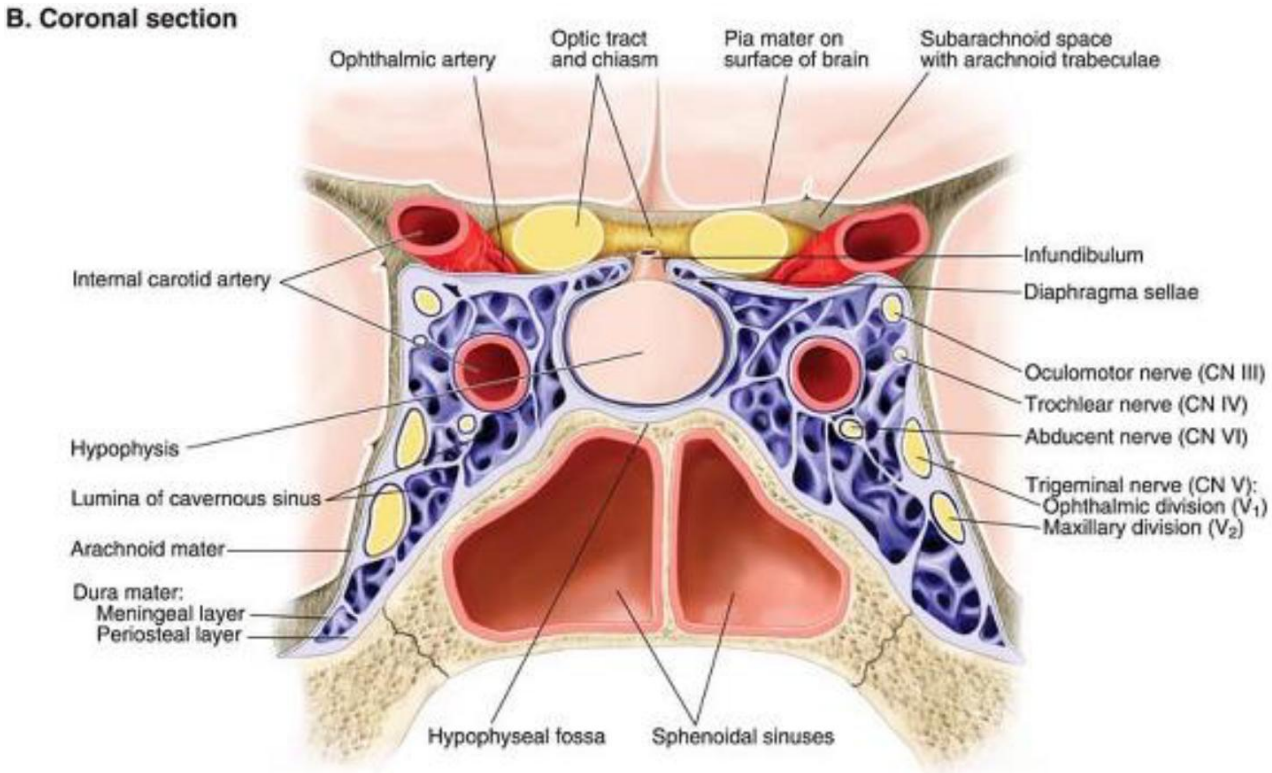
- Structures in the **lateral wall** of each cavernous sinus are, from *superior to inferior* **OTOM:**

1. **The Oculomotor nerve**
2. **The Trochlear nerve**
3. **The Ophthalmic nerve**
4. **The Maxillary nerve**



Internal Carotid Artery – Passes Through Cavernous Sinus

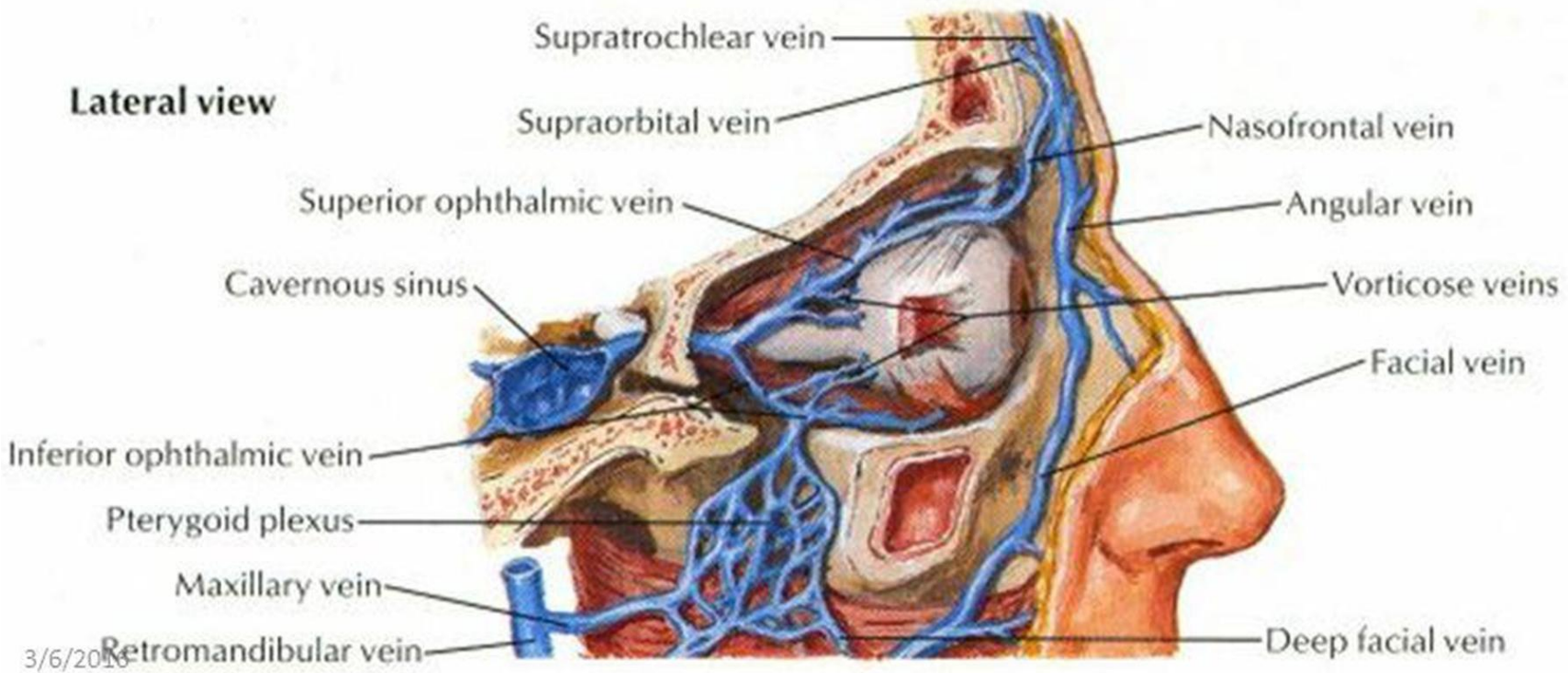


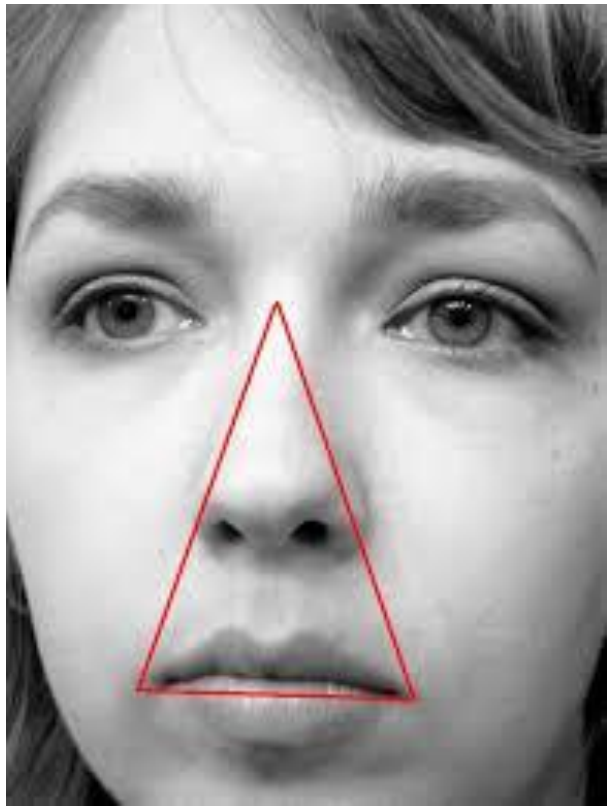


Contd..

- Each sinus has an important communication with the **facial vein** through the superior ophthalmic vein.

- This is a route by which infection can travel from the facial skin to the cavernous sinus.





Dangerous area of face

Cavernous Sinus Thrombosis

- **Causes:**
  - Bacterial infection that has spread from the sinuses, teeth, ears, eyes, nose, or skin of the face.

- **Symptoms**:
  - Bulging eyeball
  - Cannot move the eye in a particular direction
  - Drooping eyelids (ptosis)
  - Chemosis (swelling or edema of the conjunctiva)
  - Headaches
  - Vision loss

Cerebral veins

- **Characteristic features:**

1. Venous return of brain doesn’t follow the arterial pattern.
2. Extremely thin walled (Absence of muscular layer).
3. No valves.
4. Run in subarachnoid space.
5. They are ***External*** and ***Internal*** veins
6. Drain into dural venous sinuses.

External veins

- **The superior cerebral veins:** pass upward over the lateral surface of the cerebral hemisphere and empty into the **superior sagittal sinus**.

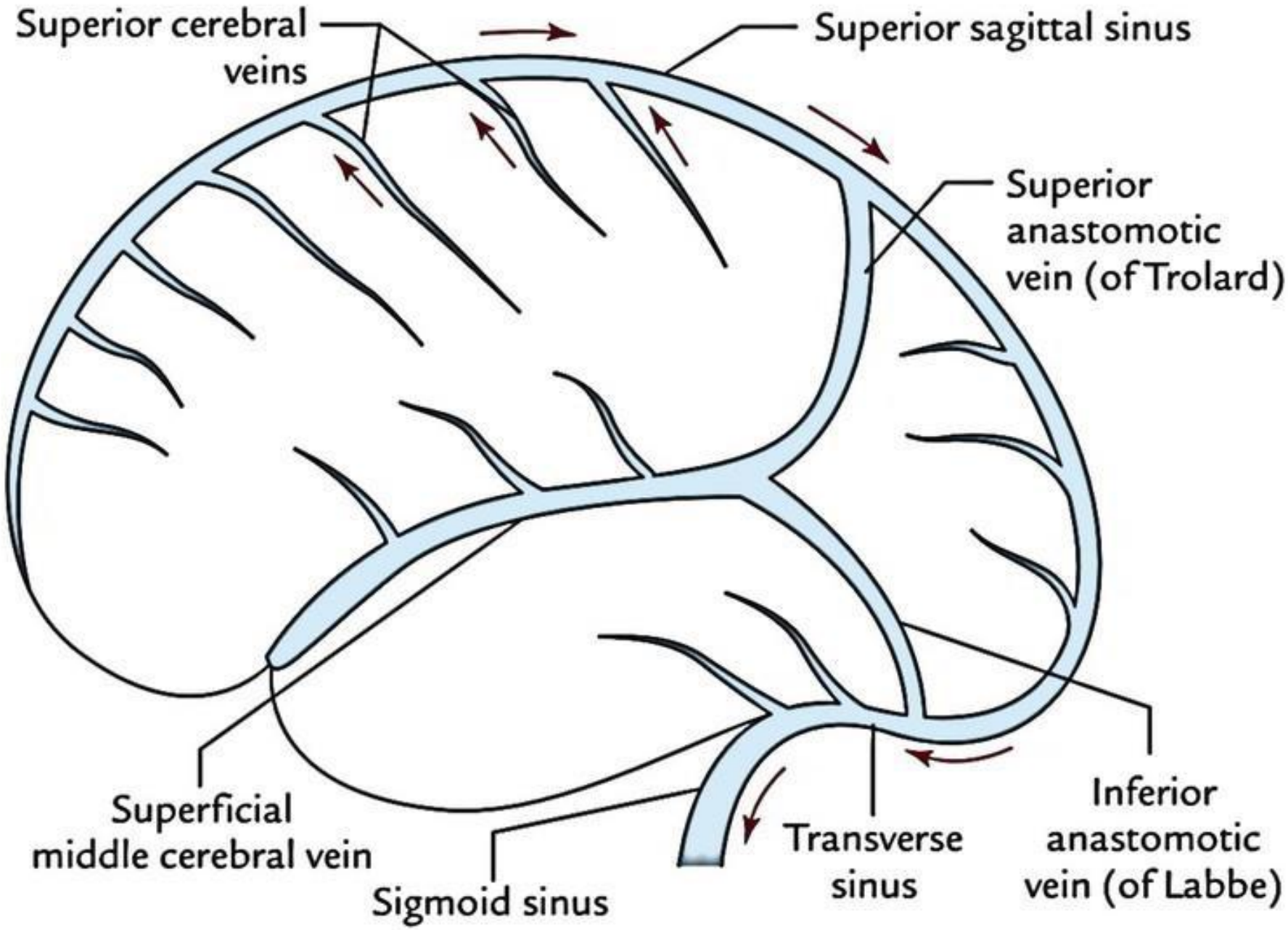
- **The middle cerebral veins** (Superficial and Deep):

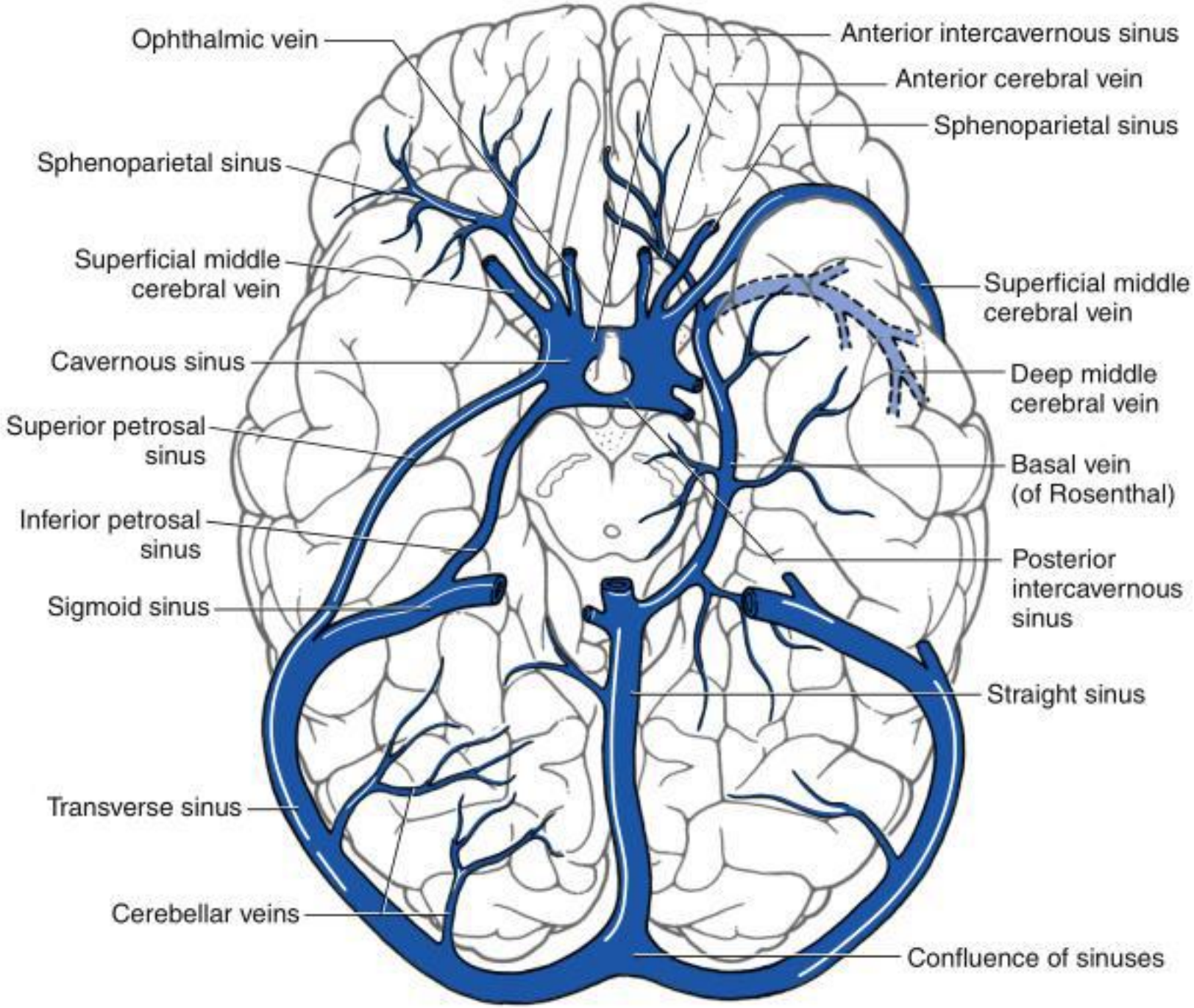
1. **Superficial middle cerebral vein:** It runs inferiorly in the lateral sulcus and empties into the **cavernous sinus**. It is connected to the superior sagittal sinus by a superior anastomotic vein and to the transverse sinus by an inferior anastomotic vein.

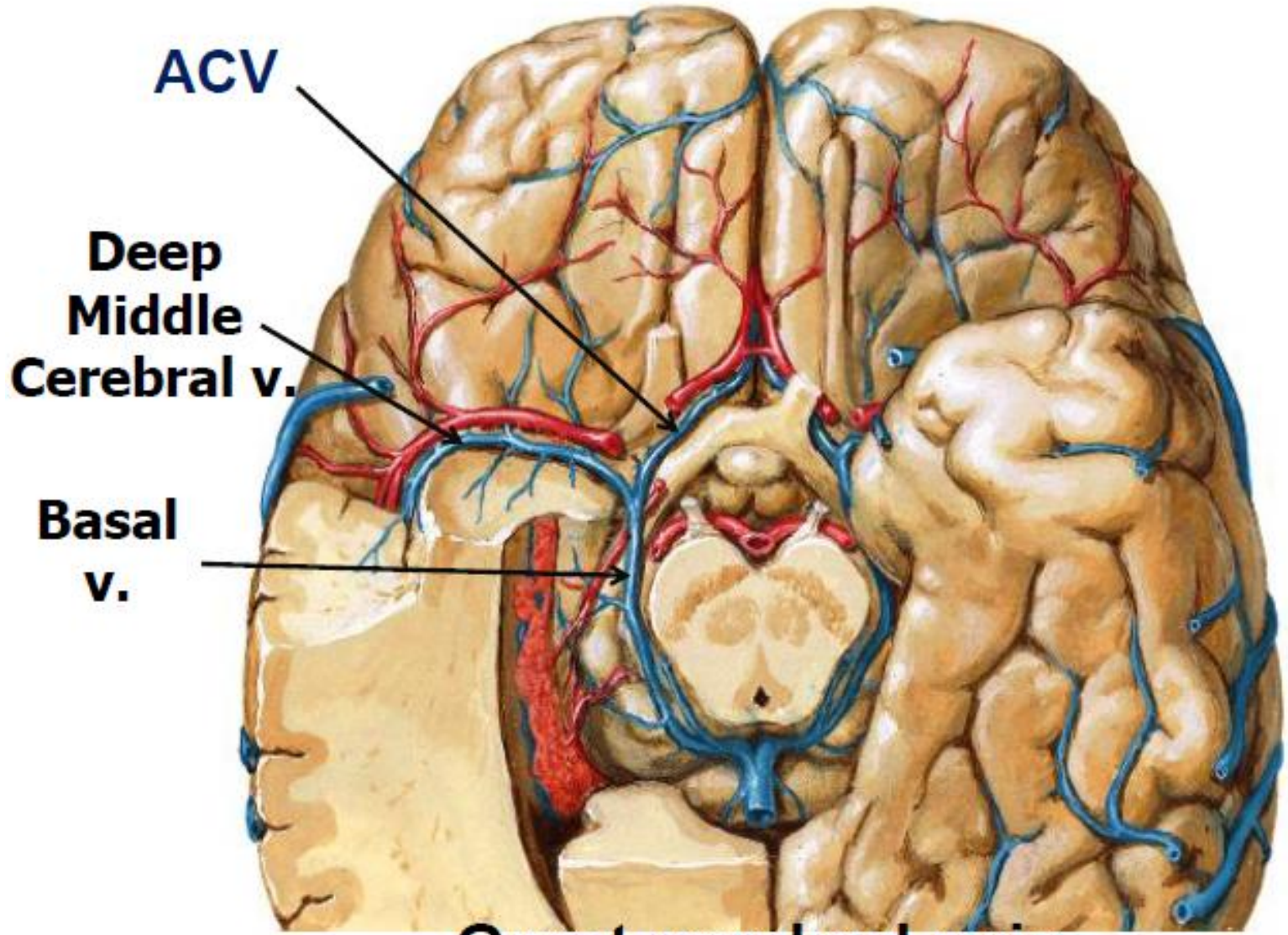
2. **The deep middle cerebral vein:** drains the insula and is joined by the anterior cerebral and striate veins to form the basal vein. The basal vein ultimately joins the great cerebral vein, which in turn drains into the **straight sinus**.

External veins

- **The inferior cerebral veins:** drain into the nearby sinuses especially the **transverse sinus**.
- **Anterior cerebral vein:** Drain medial surface of cerebral surface. Runs along anterior cerebral artery.


Superior cerebral veins
Superior sagittal sinus
Superior anastomotic vein (of Trolard)
Superficial middle cerebral vein
Sigmoid sinus
Transverse sinus
Inferior anastomotic vein (of Labbe)

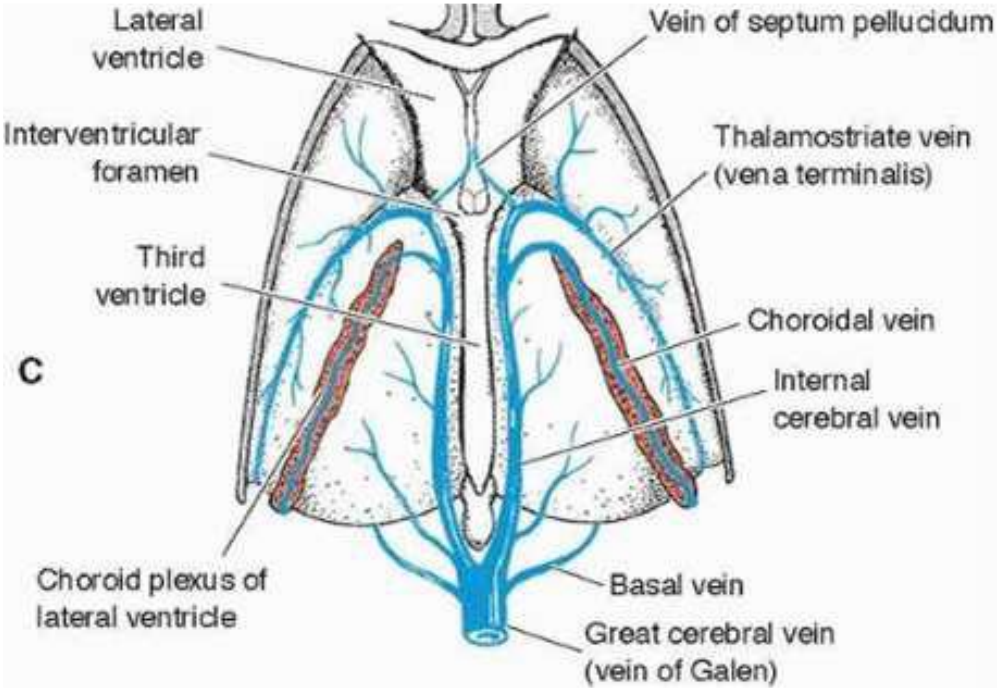

Ophthalmic vein
Sphenoparietal sinus
Superficial middle cerebral vein
Cavernous sinus
Superior petrosal sinus
Inferior petrosal sinus
Sigmoid sinus
Transverse sinus
Cerebellar veins
Anterior intercavernous sinus
Anterior cerebral vein
Sphenoparietal sinus
Superficial middle cerebral vein
Deep middle cerebral vein
Basal vein (of Rosenthal)
Posterior intercavernous sinus
Straight sinus
Confluence of sinuses

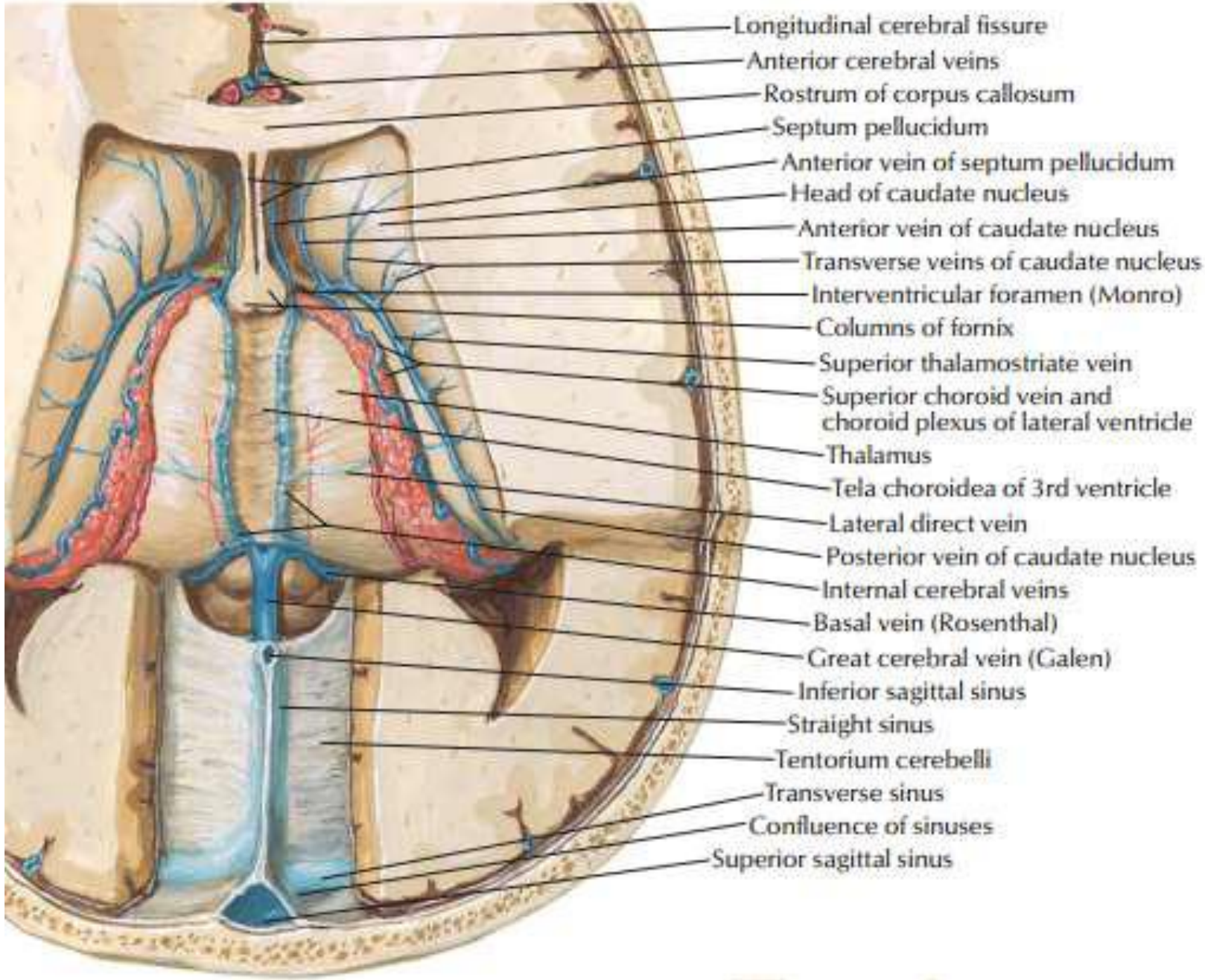


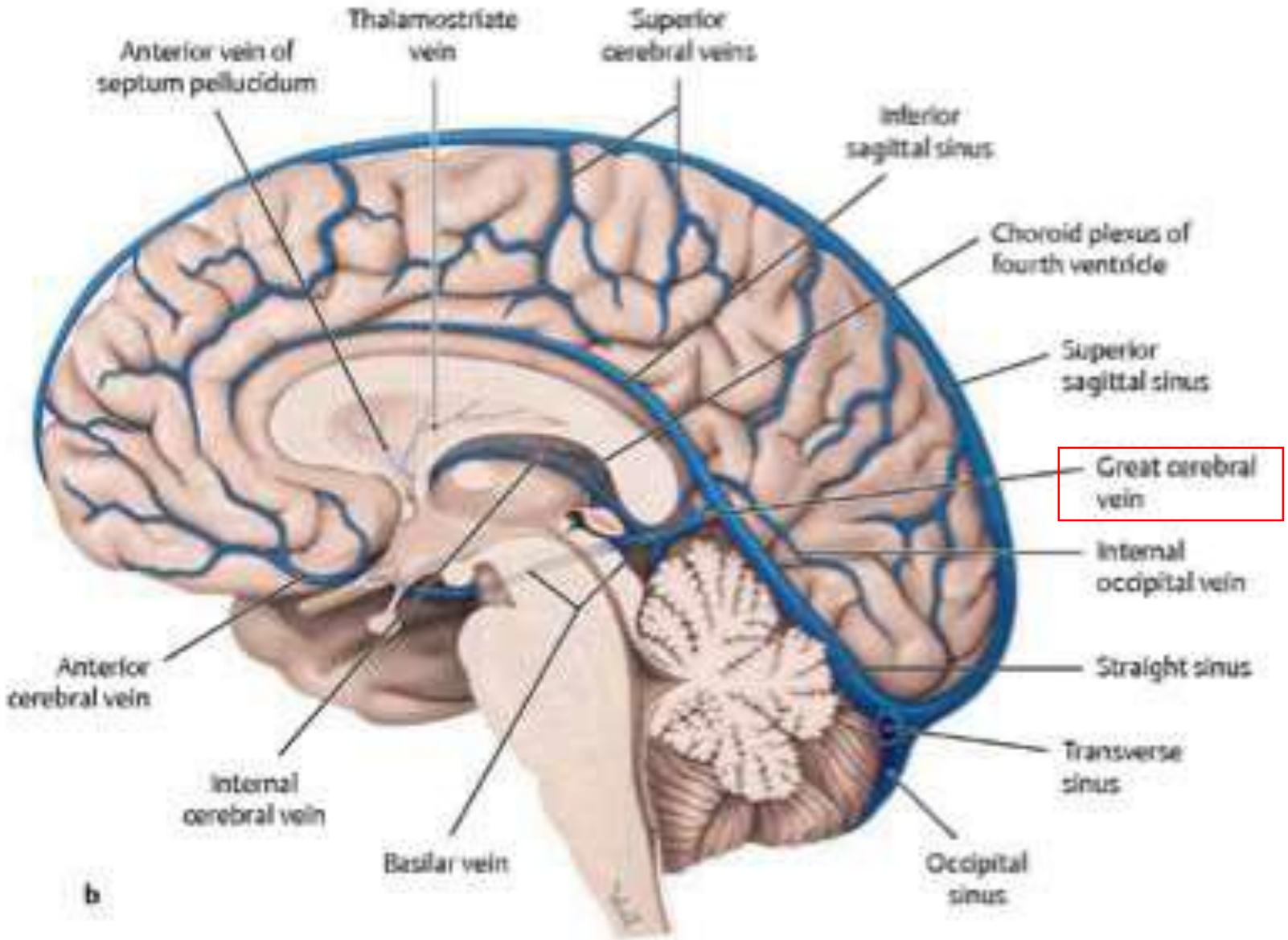
Great cerebral vein

Internal veins

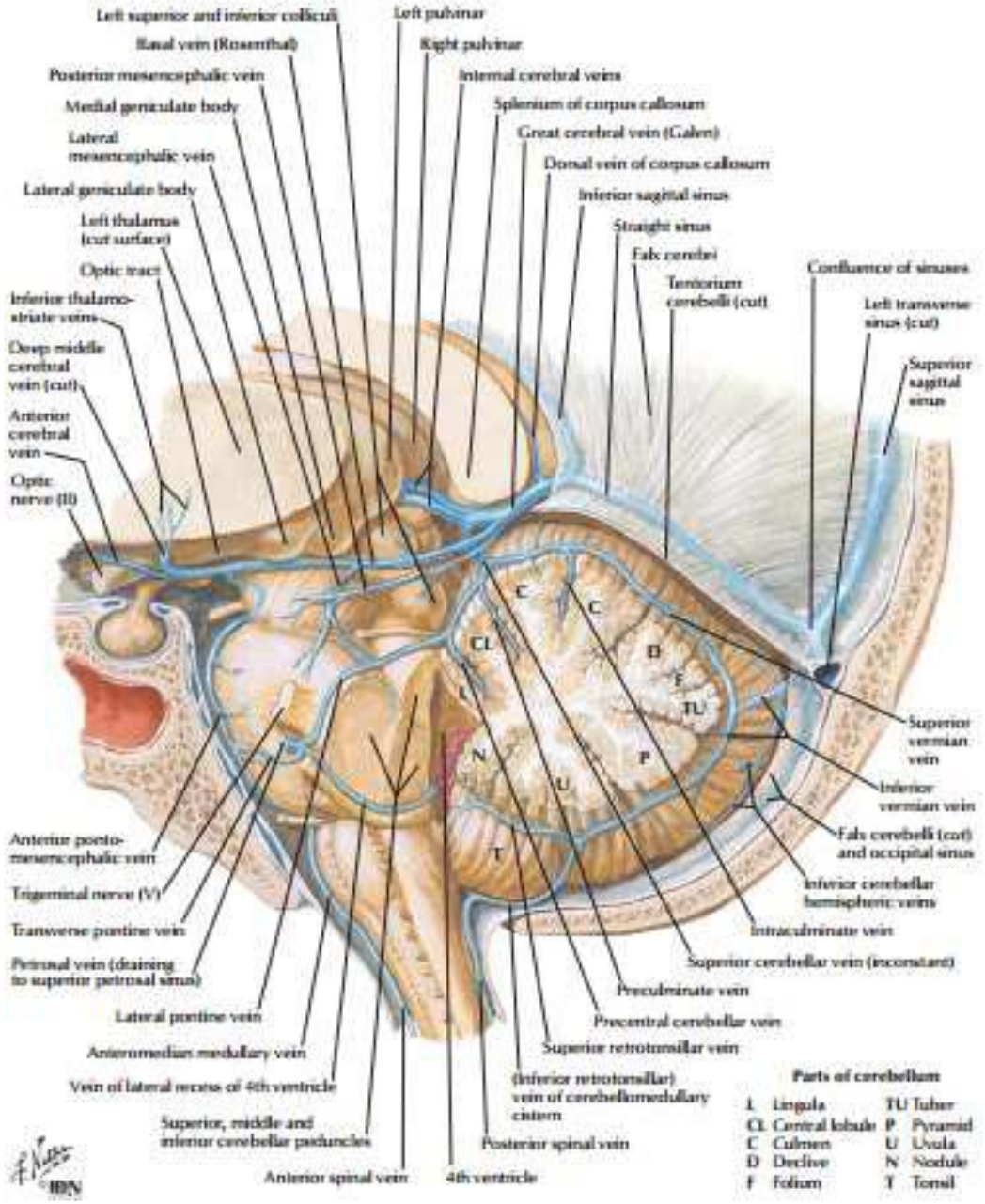
- Two internal cerebral veins on either side of midline in tela choroidea of 3rd ventricle.
  - Formed by the union of:
    1. Septal
    2. Thalamostriate
    3. Choroidal vein
  - Join to form great cerebral vein (of Galen) → Empties into **straight sinus**.




Longitudinal cerebral fissure
Anterior cerebral veins
Rostrum of corpus callosum
Septum pellucidum
Anterior vein of septum pellucidum
Head of caudate nucleus
Anterior vein of caudate nucleus
Transverse veins of caudate nucleus
Interventricular foramen (Monro)
Columns of fornix
Superior thalamostriate vein
Superior choroid vein and
choroid plexus of lateral ventricle
Thalamus
Tela choroidea of 3rd ventricle
Lateral direct vein
Posterior vein of caudate nucleus
Internal cerebral veins
Basal vein (Rosenthal)
Great cerebral vein (Galen)
Inferior sagittal sinus
Straight sinus
Tentorium cerebelli
Transverse sinus
Confluence of sinuses
Superior sagittal sinus


Anterior vein of septum pellucidum
Thalamostriate vein
Superior cerebral veins
Inferior sagittal sinus
Choroid plexus of fourth ventricle
Superior sagittal sinus
Great cerebral vein
Internal occipital vein
Straight sinus
Transverse sinus
Occipital sinus
Anterior cerebral vein
Internal cerebral vein
Basilar vein
b

- The **midbrain** is drained by veins that open into the basal or great cerebral veins.
- The **pons** is drained by veins that open into the basal vein and cerebellar veins.
- The **medulla oblongata** is drained by veins that open into the spinal veins
- The **cerebellum** is drained by veins that empty into the great cerebral vein.

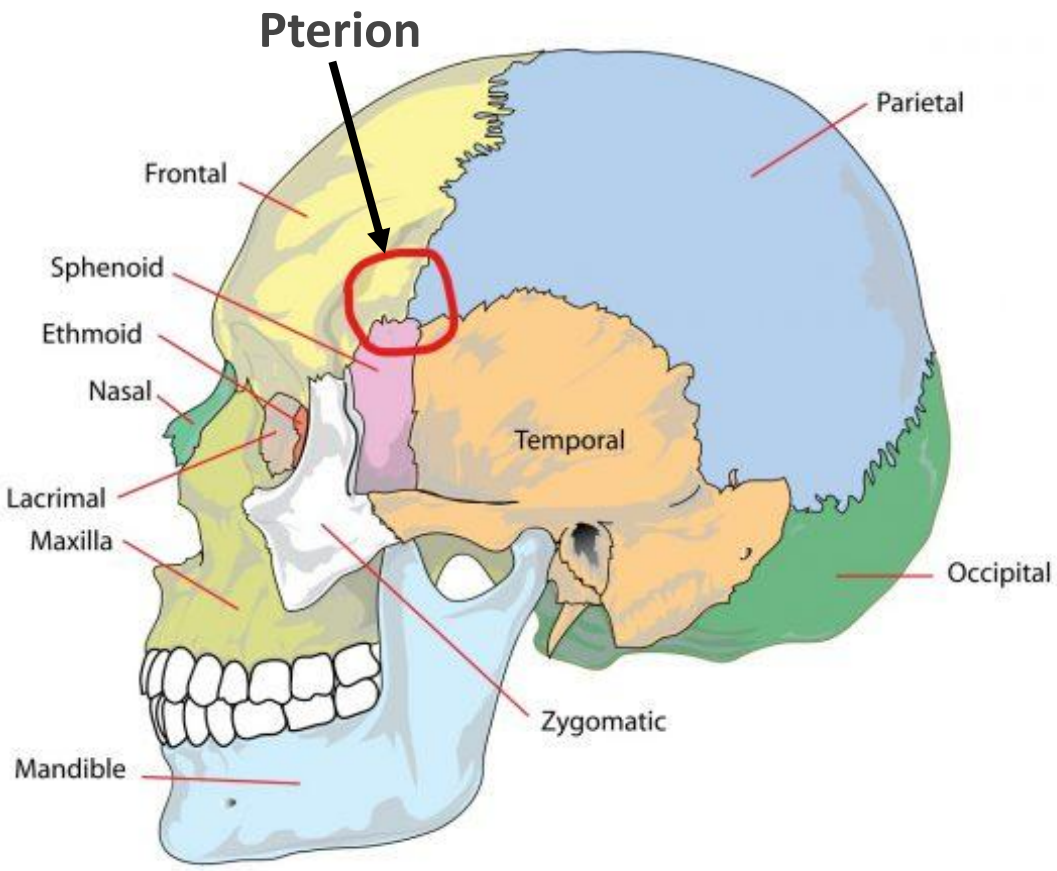


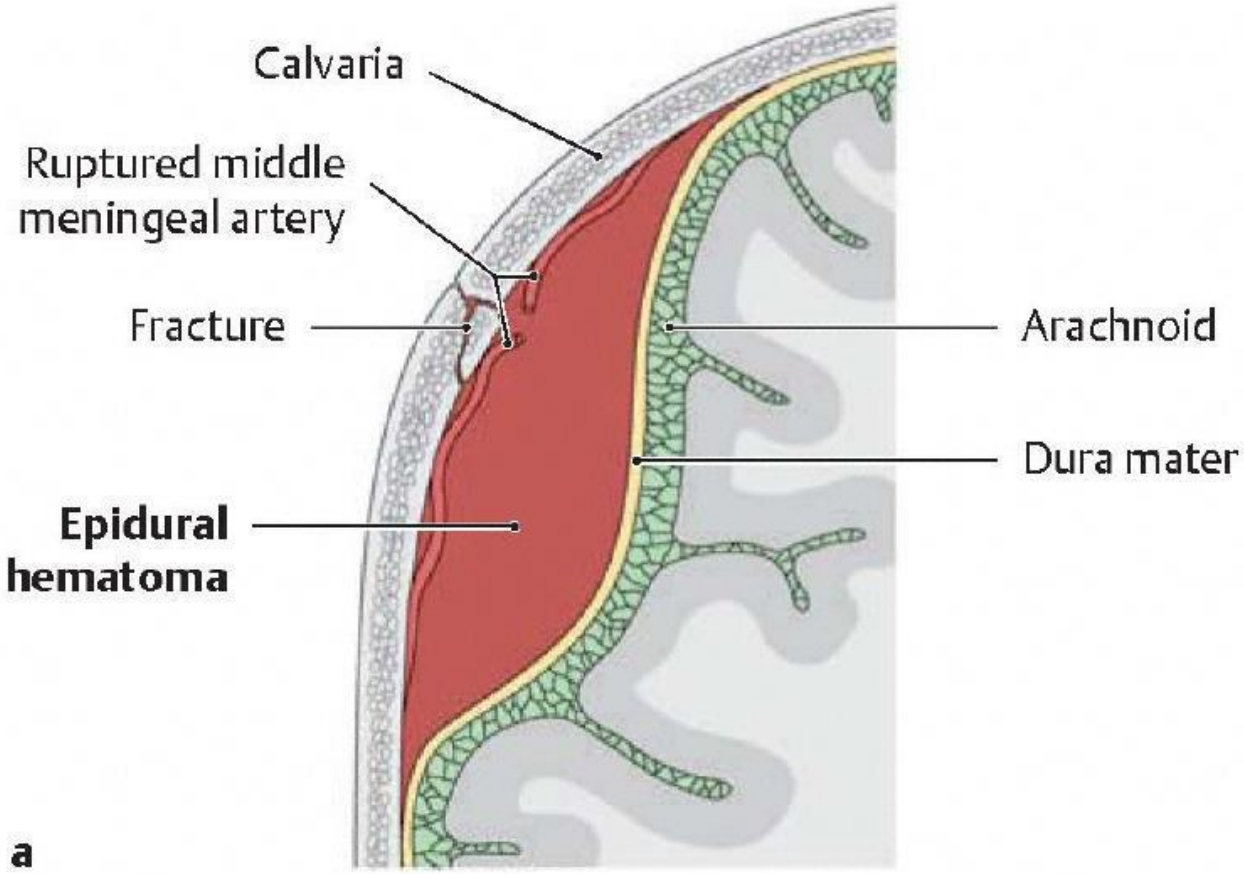
Intracranial Hematoma

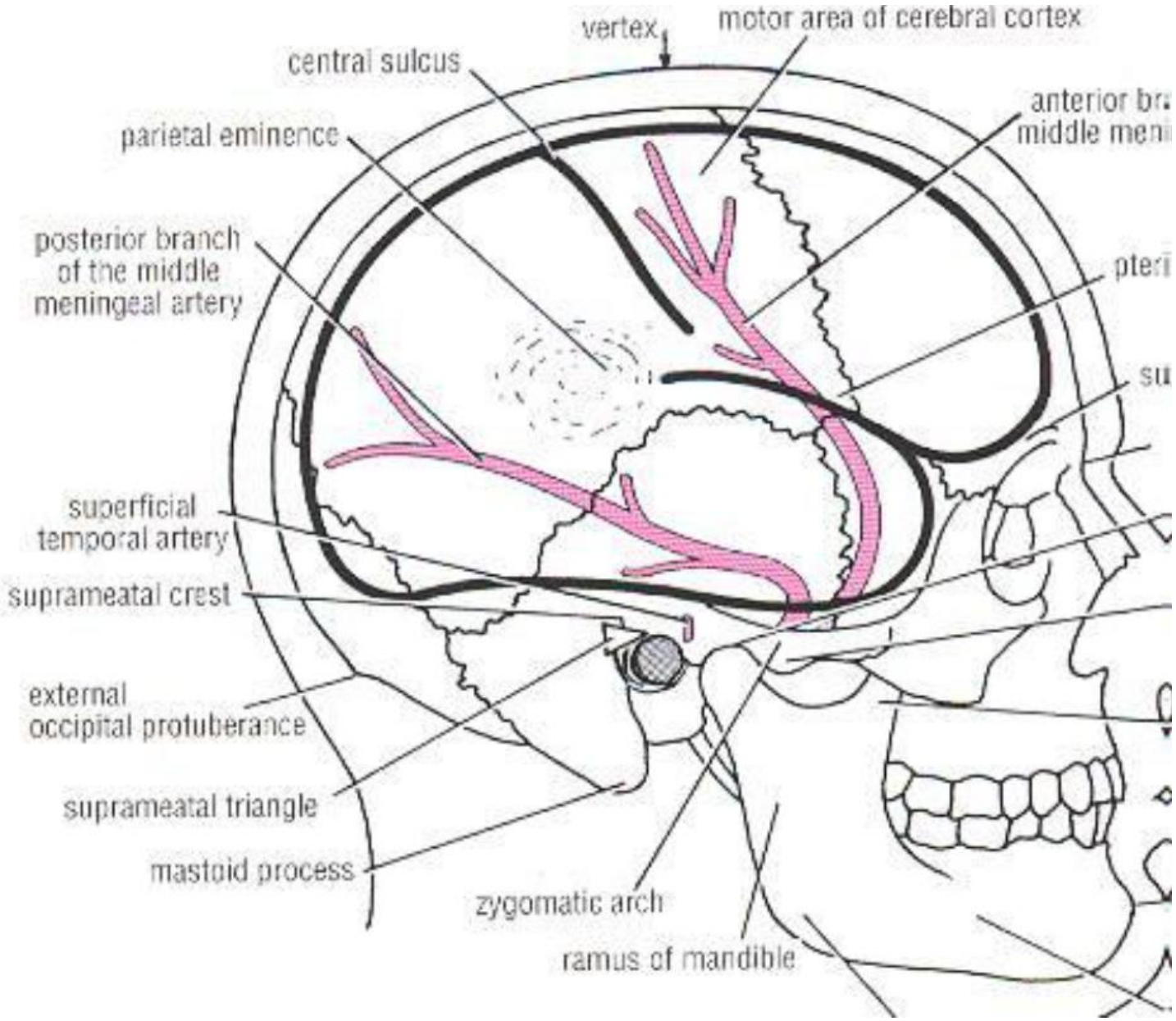
1. Epidural hematoma
2. Subdural hematoma
3. Subarachnoid hematoma

Epidural hematoma

- Or **Extradural Hemorrhage**
- Bleeding occurs between dura mater and the inner surface of skull
- **Cause:** most commonly caused by skull trauma in the temporoparietal region and bleeding from the anterior branch of middle meningeal artery.

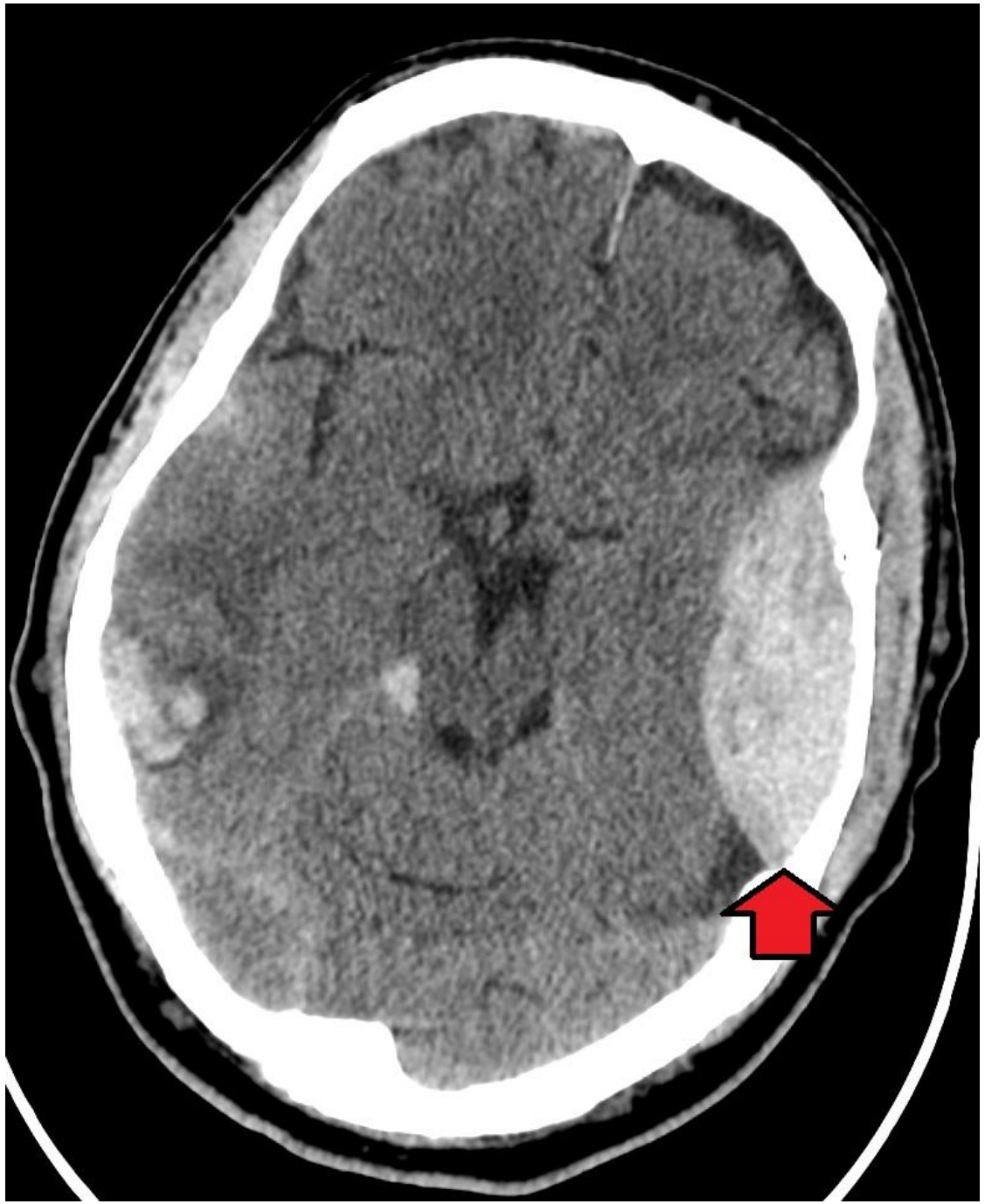

Pterion
Parietal
Frontal
Sphenoid
Ethmoid
Nasal
Temporal
Lacrimal
Maxilla
Occipital
Zygomatic
Mandible


Calvaria
Ruptured middle meningeal artery
Fracture
Arachnoid
Dura mater
Epidural hematoma
a


vertex
motor area of cerebral cortex
central sulcus
parietal eminence
posterior branch of the middle meningeal artery
superficial temporal artery
suprameatal crest
external occipital protuberance
suprameatal triangle
mastoid process
zygomatic arch
ramus of mandible

Epidural hematoma by CT scan:

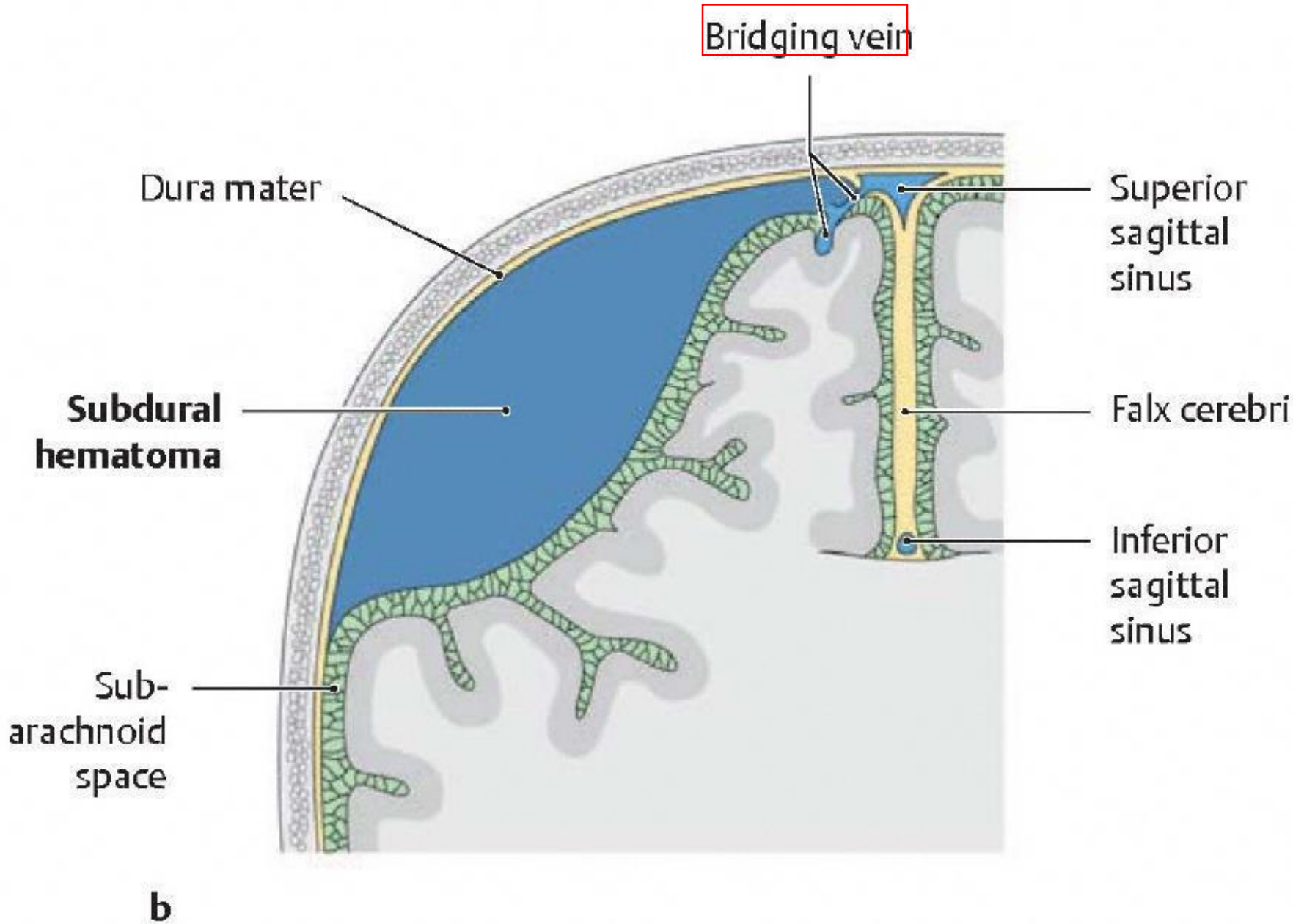
- Convex in shape



Subdural hematoma

- Bleeding occurs between inner layer of dura mater and arachnoid mater.

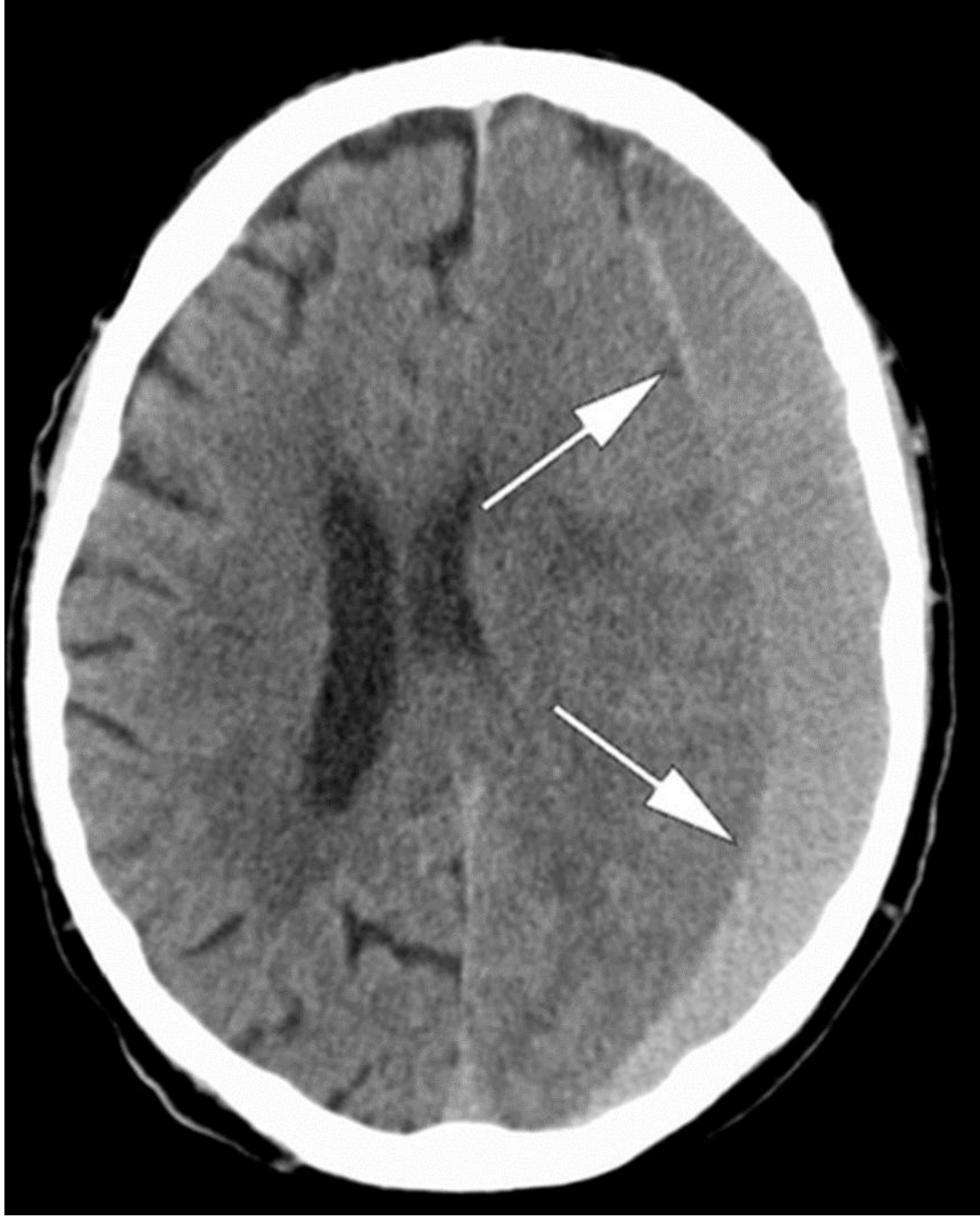
- **Cause:** blow on the front or back of the head causing anteroposterior displacement of the brain within the skull → tears in bridging veins that cross the subdural space into the venous sinuses.


Bridging vein
Dura mater
Superior sagittal sinus
Subdural hematoma
Falx cerebri
Inferior sagittal sinus
Sub-arachnoid space

b

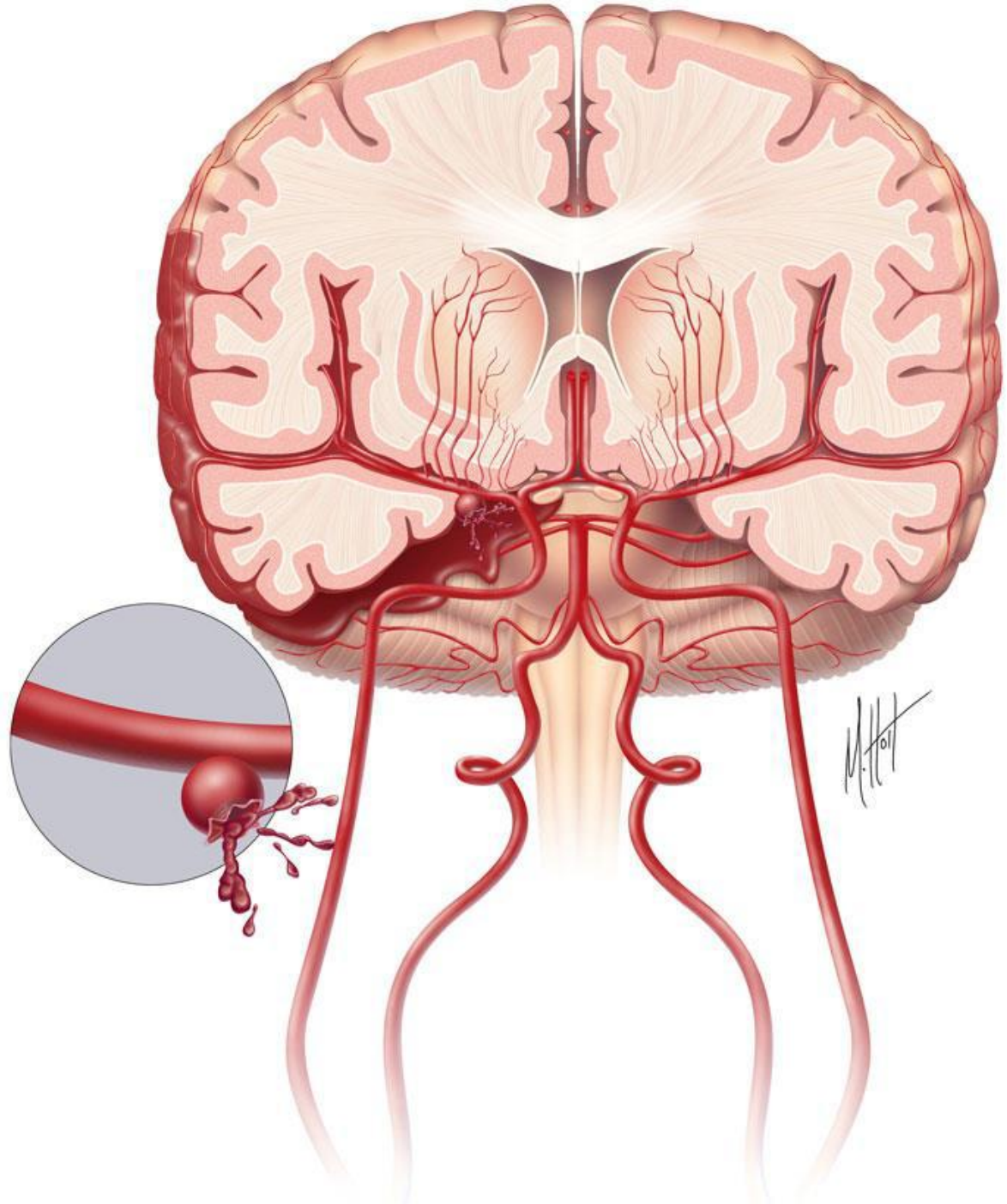
Subdural hematoma by CT scan:

- Concave in shape

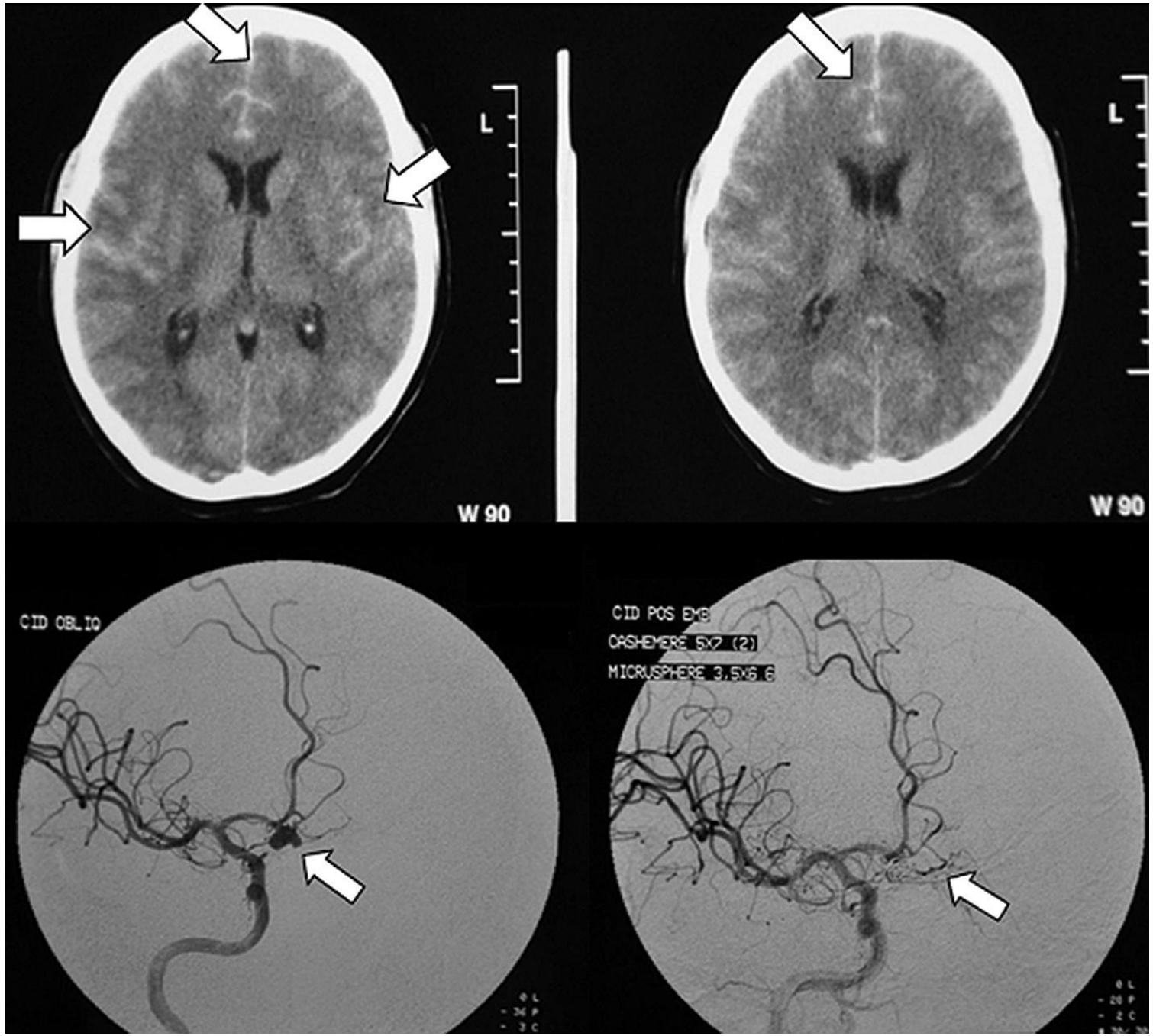


Subarachnoid Hemorrhage

- Bleeding occurs in the subarachnoid space between the arachnoid mater and the pia mater.
- **Cause:** usually from a ruptured cerebral aneurysm on the circle of Willis.
- The diagnosis is established by withdrawing heavily blood- stained CSF through a **lumbar puncture**.



CT scan of the brain showing subarachnoid hemorrhage as a white area in the center and stretching into the sulci to either side.


L
W 90
L
W 90
CID OBL IQ
CID POS EMB
CASHEMERE 5X7 (2)
MICROSPHERE 3,5X6 6

Sign and symptoms of intracranial hematoma

- Symptoms might develop right after the trauma to the head, or they may take weeks or longer to appear **"lucid interval"**.

- With time, pressure on brain increases, producing the following symptoms:
  - **Increasing headache**
  - **Vomiting**
  - **Drowsiness and progressive loss of consciousness**
  - **Dizziness**
  - **Stiffness of the neck**
  - **Confusion**
  - **Contralateral hemiparesis**

Thank you

Ayman.alzubi@yu.edu.jo