

Lecture:



Physiology of Brain Circulation & CSF Formation

Dr. Eyad M. Hussein

Ph.D. of Neurology

**Consultant & Head of Neurology Department,
Nasser Hospital**

الرجاء تحويل الجوال إلى وضع
الصامت مع الشكر



Cerebral Blood Flow

Cerebral blood flow (CBF) is the blood supply to the brain in a given time.

Brain weight $\rightarrow$ 1.3 kilo.

In an adult, CBF is typically **750 ml/min**.

50-54 ml of blood per 100 g of brain tissue per min.

Ischemia results if blood flow to the brain below **18-**

25 ml per 100 g per min, and **tissue death** occurs if flow decreased below **8-10 ml** per 100 g per minute.

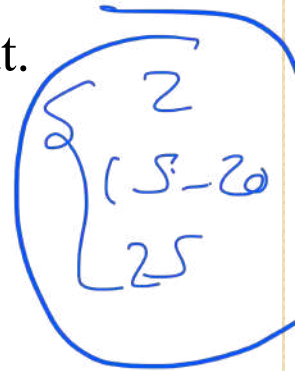
$\downarrow$ CBF :- 18-25 :- Ischemia

8-10 : Brain cell death [Irreversible damage]

transient Ischemic attack
cell death

Cerebral Blood Flow

- The adult brain weight is about 1300 – 1500 g (2% of Total Body Weight).
- **Consumes:**
 - ✓ “15-20% O₂” of the total cardiac output.
 - ✓ 25% glucose of Body
- Able to respond to variations in demand.



تسمه ذاتی بار B.F. ۱۸ Brain

Brain Autoregulation

• ریتاز با رشح و انقباض (تنفس)

The brain is very sensitive to **over and under perfusion**.

• **Cerebral autoregulation** refers to the physiological mechanisms that maintain blood flow at an appropriate level during changes in blood pressure.

Physiological Mechanisms of Autoregulation:

• **Myogenic/Arterial blood pressure.**

• **Chemical:**

✓ Arterial partial pressure of carbon dioxide **"PaCO₂"**.

✓ Arterial partial pressure of oxygen **"PaO₂"**.

• **Metabolic regulation.**

• **Neurogenic regulation.**

$\uparrow \text{CO}_2 \rightarrow \text{vaso dilation}$

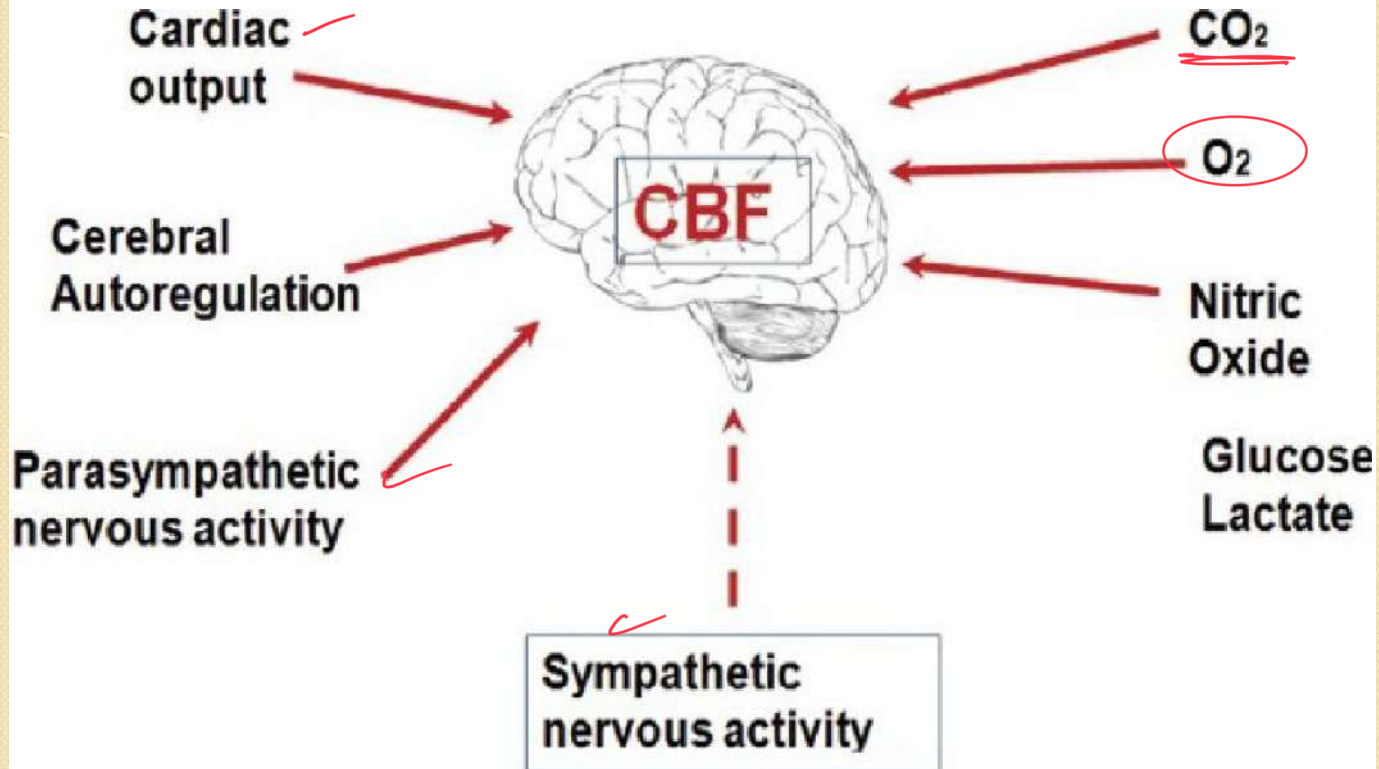
$\uparrow \text{O}_2 \rightarrow \text{vaso constriction}$
[hyper ventilation]

$\text{hypo glycemia} \rightarrow \text{vaso dilation}$

$\uparrow \text{BP} \rightarrow \text{vaso constriction}$

$\downarrow \text{BP} \rightarrow \text{vaso dilation}$

Factors Affecting Cerebral Blood Flow



Myogenic / Arterial Blood Pressure

A. Blood Pressure

- Arterioles **dilate** or **constrict** in response to changes in

BP and ICP in order to maintain a constant CBF.

- The response to ^{↓ BP} **lower pressure**, is arteriolar ^{compensatory} **dilation**

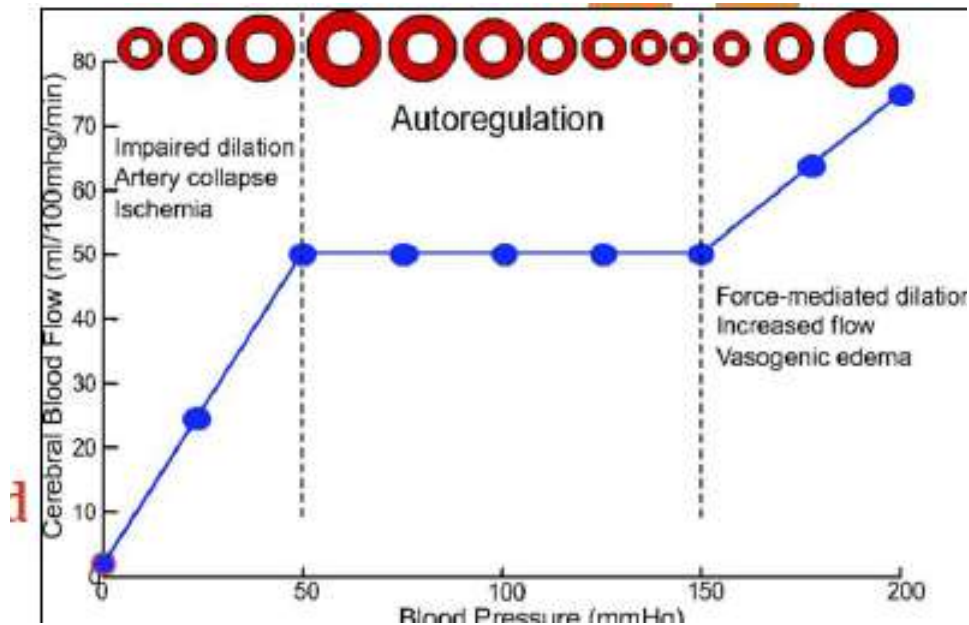
in the brain.

- While when ^{↑ BP} **blood pressure rises** they **constrict**. ^{Auto regulation}

more than 250 will be fatigue of ↑ lead to vaso dilation (pathogenesis)
this lead to Acute hypertension encephalo pathy.
injury → edema → Cerebral Brain → Cerebral
mechanical ventilation under hyper ventilation → Brain edema → Cerebral

Cerebral blood flow is “auto-regulated” extremely well between arterial pressure limits of 60 and 140 mmHg.

Thus, **hypotension** can result in **severe cerebral ischemia** & **hypertension** can result in **stroke or rupture**.



Arterial Blood Pressure *regulation of CBF*

Cerebral Perfusion Pressure (CPP)

$$\text{CPP} = \text{MAP} - \text{ICP}$$

MAP = Mean Arterial Pressure

ICP = Intra Cerebral Pressure

ICP – can be measured directly.

MAP: pushes blood into the brain.

Intracranial Pressure (**ICP**).

$$\text{MAP} = \text{Diastolic pressure} + \frac{1}{3} \text{Pulse pressure}$$

Dis. and Systolic. الفرق بينه 1/3

Pulse pressure = Systolic BP – Diastolic BP.

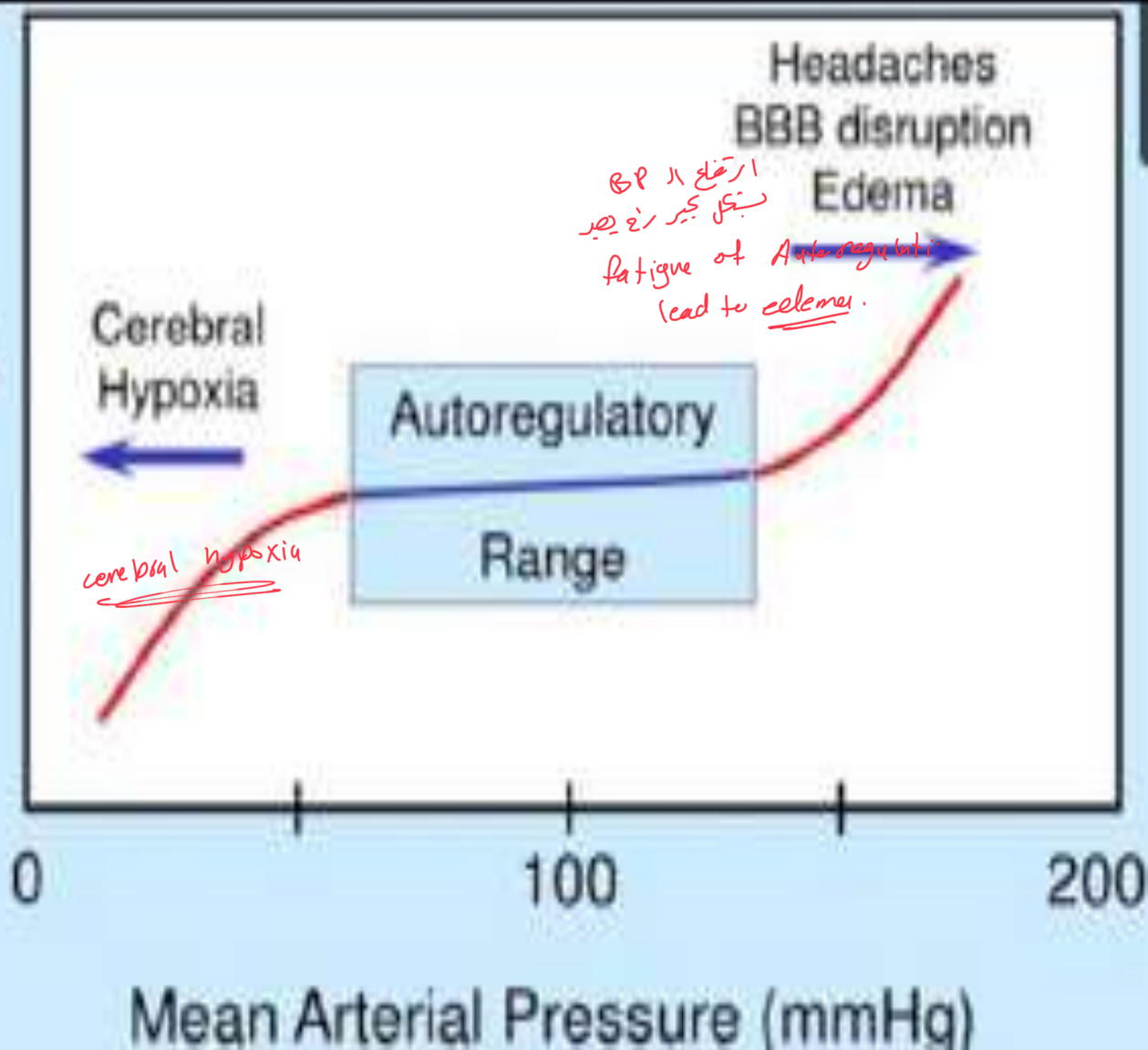
$$\text{Eg. BP} = 140/80, \text{ MAP} = 80 + 20 = 100 \text{ mmHg}$$

$$140 - 80 = 60$$

$$\frac{1}{3} \times 60 = 20$$

An autoregulatory plateau between mean arterial pressures of 60 and 150 mmHg

Cerebral
Blood
Flow

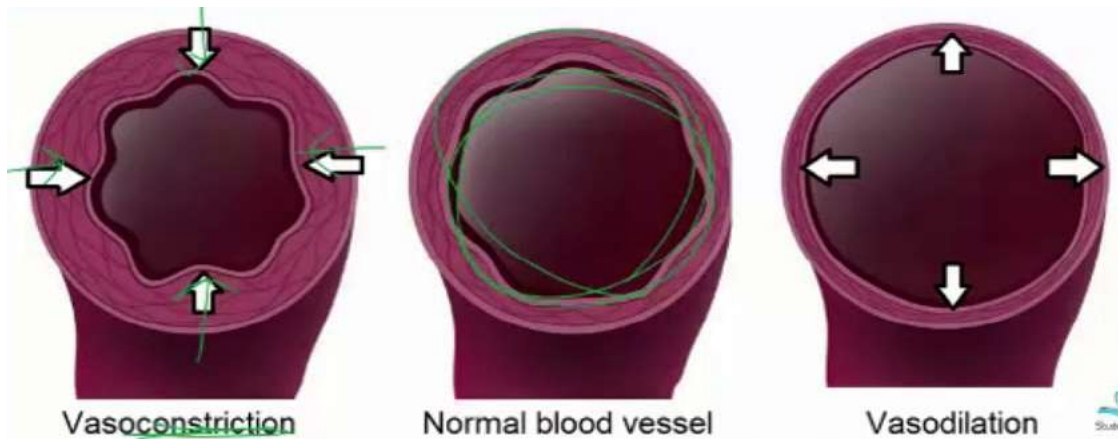


Cerebral Blood Flow

- **CBF**= Cerebral perfusion pressure (**CPP**) divided by the cerebrovascular resistance (**CVR**).
- **CBF** = **CPP** / **CVR**
- **CPP** = MAP – ICP
- **CPP** = is normally between 70 - 90 mmHg in an adult human.
- **Increase in ICP** → decreases CBF & cerebral perfusion.
- Normal intracranial pressure is **10 mmHg**.

Chemical Autoregulation

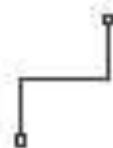
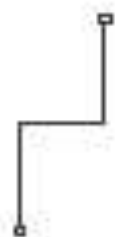
- Elevation of PaCO₂, leads to vasodilatation “High ICP”.
- Depression of PaCO₂, leads to vasoconstriction.
- Elevation of PaO₂, leads to vasoconstriction
“Hyperventilation used for management of brain oedema”.
- Depression of PaO₂, “Hypoxia”: leads to vasodilatation
“High ICP”.



↓Oxygen
conc,

↑ CO₂ con.
(Hypercapnia)
Or ↓ BP

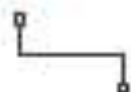
↓CO₂ conc. /
↑ BP /
↑ventilation



↑CBF

Dilatation of
cerebral vessels

Vasoconstriction



↑BF

↓BF

↑Blood
Volume



↓Blood
Volume

Arterial Blood Pressure Autoregulation

- **Baseline CBF:** 50–54 ml/100g/min
- **Critical ischemic threshold:** 20–25 ml/100g/min
 - *lead to ischemic changes*
 - below lower limit of autoregulation
 - Watershed zones are particularly vulnerable
- **Severe Hypertension:**
 - Damage to blood brain barrier.
 - Risk of cerebral oedema and acute hypertensive encephalomalacia due to vasodilation.

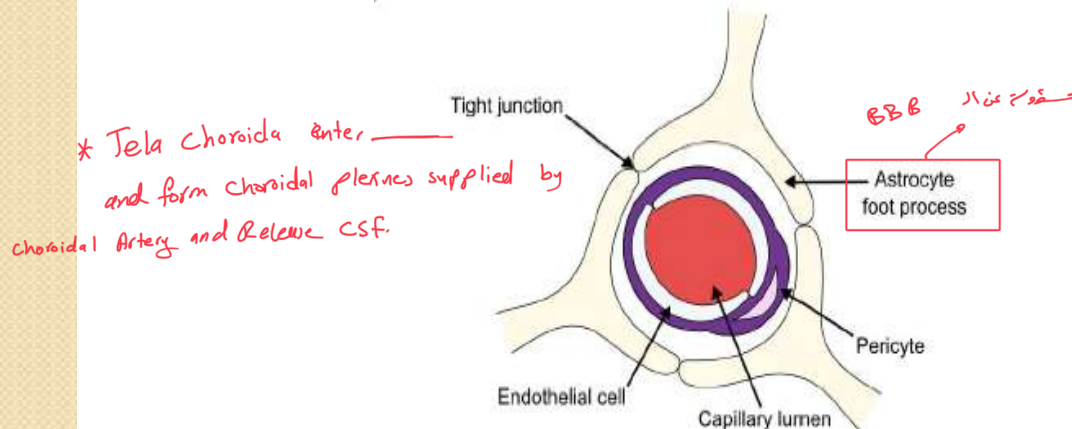
Neurogenic Autoregulation

● Neurogenic Autoregulation:

- **Sympathetic fibres:** vasoconstriction
- **Parasympathetic fibres:** vasodilatation

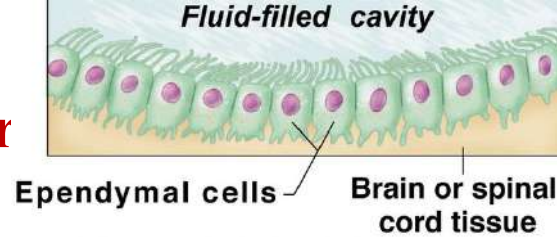
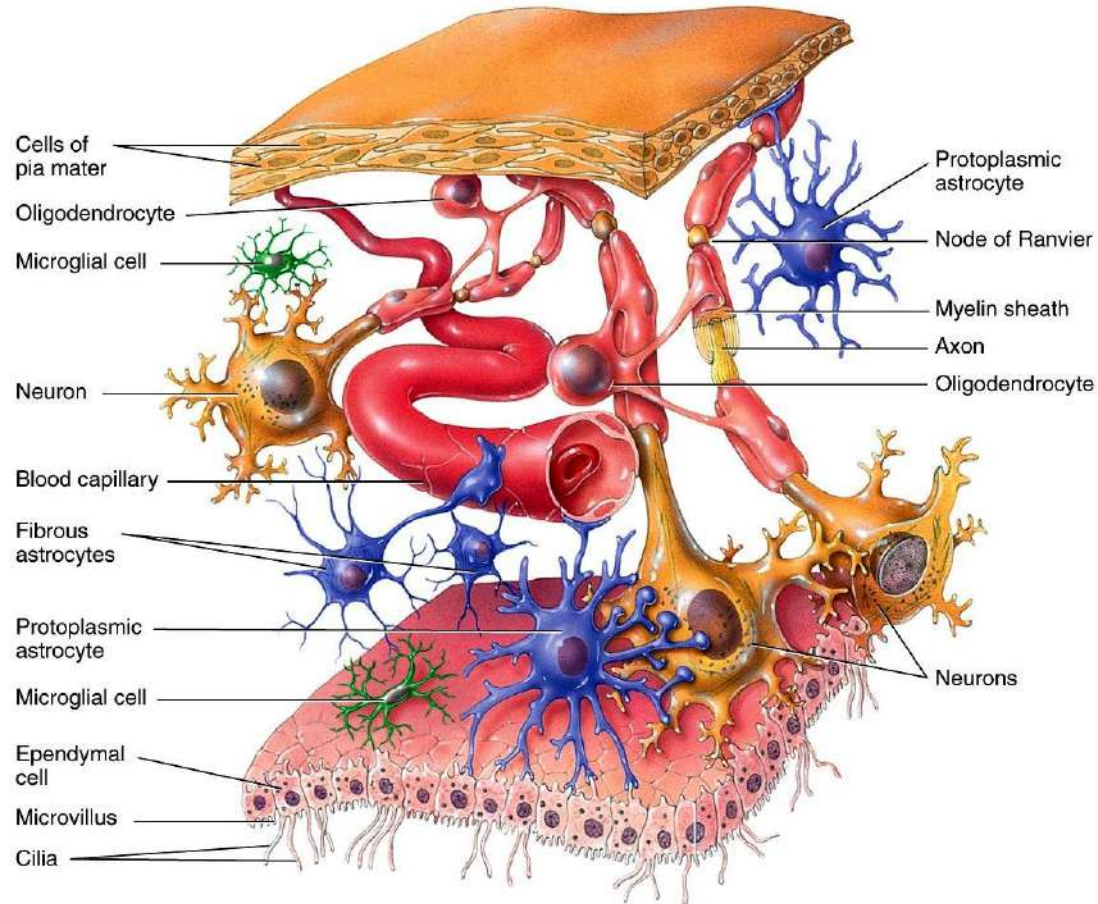
The Blood–Brain Barrier

- It is the barrier between cerebral capillary blood, the CSF and brain tissue.
- CSF fills the ventricles and the subarachnoid space.
- It consists of the **endothelial cells of the cerebral capillaries** and the ^{release CSF}**choroid plexus epithelium**.



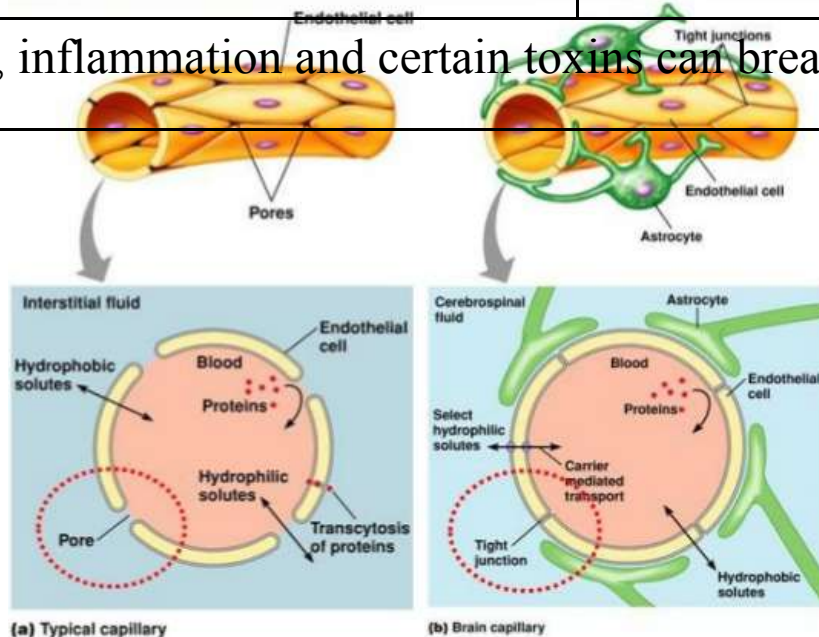
Blood-Brain Barrier

چینج ۱۷۷۷ سن ایوار لا Brain سٹو
 مہیج لہوچہ ایوار بالہفول مٹی ار
 Alcohol, O₂



Blood-Brain Barrier

Can Pass	Cannot Pass
<p><u>Glucose</u> (via transport proteins)</p> <p>Lipid-soluble substances</p> <p>□ <u>O₂</u>, <u>CO₂</u>, <u>alcohol</u>, <u>anesthetics</u></p> <p><i>stroke is ↓ loss of all sensation</i></p>	<p>Large <u>molecules</u> ex. <u>Proteins</u></p> <p>Most antibiotic drugs</p>
<p>Trauma, inflammation and certain toxins can break down the BBB</p>	



Functions of the Blood–Brain Barrier

1. **It maintains a constant environment for neurons** in the CNS and protects the brain from endogenous or exogenous toxins.
يُحافظ على دخول مغذيات الخروج المواد
2. **It prevents the escape of neurotransmitters from** their functional sites in the CNS into the general circulation.
يُحافظ على انتقال الناقلات العصبية ومنعها من الخروج من الدماغ - Brain
3. **Drugs penetrate the blood.**

Development of BBB

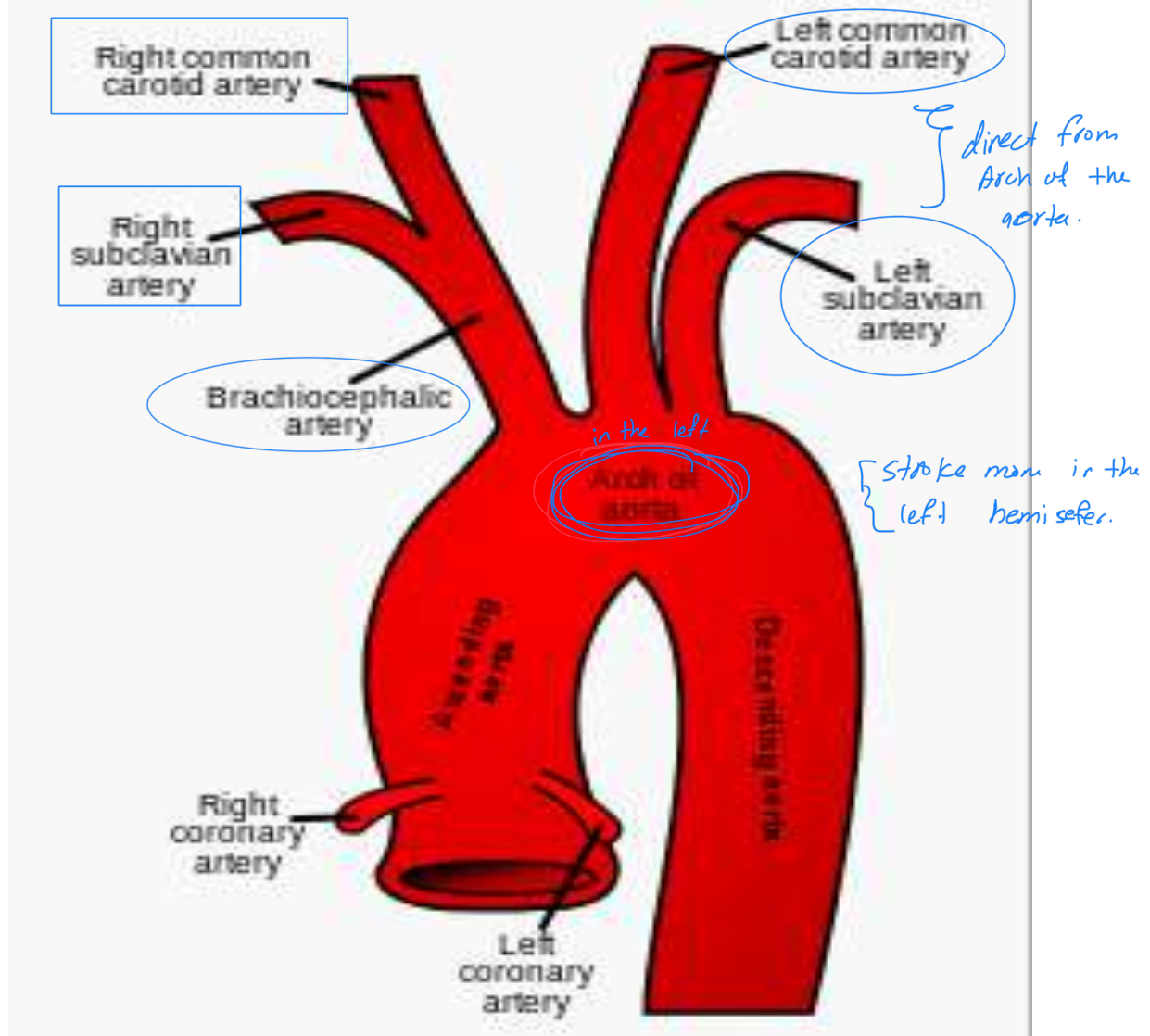
- Premature infants with hyperbilirubinemia,
in children ↑ Bili lead to jaundice if it ↑↑ Bili: enter BBB.
free bilirubin pass BBB, and may stain basal
nuclei causing damage (Kernicterus).

histo 1. { macroglial
microglial
Astrocyte
oligodendrocyte.

Blood Supply of the Brain

Brain blood supply formed of two main systems (arteries):

1. ^{anterior system}
Internal carotid system: Right & Left internal carotid arteries (ICA).
70-80% of Brain structure
2. ^{post. system}
Vertebro-basilar system: Right & Left vertebral arteries (VA).
*20-30% of Brain
to Post. structure*



I. The Internal Carotid Artery (ICA)

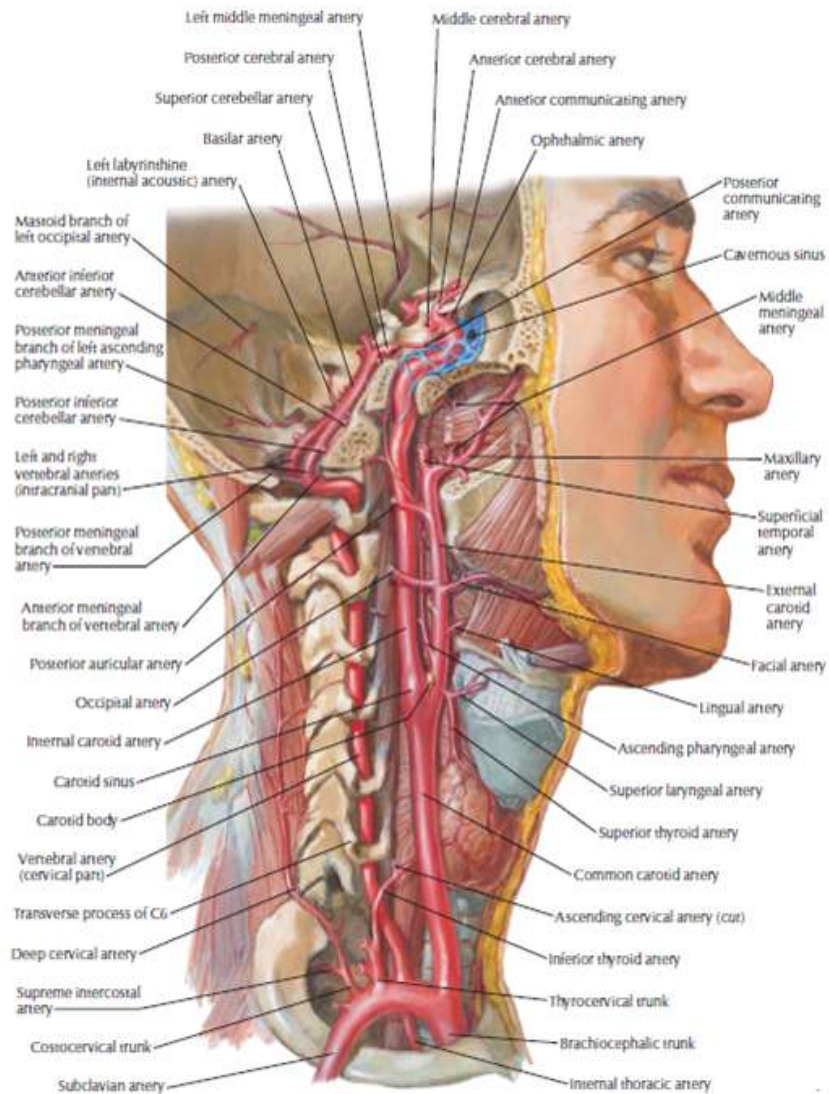
no branch in the neck.

❖ **Origin:** arises in the neck of terminal branches of the *common carotid artery.*

CCA (**at Bifurcation**), at the level of the upper border of the thyroid cartilage (**opposite the disc between C₃ & C₄**).

❖ **Function:** the ICA supplies structures in the orbit and a large part of the brain (**70- 80% of the brain blood supply**).

- Each ICA enters the skull through **the carotid foramen**.
- It gives **No branches** at the neck.



Branches of the Internal Carotid Artery

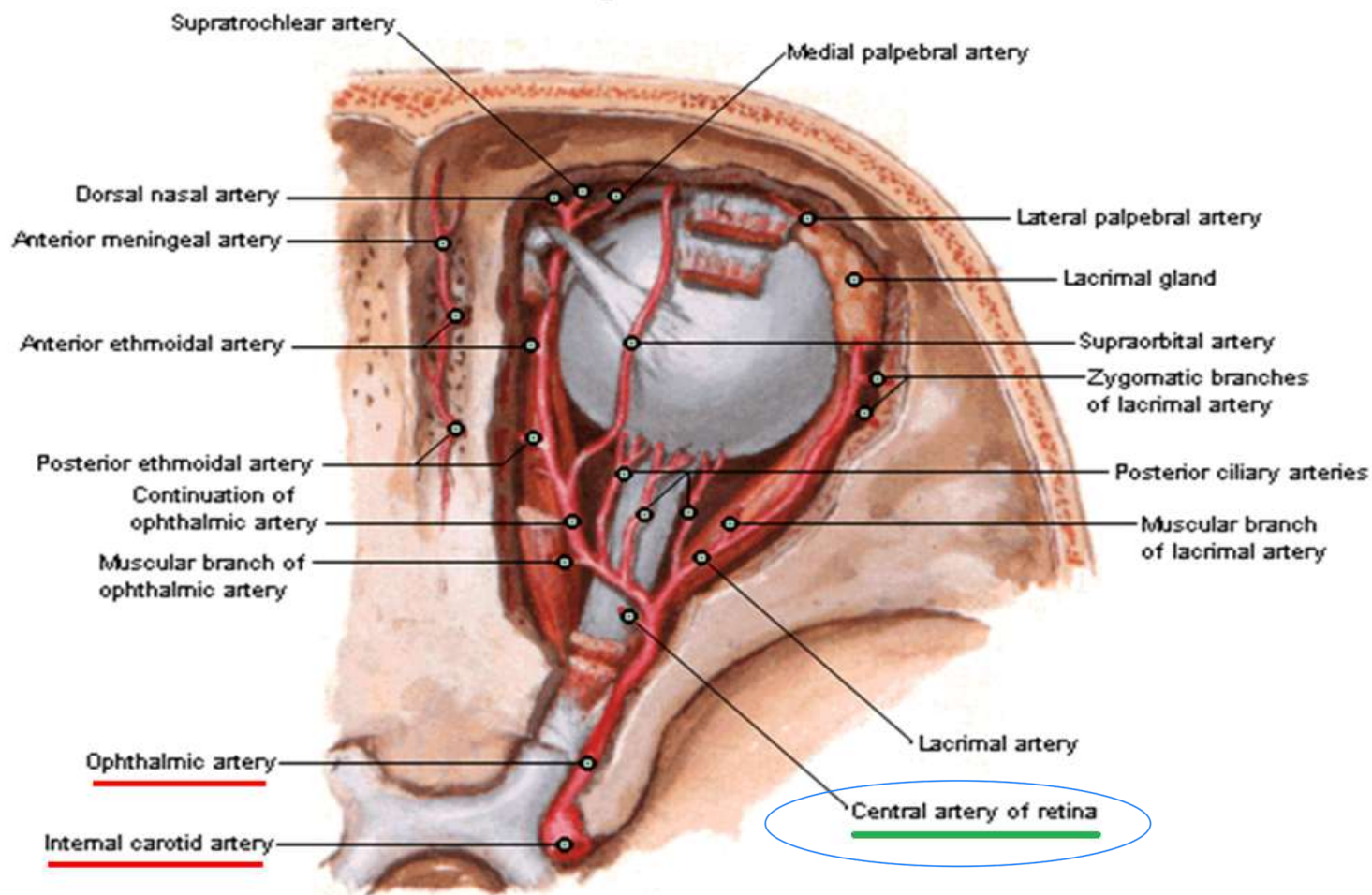
1. Ophthalmic artery. *to the eye and orbit content [nose] give central retinal Artery.*
2. Posterior communicating artery. *Join with post. cerebral Artery to form the circle of Wills.*
3. Anterior choroidal artery. *to choroidal plexus in ventricular system*
4. Anterior cerebral artery (ACA). *small medial Branch.*
5. Middle cerebral artery (MCA). *largest Branch of ICA
lateral Branch.*

1. Ophthalmic Artery

- *First Branch of ICA*
Ophthalmic artery which enters the orbit through the optic canal with the optic nerve.
- Supply the eye, orbit contents & gives *scalp and dorsal part of the nose.* **central retinal artery.**
- Also supply the frontal sinuses, part of frontal area of scalp and dorsal part of nose.
- Its occlusion results in **Ipsilateral Blindness.**
in central retinal Artery.

Arteries and Veins of Orbit and Eyelids

Superior View



2. Posterior Communicating Artery

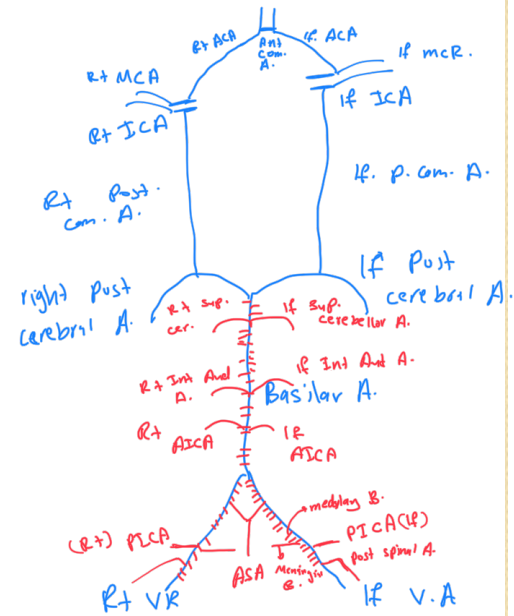
- The posterior communicating artery joins the **ICA** with the corresponding **posterior cerebral artery** to establish the circle of Willis.

□ It supplies:

- Optic tract and chiasma.
- Part of diencephalon.
- Walls of third ventricle.
- A common site of **Aneurysms**.

Top
lat. medullary syndrome
 PICA → PIC A syndrome
 Wallenberg's syndrome.

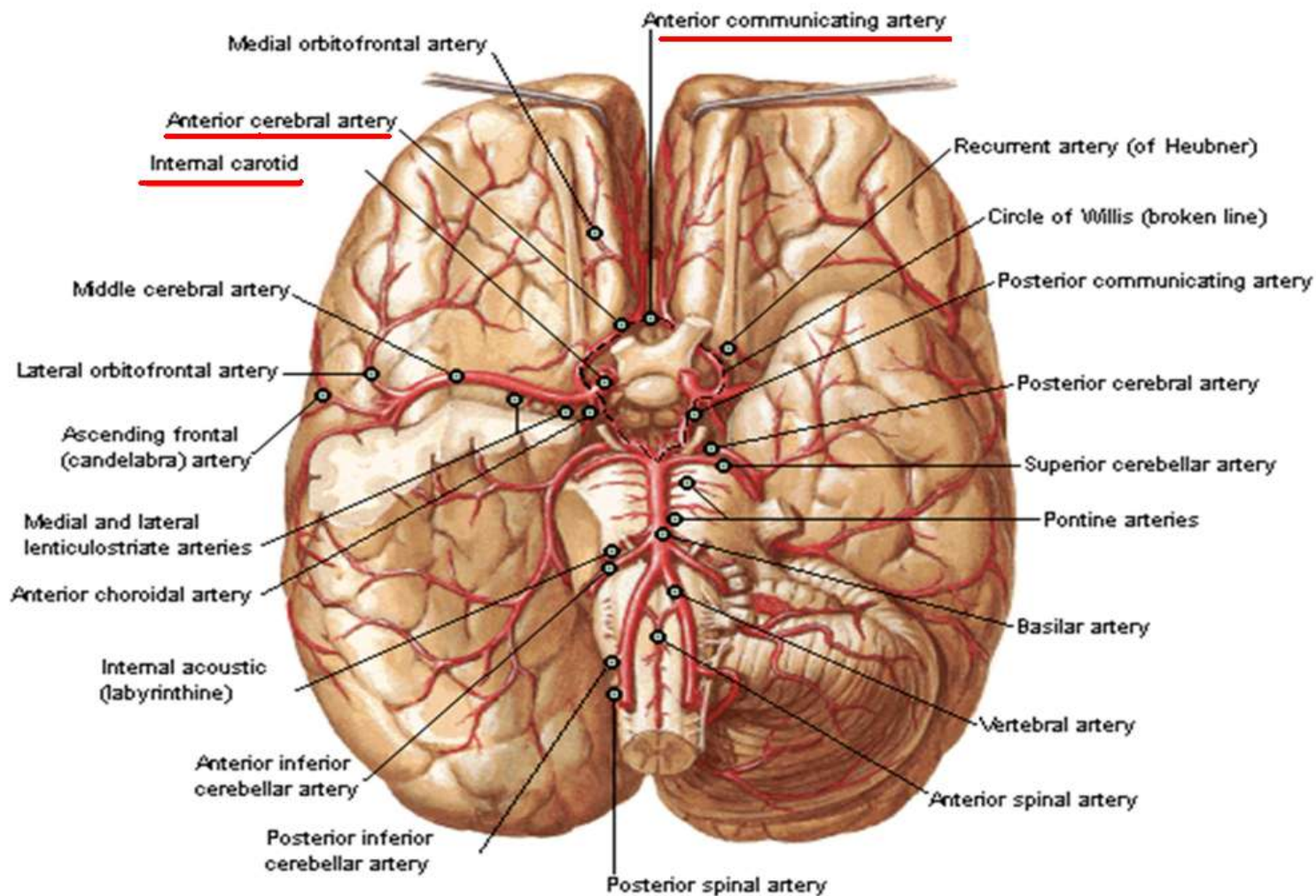
if there is dilatation



Cerebral Blood supply.

Arteries of Brain

Inferior View



3. Anterior Choroidal Artery

3rd Branch.

- **Origin:** from the ICA just before origin of the anterior & middle cerebral arteries.

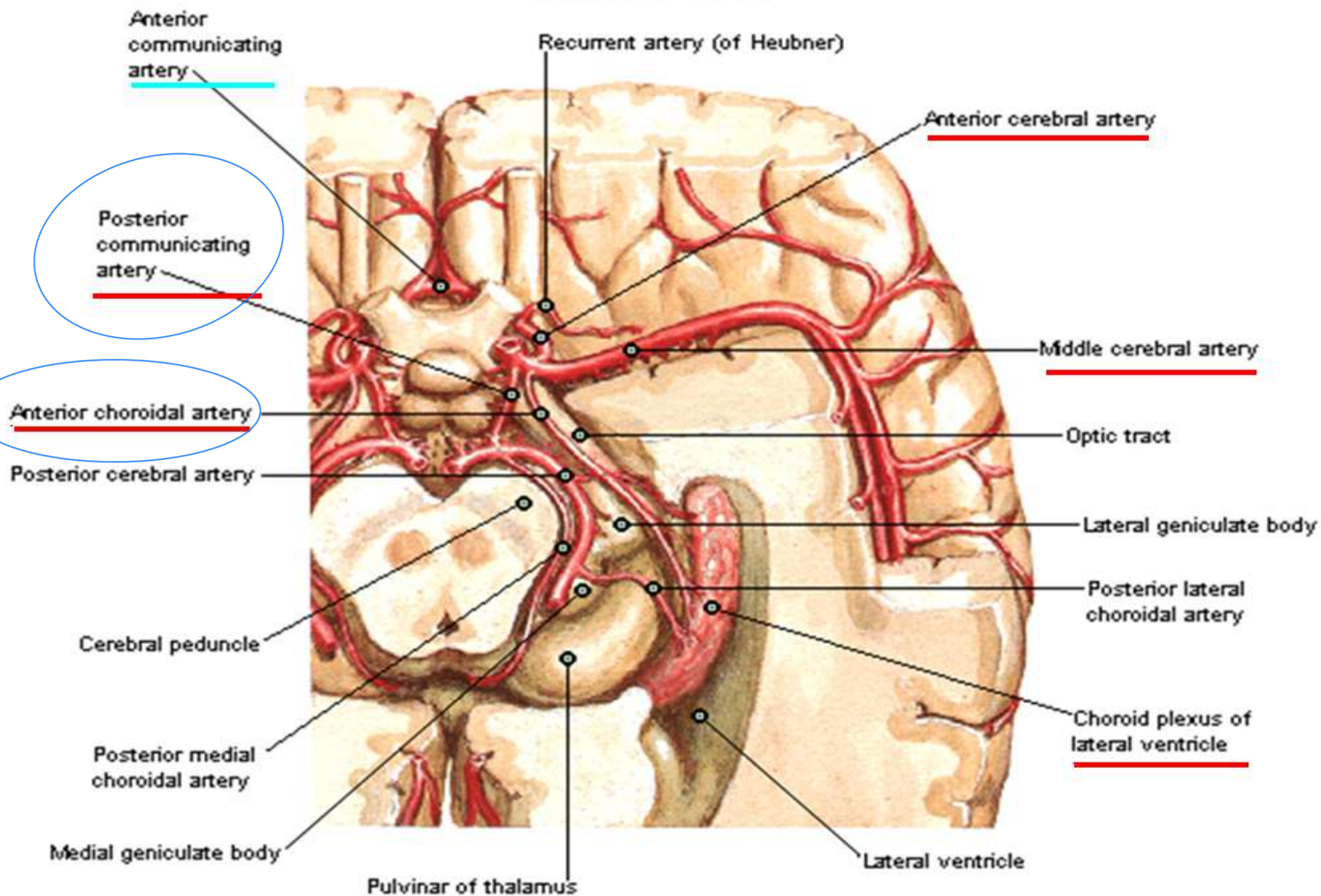
main functi:- Blood supply of choroid plexus of lat. and 3rd ventricle
production of CSF

- **It supplies:**

- Choroid plexus of the lateral and third ventricles.
- Optic tract and optic chiasma.
- Hippocampus, tail of caudate nucleus, amygdaloid nucleus, globus pallidus and crus cerebri.
- Lateral geniculate body.
- Posterior limb of internal capsule.

Arteries of Brain [Continued]

Inferior View



4. Anterior Cerebral Artery (ACA)

- It is the smaller terminal branch of the ICA.
- It runs forward and joins the ACA of the opposite side by the **anterior communicating artery (the commonest site of Aneurysms)**.

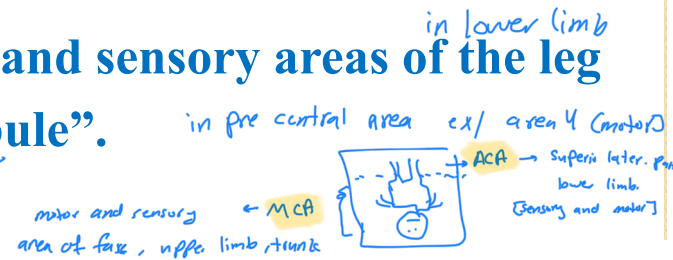
□ Branches of the ACA:

1. **Cortical branches.**
2. **Central branches (Striate arteries).**

Territory of Anterior Cerebral Artery (ACA)

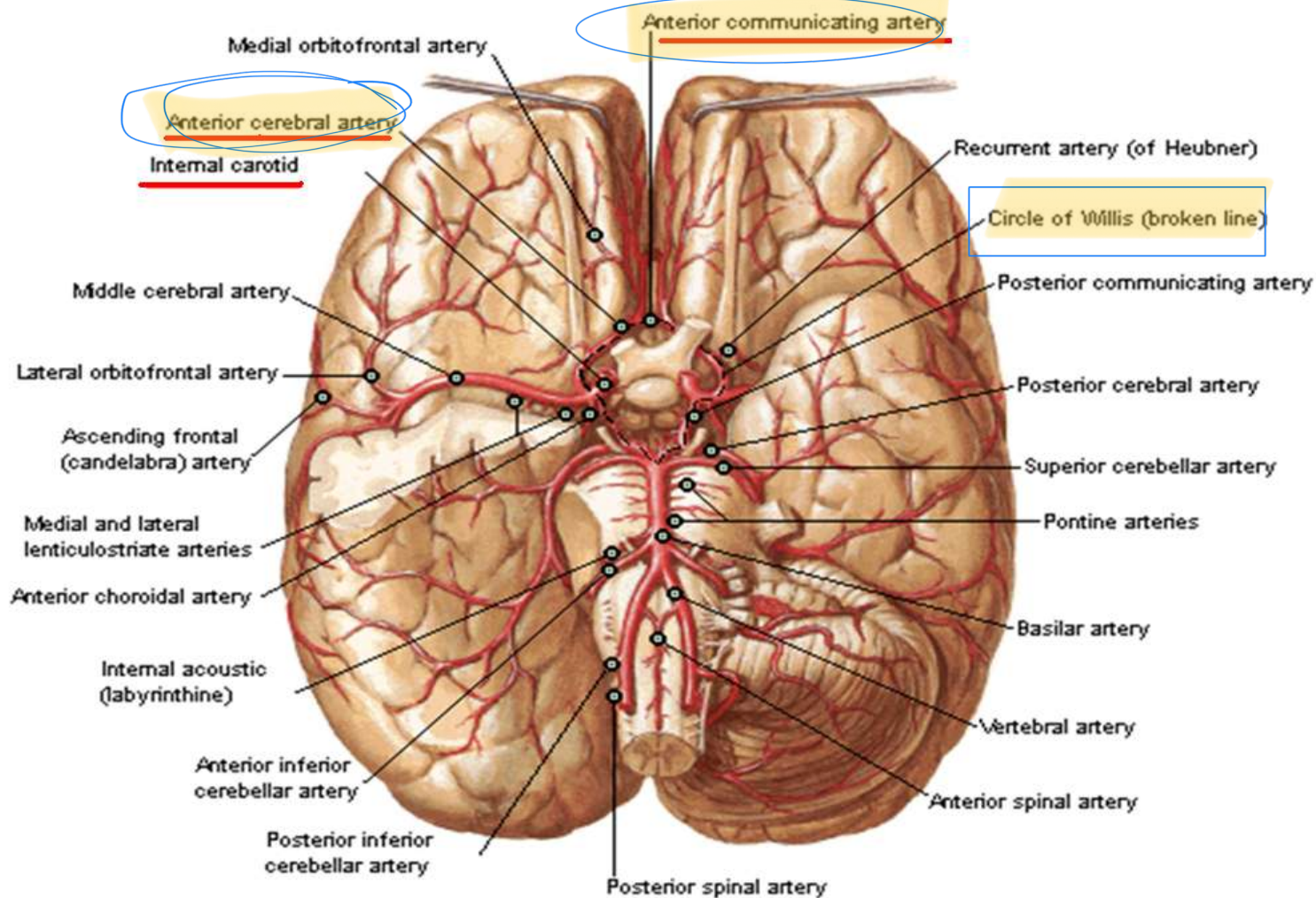
- Medial surface of the cerebral hemisphere from frontal pole to the parieto-occipital sulcus.
- Medial 1/3 of the orbital surface of the frontal lobe.
- Superior lateral surface of cerebral hemisphere (**except occipital lobe**).
- Anterior part of lentiform nucleus.
- Head of caudate nucleus.
- Supplies part of the corpus striatum and the anterior limb of the internal capsule via the **medial striate artery (of Heubner)**.

N.B.: The ACA supplies motor and sensory areas of the leg and foot “paracentral lobule”.



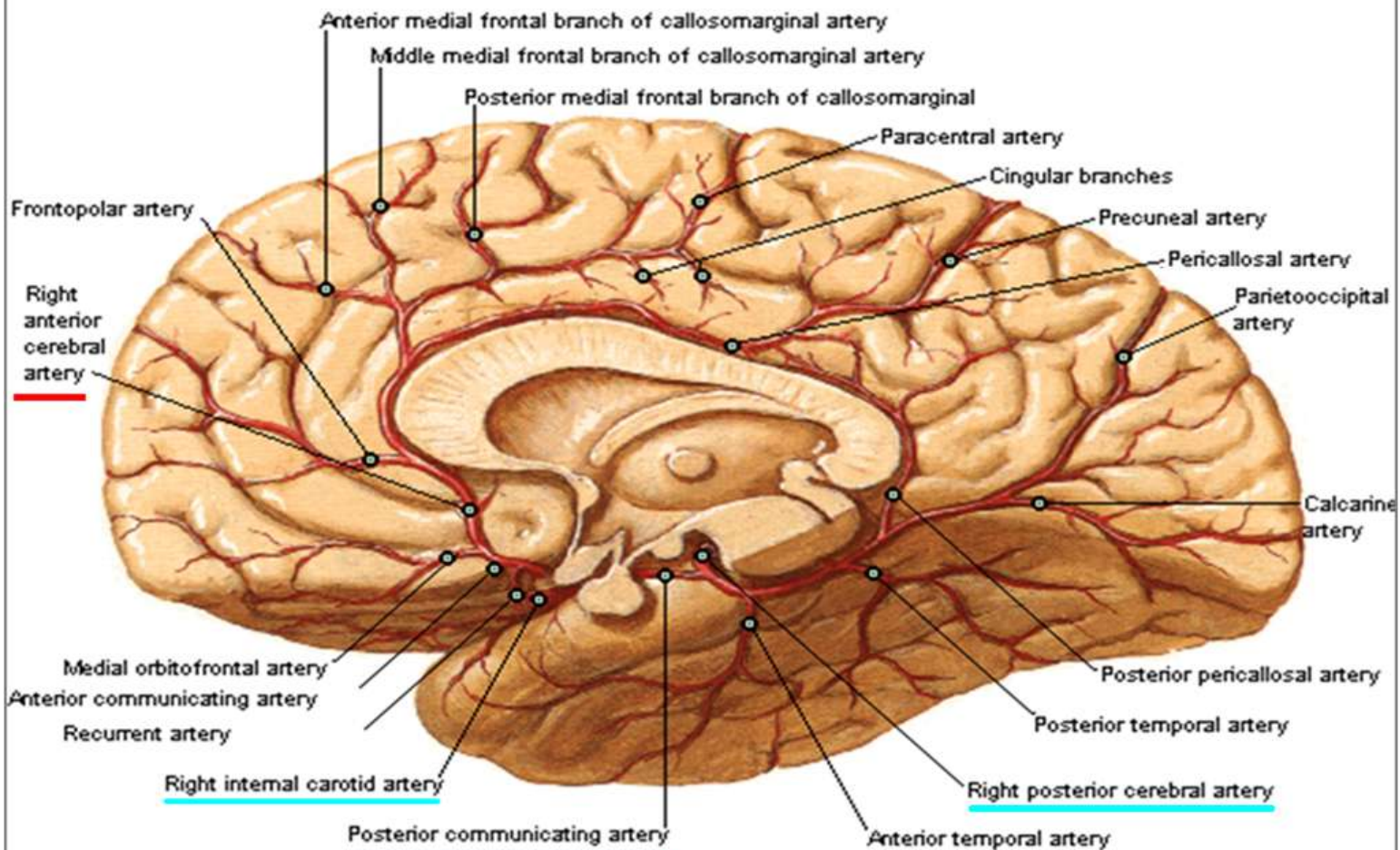
Arteries of Brain

Inferior View



Arteries of Brain

Medial View

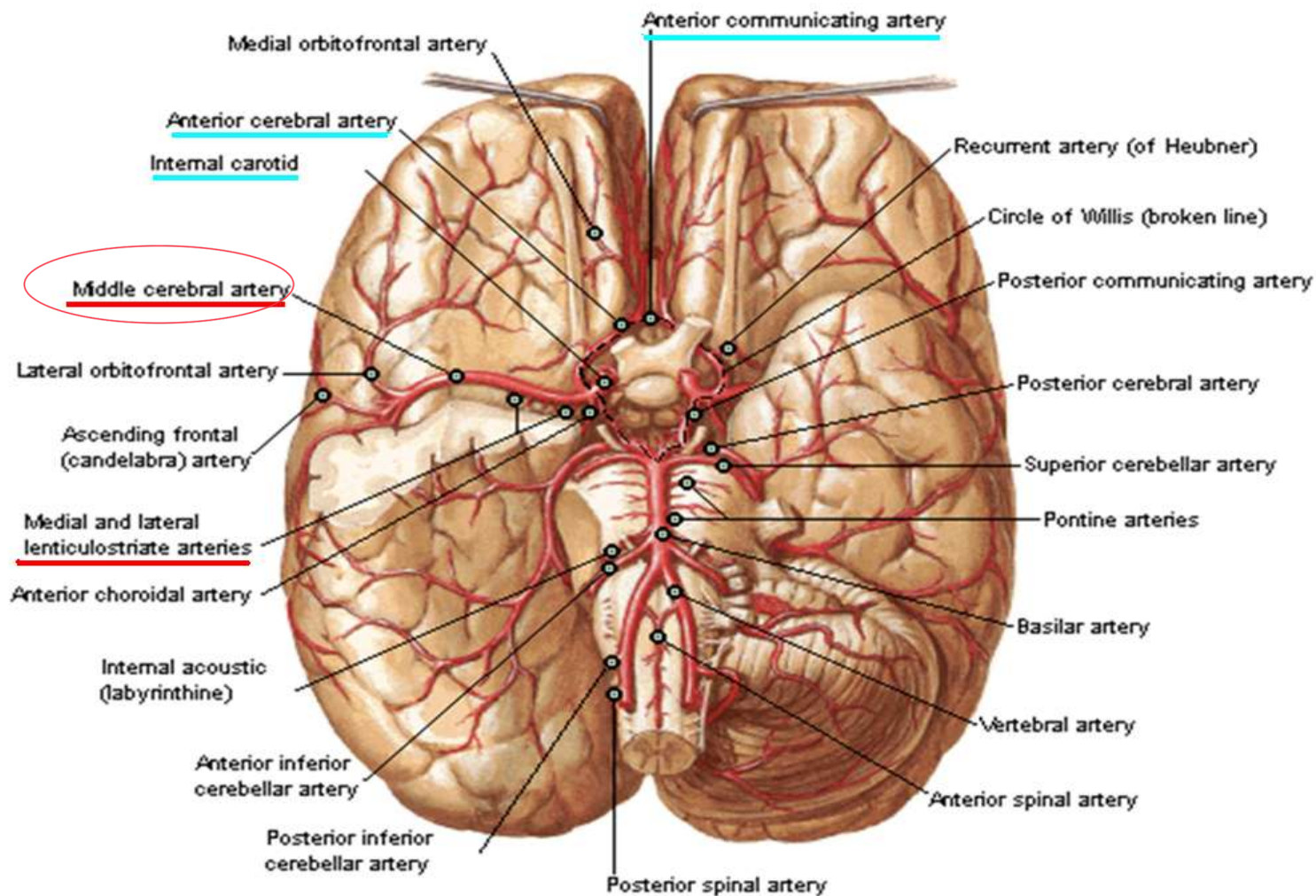


5. Middle Cerebral Artery (MCA)

- ❖ The lateral branch as the **largest of the 2 terminal branches** of ICA. *medial sulcus 10 JP 28*
- ❖ It pass laterally in the stem of **the lateral sulcus.**
- ❖ It turns backwards and upwards in the posterior ramus of the lateral sulcus.
- ❖ Finally it divides into:
 - **Cortical branches.** *superficial*
 - **Central branches.** *deep*

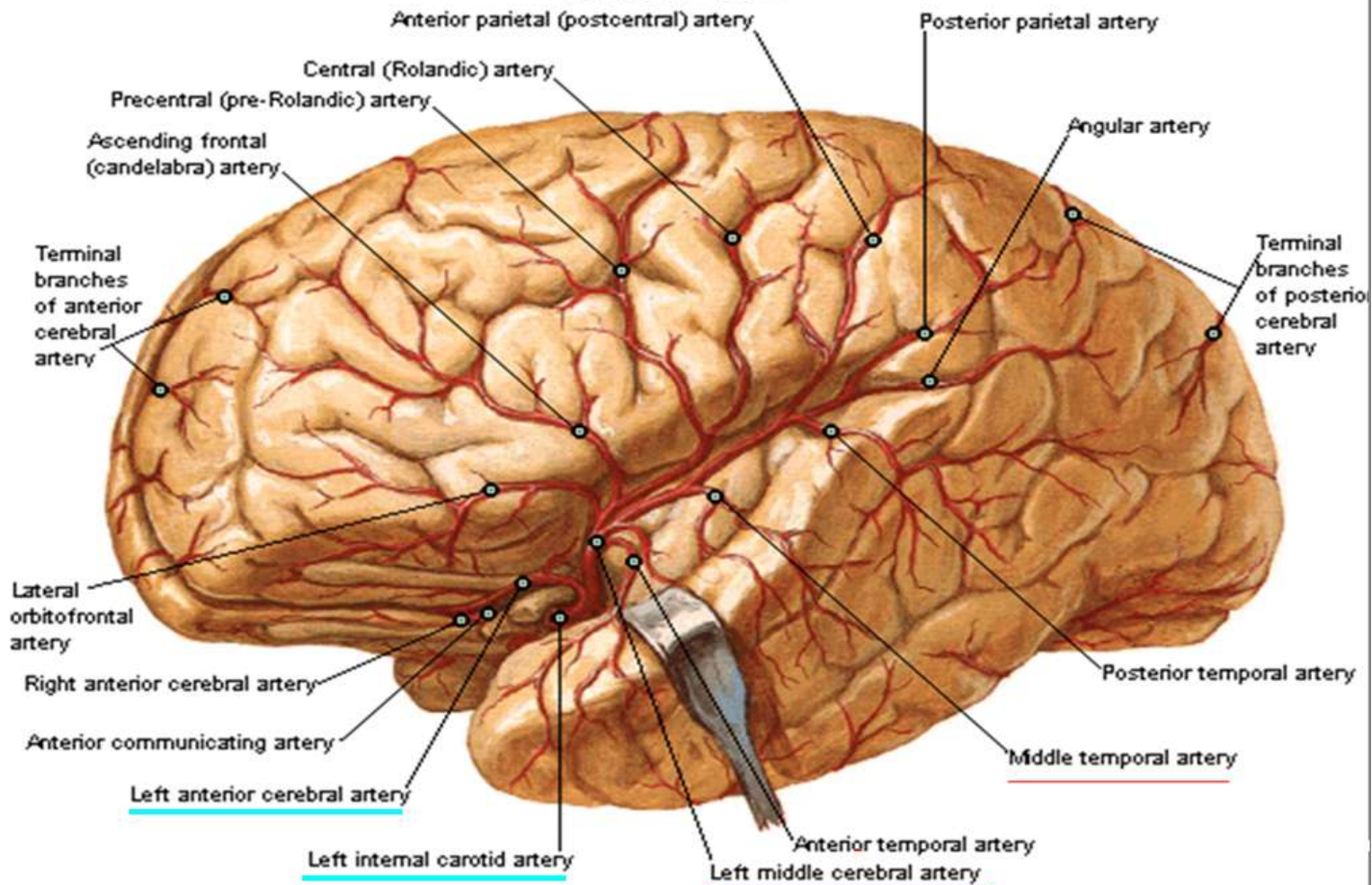
Arteries of Brain

Inferior View



Arteries of Brain

Lateral View



Territory of Middle Cerebral Artery (MCA)

1. Cortical branches: **supply:**

- Lateral 2/3 of the orbital part of frontal lobe.
- Temporal pole and insula.
- Most of the lateral surface of cerebral hemisphere
 - Except:**
 - ^{superior lateral} **The upper part (superior inch):** supplied by the **ACA**.
 - ^{inferior temporal} **Lower part of temporal lobe:** supplied by the **PCA**.
 - **Occipital lobe:** supplied by the **PCA**.
 - **Supplies the trunk, arm, and face areas of the cortical motor and sensory areas.**

2. **Central Branches:** are many branches called **striate arteries:**

^{short}
a. **Medial striate arteries:** **supply:**

- Posterior part of lentiform nucleus.
- Body of caudate nucleus.
- The most of the internal capsule (posterior limb, genu, and posterior part of anterior limb).

^{long}
b. **Lateral striate arteries:** **supply:**

- Corpus striatum (lentiform & caudate).
- Most of the internal capsule.
- One of these arteries is large and is liable to hemorrhage it is called **the artery of cerebral hemorrhage (Charcot's artery)**.

গড় গড়ের দাঁ :- faciobrachial type of
hemi plegia
affect the face and
upper limb more than lower
limb.
ACA like & MCA like

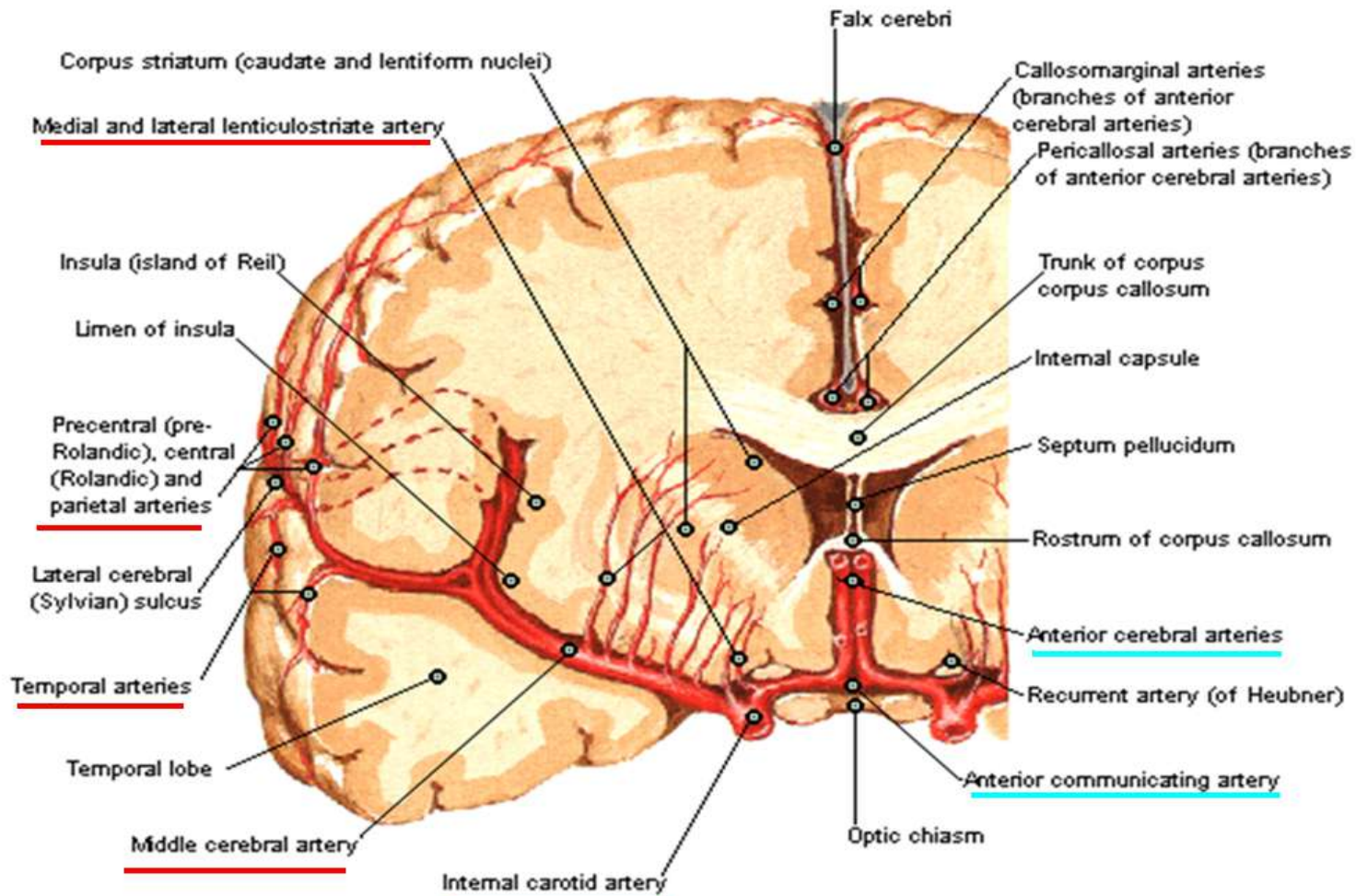
in BP

→ 70% of hemorrhage occur in basal nuclei..

SM thin. lead to rupture
of A. when there is ↑ BP.

Arteries of Brain

Frontal Section



II. The Vertebrobasilar System

A. Vertebral Artery

- **Origin:** each vertebral artery arises from the first part of subclavian artery.

- Supplies structures of the brain (20- 30% of the brain blood supply).

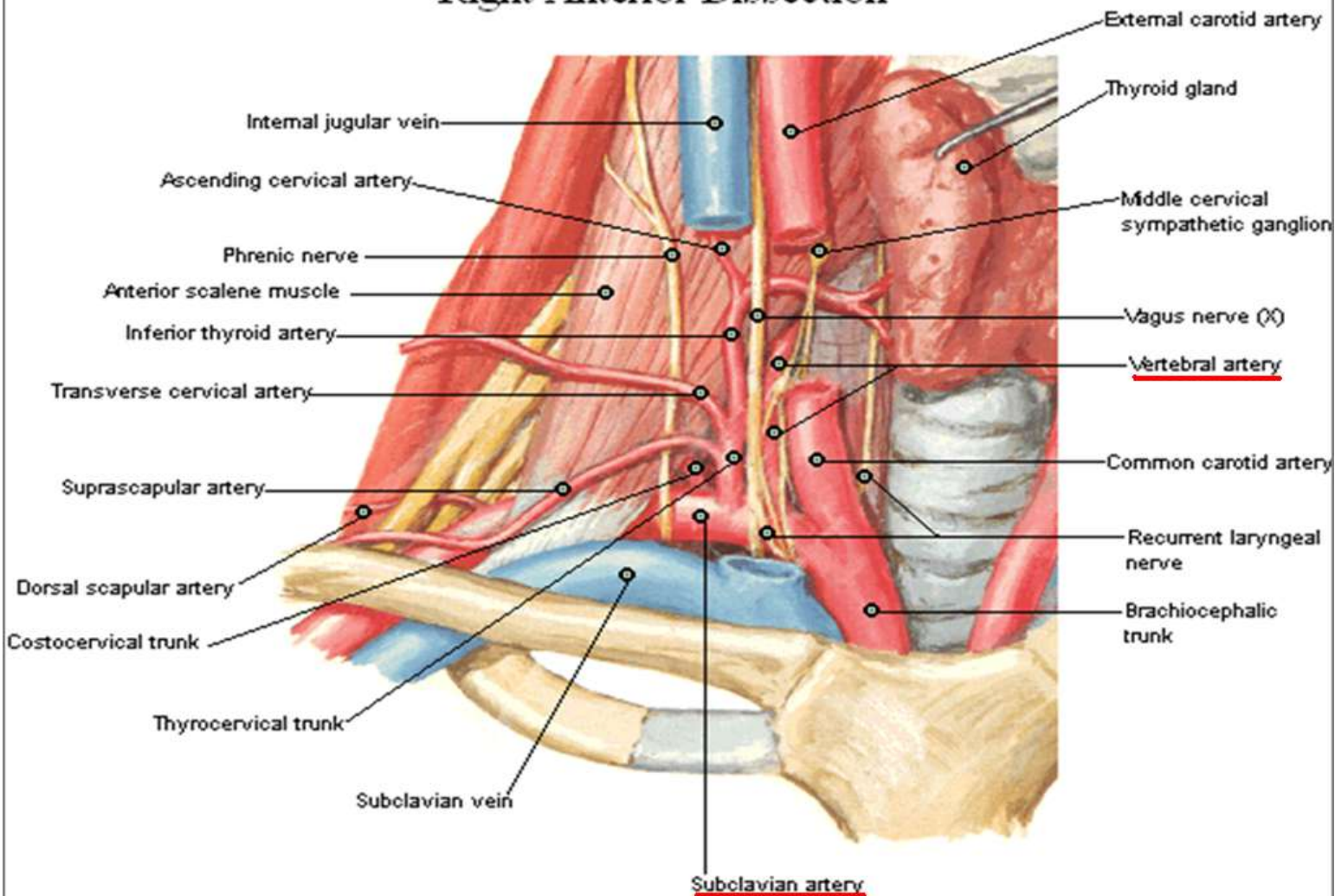
- **Course:**

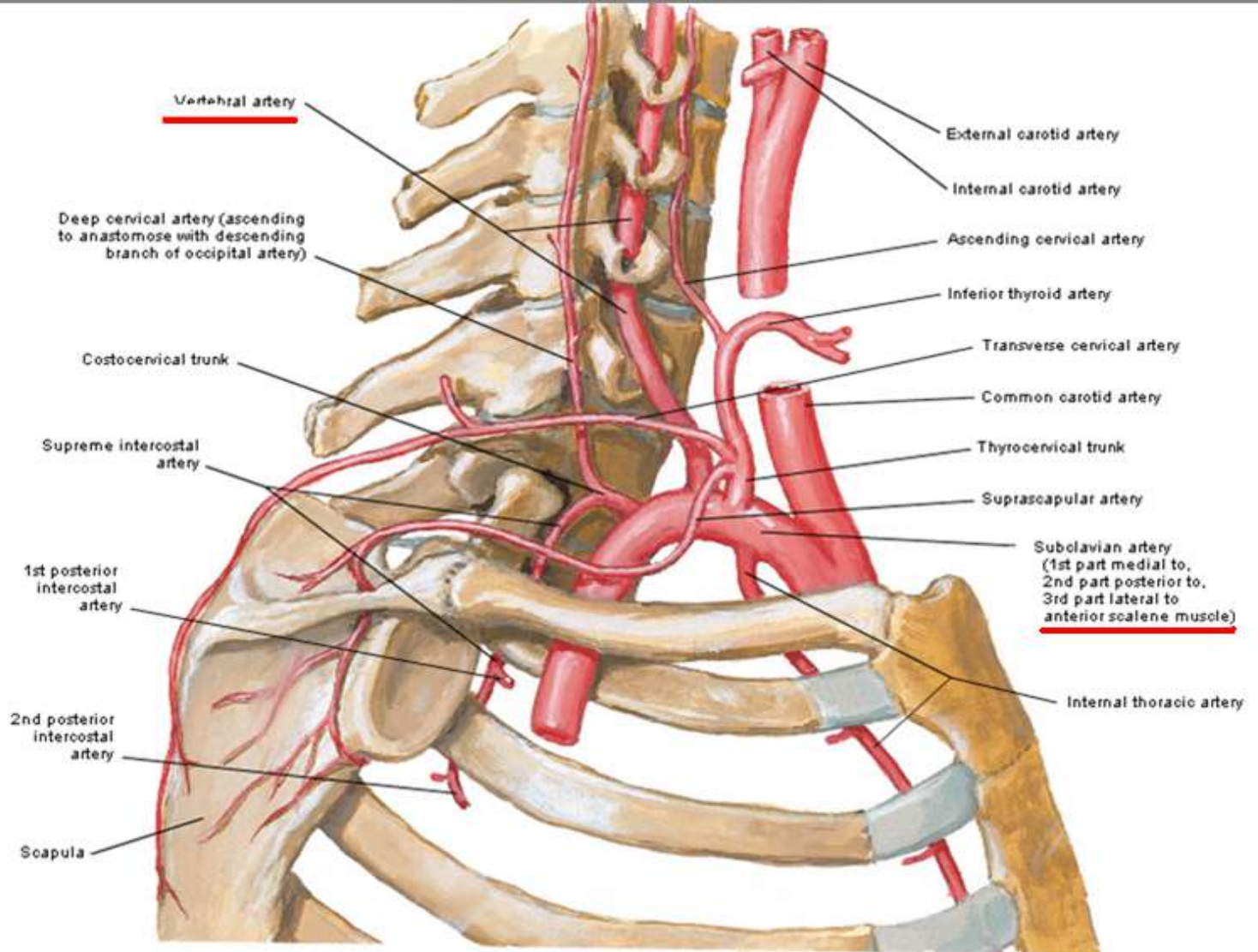
From subclavian artery → then passes ^{ascend} upwards through the transverse foramina of the upper 6 cervical vertebrae → ^{transverse} foramen magnum → they pass upward and medially in front of the medulla oblongata → ^{Join together} at the lower border of pons two vertebral arteries unite to form the single

Basilar Artery. ^{Lies} end by Post. cerebral A.

Subclavian Artery

Right Anterior Dissection





Branches of the Vertebral Artery

1. **The meningeal branches:** are small and supply the bone and dura in the posterior cranial fossa.
2. **Posterior spinal arteries:** may arise from the posterior inferior cerebellar artery.
3. **Anterior spinal artery:** it unites with the other one to form the one anterior spinal artery.
4. **Medullary branches:** supply the ventral part of medulla oblongata.
5. **Posterior inferior cerebellar artery.**

→ ant. cord syndrome if there is occlusion in the A. SA

Posterior Inferior Cerebellar Artery (PICA)

□ The largest branch of vertebral artery.

• It supplies the:

• Posterior part of inferior surface of cerebellum.

• Inferior cerebellar peduncle.

• Posteriolateral part of medulla oblongata.

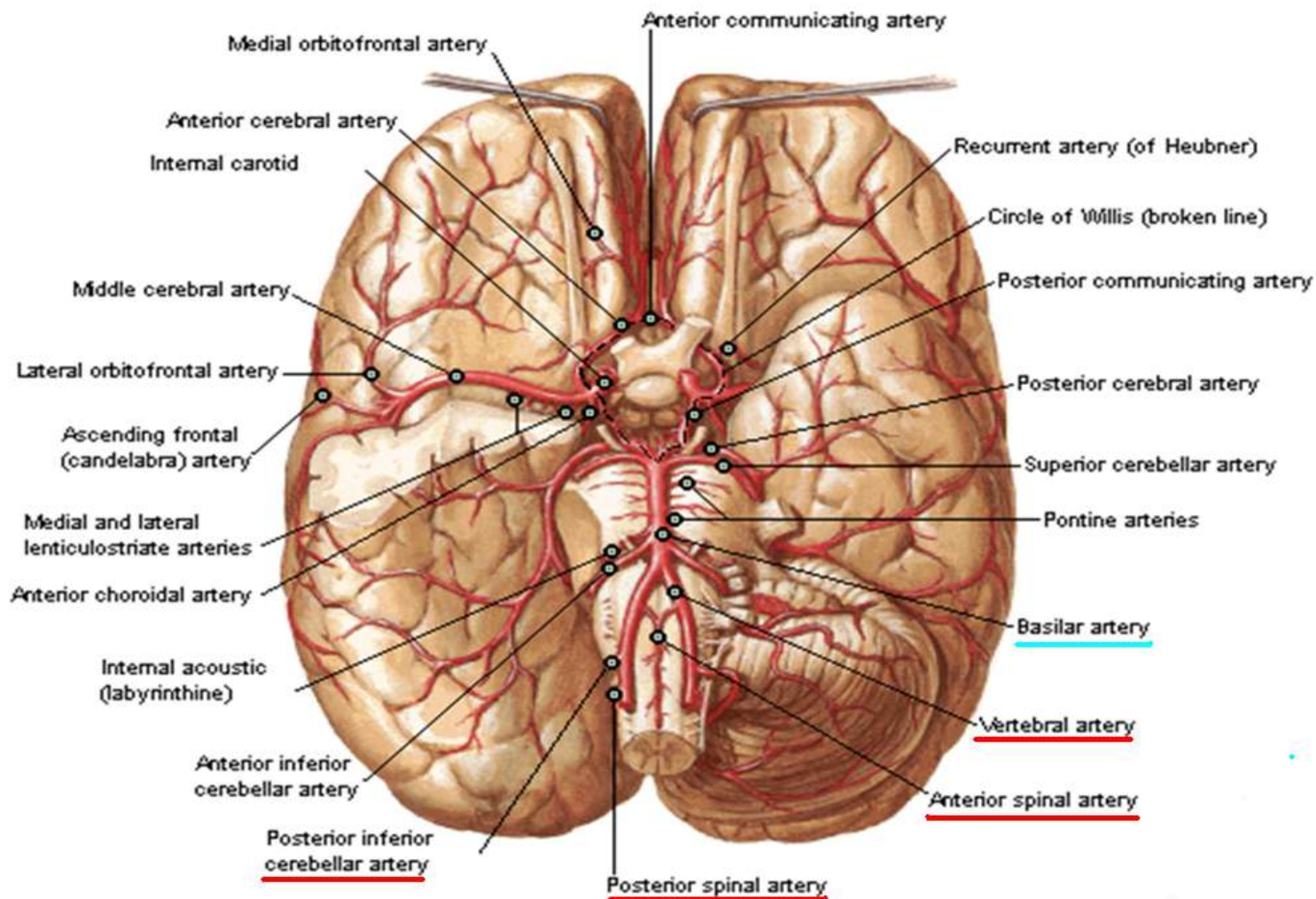
• Choroid plexus of 4th ventricle.

❖ Occlusion of this artery leads to lateral medullary syndrome (Wallenberg's syndrome).

→ medial medullary syndrome due to occlusion of one of the origin of the ASA.

Arteries of Brain

Inferior View



single Basilar Artery

in ear

- **Origin:** at the lower border of pons by the union of the two vertebral arteries.
- It ascends along the basilar groove in front of the pons.
- **Termination:** at the upper border of the pons by dividing into two terminal branches (posterior cerebral arteries).
- It lies medial to the abducent and oculomotor nerves.

Branches of the Basilar artery

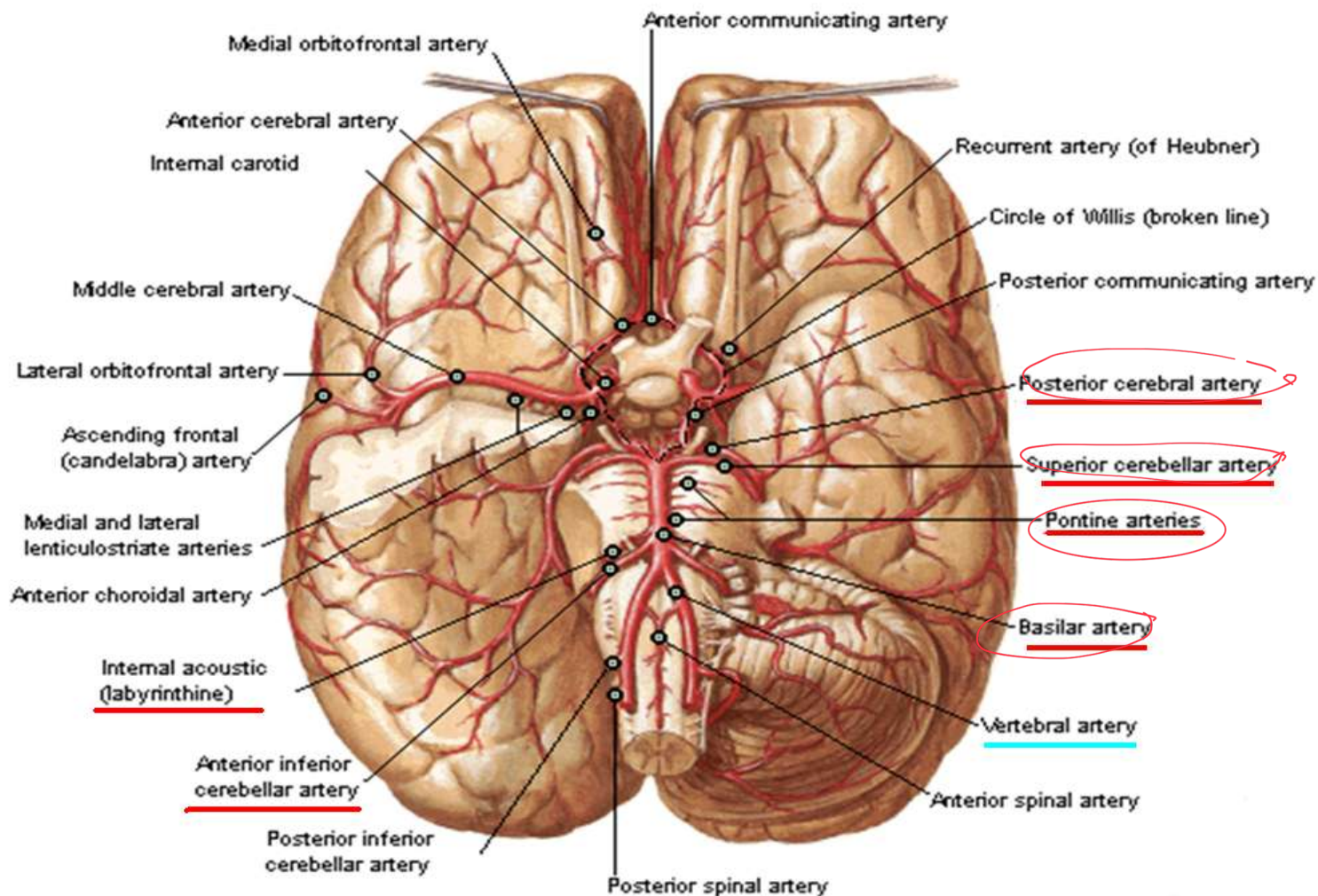
AICA

1. **Anterior inferior cerebellar artery:** supplies the anterior part of inferior surface of the cerebellum.
2. **Internal auditory (labyrinthine) artery:** it arises either from basilar or anterior inferior cerebellar arteries. Supplies the inner ear.
3. **Pontine (paramedian) branches:** are small branches to supply the pons.
4. **Superior cerebellar artery:** the oculomotor nerve separates it from the posterior cerebral artery. Supplies the superior surface of cerebellum, superior cerebellar peduncle, pons and midbrain.
cranial nerve number 3
5. **Posterior cerebral artery:** terminal branches.
firm nerve pulse ← aneurysm 90° to sup. 1st, post 1st

middle post. > double blood supply → 1st macula 1st area 1st spearing.
↳ if there is occlusion lead to :- Contra lateral hemiparesis with macular sparing.

Arteries of Brain

Inferior View

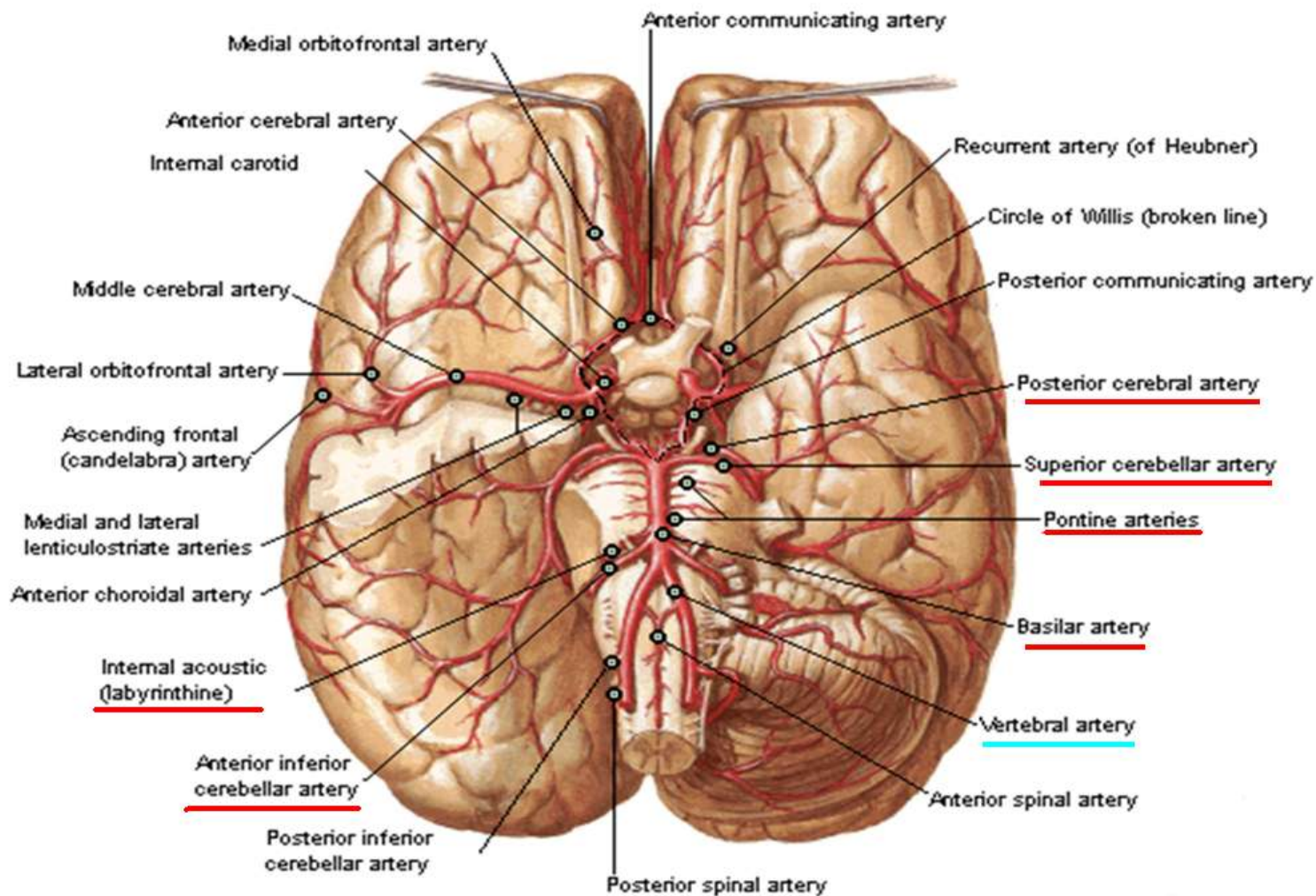


Posterior Cerebral Artery (PCA)

- It is the largest and terminal branches of the basilar artery at the upper border of the pons.
- It is separated from the superior cerebellar artery by **the oculomotor nerve.**
- Connects with the ipsilateral ICA by **the posterior communicating artery.** *to form the circle of will*

Arteries of Brain

Inferior View



Branches of Posterior Cerebral Arteries

1.

Cortical Branches:

if there is damage lead to contralateral hemiparesis with macular sparing

- Inferiolateral part of temporal lobe.
- Occipital lobe "Visual cortex".

2. Central Branches:

- Supply parts of the thalamus, medial geniculate body, splenium of the corpus callosum, lentiform nucleus, midbrain, and pineal body.

3. Posterior Choroidal Arteries:

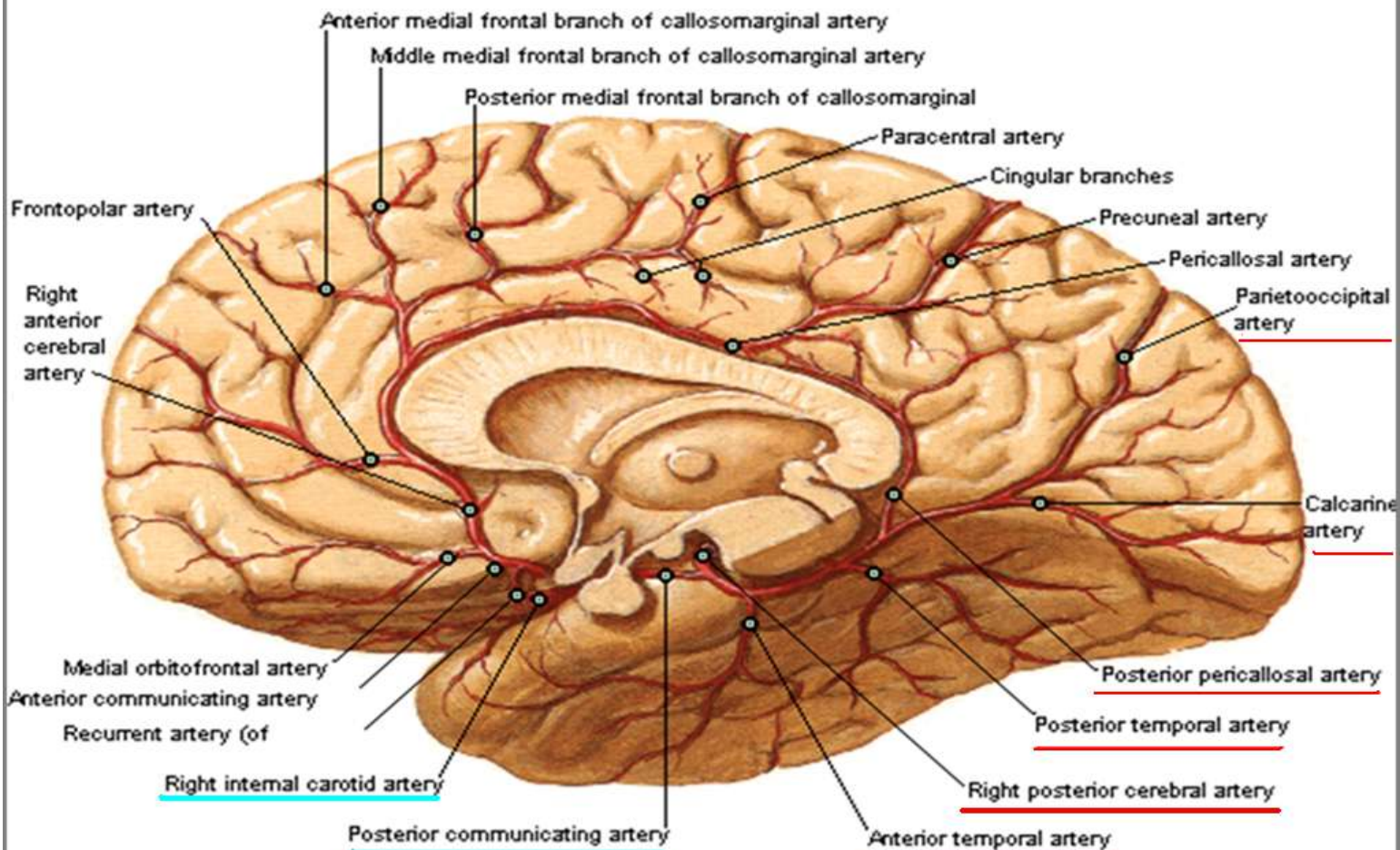
Visual cortical area

- supply the choroid plexus of the lateral and third ventricles.

middle 1) macula 2) 2

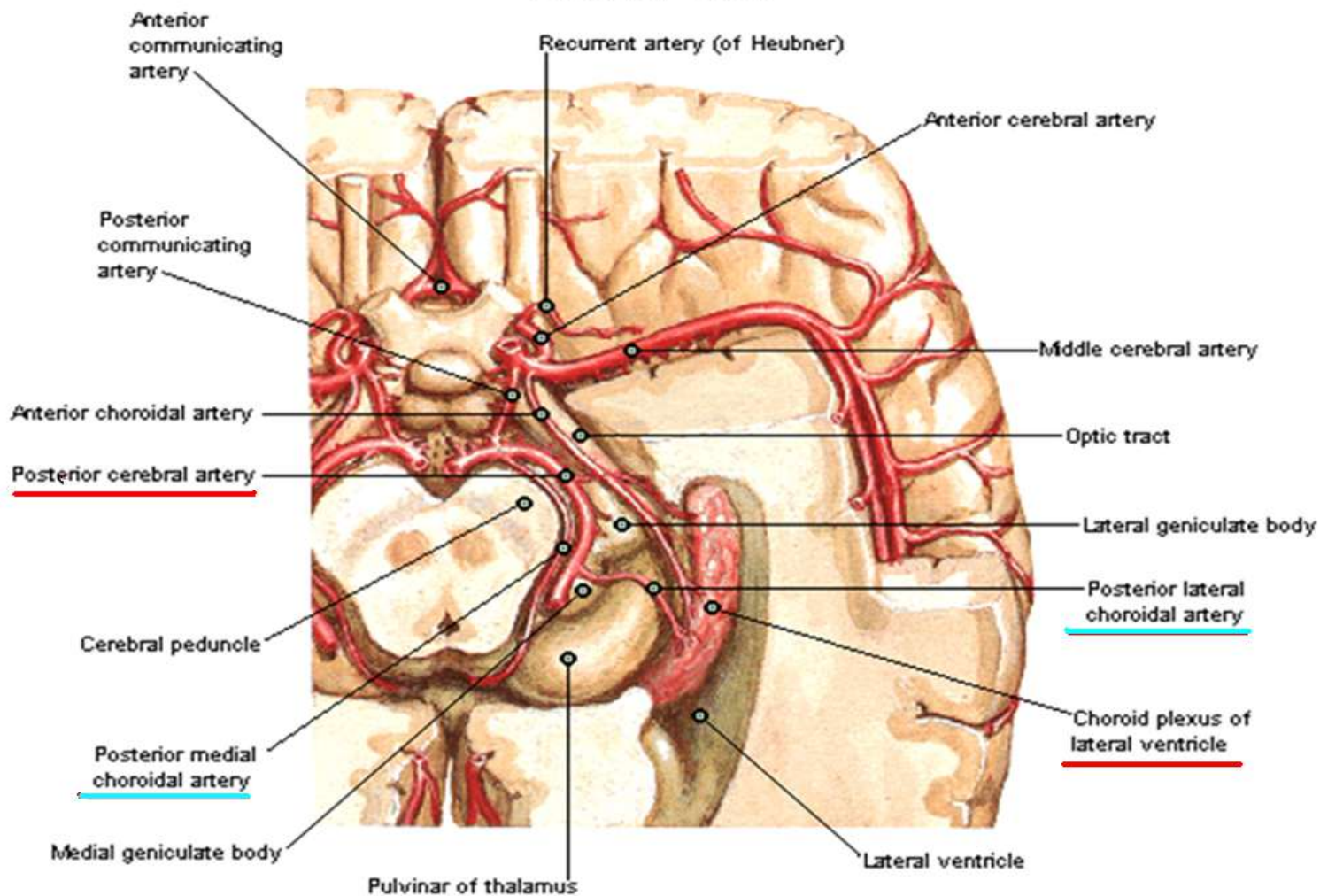
Arteries of Brain

Medial View



Arteries of Brain [Continued]

Inferior View



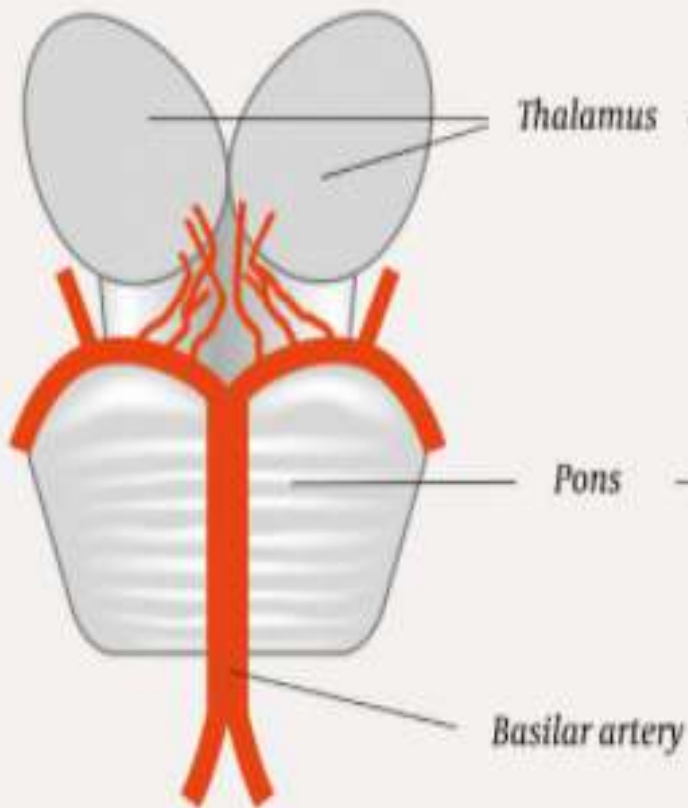
note

single A. supply both. RA, LF thalamus.

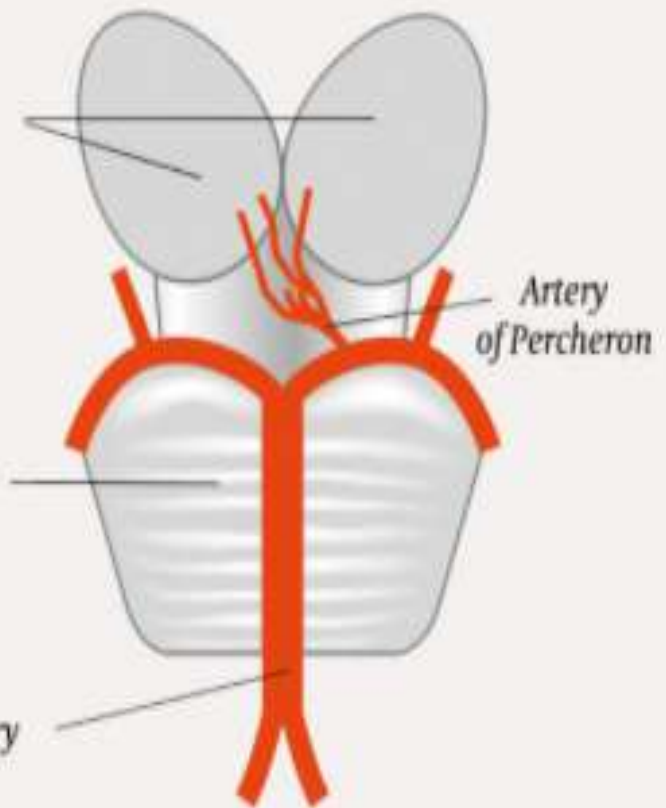
The **artery of Percheron** is a rare anatomical variation in the brain vascularization in which a single arterial trunk arises from the PCA to supply **both** sides of the thalamus and midbrain.

*bilateral infarction in thalamus
A. of percheron is distinctive*

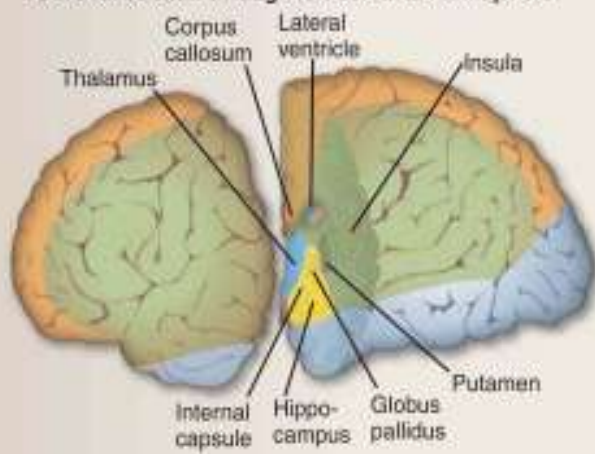
Normal anatomy



Anatomy with artery of Percheron



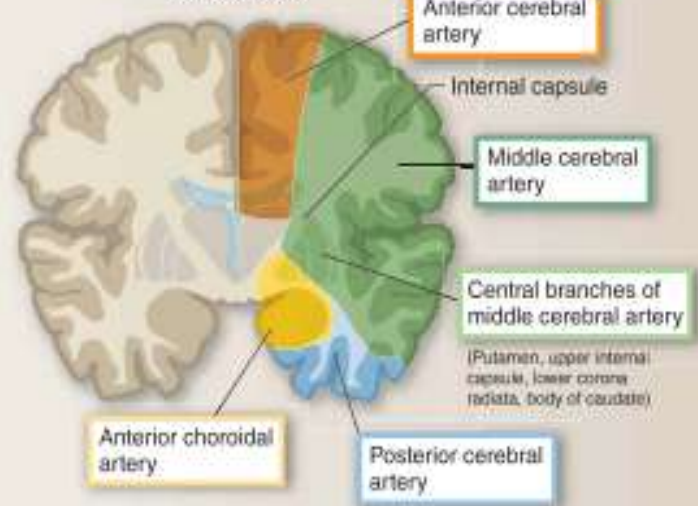
Lateral view **Coronal section through left cerebral hemisphere**



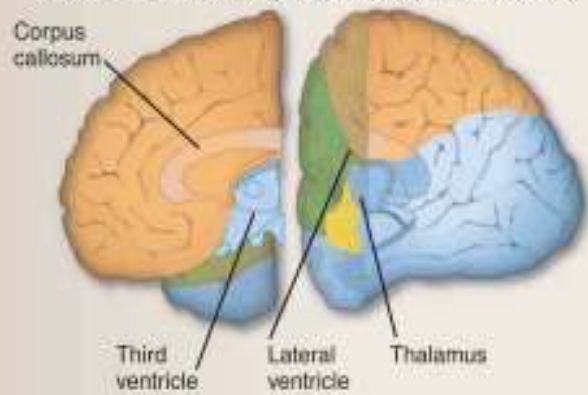
Arteries



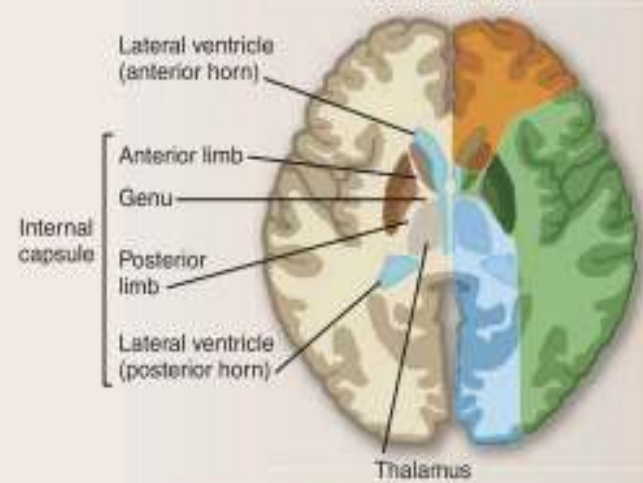
Coronal view



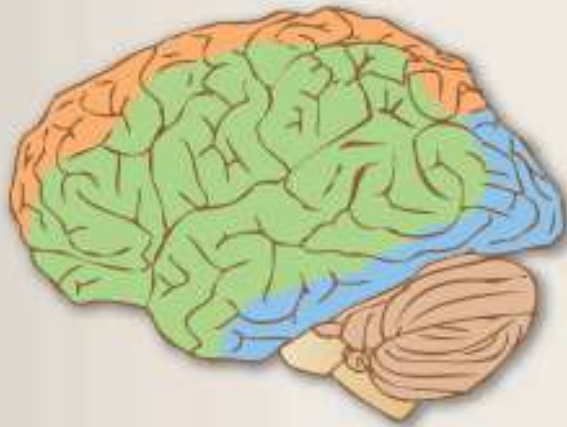
Medial view **Coronal section through right cerebral hemisphere**



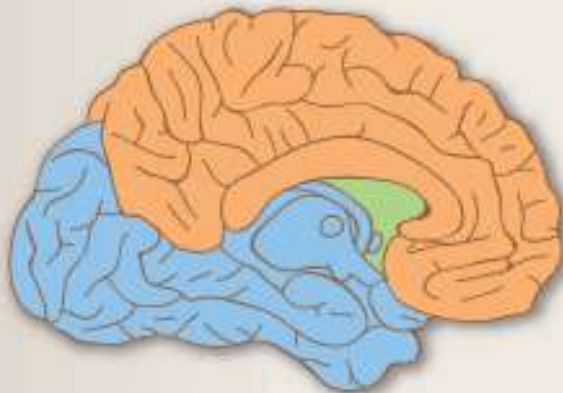
Horizontal view



Lateral view of left hemisphere



Medial view of left hemisphere

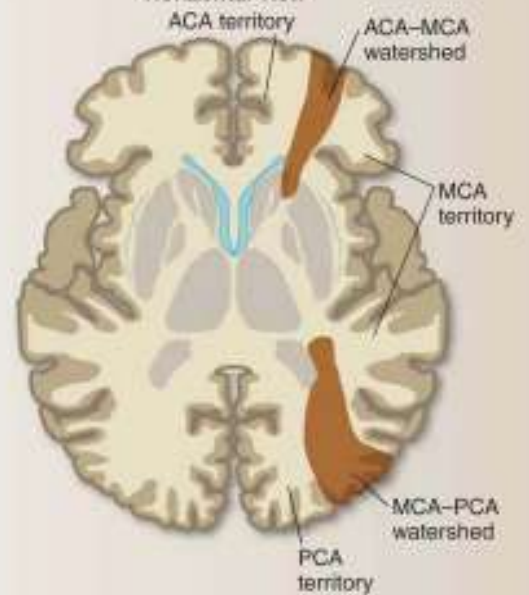


MCA

ACA

PCA

Horizontal view



Inferior view



Circle Of Willis

❖ **Definition:** it is an arterial anastomoses between **the** ^{Basilar} vertebral and ^{system} internal carotid arteries of both sides).

❖ It lies in the interpeduncular fossa at the base of the brain

❖ **Function:**

- Direct blood to other branches in cases of occlusion.
- Connect carotid system with vertebrobasilar system.

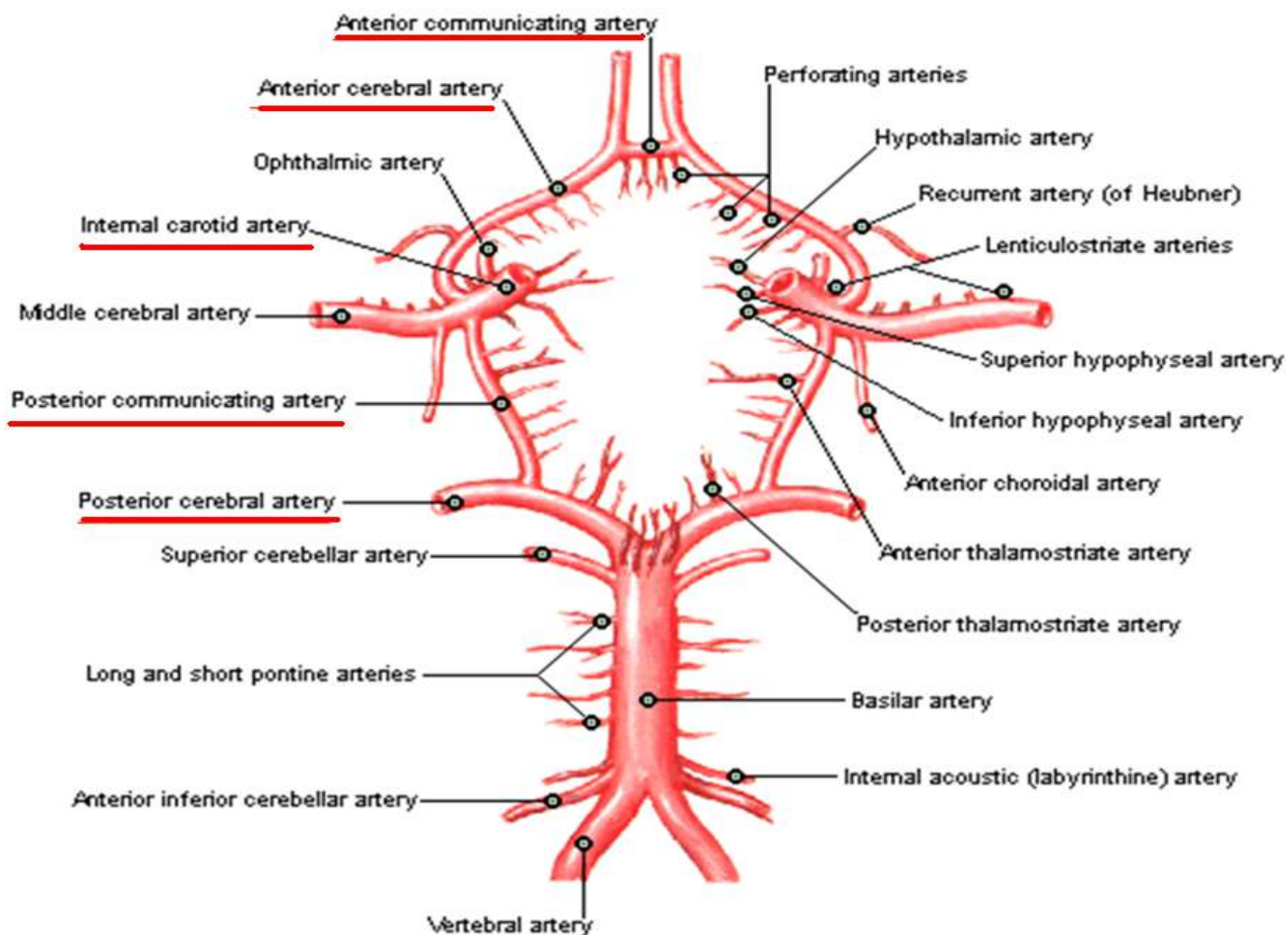
Circle Of Willis

[10A]

- ✓ 1. Anterior communicating artery.
- ✓ 2. Right & left of ACA.
- ✓ 3. Right & left ICA.
- ✓ 4. Right & left posterior communicating arteries.
- ✓ 5. Right & left PCA.
- ✓ 6. Basilar artery.

Circle of Willis - Vessels Dissected Out

Inferior View



The Important Anastomoses Between the Cerebral Arteries

1. Anastomoses between the branches of the cerebral arteries on the surface of the cerebral hemisphere.
2. The circle of Willis: between ICA and vertebro-basilar system.
3. Anastomoses between the branches of the internal and external carotid arteries:
 - a. Anastomoses between the branches of the ophthalmic artery with the facial and maxillary^{ECA} arteries.
 - b. Anastomoses between the meningeal branches of the internal carotid artery with middle meningeal branch of maxillary artery.

Venous Drainage

A.

^{external}
Superficial cerebral veins: laceration of these vessels results in subdural hemorrhage (hematoma).

B.

Deep cerebral veins.

C.

Dural Cerebral Sinuses. ex/ superior sagittal inf. cavernous.

→ dural mater is thick memb. 2 layers for protection function
* form cerebral dural venous sinus between 2 layers of dural mater

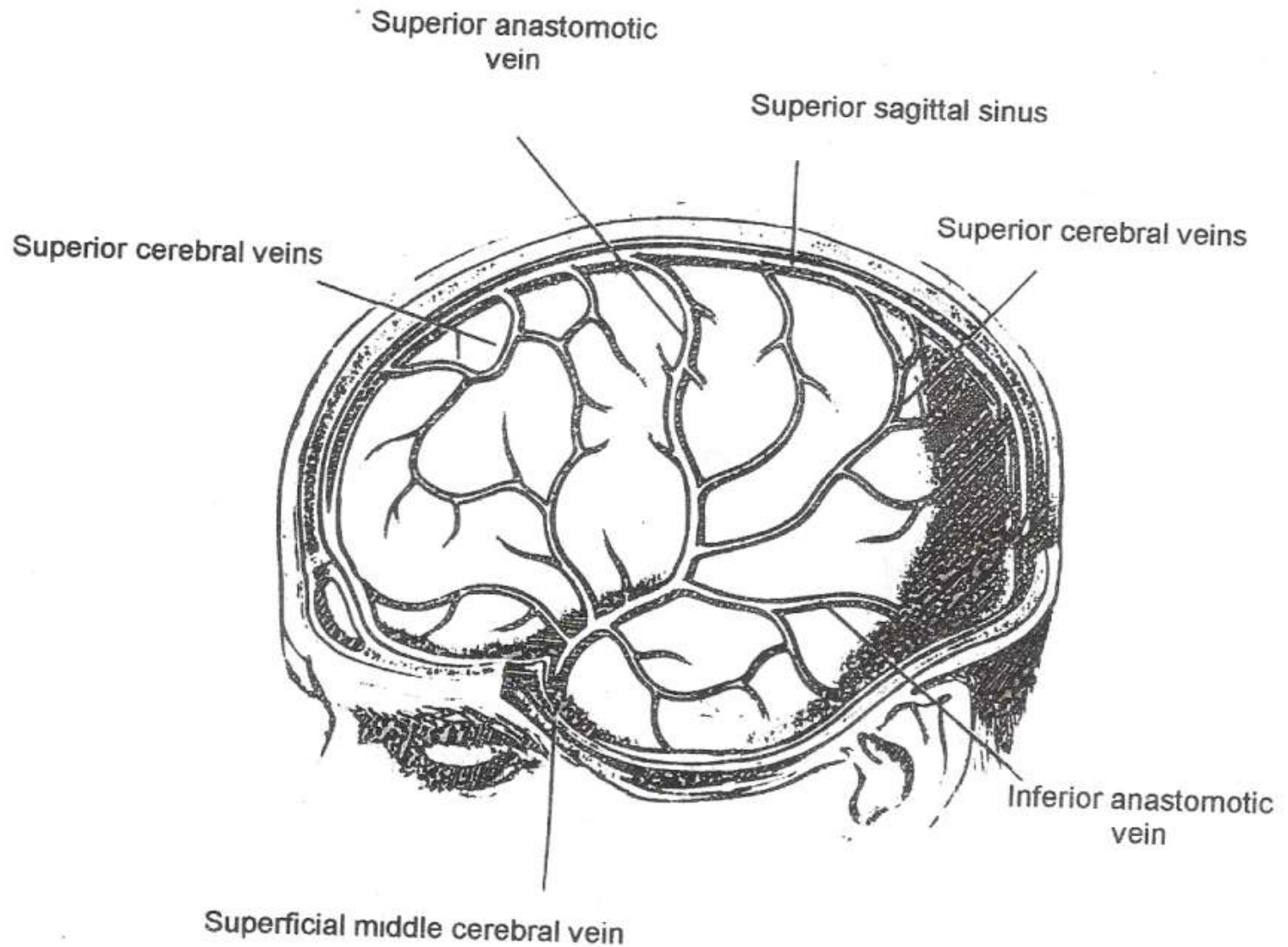
The veins of the brain have no muscular tissue in their thin layer.

No valves.

→ drain into dural venous sinuses or cranial

Cerebral Veins

1. **Superior cerebral veins:** drain into **the superior sagittal sinus.**
2. **Inferior cerebral veins:** drain into **the petrosal and transverse sinuses.**
3. **Middle cerebral veins:**
 - a. **Superficial middle cerebral veins:** drain into **the cavernous sinus.**
 - b. **Deep middle cerebral veins:** drain into **basal vein → the straight sinus.**



large vein

4. **Basal veins (vein of Rosenthal)**: by union of three veins:

Deep middle cerebral vein.

Anterior cerebral vein.

Striate veins.

- The two basal veins drain into **the great cerebral vein.**

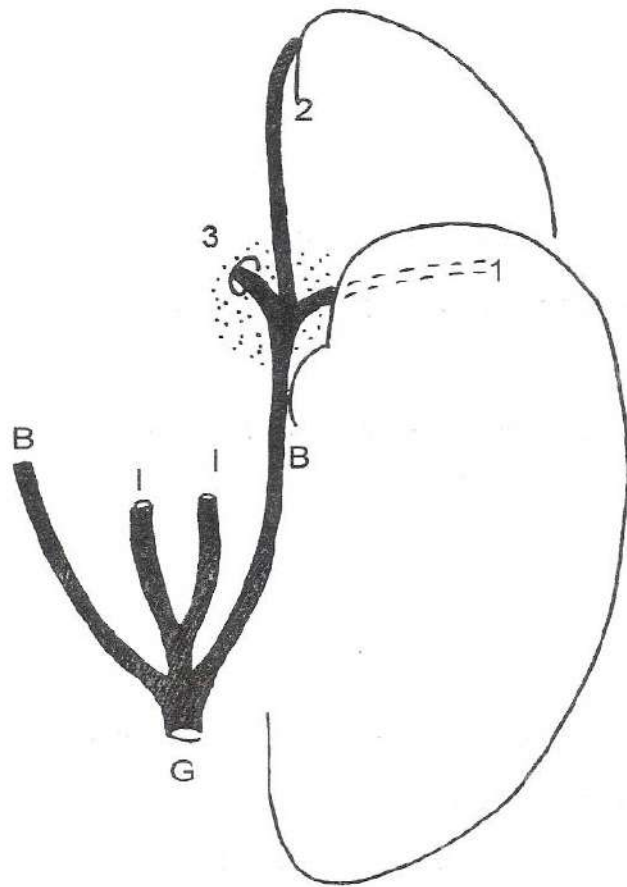
5. **The Internal Cerebral Veins:** formed by the union of

- **Thalamostriate vein**

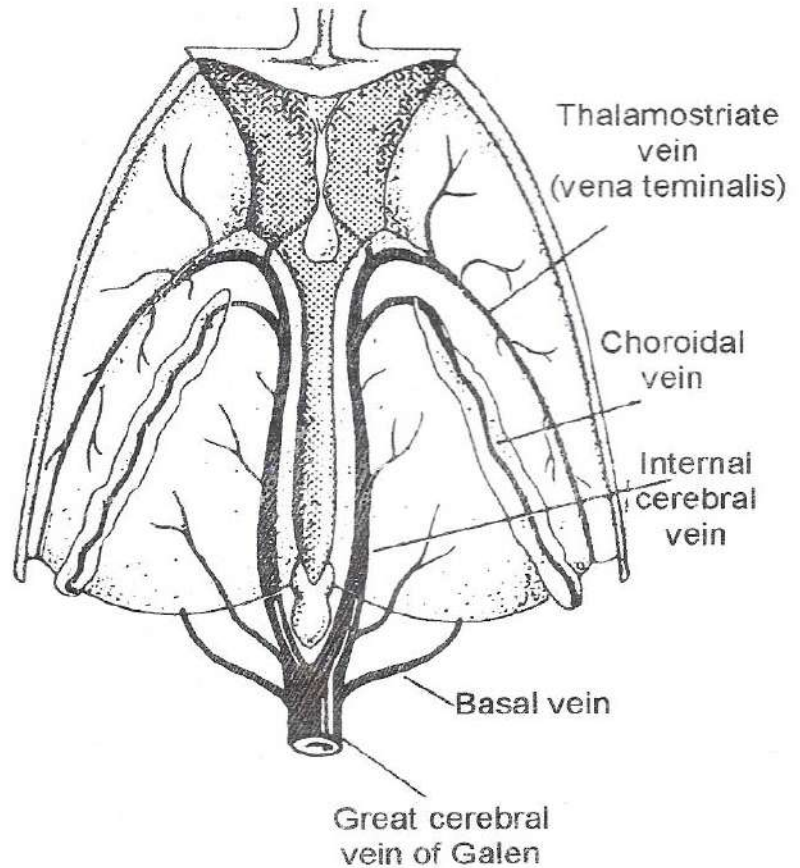
- **Choroid vein.**

- The two internal cerebral veins form **the great cerebral vein,** which drains into **the straight sinus.**

↖ 2 Basal
↘ 2 internal

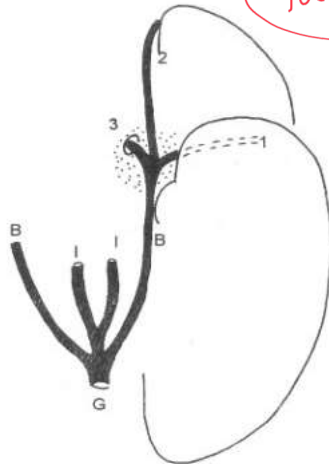


- 1- Deep middle cerebral vein.
- 2- Anterior cerebral vein.
- 3- Striate vein.
- B.: Basal vein.
- I.: Internal cerebral vein.
- G.: Great cerebral vein.

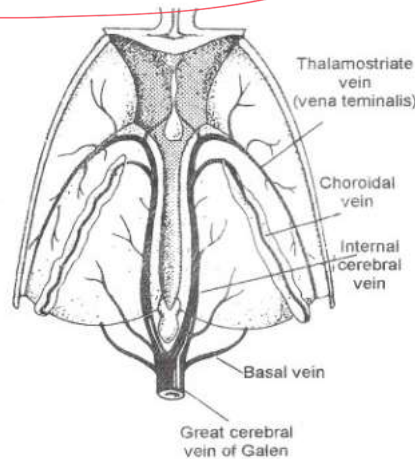


6. Great cerebral vein (vein of Galen): ^{y vein}

- Is the main vein of the medial surface of C.H.
- Formed by union of **the two internal cerebral veins**.
- **The great cerebral vein** unites with **the inferior sagittal sinus** to form **the straight sinus**.
- It receives also **the two basal veins**.



1- Deep middle cerebral vein.
2- Anterior cerebral vein.
3- Striate vein.
B.: Basal vein.
I.: Internal cerebral vein.
G.: Great cerebral vein.



The Cerebral Dural Sinuses

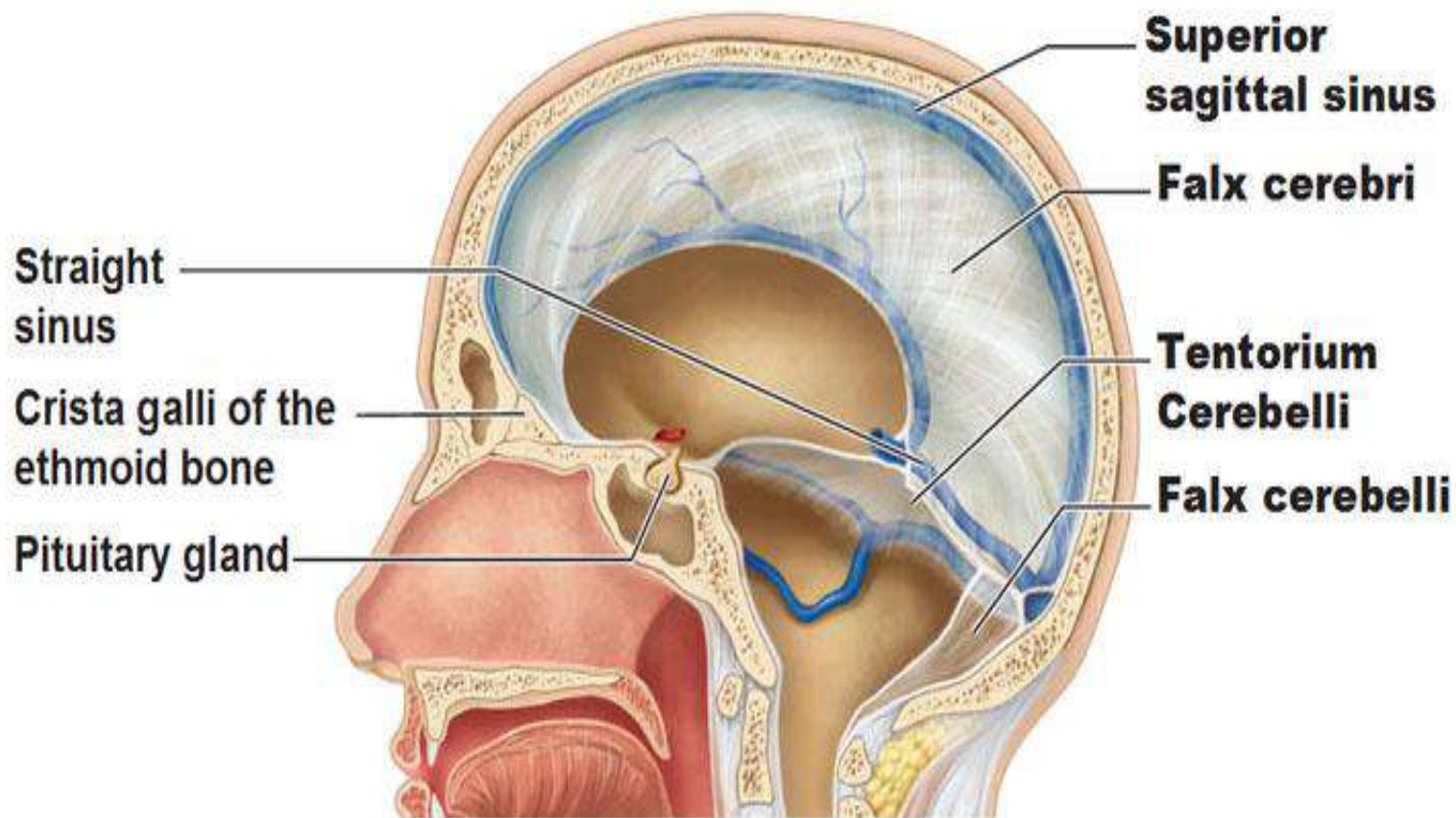
- The dural venous sinuses (also called dural sinuses, cerebral sinuses, or cranial sinuses) are venous blood filled space found between two layers of dura mater in the brain.
- They receive blood from superficial and deep veins of the brain.
- They receive CSF from the subarachnoid space (by the arachnoid granulation and villi).
Handwritten notes: "تغذية 3L" (3L nutrition) and "تغذية 5 لترات" (5 liter nutrition) with arrows pointing to CSF and subarachnoid space respectively.
- The dural sinuses finally connected with the internal jugular vein.
Handwritten note: "to the Rt. atrium" with an arrow pointing to the internal jugular vein.
- There are at least three single and six paired dural sinuses.

The Single Venous Sinuses

in the midline

1. The superior sagittal sinus: usually terminates in **the right transverse sinus**.
2. The inferior sagittal sinus: joins the great cerebral vein *+ great cerebral vein.* to form **the straight sinus**.
3. The straight sinus “tentorial or rectus sinus”: usually drains into **the left transverse sinus**.

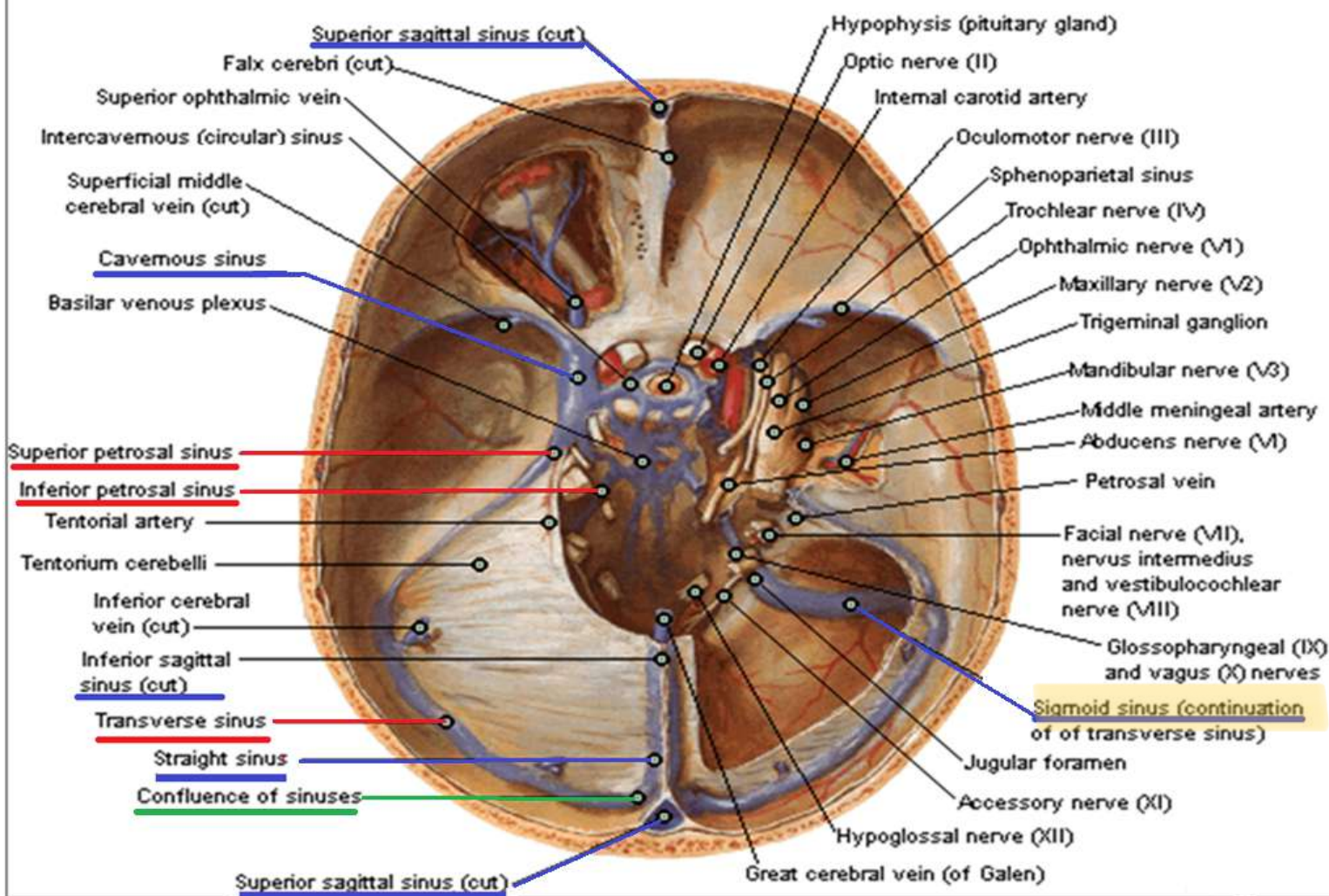
The Dura Mater and Dural Sinuses

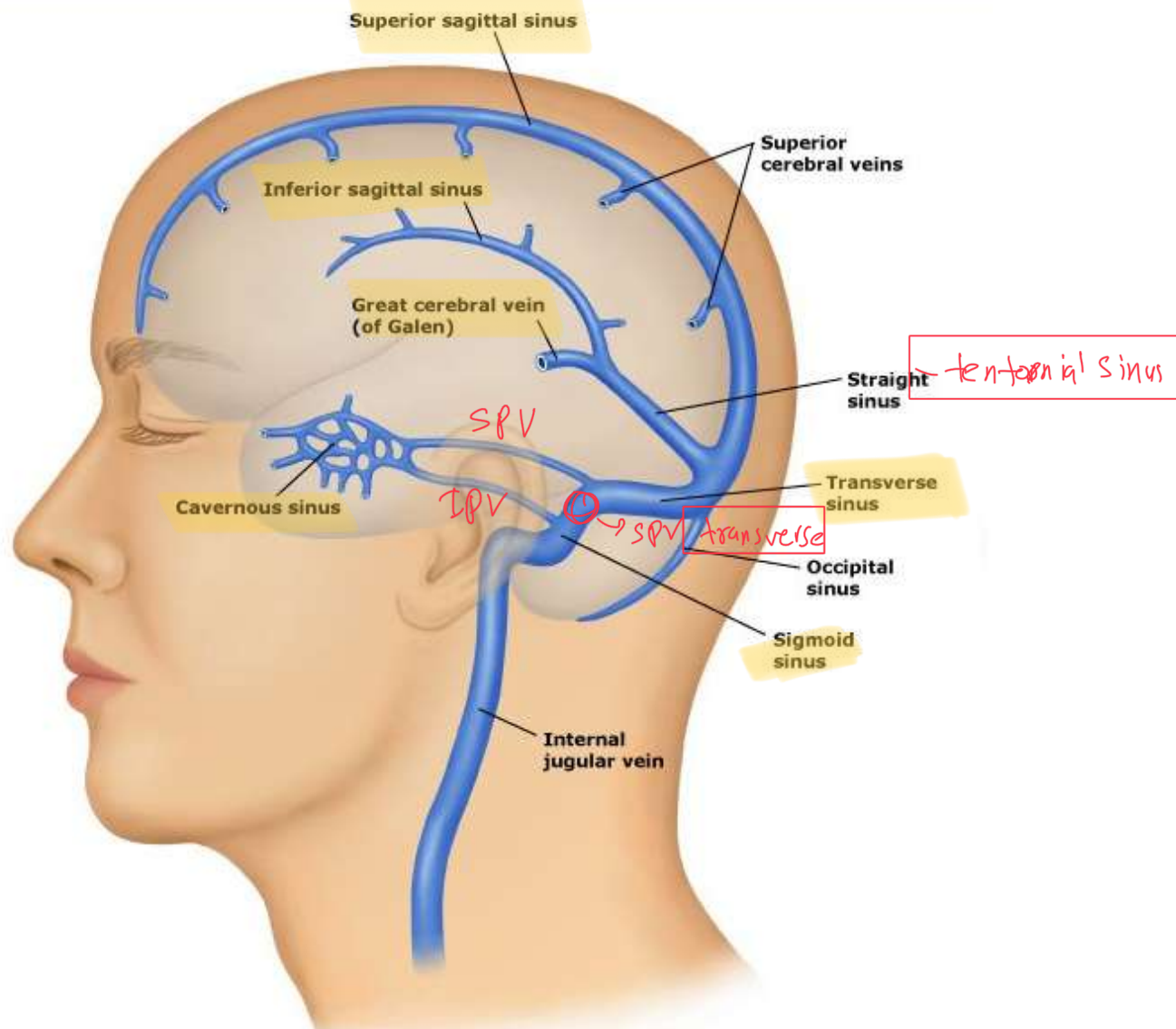


(a) Midsagittal view

The Paired Sinuses

1. **The sphenoparietal sinus:** drains into **the cavernous sinus.**
2. **The cavernous sinuses:** drains into **the superior and inferior sinuses.**
3. **The superior petrosal sinuses:** extends from the cavernous sinus to the junction of **the transverse and sigmoid sinus.**
↳ petrosal
4. **The inferior petrosal sinuses:** drains the cavernous sinus into the **sigmoid sinus.**
5. **The transverse (lateral) sinuses:** drains into **the sigmoid sinus.**
2. **The sigmoid sinuses:** drains into **the internal jugular vein.**





The Cavernous Sinuses



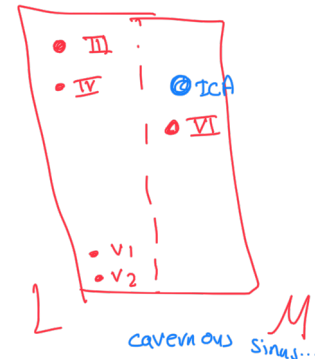
Contains within the **lateral wall** of the cavernous sinus:

1. The oculomotor nerve.
2. The trochlear nerve.
3. The ophthalmic division of the trigeminal nerve.
4. The maxillary division of the trigeminal nerve.



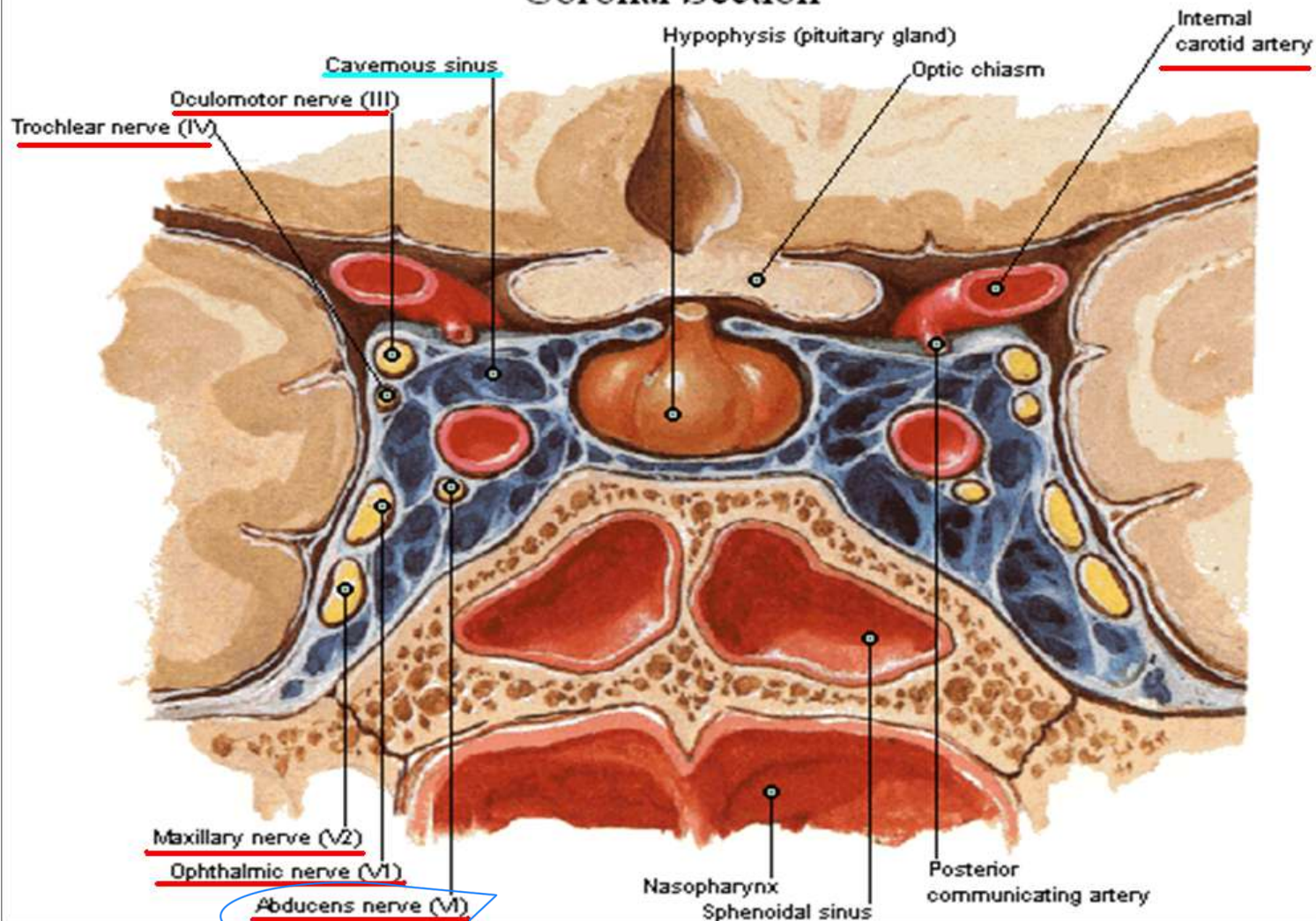
Contains within the **medial wall** of the cavernous sinus:

5. The abducent nerve.
6. The internal carotid artery.



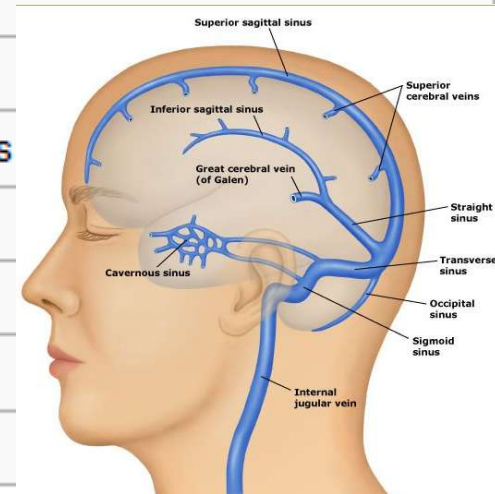
Cavernous Sinus

Coronal Section



The Cerebral Dural Sinuses

Name	Drains to
Inferior sagittal sinus	Straight sinus
Superior sagittal sinus	Typically becomes right transverse sinus or confluence of sinuses
Straight sinus	Typically becomes left transverse sinus or confluence of sinuses
Occipital sinus	Confluence of sinuses
Confluence of sinuses	Right and Left transverse sinuses
Sphenoparietal sinuses	Cavernous sinuses
Cavernous sinuses	<u>Superior and inferior petrosal sinuses</u>
Superior petrosal sinus	<u>Transverse sinuses</u>
Transverse sinuses	<u>Sigmoid sinus</u>
Inferior petrosal sinus	<u>Sigmoid sinus</u>
Sigmoid sinuses	Internal jugular vein



The **confluence of sinuses** is the connecting point of the superior sagittal sinus, straight sinus and transverse sinus.

Blood Supply of the Spinal Cord

1. **Anterior (ventral) spinal artery.**
2. **Posterior spinal arteries (right and left).**
3. **Radicular arteries.**

Blood Supply of the Spinal Cord



Arise from the:

A.

Vertebral Arteries: a branch of the subclavian

2 Ant. join together and form single Ant spinal A.

artery. Gives rise to **the anterior spinal artery** and

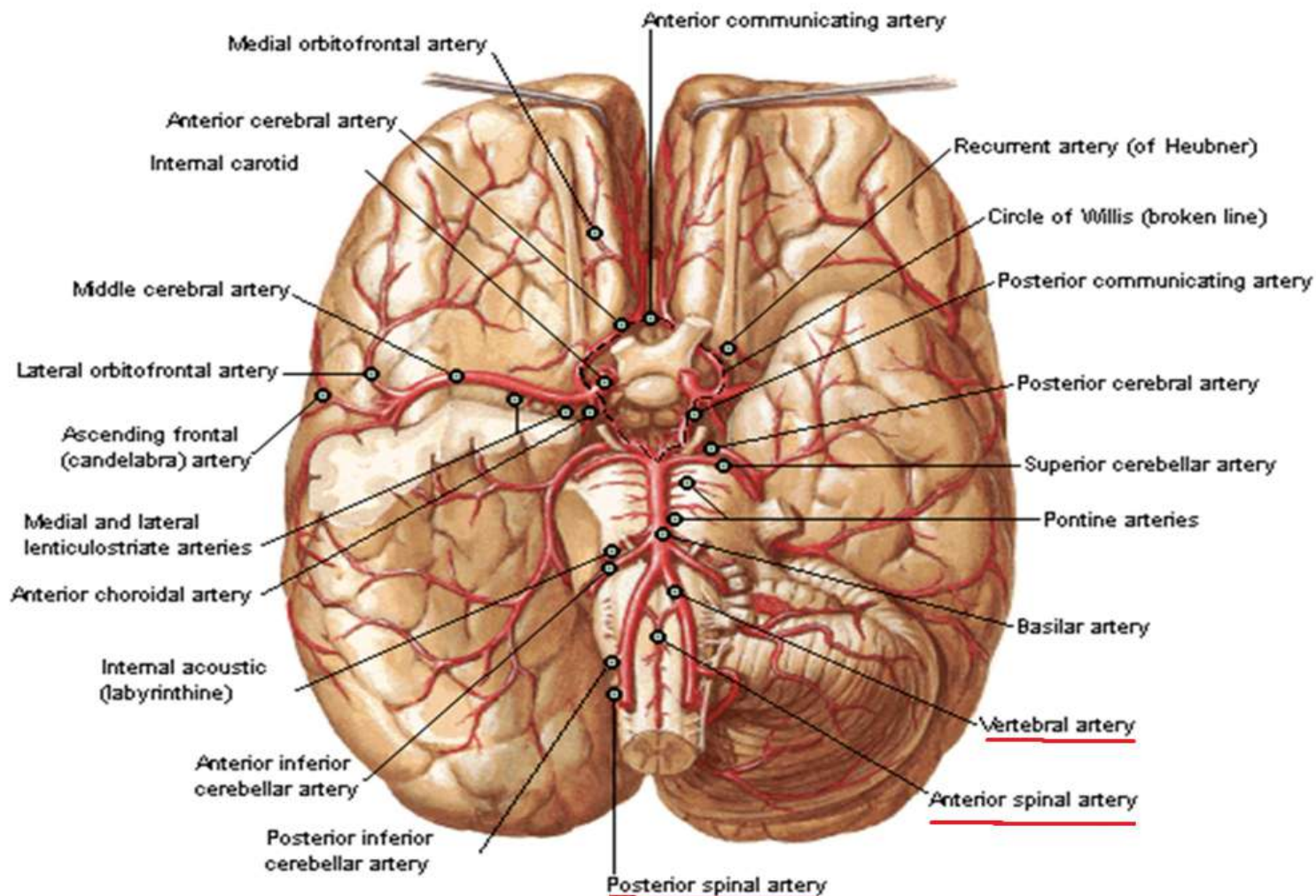
may give rise to **the posterior spinal artery.**

B.

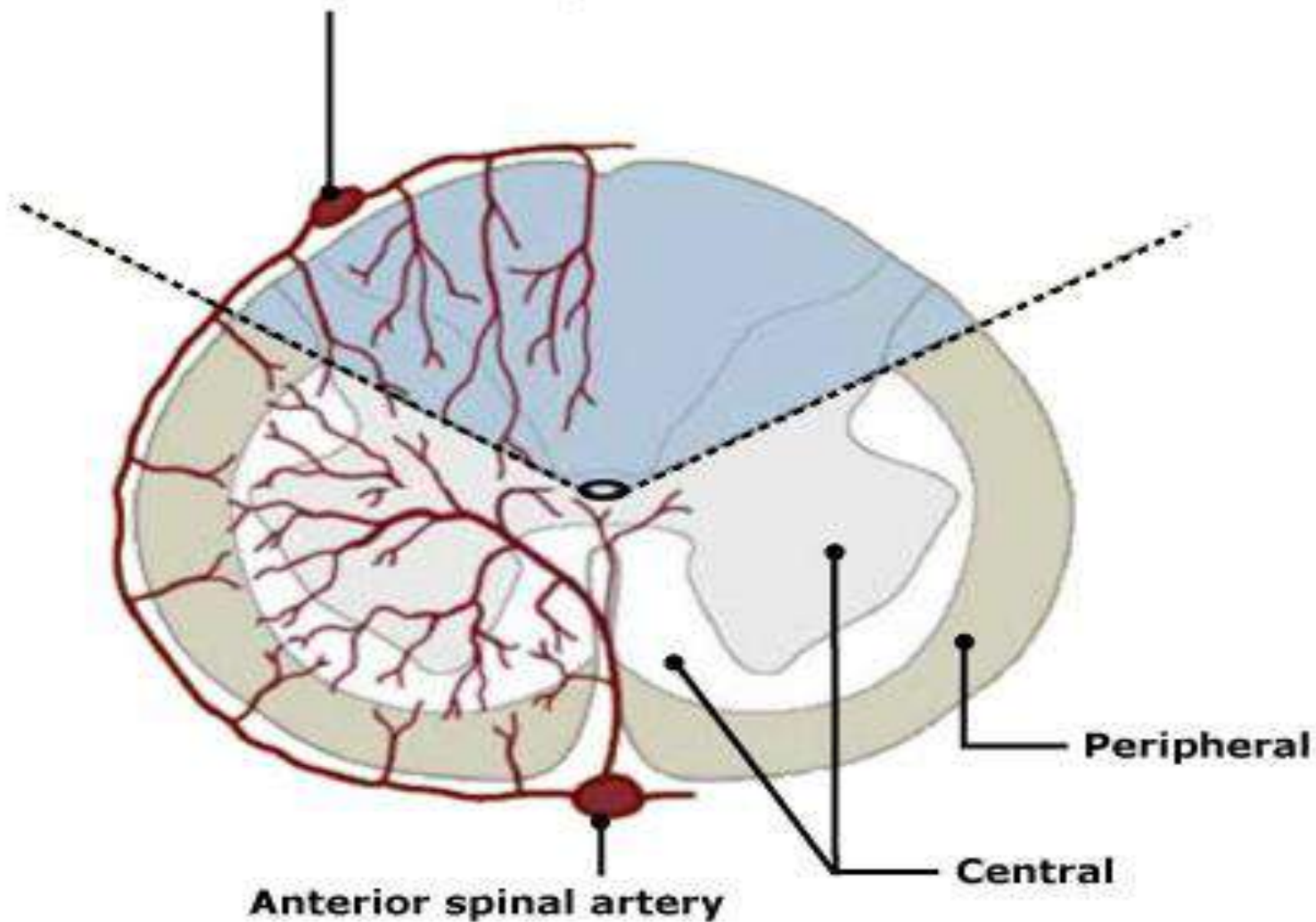
Segmental “Radicular” Arteries.

Arteries of Brain

Inferior View



Posterior spinal artery



Anterior spinal artery

Peripheral

Central

1. Anterior Spinal Artery

Formed inside the cranial cavity by the union of right & left anterior spinal arteries arising from the **right and left vertebral arteries**.

It descends in front of the anterior median fissure of the spinal cord. *if the one of the origin occluded lead to medial medullary syndrome. → R+. → Lt.*

Supplies the anterior two-third of the spinal cord *single → anterior lateral 2/3*
(anterior and lateral columns, anterior and lateral horn cells).

Supplies **the pyramid, medial lemniscus, and hypoglossal nucleus in the medulla** *from the vertebral A. and pass to the Ant. medial fissure supply Ant. lateral 2/3 of SC.*

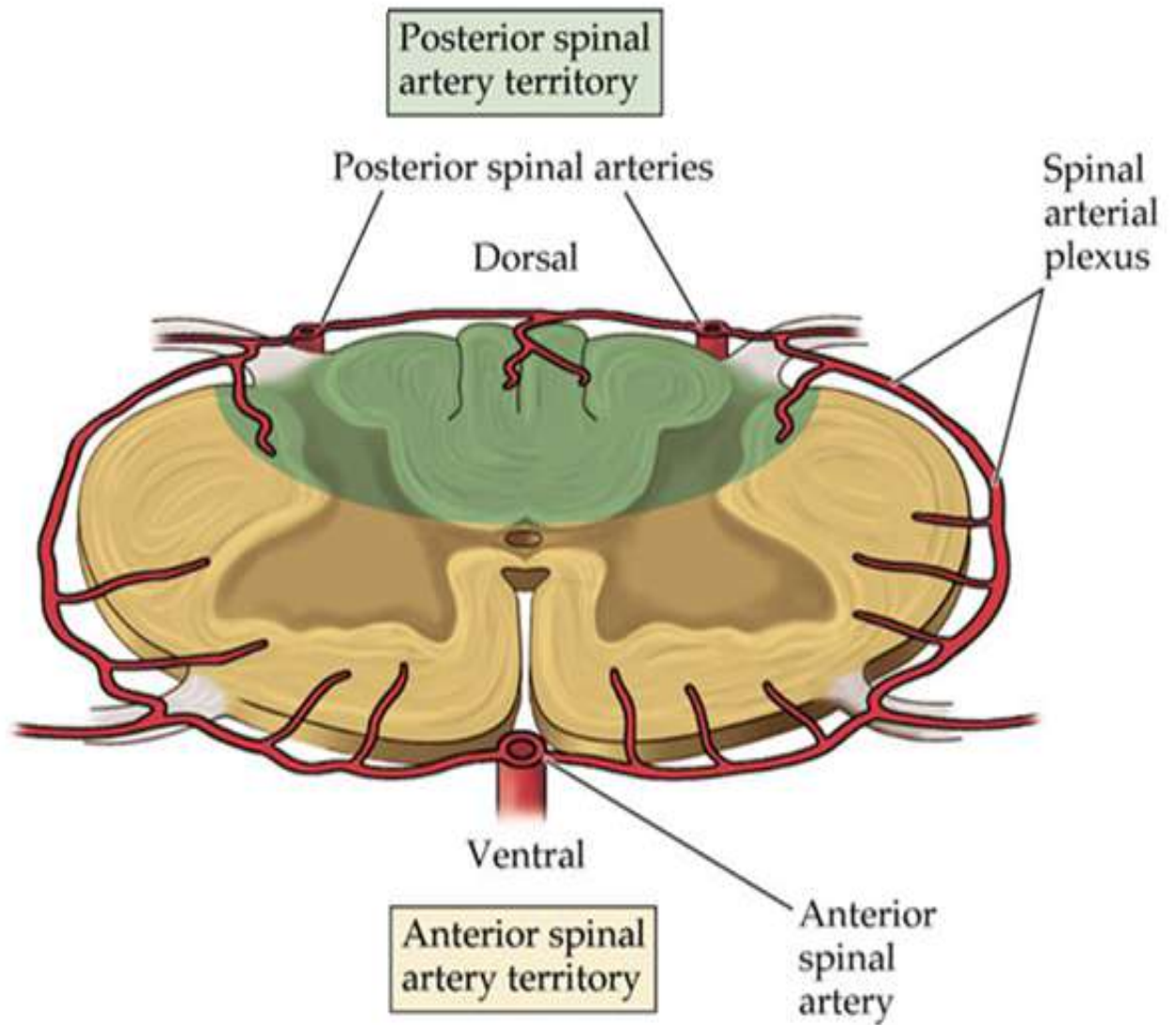
The anterior spinal artery is **the longest artery in the body**. *if the Ant. Spinal A. → occluded lead to :- Anterior cord syndrome.*

2. Posterior Spinal Arteries

من القاع ما يخرج من ال vertebral A
PICA ال
↳ rare

- Two posterior spinal arteries (Right & Left).
- Each artery arises inside the cranial cavity from **vertebral artery** and may be arises from **PICA**. rarely.
- $\frac{1}{2}$ → Supply posterior one third of the spinal cord (**Posterior horns and posterior columns**).
- Supply the **Gracile and Cuneate nuclei in the medulla**.
+ nuclei of post. horn cell.

→ arise from vertebral A. and supply → post 1/3
Lf Rt
may be arise from PICA



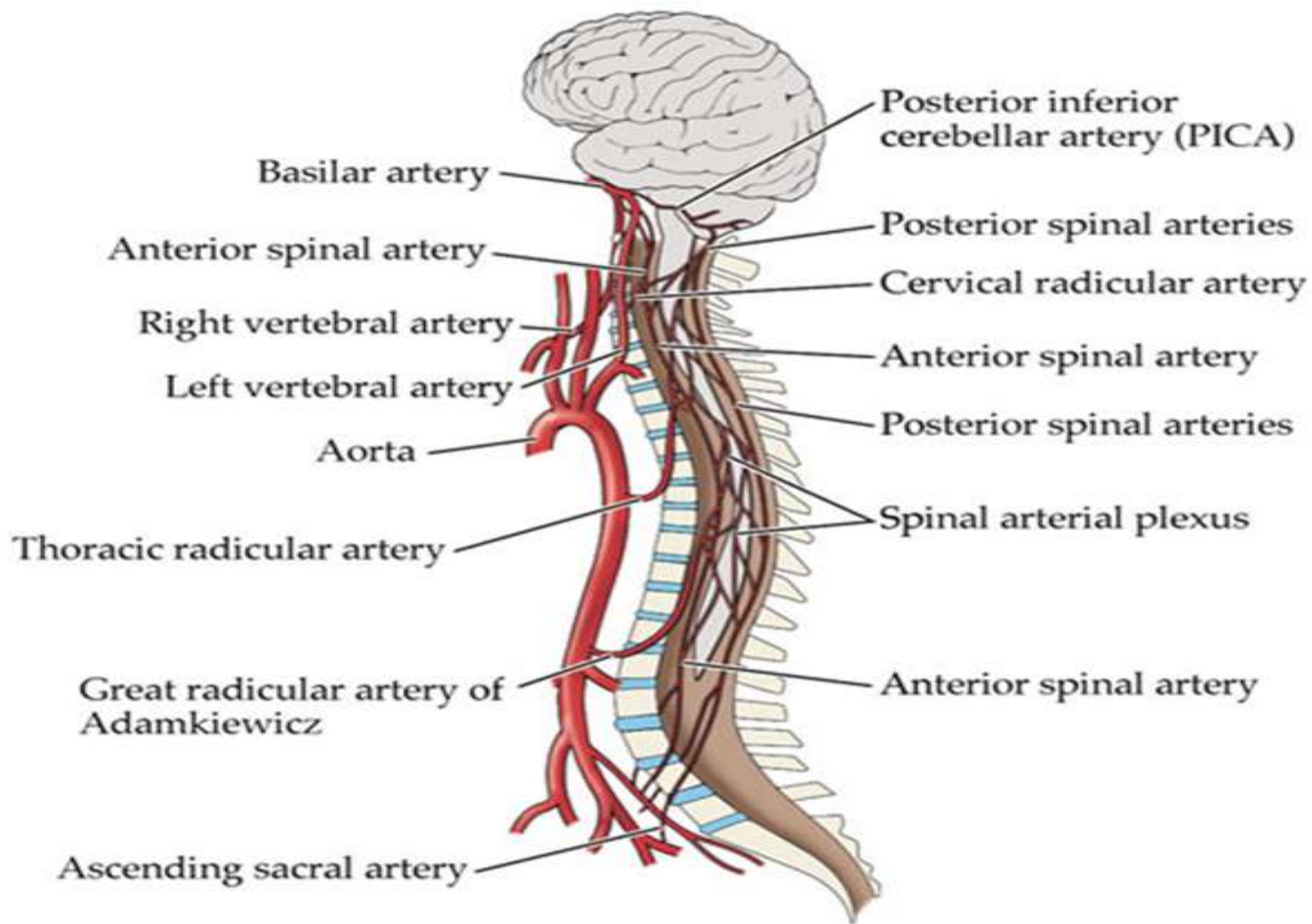
B. Segmental Arteries

Ant.
 comm. with Ant. spinal A.
 Post.
 L communicate with post. spinal A.

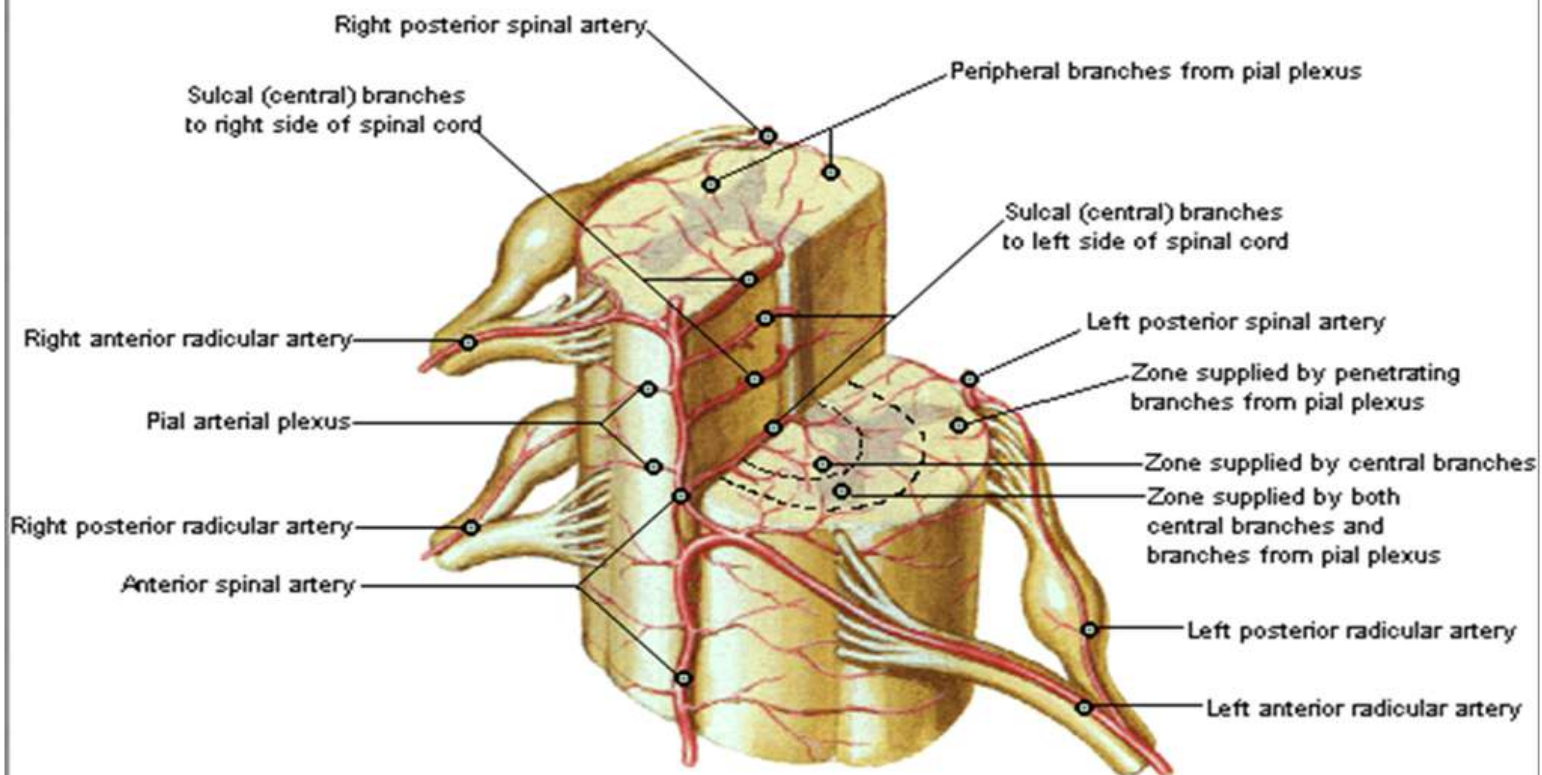
- Arise from **the aorta, vertebral arteries, and common iliac arteries** as **medullary arteries** “**Radicular arteries**”, which anastomose with the anterior and posterior spinal arteries.

- One large “great” radicular artery (artery of Adamkiewicz). Its origin varies from **T12 to L4**, and it usually arises on **the left side**.

spinal cord, celiac
at level T12-L4



Arteries of Spinal Cord - Intrinsic Distribution



Classification of Stroke

Ischemic Stroke: 85%.

← due to occlusion

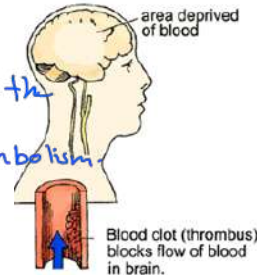
Thrombotic. → Atherosclerosis of the heart

Embolic. → Cardio or arterio arterial embolism
↓
more

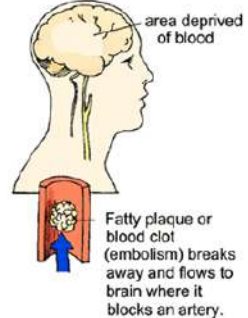
Lacunar.

Hemodynamic.

Thrombotic Stroke



Embolic Stroke



Hemorrhagic Stroke: 15 %.

← due to rupture

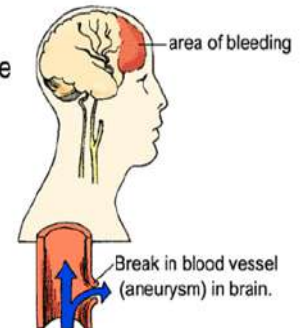
rupture of intra-cerebral or intracerebellar

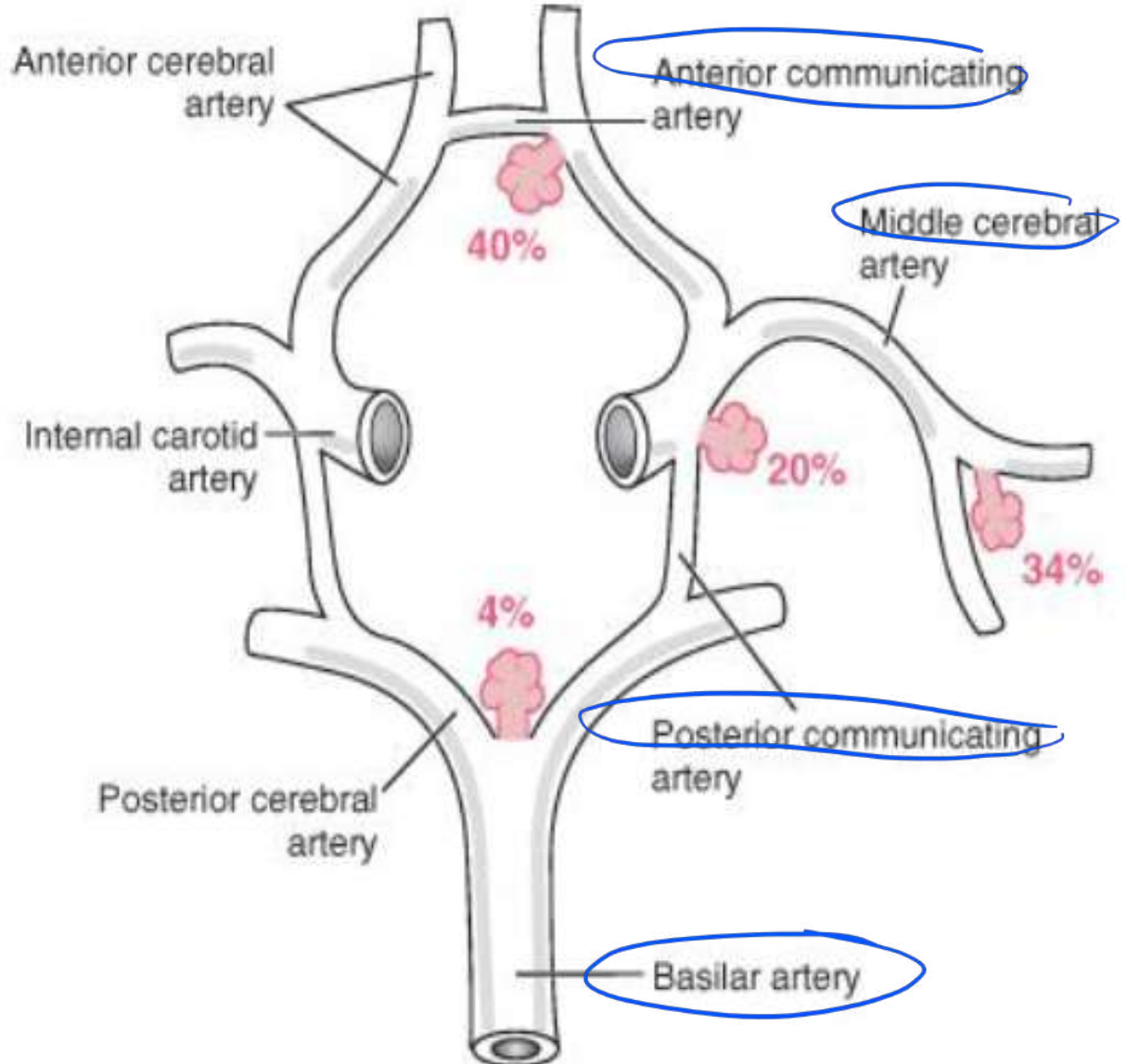
Intracerebral and
intracerebellar
hemorrhage 10%.

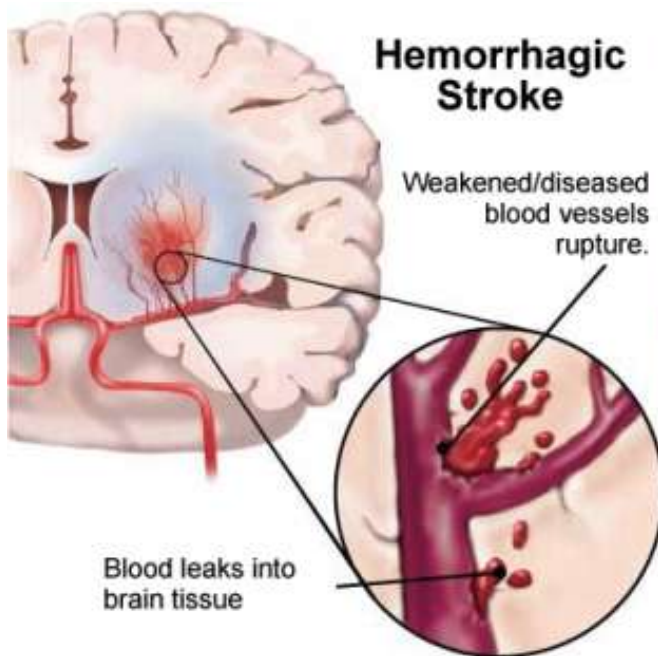
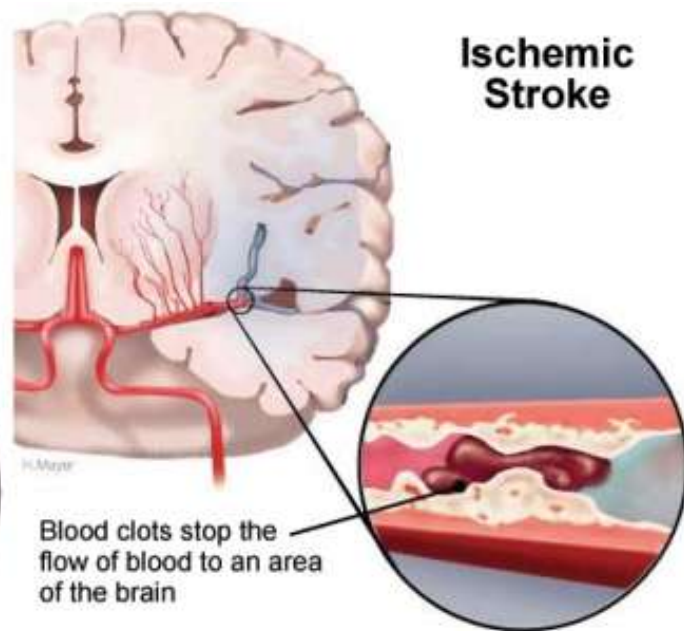
Subarachnoid hemorrhage 5%.

↳ due to rupture of aneurysm of artery in the subarachnoid space.

Cerebral Hemorrhage





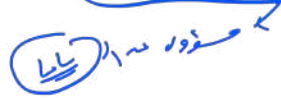


intra cerebral hematoma → rupture in the penetrating [central-cortical] A.

Internal Carotid Artery Occlusion

1. The symptoms and signs are those of **MCA** including contralateral ^{CL} hemiparesis ^{weakness} and hemianesthesia.
2. There is partial or complete loss of vision ^{IL} on the same side, but permanent loss is rare (emboli dislodged from the internal carotid artery reach the retina through the ophthalmic artery).

Occlusion of the main Anterior Cerebral Artery



Contralateral weakness and hyperreflexia in the lower extremity.

dominant in the LL ← motor symptoms

Contralateral somatosensory loss in the lower extremity with paresthesia, numbness, and loss of vibration sensation.

hemiplegia

Urinary incontinence with bilateral infarction.

Apraxia. *loss of motor skills*

Mentality and personality changes.

[depression]

Occlusion of the main Middle Cerebral Artery

- Contralateral facial weakness and weakness and loss of sensation in the upper extremity and face “Contralateral

↗ in the face and UL

faciobrachial type hemiplegia and hemihypoesthesia”.

- Loss of sensory discrimination and stereognosis.

- Hemineglect (may occur with either left or right parietal lesions).

- Conjugate deviation of the eyes to the affected side

- Frontal lobe syndrome.

- Broca's expressive aphasia, agraphia.

- Wernicke “sensory” aphasia.

- Contralateral homonymous hemianopia (damage to the optic radiation).

- Anosognosia.

Occlusion of the main Posterior Cerebral Artery

version 1.0

- **Unilateral Lesion of occipital lobe:** **contralateral homonymous hemianopia** with **macular sparing** due to the occipital pole receiving collateral blood supply from the middle cerebral artery.

- **Bilateral Lesion of occipital lobe:** **cortical blindness**

(pupils are reactive to light).

after occlusion in the Basilar A. the 2 post. cerebral... are not affected

- **Irritation of occipital lobe:** Visual hallucination.

- Memory deficit (**amnesia**).

- **Visual agnosia.**

- **Thalamic syndrome.**

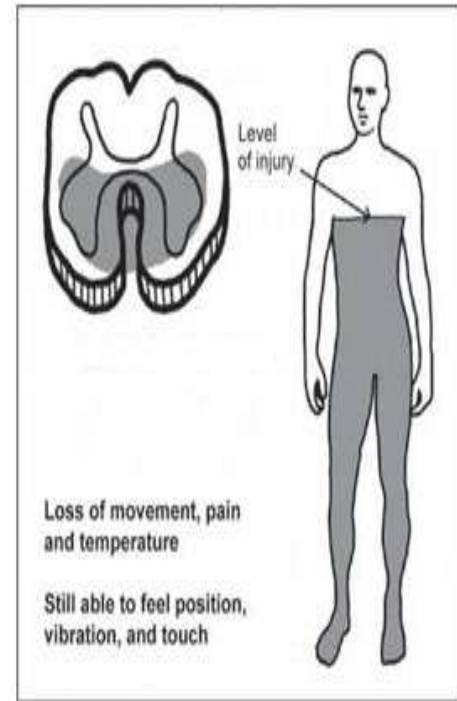
↳ CL Anesthesia of pain, temp.
CL loss of deep sensation
CL hemipain

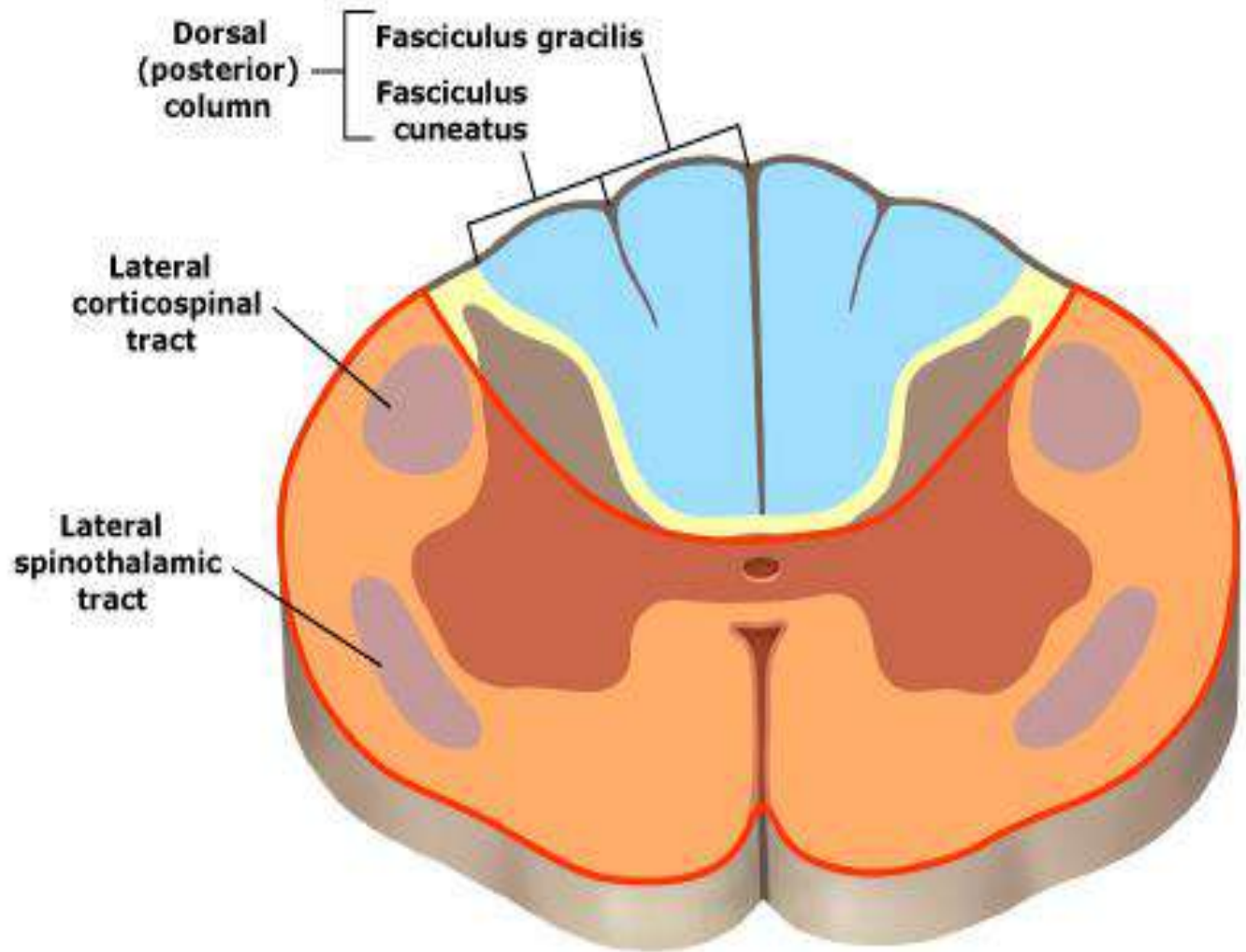
Vertebrobasilar Artery Occlusion

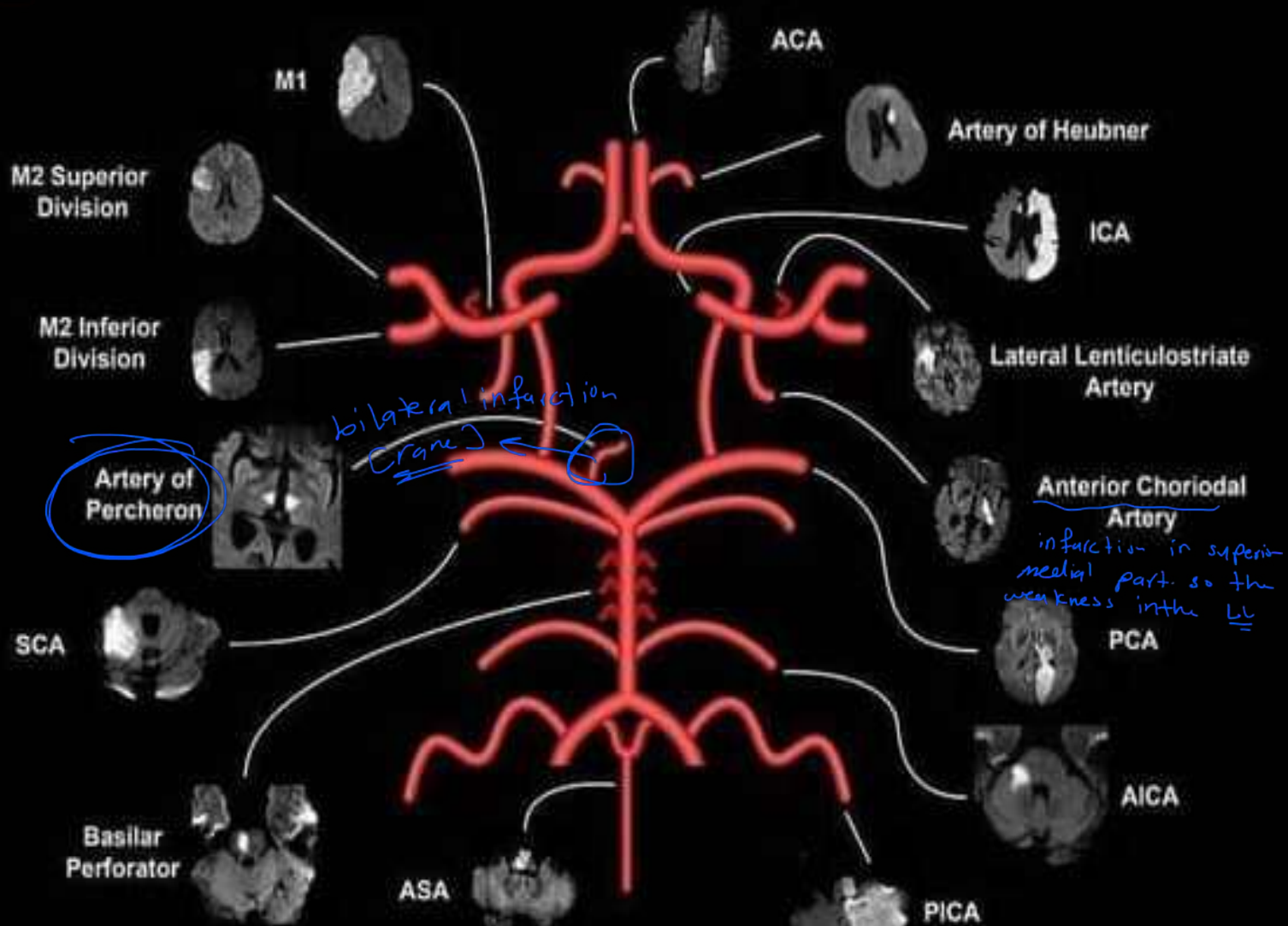
1. Ipsilateral pain and temperature sensory loss of the face and contralateral pain and temperature sensory loss of the body
as lat. medullary syndrome.
due to damage of descending spinal nucleus of cns before crossing
+ crude touch + proprioception
2. Attacks of hemianopia or complete cortical blindness.
due damage of lat. hemispheres or depend on the the syndrome or medial
[CCL]
3. Bulbar syndrome.
medial medullas
↓
loss of fine touch + proprioception.
lat. medullary
↓
loss of the pain, temp, crude touch.
4. Vertigo, nystagmus, nausea, and vomiting
5. Ipsilateral Horner syndrome
6. Ipsilateral ataxia and other cerebellar signs
7. Unilateral or bilateral hemiparesis
8. Coma

Anterior Spinal Artery Occlusion

- Lesion of the anterior part of the SC.
- Total loss of motor function on both sides below the level of lesion.
- Loss of pain and temperature sensations on both sides below the level of lesion.
- Dysfunction of sphincter tone.
- Deep sensation “proprioception” is preserved.







The Cerebro-Spinal Fluid

↳ released in the ventricular system to the subarachnoid space.

Definition: it is the fluid which circulates in the ventricles and central canal of the CNS and also fills the subarachnoid space.

Production of the C.S.F.:

- The C.S.F. is secreted by the ependymal cells covering the choroid ^{mainly} plexuses of the ventricles, mainly the lateral ventricles. and 3rd ventricle or 4th ⇒ دو
- The ependymal cells extract the CSF from the capillaries and secrete it into the cavity of the ventricles.
arterial blood ← يخرج
then to venous blood.

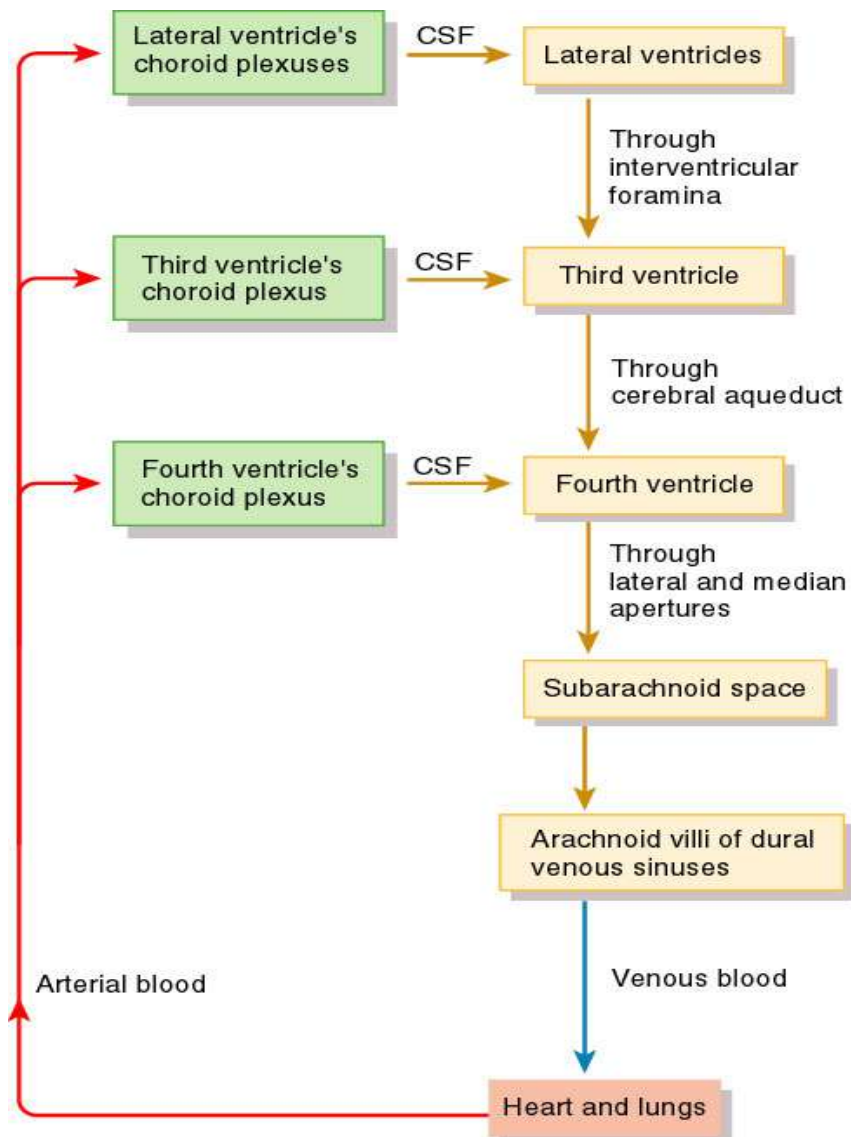
Formation of Cerebrospinal Fluid

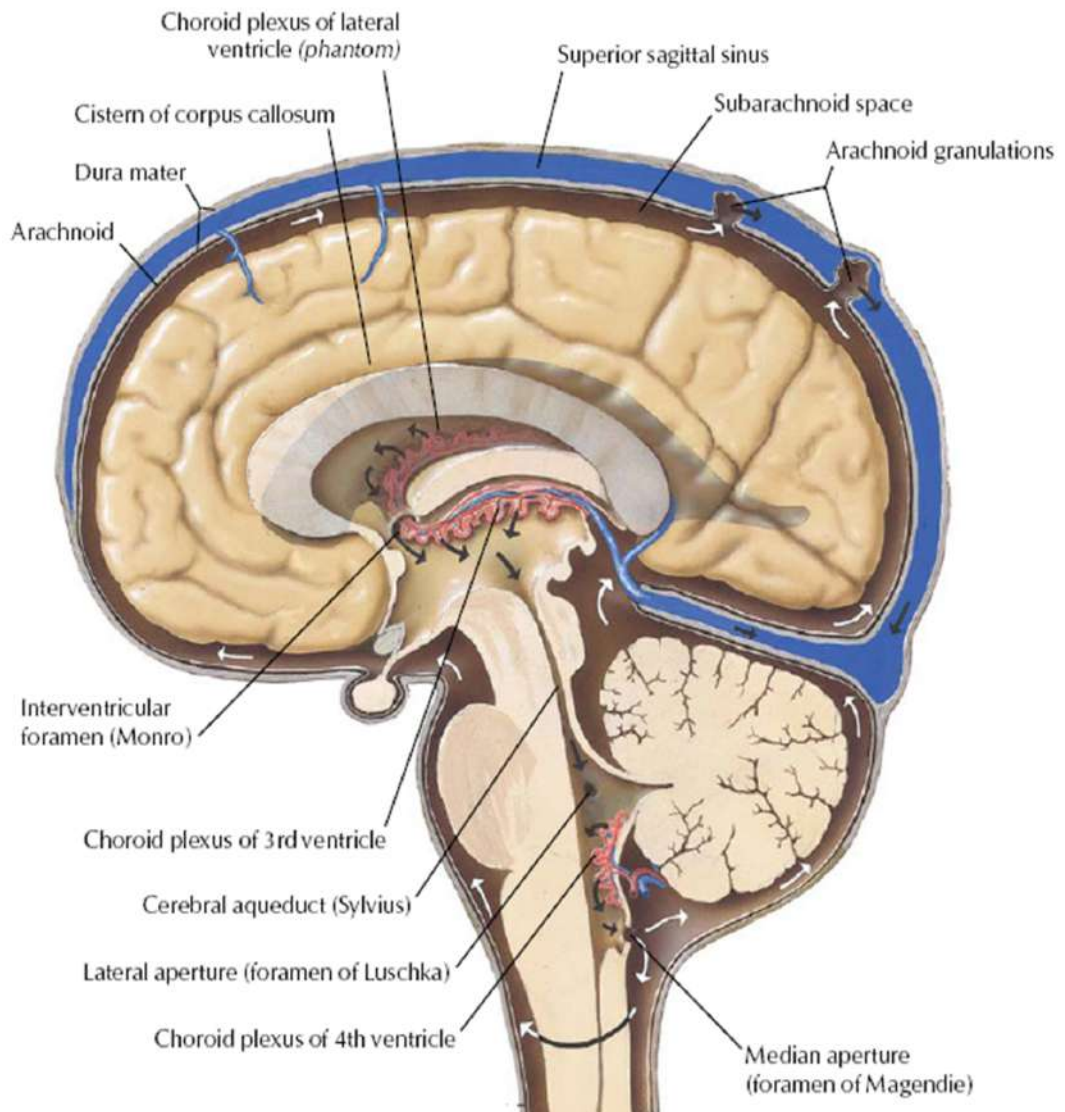


- **CSF is formed mainly** in the choroid plexuses of the lateral, 3rd & 4th ventricles.
- Some originates from **the ependymal cells** lining the ventricles & from the brain substance through the perivascular spaces.
- The choroid plexuses actively secrete CSF.

Circulation of the Cerebro-Spinal Fluid

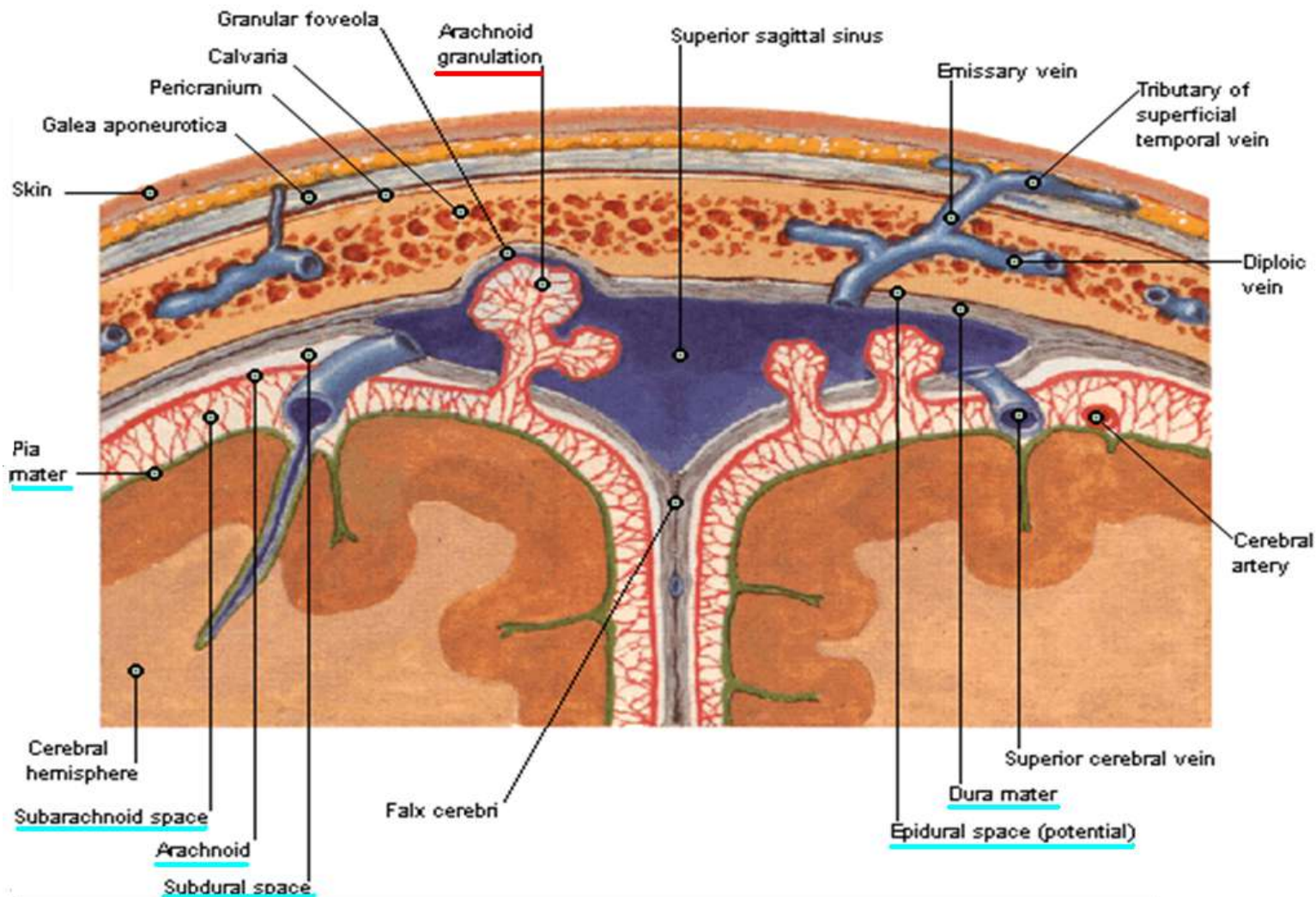
→ there is indirect connection between Rt/Lt H.V. So the CSF
 The CSF in each lateral ventricle → ^{cavity of cerebral hemisphere} interventricular foramen of
^{Rt, Lt thalamus} Monro → ^{interthalamic adhesion} third ventricle → ^{CSF} aqueduct of Sylvius → ^{cavity of rhombencephalon} fourth
ventricle → some fluid enter the central canal of spinal cord but
 the majority passes through the 3 foramina (one median of
foramen Magendie to ^{cisterna magna} cerebellomedullary cistern of
subarachnoid space & two lateral foramina of Luschka to
pontine cistern of subarachnoid space) → subarachnoid space
 where it flows over the surface of the brain and spinal cord.
 → then will be absorbed by the arachnoid villi, granulation
 → dura venous sinus → internal jugular vein → atrium in heart





Absorption of the Cerebro-Spinal Fluid

- The CSF circulates in the subarachnoid space.
- Absorbed by arachnoid villi and granulations which absorbs the C.S.F. from the subarachnoid space into the dural venous sinuses, ^{بالأخص} especially the superior sagittal sinus to reach the blood stream.



Functions of the Cerebro-Spinal Fluid

1. Support and protects the CNS against ^{vent} trauma.
2. It takes the place of the lymph in the CNS which is devoid of lymphatic vessels.
3. Regulation of the intracranial pressure.
4. Removes metabolites and toxics from the central nervous system.
5. Nourishes the central nervous system.

Draw

Characters of the Normal Cerebro-Spinal Fluid

بدراسة، lumbar puncture شق في السائل -

أما له كما أنه على أنه المحتمل يكون meningitis.

- **Appearance:** clear watery fluid, isotonic.
- **Amount:** 100- 150 ml.
- **Replacement:** it continuously produced and absorbed at a rate of 400-500 ml daily (it is replaced 3 times per day).
- **Pressure:** 100-180 mm of water.
- **Rate of production:** 0,3-0,4 ml/min. منه هو عدد RBC
- **Cells:** 0-5 WBCs per cubic millimeter. mainly lymphocyte.
- **Glucose:** 60 mg/dl (70% of serum glucose).
- **Total protein:** 15-45 mg/dl.

Formation of CSF by the Choroid Plexus Epithelium

- Lipid-soluble substances (CO_2 and O_2) and H_2O freely cross the blood–brain barrier and equilibrate between blood and CSF.
- **Protein** and **cholesterol** are **excluded** from the CSF because of their **large molecular size**.
- Other substances are transported by carriers in the choroid plexus epithelium.
- They may be secreted from blood into the CSF or absorbed from the CSF into blood.

clear CSF / سائل شفاف no distortion in RBC / not ← traumatic blood ← Blood lies above LP lies below ←
يعتبر CSF غير [مضطرب] ← subarachnoid bleeding

CSF Sampling

● To analyse the constituents of the CSF:

تحليل

○ Meningitis

○ Malignant disease

○ Multiple sclerosis and other neurological diseases

*نقص البروتين /
oligo clonal band*

MS
Ig. → +ve in MS

● To remove CSF to reduce intracranial pressure:

TK HTN

○ For Surgical access

○ Pseudotumor cerebri

benign

Hydrocephalus

● **Definition:** Distension of the ventricular system (Ventriculomegaly) due to inadequate passage of CSF from its point of production to the point of absorption”.

● **3 causes:**

1. Choroid plexus papilloma: Rarely over-secretion of CSF.
2. Can be from Obstruction to flow of CSF from the ventricles into the subarachnoid Space (**Obstructive**)
 - Masses in ventricles or adjacent brain.
 - Developmental membranes or stenosis of aqueduct.
3. Can be from failure of absorption (**Communicating**)
 - Failure of the absorbing mechanism usually after a change in CSF contents e.g. acutely after Meningitis or SAH, Chronically also. Cryptogenic, congenital



Raised CSF Pressure & Papilledema

- The optic nerves are surrounded by sheaths derived from the pia mater, arachnoid mater, and dura mater.
- A rise of CSF pressure will compress the thin walls of the retinal vein.
- This will result in congestion of the retinal vein, bulging forward of the optic disc, and edema of the optic disc (**papilledema**).
- Persistent **papilledema** leads to optic atrophy and blindness.

