

**Blood Supply
Objectives**

1. Describe the route of the anterior and posterior blood supply of the brain.
2. List the main arteries and branches of the anterior and posterior blood supply to the brain and describe their course and distribution.
3. Describe the blood supply to the cerebral cortex, diencephalon, brainstem, and spinal cord.
4. Describe the route of the venous drainage from the brain.
5. Explain the following events that lead to a cerebrovascular incident: aneurysm, cerebral embolism, arteriovenous malformation.
6. Explain the different types of hemorrhages and where they are most likely to occur.
7. If given patient symptoms, be able to identify the artery which is involved in the cerebrovascular incident.

Blood Supply

Outline

I. General Information

II. Blood supply to the brain

A. Anterior blood supply

1. Ophthalmic a.
2. Posterior communicating a.
3. Choroidal a.
4. Anterior cerebral a.
 - a. Pericallosal a.
 - b. Callosal marginal a.
5. Middle cerebral a.
 - a. Lenticulostriate (lateral striate) a.

B. Posterior (vertebrobasilar) blood supply

1. Vertebral a.
2. Posterior spinal a.
3. Anterior spinal a.
4. Posterior inferior cerebellar a. (PICA)
5. Basilar a.
 - a. Anterior Inferior cerebellar a.
 - b. Pontine a.
 - c. Superior cerebellar a.
 - d. Posterior cerebral a.

C. Circle of Willis

1. Anterior communicating a.
2. Anterior cerebral a.
3. Internal carotid a.
4. Posterior communicating a.
5. Posterior cerebral a.
6. Basilar a.

D. Watershed areas

III. Veins and Venous sinuses

A. Superficial cerebral veins

1. Superficial middle cerebral vein
2. Superior anastomotic vein of Trolard
3. Inferior anastomotic vein of Labbe

B. Deep cerebral veins

1. Thalamostriate v.
2. Internal cerebral v.
3. Great cerebral vein of Galen

C. Basal aspect of brain

1. Cavernous sinus
2. Basal vein of Rosenthal

D. Sinuses

1. Straight sinus
2. Confluence of sinuses
3. Tranverse sinuses
4. Sigmoid sinuses
5. Internal jugular veins

IV. Blood supply to the Spinal Cord

- A. Anterior spinal a.
- B. Posterior spinal aa.
- C. Radicular aa.
- D. Segmental (spinal medullary) aa.
- E. Spinal medullary artery of Adamkiewicz

V. Blood supply to the Brainstem

VI. Events that lead to cerebrovascular problems

- A. Aneurysm
- B. Cerebral embolism
- C. Arteriovenous malformation

VII. Hemorrhage

- A. Meningeal hemorrhage
 1. Epidural hemorrhage
 2. Subdural hemorrhage
 3. Subarachnoid hemorrhage
- B. Cerebral hemorrhage

Blood Supply

Blood Supply
B. Puder, Ph.D.
TUCOM

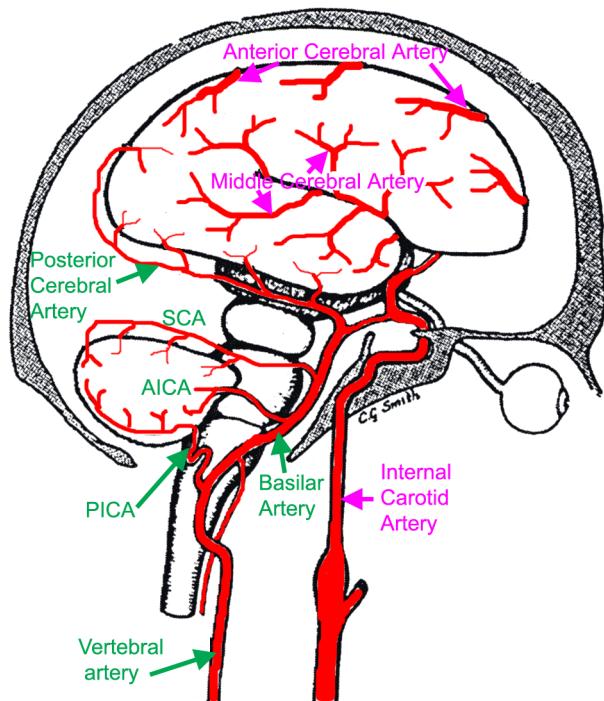
I. General Information

50% of problems in the cranial cavity are **vascular** and result in neurological deficits. The brain equals 2% of total body weight but receives **15-17% of total cardiac output**. The brain consumes **20% of the oxygen** used by the body. **Loss of consciousness** results if the brain is **deprived of blood** for 10-12 seconds and after 3-5 minutes, **brain damage** may result.

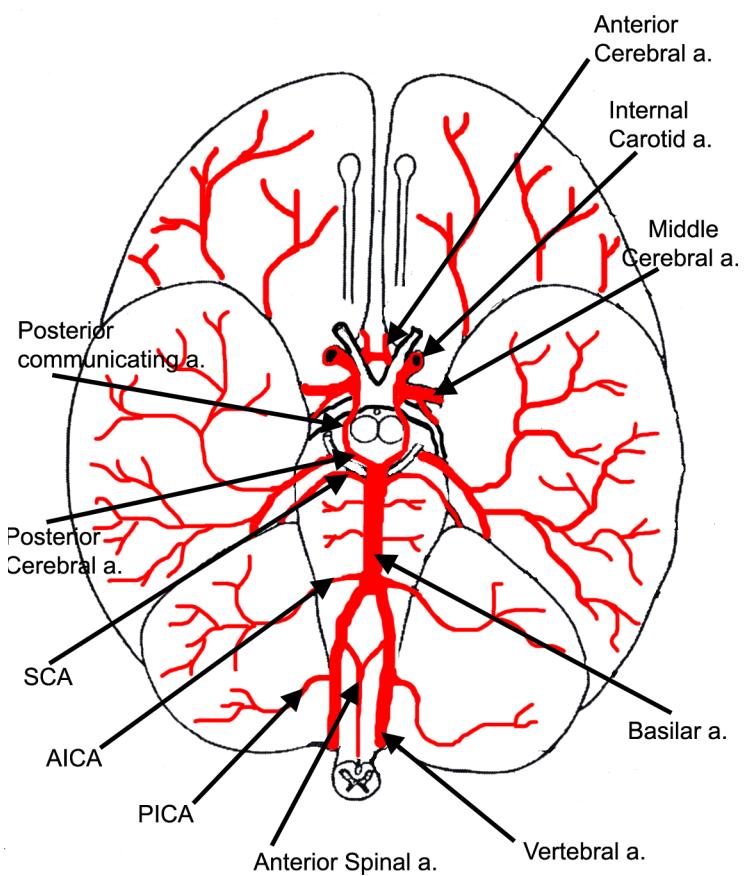
II. Blood supply to the brain

The blood supply to the brain can be divided into **2 major divisions**.

1. The **anterior** or rostral blood supply which consists of **2 internal carotid arteries** which in turn will give off several branches to supply specific brain areas.
2. The **posterior or vertebrobasilar system** which consists of **2 vertebral arteries** which in turn join to form 1 basilar artery. This system also give off several branches to supply the spinal cord, brainstem, cerebellum, and posterior cerebral cortex.



Lateral view of blood supply to the CNS



Inferior (ventral) view of the CNS blood supply

A. Anterior blood supply

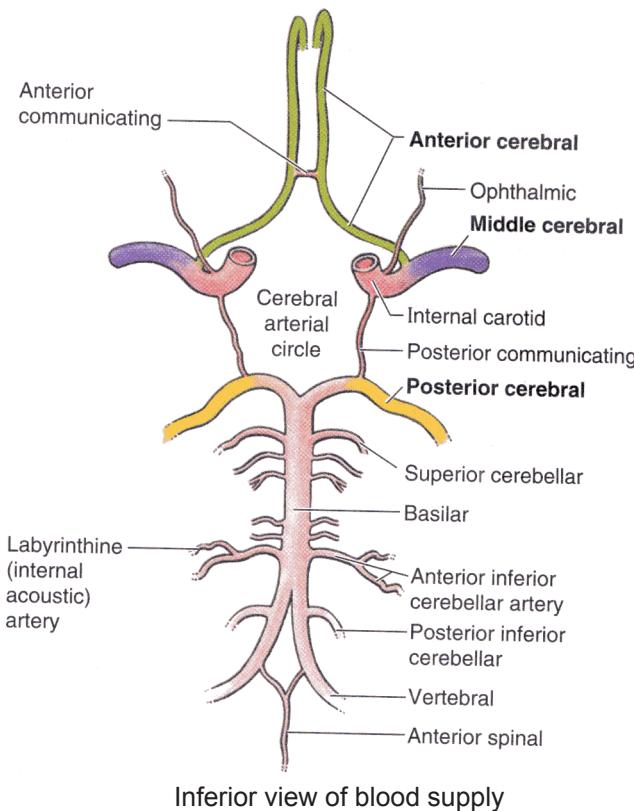
The **internal carotid arteries** arise from the right and left common carotid arteries in the neck. It passes through the carotid canal, the cavernous sinus and pierces dura and travels in subarachnoid space.

Branches of the internal carotid artery

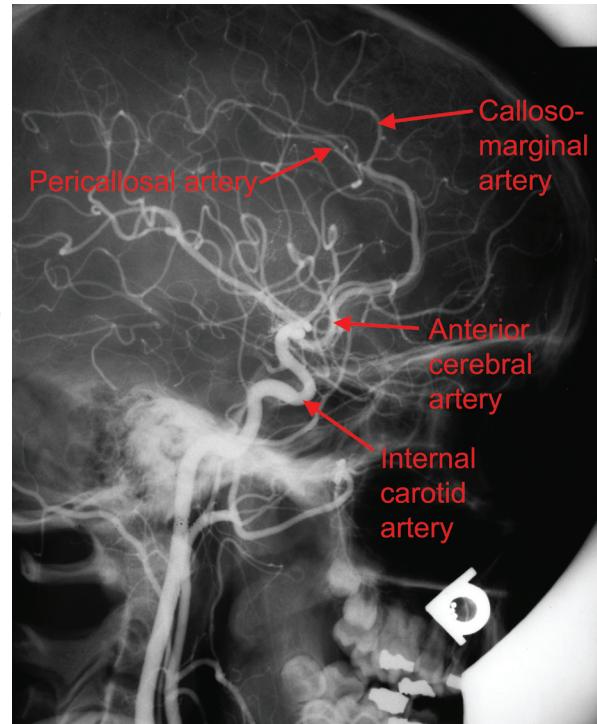
1. The internal carotid gives off the **ophthalmic artery** as it leaves the cavernous sinus. The ophthalmic artery supplies the eye and orbit and gives off the central artery of the retina.
2. The **posterior communicating artery** forms part of the circle of Willis and is posterior to cranial nerve III.
3. **Choroidal artery** enters inferior horn of the lateral ventricle and supplies choroid plexus, cerebral peduncles, optic tract
4. **Anterior cerebral artery (ACA)** supplies the medial surface of cerebral cortex to the parieto-occipital sulcus. The anterior communicating artery (also part of the circle of Willis) joins the right anterior cerebral artery with the left anterior cerebral artery.

2 major **branches of ACA** are the

1. **pericallosal artery**
2. **callosal marginal artery**



Adapted from Clinically Oriented Anatomy,
Moore & Daily



Angiogram depicting the lateral view of the internal carotid artery and some of its branches

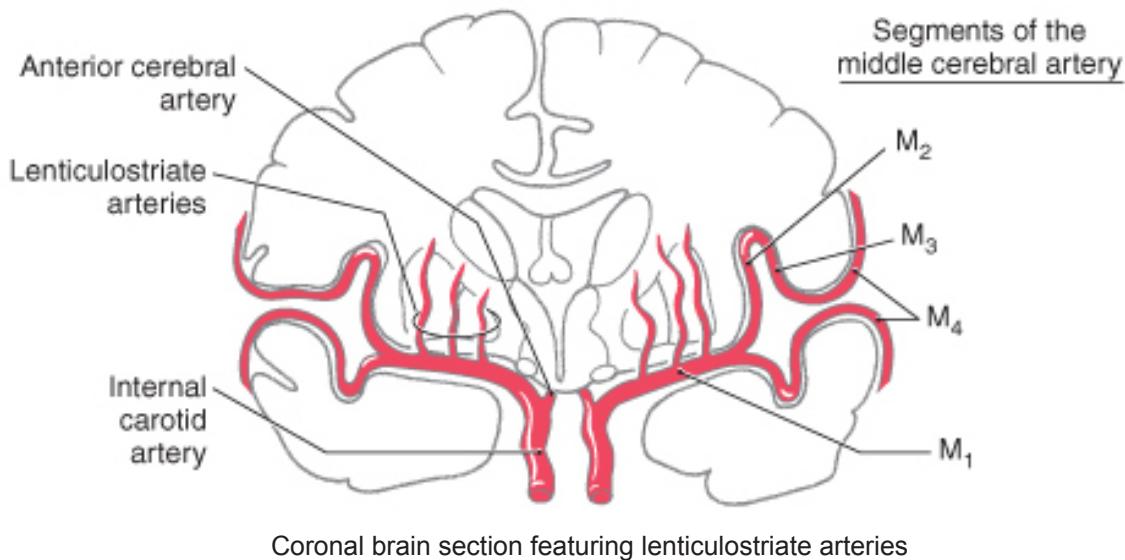
Branches of the Internal Carotid artery continued

4. **The Middle cerebral artery** is the largest branch off of the internal carotid artery and supplies the lateral surface of the hemisphere except for the superior aspect and the occipital and inferolateral aspects.

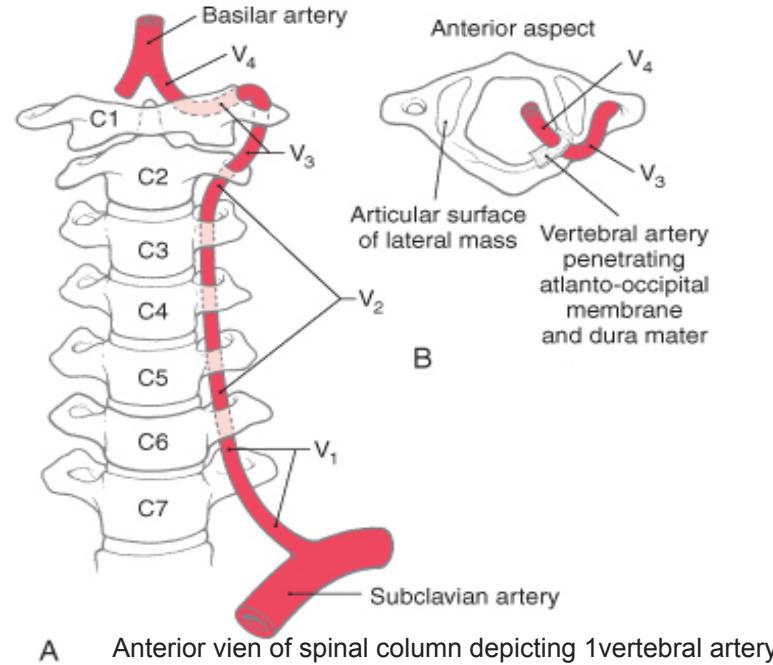
Branches of the middle cerebral artery

The **lenticulostriate arteries (lateral striate)** supply major internal structures and when damaged, is involved in the “classic” stroke.

Adapted from Fundamental Neuroscience for Basic and Clinical Application, D.E. Haines



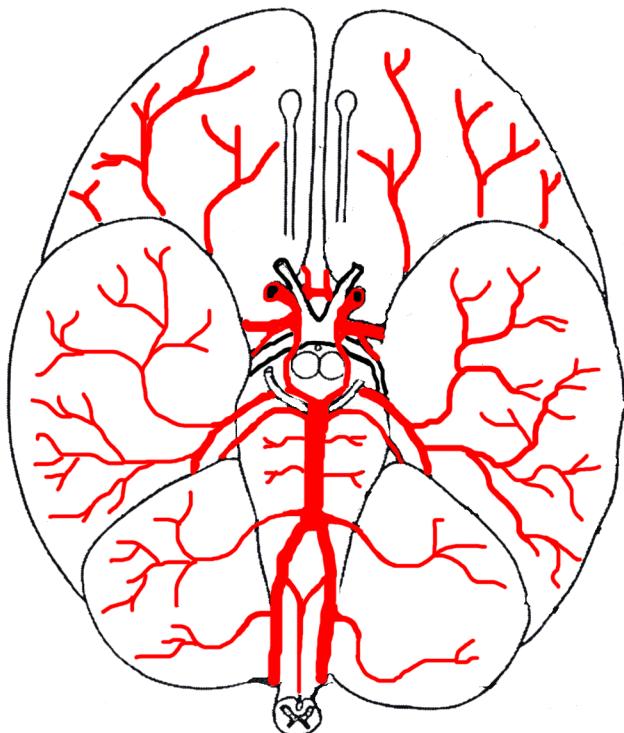
Coronal brain section featuring lenticulostriate arteries



A Anterior view of spinal column depicting 1vertebral artery

Branches of the vertebrobasilar system

1. 2 **Posterior spinal arteries** arise either from the **vertebral arteries** (25%) or the **posterior inferior cerebellar arteries** (a branch of the vertebral a.)(75%). Posterior spinals will supply the posterior aspect of the spinal cord.
2. 1 **anterior spinal artery** is formed from the **2 vertebral arteries**. Anterior spinal artery supplies the anterior aspect of the spinal cord.
3. **Posterior Inferior cerebellar artery** supplies deep cerebellar structures, inferior cerebellum & medulla



Branches of the vertebrobasilar system continued

4. The **Basilar artery** is formed by the union of the **2 vertebral arteries**

Branches of the basilar artery

1. **Anterior inferior cerebellar arteries (AICA)** supply anterior and inferior cerebellum and parts of the medulla and pons

2. **Pontine arteries** supply the pons

branches are:

1. paramedian

2. long and short circumferential

3. **Superior cerebellar artery** supplies part of the midbrain, pons, superior surface of the cerebellum,

4. **Posterior cerebral artery** supplies occipital lobe and medial surface of temporal lobe and sends branches to the midbrain and thalamus

The posterior communicating artery joins the posterior cerebral artery to the anterior circulation thus completing the circle of Willis.

Circle of Willis

Formed by the **anastomosis of the anterior and posterior blood systems**.

Consists of :

anterior communicating artery

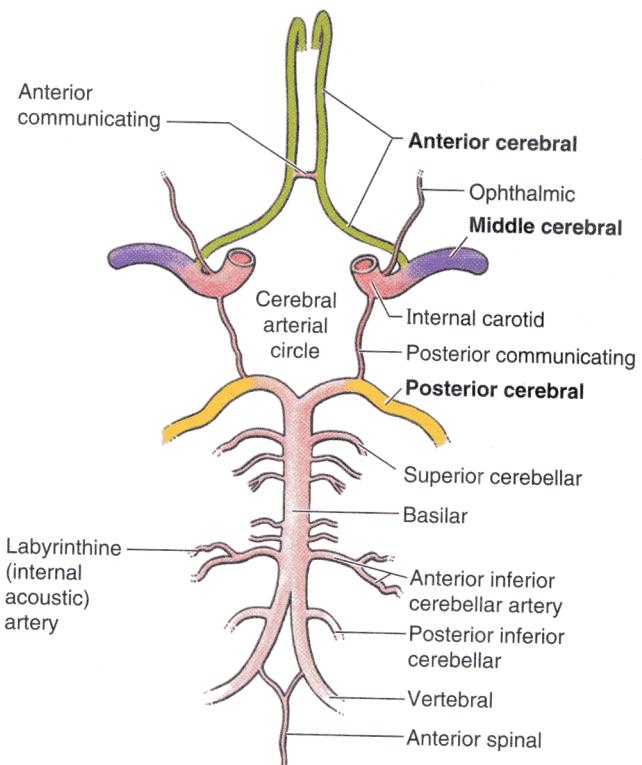
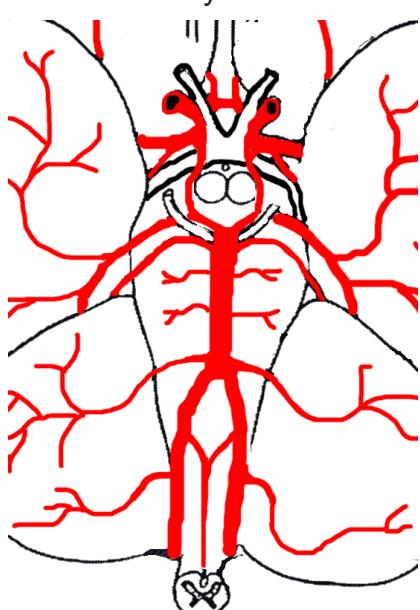
anterior cerebral artery

internal carotid artery

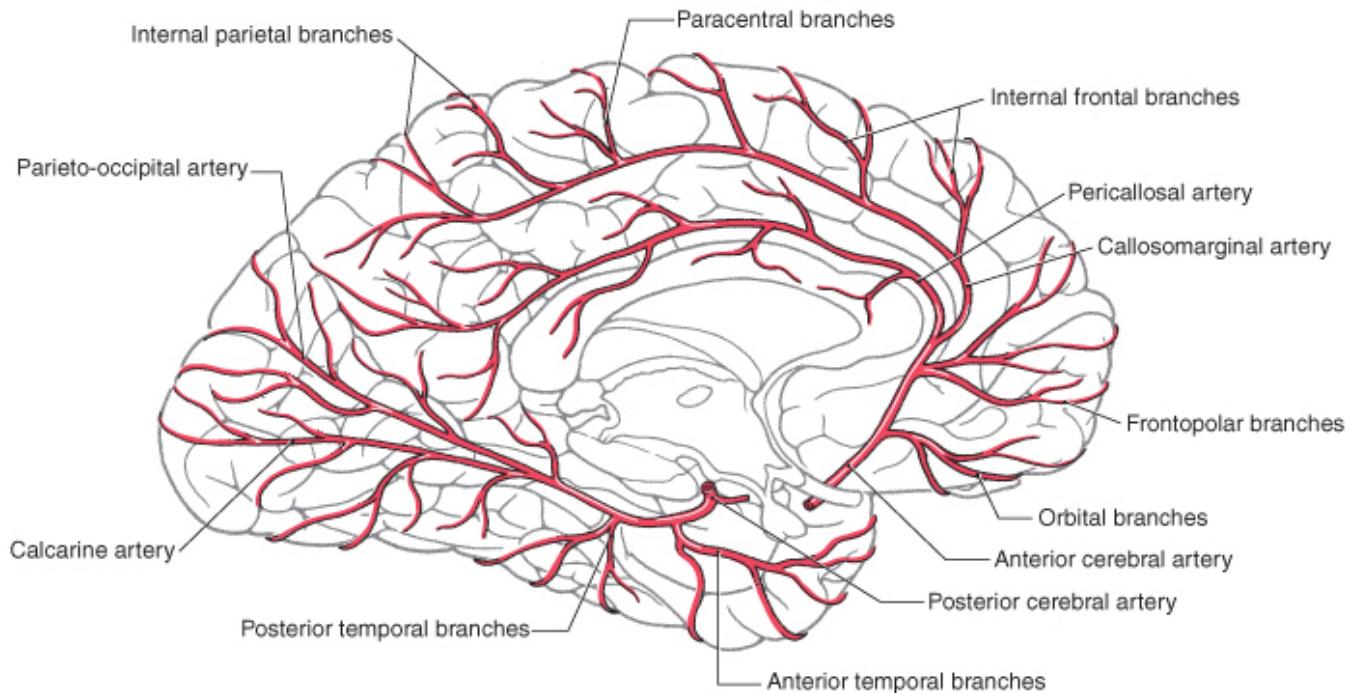
posterior communicating artery

posterior cerebral artery

basilar artery



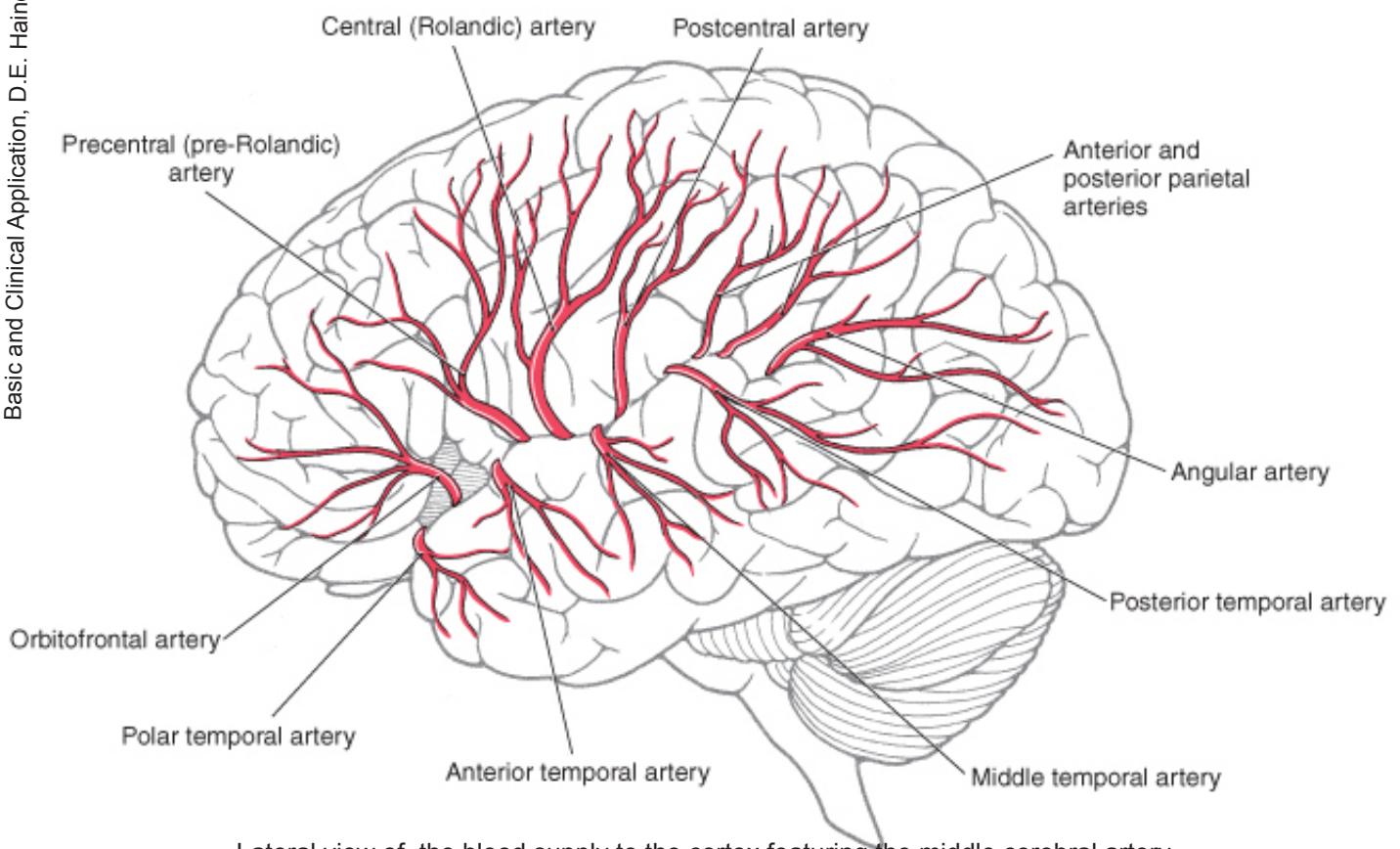
Inferior view of blood supply



Mid sagittal view of blood supply to the cortex featuring the anterior and posterior cerebral arteries

***Note: You do not have to learn all the names on these 2 images. Only anterior cerebral artery, posterior cerebral artery, pericallosal a., callosalmarginal a., and calcarine a.

Adapted from Fundamental Neuroscience for Basic and Clinical Application, D.E. Haines



Lateral view of the blood supply to the cortex featuring the middle cerebral artery

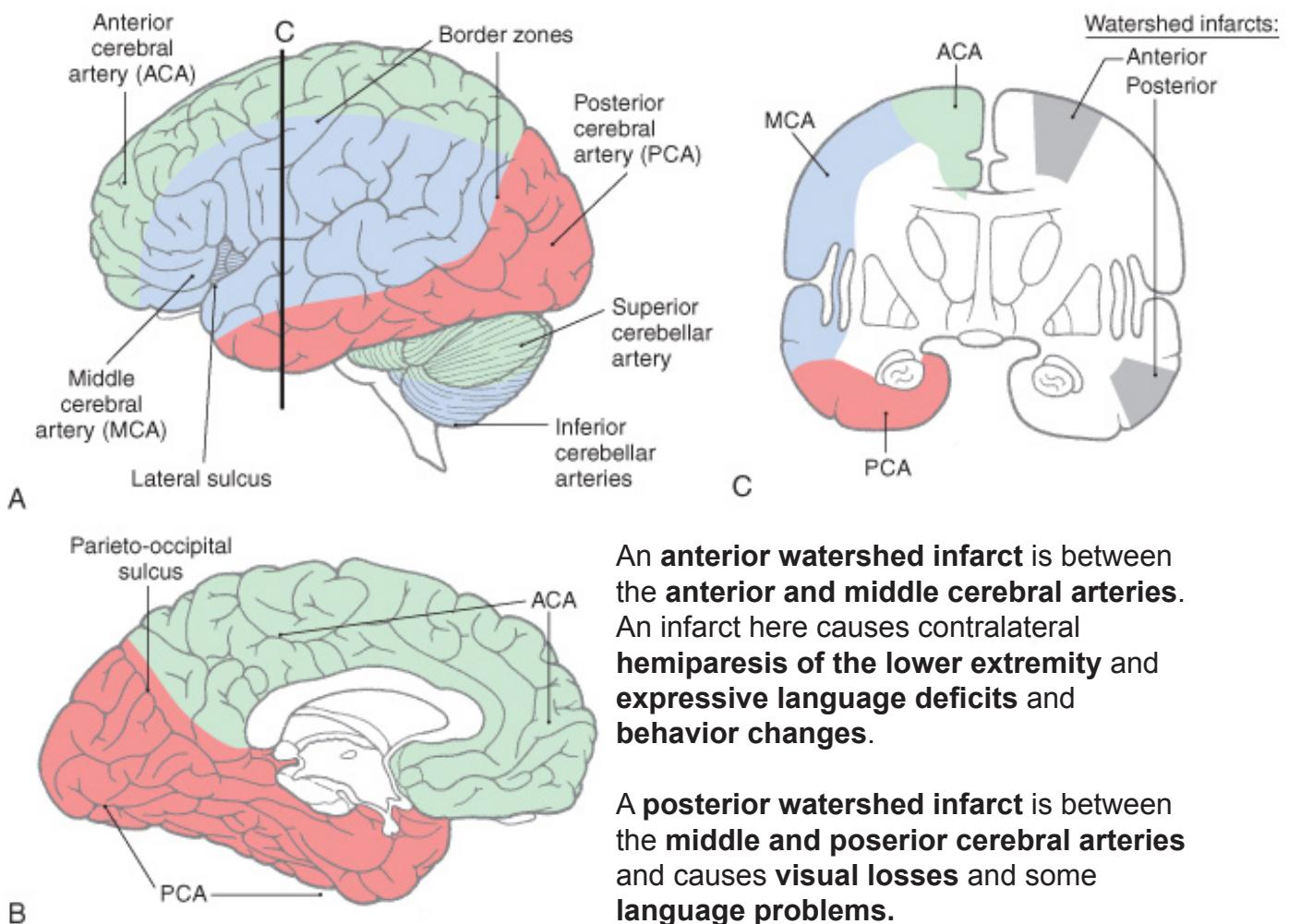
D. Watershed areas

The areas where the 2 major cerebral arteries terminate are called watershed areas. The brain tissue in the watershed areas is susceptible to damage during hypotension or other events of low or poor blood perfusion.

10% of all infarcts (cell tissue death) are from watershed infarcts.

2 major border zones exist

1. **Anterior border zone** between the regions supplied by the anterior and middle cerebral arteries
2. **Posterior border zone** between the regions supplied by the middle and posterior cerebral arteries.



An **anterior watershed infarct** is between the **anterior and middle cerebral arteries**. An infarct here causes **contralateral hemiparesis of the lower extremity** and **expressive language deficits and behavior changes**.

An **posterior watershed infarct** is between the **middle and posterior cerebral arteries** and causes **visual losses** and some **language problems**.

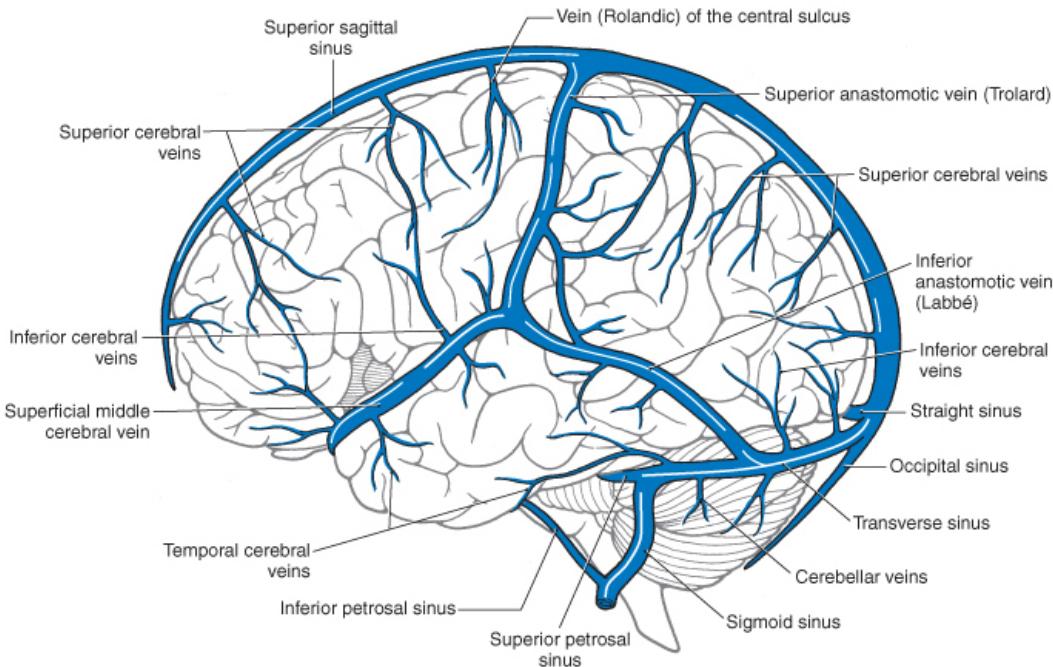
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III. Veins and Venous sinuses

Venous blood from superficial and deep veins enter the dural sinuses and drain out the internal jugular vein to the heart

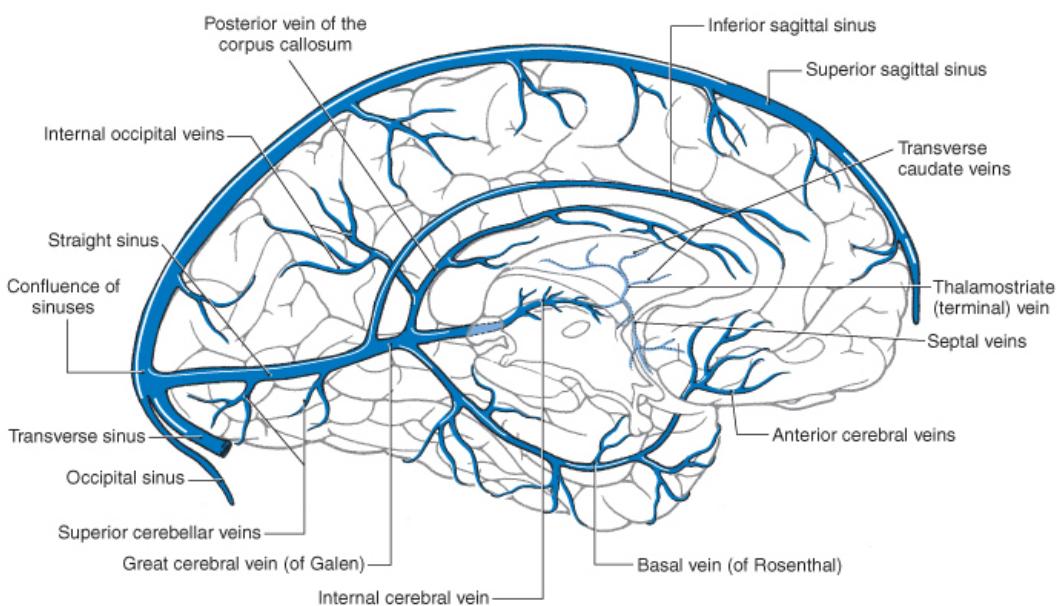
A. Superficial cerebral veins

1. **Superficial middle cerebral vein** to cavernous sinus
2. **Superior anastomotic vein of Trolard** to superior sagittal sinus
3. **Inferior anastomotic vein of Labbe** to transverse sinus



B. Deep cerebral veins

1. **Thalamostriate vein**
2. **Internal cerebral veins**
3. **Great cerebral vein of Galen**



C. Basal Aspect of Brain

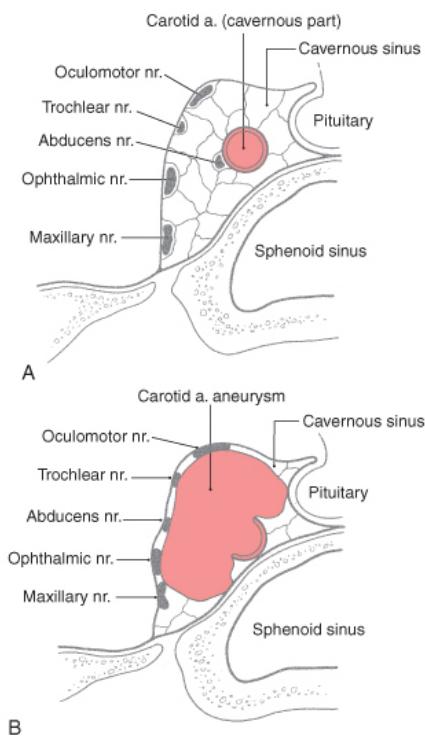
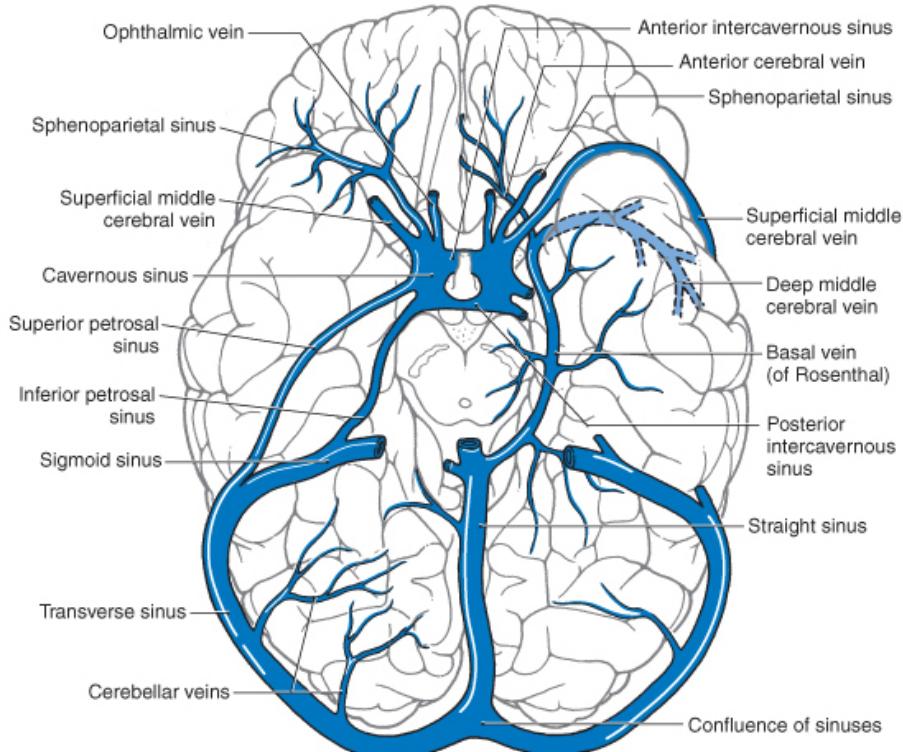
1. Cavernous Sinus

drains into the superior or inferior petrosal sinuses which drain into the sigmoid sinus and internal jugular veins respectively

2. Basal vein of Rosenthal

receives blood from the medial temporal lobe and drains into the straight sinus

No valves in venous system so bacteria can travel into brain



Clinical Aspect:

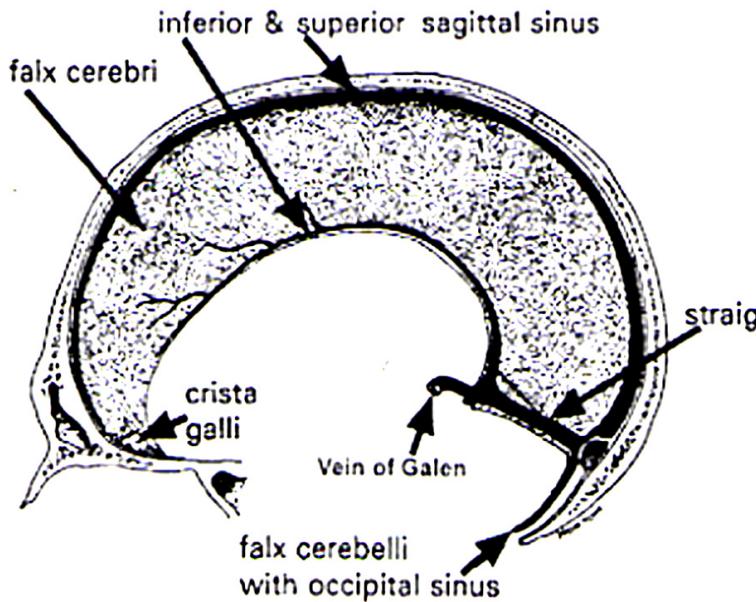
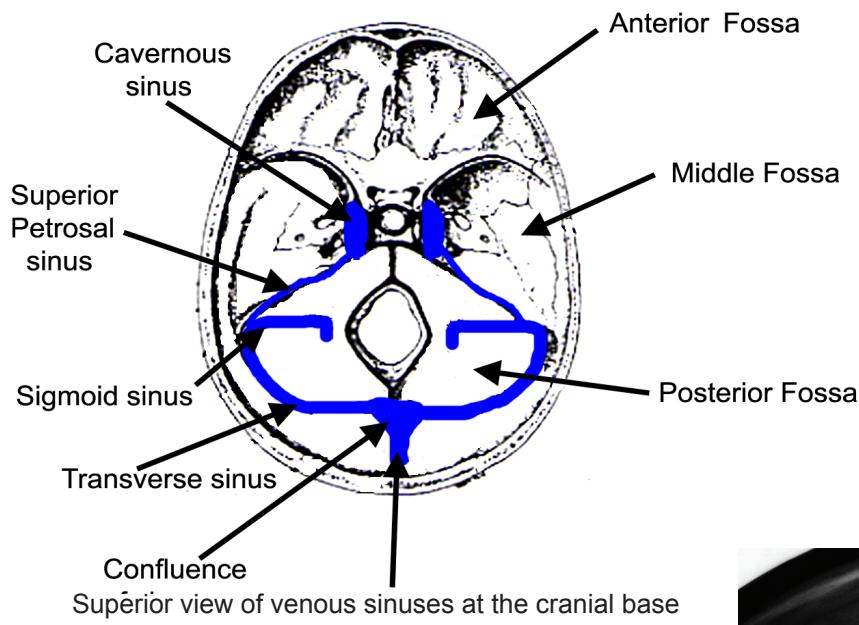
The internal carotid arteries travel through the cavernous sinus along with cranial nerves III, IV, V₁, V₂, and VI.

If the carotid artery would rupture (in the cavernous sinus area) it would affect not only the blood supply to the cortical areas, but also the cranial nerves in this area as well.

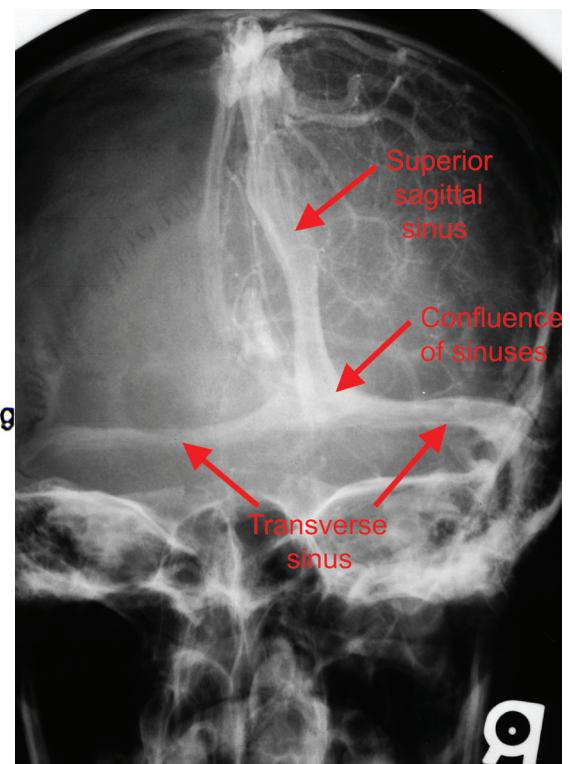
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D. Sinuses

1. Straight sinus drains into Confluence of Sinuses
2. Confluence of Sinuses
receives venous blood from:
straight sinus
superior sagittal sinus drains into
3. 2 transverse sinuses which drain into the
4. sigmoid sinuses to the
5. internal jugular veins



Lateral view of falx cerebri with sinuses



Venogram of sinuses, posterior view

IV. Blood Supply to the Spinal Cord

Blood supply to the spinal cord consists of:

- **1 Anterior Spinal Artery**

(supplies **anterior 2/3** and **lateral part** of cord - including anterior horns {lower motor neurons}, anterolateral tracts {pain and temperature pathway} and lateral corticospinal tracts {upper motor neurons}).

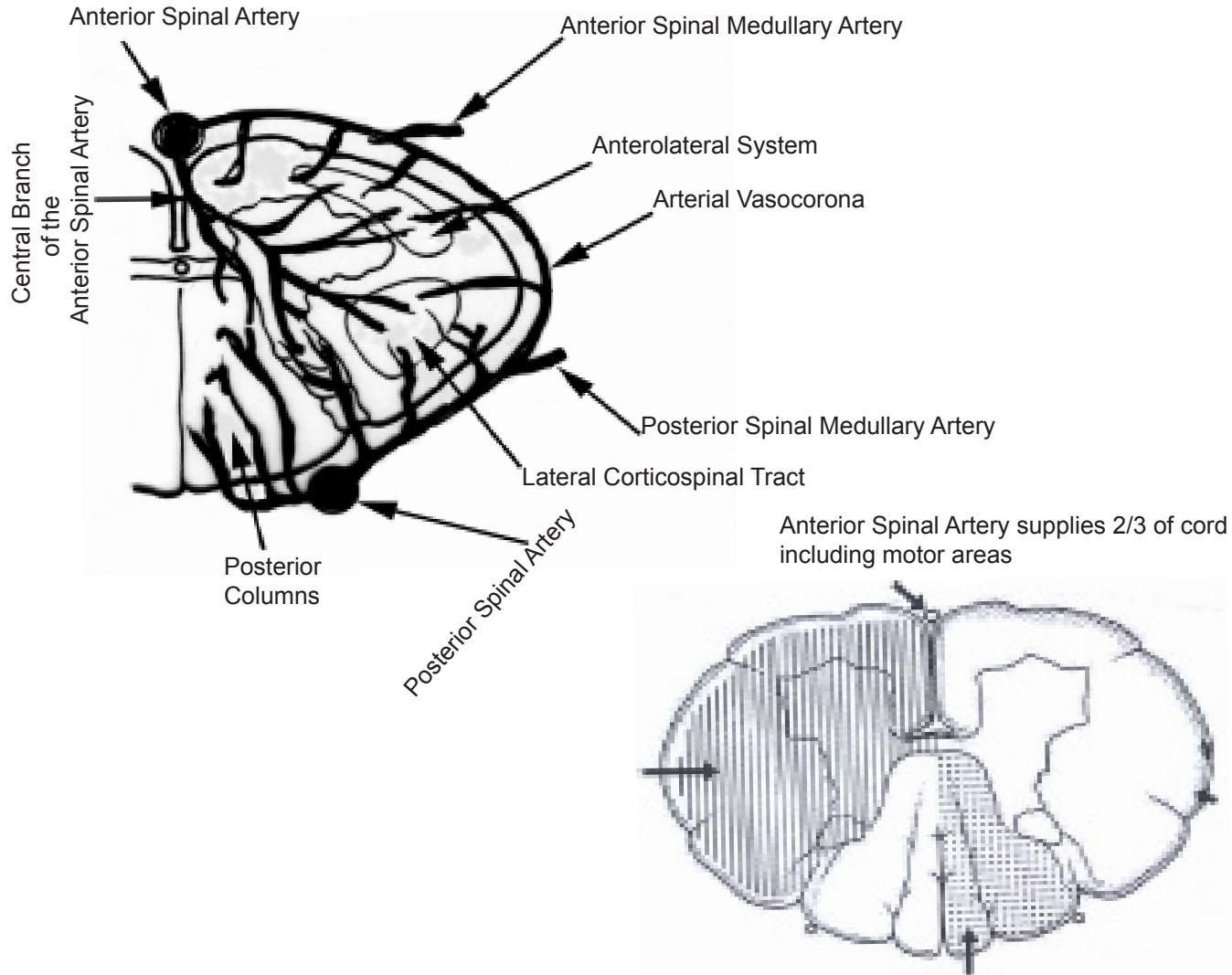
- **2 Posterior Spinal Arteries**

(supply the **posterior 1/3** of the cord - this includes the posterior columns {fine touch and proprioception}).

The **anterior spinal artery originates from vertebral arteries**, and the **posterior spinal arteries are usually a branch of the PICA**

and are supplemented by segmental branches mainly from the aorta.

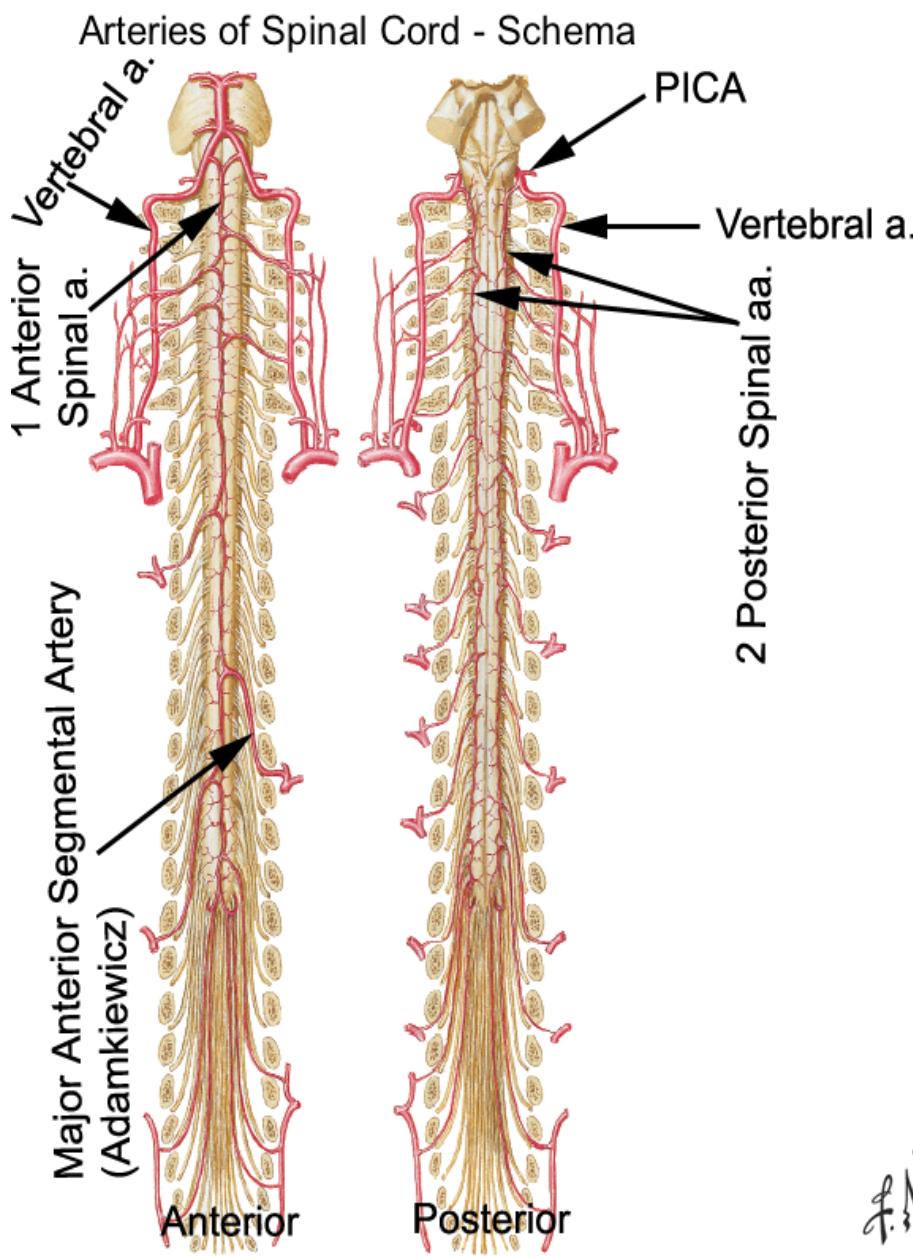
- **Radicular arteries** are a branch of the segmental artery and supply the **posterior and anterior roots and posterior (dorsal) root ganglia**
- Branches of Segmental arteries that supply the cord are called **Spinal Medullary arteries**



Clinical Aspect: The **artery of Adamkiewicz** is at **T12 -L2** on the left and is an important source of blood supply to the lumbar cord. If accidentally tied off during surgery, the patient will become **paraplegic**.

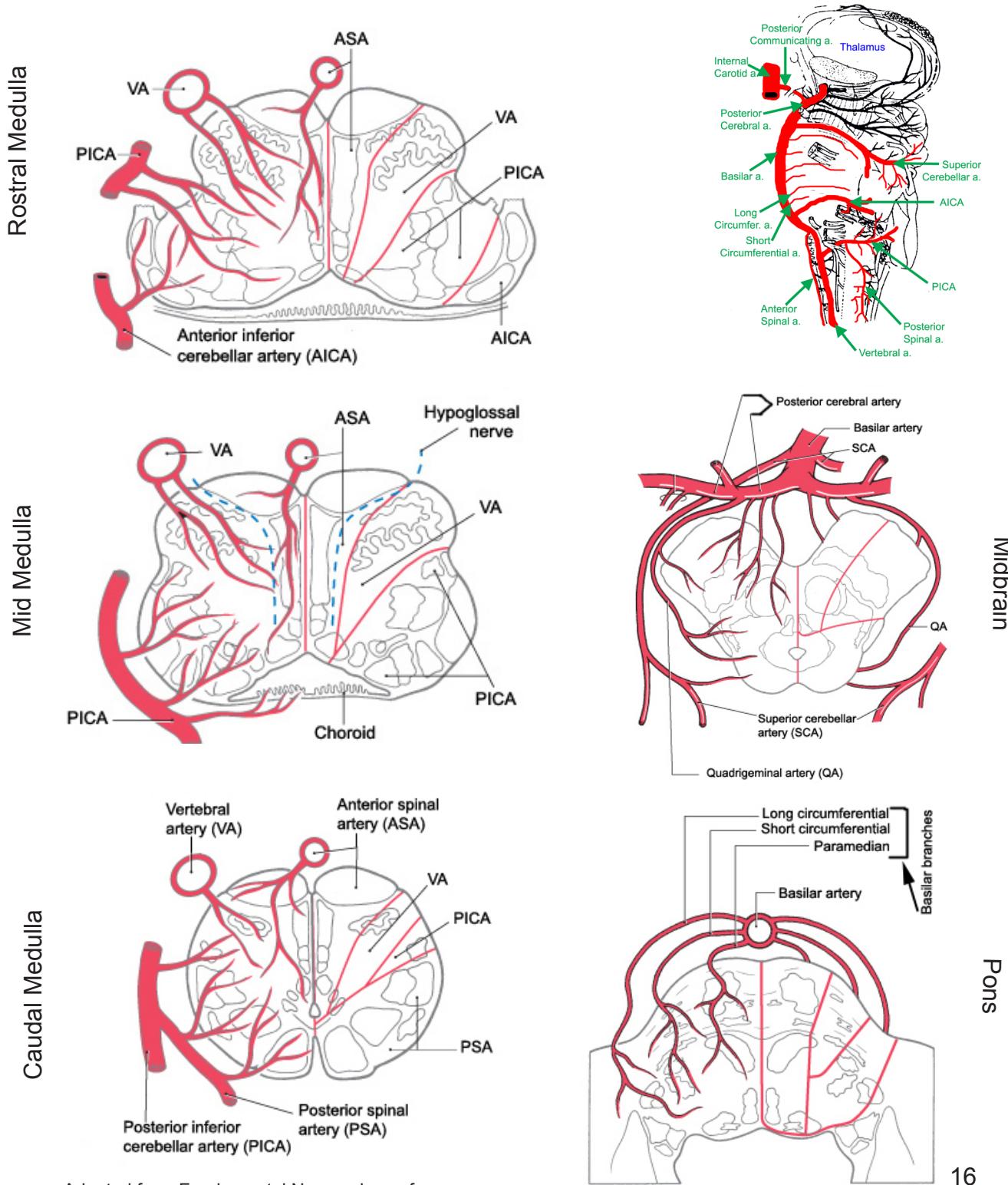
Lesions involving the **Anterior Spinal artery** can show **motor deficits** (both **upper** and **lower motor neuron signs**) and **sensory loss** (**Pain** and **Temperature**).

Lesions involving the **Posterior spinal arteries** can show **sensory losses** including loss of **fine touch** and **proprioception**.



V. Blood supply to the brainstem

The brainstem is divided into vascular zones which represent the specific artery that supplies that region of the brainstem. Different nuclei and tracts reside in these zones, therefore a vascular incident to a specific artery will affect a specific zone which contains specific nuclei and tracts. A patient will display different symptoms according to these zones which will help you determine the affected brainstem zone and the artery involved.



Adapted from Fundamental Neuroscience for Basic and Clinical Application, D.E. Haines

VI. Events that can lead to cerebrovascular problems

1. **Aneurysm** - a dilation of the blood vessel wall (in the tunica media)
 - they vary size
 - 85% are on internal carotid branches
 - located at branch points or abrupt turns
2. **Cerebral embolism** - occlusion of a vessel by extraneous material
 - (eg. clot, tumor, bacteria, plaque)
 - Occlusion leads to ischemia (inadequate blood flow)
 - Prolonged occlusion leads to infarction (cell and tissue death = necrosis)

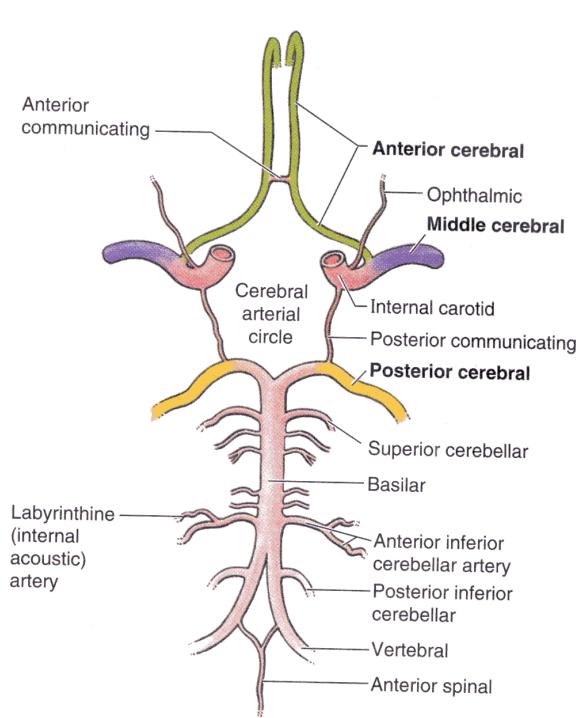
One cause for an occluded artery is **atherosclerotic disease** which can form at the bifurcation of the common carotid. When these plaques break off or dislodge, they will travel through the vasculature until they get stuck.

Thrombus = embolus made up of all blood

small emboli occlude small vessels and give rise to **transient ischemic attacks (TIAs)** which is a sudden loss of neurologic function that resolves itself in a few minutes to a few hours (up to 24).

large emboli occlude major vessels and cause **sudden catastrophic neurological problems** which may result in permanent deficits or death.

3. **Arteriovenous malformation** - when major **arteries and veins** don't develop normally. Capillary bed is missing, brain tissue is not normal.



Inferior view of blood supply

Adapted from Clinically Oriented Anatomy,
Moore & Daily

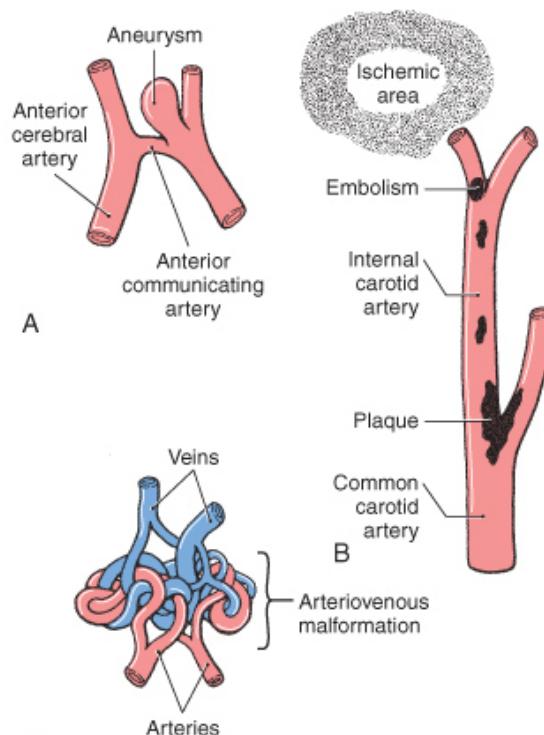


Diagram showing cerebrovascular problems

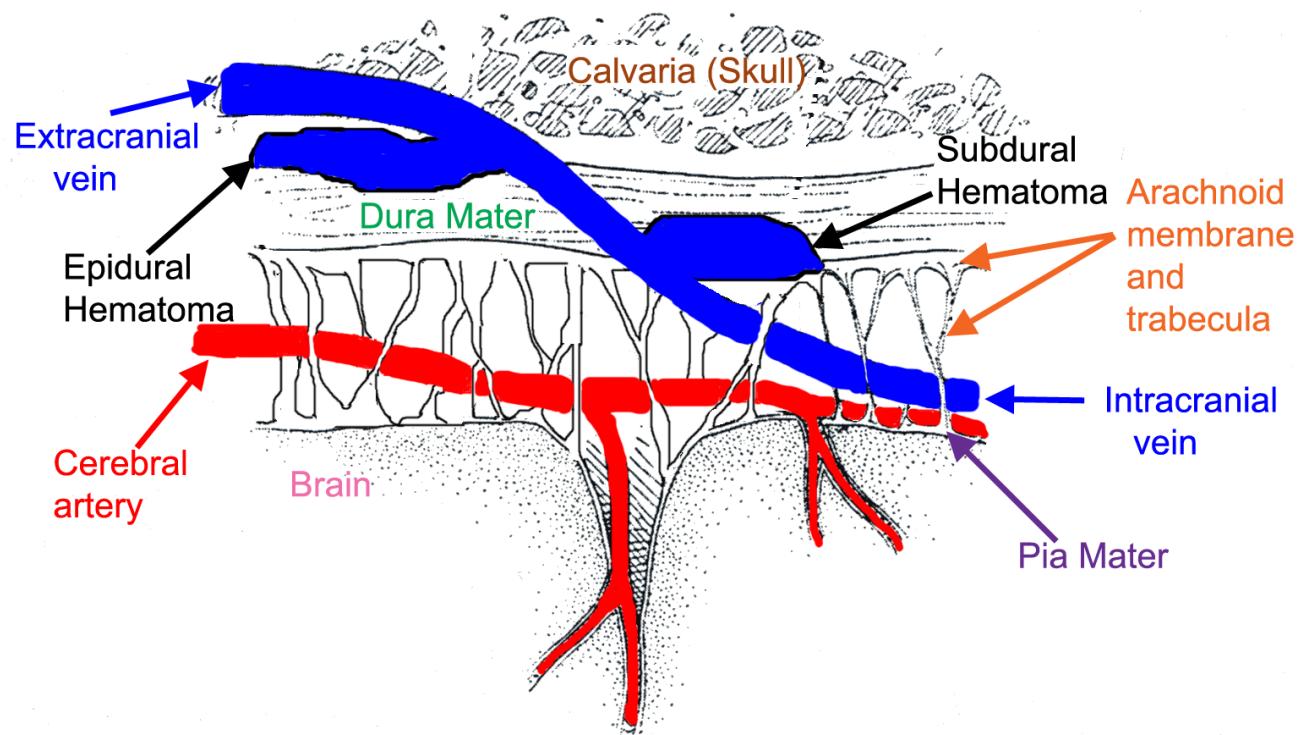
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VII. Hemorrhage (Bleeding)

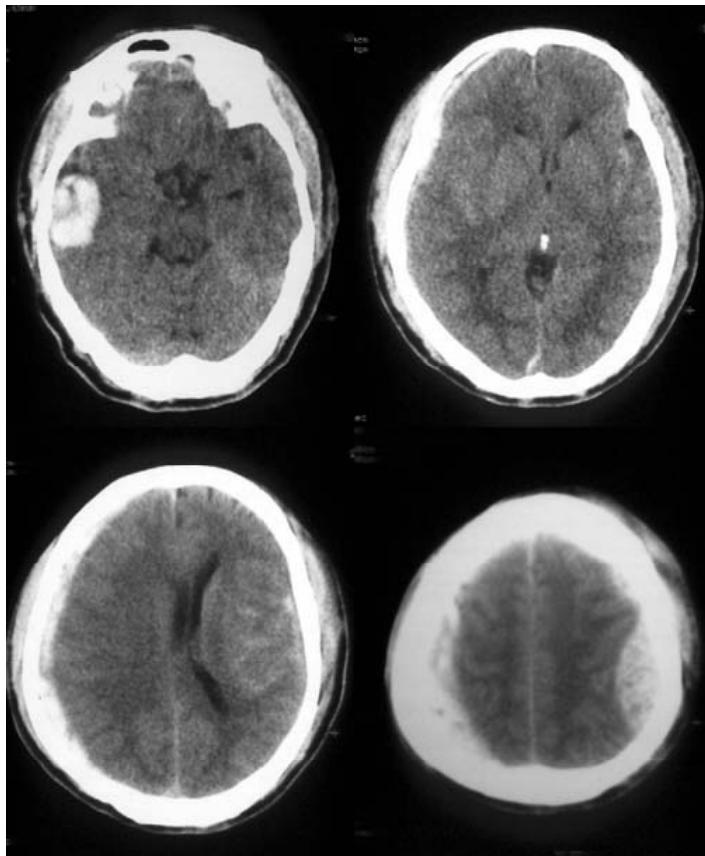
Types of hemorrhages:

A. Meningeal hemorrhage

1. **Epidural hemorrhage** - extravasated blood strips dura from skull
Injury to **meningeal a.or v.**
Usually to a blow to the head.
Appears short and wide because blood won't cross where the dura is still attached to the cranial suture lines
2. **Subdural hemorrhage** - Occurs between the arachnoid and dura
Results from the **bridging veins** tearing as they enter the superior sagittal sinus from a front or back blow to the head.
Appears long and thin because blood is running between the layer of dura and arachnoid.
3. **Subarachnoid hemorrhage** - Caused by trauma or intracranial aneurysm of arteries. Symptoms of an arterial bleed are sudden onset of headache, stiff neck and loss of consciousness.

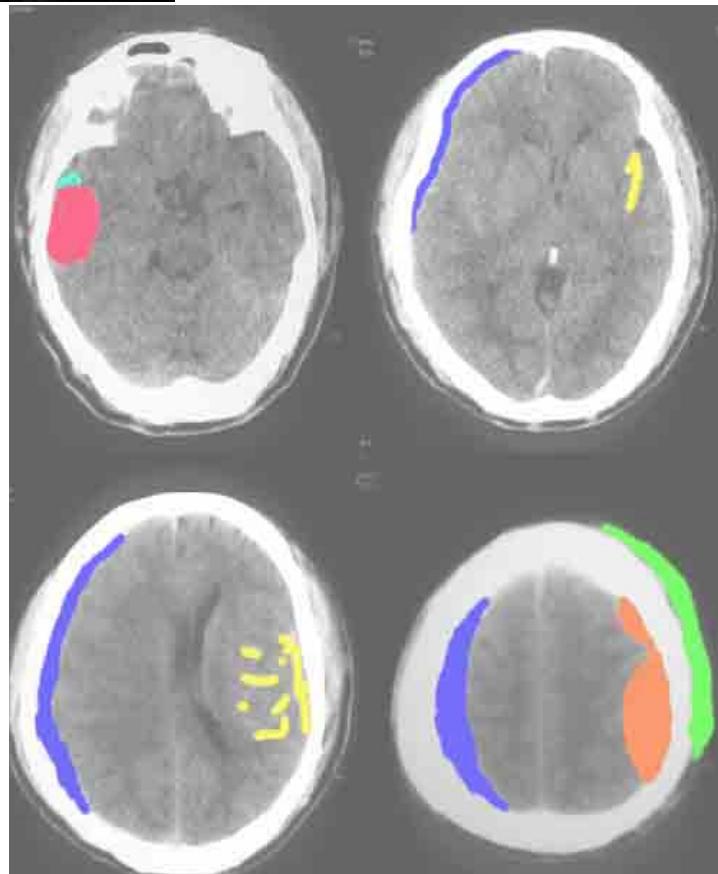


View of brain, meninges, and skull with associated arteries and veins



CT brain scans depicting various examples of brain hemorrhages.
Horizontal sections.

- Scalp Hematoma
- Contusion/Intracranial Hemorrhage
- Edema
- Subdural Hemorrhage
- Epidural Hemorrhage
- Subarachnoid Hemorrhage



B. Cerebral hemorrhage - can be caused by **hypertension** and can occur at the **lenticulostriate arteries** to cause the “classic “ stroke.
(Stroke - inadequate or loss of blood supply to the brain)

