Cerebral Blood Circulation

Please view our Editing File before studying this lecture to check for any changes.
Objectives

✓ List the cerebral arteries.
✓ Describe the cerebral arterial supply regarding the origin, distribution and branches.
✓ Describe the arterial Circle of Willis.
✓ Describe the cerebral venous drainage and its termination.
✓ Describe arterial & venous vascular disorders and their clinical manifestations.
REVIEW: The Brain

- Large mass of nervous tissue located in cranial cavity.
- Has four major regions.

**Cerebrum** (Cerebral hemispheres)

- The largest part of the brain, and has two hemispheres.
- The surface shows elevations called gyri, separated by depressions called sulci.
- Each hemisphere divided into four lobes by deeper grooves.
- Lobs are separated by deep grooves called fissures.

**Diencephalon:** Thalamus, Hypothalamus, Subthalamus & Epithalamus

**Brainstem:** Midbrain, Pons & Medulla oblongata

**Cerebellum**
REVIEW: Blood Vessels & Histology

- Blood vessels are the part of the circulatory system that transports blood throughout the human body.

- There are three major types of blood vessels:
  - Arteries, which carry the blood away from the heart.
  - Capillaries, which enable the actual exchange of water and chemicals between the blood and the tissues.
  - Veins, which carry blood from the capillaries back toward the heart.

- The word vascular, meaning relating to the blood vessels, is derived from the Latin vas, meaning vessel.

- Avascular refers to being without (blood) vessels.

- The arteries and veins have three layers, but the middle layer is thicker in the arteries than it is in the veins:
  1. Tunica Intima (the thinnest layer): a single layer of simple squamous endothelial cells.
  2. Tunica Media (the thickest layer in arteries): is made up of smooth muscle cells and elastic tissue.
  3. Tunica Adventitia (the thickest layer in veins) entirely made of connective tissue.

- Capillaries consist of little more than a layer of endothelium and occasional connective tissue.
REVIEW: Blood

- Blood is the actual carrier of the oxygen and nutrients into arteries.
- Blood is made mostly of plasma, which is a yellowish liquid that is 90% water.
- Plasma contains also salts, glucose and other substances.
- Most important, plasma contains proteins that carry important nutrients to the body’s cells and strengthen the body’s immune system.
- Blood has main 3 types of blood cells that circulate with the plasma.

Cerebral Circulation

- It is the movement of blood through the network of blood vessels to supply the brain.
- The movement of blood in the cerebral circulation is called cerebral blood flow.
- The arteries carry oxygenated blood and other nutrients to the brain.
- The veins carry deoxygenated blood back to the heart removing carbon dioxide and other metabolic products.
Cerebral Arterial supply

The arterial supply of the cerebrum is composed of/provided by 2 arterial systems:

1) Carotid System
Composed of:
- Internal carotid artery and its branches:
  - Anterior cerebral artery
  - Middle cerebral artery

Supply anterior portion of brain

2) Vertebro-Basilar System
The two vertebral arteries (from the subclavian artery) unite to form basilar artery.
It divides at the upper border of pons into two posterior cerebral arteries

Supply posterior portion of brain

*Posterior communicating arteries are part of Circle of Willis

Only on the boys’ slides
Anterior Cerebral Artery (ACA)

Supplies:
1. Orbital and medial surfaces of frontal and parietal lobes.
2. A narrow part on the superolateral surface.

Middle Cerebral Artery (MCA)

Supplies:
Entire Superolateral surface*:
1. Somatosensory Cortex
2. Motor Cortex
3. Language areas:
   • **Broca’s Area**: linked to speech production.
   • **Wernicke’s Area**: It is involved in the understanding of written and spoken language
4. Auditory areas:
   • Primary auditory area
   • **Heschl’s Gyrus**: to process incoming auditory information

Notes:
*Except for a narrow part by the ACA.
MCA supplies all the motor area except the leg area.
(Snell) except foot and perineum
Posterior Cerebral Artery (PCA)

**Supplies:**
1. Anterior and inferior **temporal** lobes
2. **Uncus:**
   - Located on the tip end of the medial surface of the parahippocampal gyrus.
   - Part of the olfactory cortex that processes information from the **sense of smell**.
3. Inferior temporal gyri
4. Inferior and Medial **Occipital lobe** (visual area)

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**Basilar artery**

**Supplies:** Mid brain and cerebellum

**Branches:**
- Anterior inferior cerebellar artery.
- Pontine branches.
- Superior cerebellar artery.

**Notes:**
- The vertebral arteries unite at the lower border of the pons to form the basilar artery.
- Pontine: related to the pons.

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*Only on the boys’ slides*
Circulus Arteriosus (Circle of wills*)

- It joins the carotid and vertebrobasilar systems**.
- It is located on the base of the brain.
- It encircles (surrounds):
  - Optic chiasma.
  - Hypothalamus.
  - Midbrain.
  - Pituitary gland.

*Named after Thomas Willis (1621–1675), an English physician.
** the circle of Willis is formed by the anastomosis between the two internal carotid arteries and the two vertebral arteries. (Snell)
Anterior Perforating Arteries

Arise from:
• Anterior cerebral artery.
• Anterior communicating artery.
• Middle cerebral artery.

Enter brain through:
• Anterior perforated substance (an irregularly quadrilateral area in front of the optic tract and behind the olfactory trigone).

Supply:
1. Large part of basal ganglia.
2. Optic chiasma.
3. Internal capsule (a white matter structure).
4. Hypothalamus.

Posterior Perforating Arteries

Arise from:
• Posterior cerebral artery.
• Posterior communicating artery.

Enter brain through:
• Posterior Perforated substance. (perforated substance: a layer of grey matter, that is pierced to allow blood vessels to pass)

Supply:
1. Ventral portion of Midbrain.
2. Parts of Subthalamus and Hypothalamus.

Circulus Arteriosus (Circle of wills*)

Branches: Perforating arteries
numerous small vessels that penetrate the surface of the brain through the anterior and posterior perforating substances.
They are divided into:

Anterior Perforating Arteries

Posterior Perforating Arteries

Arise from:
• Posterior cerebral artery.
• Posterior communicating artery.

Enter brain through:
• Posterior Perforated substance. (perforated substance: a layer of grey matter, that is pierced to allow blood vessels to pass)

Supply:
1. Ventral portion of Midbrain.
2. Parts of Subthalamus and Hypothalamus.
Arterial Disorders

**Stroke**
- It happens when blood supply to the brain is interrupted or reduced.
- Sudden occlusion
- It can be: Ischemic or hemorrhagic.

**Aneurysm**
- Localized, blood-filled balloon-like bulge in the wall of a blood vessel.

**Angioma**
- Benign tumors derived from cells of the vascular or lymphatic vessel walls (epithelium) or derived from cells of the tissues surrounding these vessels.
Effects of **Occlusion** of Cerebral Arteries
# Effects of Occlusion of Cerebral Arteries (Manifestations)

| Anterior Cerebral Artery | 1. Motor disturbance in contralateral distal leg  
2. Difficulty in **prefrontal lobe** functions:  
   • Cognitive thinking  
   • Judgement  
   • Motor initiation  
   • Self monitoring |
|--------------------------|---------------------------------------------------|
| Middle Cerebral Artery   | 1. Contralateral **weakness** of:  
   • face, arm, and hands more than legs  
2. Contralateral **sensory loss** of:  
   • face, arm, and hands more than legs  
3. Visual field cut (damage to **optic radiation**)  
4. **Aphasia** (language disturbance):  
   • In Broca’s area: production  
   • In Wernicke’s area: comprehension |
| Posterior Cerebral Artery| 1. **Visual** disturbances:  
   • Unilateral lesion: contralateral homonymous hemianopsia  
   • Bilateral lesions: cortical blindness, patients unaware they cannot see (Anton’s Syndrome)  
2. **Memory** impairment: if temporal lobe is affected |

**Notes:**
- Optic radiation: axons from the neurons in the lateral geniculate nucleus to the primary visual cortex.
- Hemianopsia: decreased vision or blindness in half the visual field.
- Homonymous hemianopsia: the loss of half of the visual field on the same side in both eyes (see picture on right).
- Cortical blindness: total or partial vision loss because of damage to the occipital cortex.
Cerebral **Venous** Drainage

- The veins are thin walled and are devoid of (don’t have) valves.
- The cortical veins are:
  - Superficial cortical veins:
    - Found in the subarachnoid space
    - Drain the cortical surface
  - Deep veins:
    - Drain the deep structures

These veins ultimately drain into:

Dural venous sinuses
# Cerebral Venous Drainage

**Superficial Cortical Veins**

They lie on the brain surface, in the **subarachnoid space**.

They are divided into:

| Superior cerebral veins | • 6 to 12 veins  
|• Drain lateral surface of brain above the lateral sulcus  
|• Terminate mainly into the **Superior Sagittal sinus**, and partly into superficial middle cerebral vein. |
|---|---|
| Inferior cerebral veins | • Run below the lateral sulcus  
|• Drain the lateral surface of the temporal lobe  
|• Terminate partly into superficial middle cerebral vein & partly into **Transverse sinus**. |
| Superficial middle cerebral veins | • Runs along the lateral sulcus  
|• Terminates into the **Cavernous sinus**  
|• Connected posteriorly by Superior & Inferior anastomotic veins to Superior Sagittal & Transverse sinuses respectively |
Cerebral Venous Drainage
Deep Cortical Veins

They drain the internal structures:
- Basal ganglia
- Internal capsule
- Thalamus

Deep cerebral veins → Internal cerebral veins → Great cerebral vein → straight sinus

They merge to form:
The two veins unit in the midline to form:
This short vessel joins the Inferior Sagittal sinus to form:
Cerebral **Venous** Drainage

**Dural venous sinuses**

- Blood flows from **transverse** & **sigmoid** sinuses into IJV **Internal Jugular Vein**.

<table>
<thead>
<tr>
<th>Paired:</th>
<th>Single:</th>
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<tbody>
<tr>
<td>Transverse</td>
<td>Superior sagittal</td>
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<tr>
<td>Sigmoid</td>
<td>Inferior sagittal</td>
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<tr>
<td>Cavernous</td>
<td>Straight</td>
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<tr>
<td>Petrosal (superior &amp; inferior)</td>
<td>Occipital</td>
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Venous disorders

**Infarction**

- refers to tissue death (necrosis) that is caused by a local lack of oxygen due to obstruction of the tissue's blood supply

**Sinus thrombosis**

- SSS (superior sagittal sinus) thrombosis*:
  - can complicate ear infection
- Cavernous sinus thrombosis: As a complication of infection in the dangerous area of the face**

- Obstruction of venous drainage of the brain leads to Cerebral swelling (edema) and raised Intracranial Pressure.

*Superior sagittal sinus thrombosis (SSST) is the most common type of dural venous sinus thrombosis and is potentially devastating
These 2 videos summarize the lecture:

Duration: 01:42

Duration: 01:18
Summary

Cerebral arterial supply

Carotid system
- Internal carotid artery
  - Anterior cerebral A
    - Supplies: 1. orbital & medial surfaces of frontal and parietal lobes
    - 2. Narrow part on the superolateral surface
  - Middle cerebral A
    - Supplies entire superolateral surface:
      1. Motor cortex
      2. Somatosensory cortex
      3. Language areas (Broca & Wernicke)
      4. Primary auditory area + association (Heschl)
  - Supplies entire superolateral surface:

Vertebro basilar system
- Divides into two posterior cerebral A
  - Supplies:
    1. Anterior and inferior parts of temporal lobe
    2. Inferior temporal gyrus
    3. Uncus
    4. Inferior and medial parts of occipital lobe

Circulus arteriosus (of willis)
- Joins carotid and vertebrobasilar systems
  - Composed of:
    1. 2 anterior cerebral A
    2. 2 internal carotid A
    3. 2 posterior cerebral A
    4. 1 anterior communicating A
    5. 2 posterior communicating A
  - Branches:
    1. APA
    2. PPA
      - Supply:
        1. Large part of basal ganglia
        2. Optic chiasma
        3. Internal capsule
        4. Hypothalamus
  - Supply:
    1. Ventral portion of midbrain
    2. Parts of subthalamus and hypothalamus
Cerebral venous drainage

Superficial cortical veins
- Superior cerebral veins (6-12)
  - Drain lateral surface of brain above the lateral sulcus
  - Terminate mainly into superior sagittal sinus and partly into superficial middle cerebral vein
- Inferior cerebral V
  - Drain the lateral surface of the temporal lobe
  - Terminate partly into superficial middle cerebral vein & partly into transverse sinus
- Superficial middle cerebral V
  - Terminates into cavernous sinus
  - Connected posteriorly by superior & inferior anastomotic vein to superior sagittal & transverse sinuses respectively

Deep cortical veins
- Drain the internal structures (basal ganglia, internal capsule, thalamus)
- Internal cerebral veins
  - Great vertebral vein
  - Straight sinus

Summary
Q1. What does the basilar artery supply?
A. Mid brain
B. cerebellum
C. A&B
D. motor cortex

Q2. Which of the following are paired Dural sinuses?
A. Inferior sagittal
B. Straight
C. Cavernous
D. Occipital

Q3. Which of the following is the one of the effects that occur when the posterior cerebral artery is occluded?
A. Visual disturbances
B. Language disturbances
C. Motor disturbance in the contralateral distal leg
D. Contralateral sensory loss of face

Q4. Which of the following supplies the Optic chiasma:
A. Anterior Perforating Arteries
B. Posterior Perforating Arteries
C. Middle Perforating Arteries
D. Anterior Cerebral Artery

Q5. Which of the following is not a branch of the basilar artery?
A. Anterior inferior cerebellar artery.
B. Pontine branches.
C. Superior cerebellar artery
D. Middle cerebral artery

Q6. What does the circle of Willis NOT encircle?
A. Optic chiasma.
B. Hypothalamus.
C. Midbrain
D. Cerebellum

Q7. What do the cerebral veins NOT drain?
A. Basal ganglia
B. Internal capsule
C. Thalamus
D. Hypothalamus

Q8. Which of the following runs below the lateral sulcus:
A. Superficial cerebral veins
B. Inferior cerebral veins
C. Superficial cerebral artery
D. Inferior cerebral artery
SAQ

Q1. From which arteries do the anterior perforating arteries arise from?
   a. Anterior cerebral artery.
   b. Anterior communicating artery.
   c. Middle cerebral artery.

Q2. Which parts do the posterior perforating arteries supply?
   a. Ventral portion of Midbrain.
   b. Parts of Subthalamus and Hypothalamus.

Q3. A 35 year old man came to the hospital complaining of impaired memory and cortical blindness.

   Which cerebral artery is affected?
   Posterior cerebral artery

   Which side is most likely affected?
   Bilateral lesion (affecting both sides) which will lead to Anton’s syndrome
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References:
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2- Greys Anatomy for Students
3- TeachMeAnatomy.com