Blood supply to the brain, CSF circulation

ED II. 2017

“The problem is, God gave man a brain and another important organ, and only enough blood to run one at a time...” R. W.

PhD Dr. David Lendvai
Vascular supply and drainage of the brain

- The brain is a highly vascular organ
- It has a high metabolic rate that reflects the energy requirements of constant neural activity
- It receives about 15% of the cardiac output and utilizes 25% of the total oxygen consumption of the body.
Topics

1. Arterial supply of the brain

2. Venous drainage of the brain

3. Chorid plexus and the circulation of CSF
Arterial supply of the brain
Arterial supply of the brain

• The brain is supplied by two internal carotid arteries and two vertebral arteries that form a complex anastomosis (circulus arteriosus, circle of Willis) on the base of the brain.
Overview of the arterial supply of the brain
Overview of the arterial supply of the brain
Internal carotid artery

Parts of the ICA:

Cervical
Petrous
Cavernous
Carotid siphon
Cerebral
Circle of Willis

- Posterior communicating artery
- Posterior cerebral artery
- Anterior inferior cerebellar artery
- Basilar artery
- Foramen magnum
- Vertebral artery
- Posterior spinal artery
- Anterior spinal artery
- Confluence of the sinuses
- Posterior inferior cerebellar artery
- Superior sagittal sinus
- Anterior cerebral artery
- Anterior communicating artery
- Middle cerebral artery
- Internal carotid artery
- Superior cerebellar artery
- Pontine arteries
Variants of the circle of Willis (after Lippert and Pabst)
Stenoses and occlusions of arteries supplying the brain

Subclavian steal syndrome (SSS)

Classically, SSS is a consequence of a redundancy in the circulation of the brain and the flow of blood.

The blood flow from the brain to the upper limb in SSS is considered to be stolen as it is blood flow the brain must do without. This is because of collateral vessels.
Middle cerebral artery
Anterior and posterior cerebral artery
Distribution areas of the main cerebral arteries
Distribution of the main cerebral arteries
Distribution of the main cerebral arteries, functional centers
Arteries of the brainstem and cerebellum
Arteries of the brainstem and cerebellum, distributions
Arteries of the brainstem and cerebellum, distributions
Venous drainage of the brain
Relationship of the principal dural sinuses to the skull
Structure of the dural sinus

- Dura mater, periosteal layer
- Superior sagittal sinus
- Emissary vein
- Galea aponeurotica
- Scalp
- Outer table
- Diploe
- Inner table
- Lateral lacuna with arachnoid villi (Pacchionian granulations)
- Dura mater, meningeal layer
- Sinus endothelium
- Falx cerebri
- Bridging vein
- Superior cerebral veins
- Extracranial scalp veins
- Diploic veins
- Granular foveola
- Arachnoid septa
Dural sinuses at the skull base
Accessory drainage pathways of the sinuses
Occipital emissary sinus
Superficial and basal veins of the brain
Regions drained by the sup. cer. veins

D Anastomoses between the superficial and deep cerebral veins
Deep cerebral veins

Anterior vein of septum pellucidum
Internal cerebral vein
Basal vein
Posterior vein of corpus callosum
Superior cerebellar veins
Veins of caudate nucleus
Interventricular foramen
Superior thalamostriate vein
Superior choroidal vein
Lateral vein of lateral ventricle
Great cerebral vein
Medial vein of lateral ventricle
Straight sinus
Confluence of the sinuses
Internal cerebral vein
Inferior sagittal sinus
Thalamostriate vein
Basal vein
Veins of the brainstem
Extracerebral hemorrhages

- Calvaria
- Ruptured middle meningeal artery
- Fracture
- Epidural hematoma
- Dura mater
- Arachnoid
- Subdural hematoma
- Bridging vein
- Superior sagittal sinus
- Falx cerebri
- Inferior sagittal sinus
- Subarachnoid space

![Images of brain structures and hemorrhages with medical imaging](image-url)
Extracerebral hemorrhages
Cerebrovascular diseases

B Cerebral venous thrombosis
Coronal section, anterior view.

a) Medial (right) and posterior (left) superior cerebral vein thrombosis.
b) Right inferior cerebral vein thrombosis.
c) Bilateral thrombosis of internal cerebral veins.

Illustrator: Markus Voll

Schuenke et al. THIEME Atlas of Anatomy • Head and Neuroanatomy
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<table>
<thead>
<tr>
<th>Vascular territory</th>
<th>Neurological symptoms</th>
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<tbody>
<tr>
<td>Anterior cerebral artery</td>
<td>Hemiparesis (with or without hemisensory deficit)</td>
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<tr>
<td></td>
<td>Bladder dysfunction</td>
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<tr>
<td>Middle cerebral artery</td>
<td>Hemiparesis (with or without hemisensory deficit) mainly affecting the arm and face (Wernicke- \n  Ischemic type)</td>
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<tr>
<td></td>
<td>Aphasia</td>
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<tr>
<td>Posterior cerebral artery</td>
<td>Hemisensory losses</td>
</tr>
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<td>Hemiplegia</td>
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Cortical blindness syndrome
CSF circulation
Chorid plexus and the circulation of CSF

- Anterior horn of lateral ventricle
- Interventricular foramen
- Suprapineal recess
- Pineal recess
- Collateral trigone
- Posterior horn of lateral ventricle
- Third ventricle
- Supraoptic recess
- Infundibular recess
- Inferior horn of lateral ventricle
- Lateral recess, ends in lateral aperture of fourth ventricle
- Cerebral aqueduct
- Fourth ventricle
- Median aperture of fourth ventricle
- Central canal
Chorid plexus

Posterior thalamic nucleus
Choroid plexus of lateral ventricle
Pineal body
Fornix
Interventricular foramen
Choroid plexus
Interthalamic adhesion
Hypothalamus
Epithalamus
Lateral aperture
Thalamus
Middle cerebellar peduncles
Median aperture
Bochdalek’s flower basket
Dura mater, perosteal layer
Superior sagittal sinus
Emissary vein
Galea aponeurotica
Scalp
Outer table
Diploe
Inner table
Lateral lacuna with arachnoid villi (Pacchionian granulations)
Dura mater, meningeal layer
Sinus endothelium
Falk cerebri
Bridging vein
Superior cerebral veins
Extracranial scalp veins
Diploic veins
Granular foveola
Arachnoid septa
Chorid plexus

- Ependyma
- CSF space
- Blood vessels

- Cuboidal epithelium
- Brush border

- Dural venous sinus
- Choroid plexus
- Arachnoid granulations

- Fourth ventricle
- Median aperture
- Cerebral aqueduct

- Subarachnoid space
- Lateral ventricle
- Third ventricle
Astrocytes (A) in rat brain, immunolabelled to show glial fibrillary acidic protein (brown). Fine processes form end-feet (E) on brain capillaries (C). Note that astrocytes have extremely dense, numerous processes: immunostaining only reveals a proportion of the processes. (Prepared by Mr Marios Hadjipavlou, King's College, London.)

The relationship between the glia limitans, perivascular cells and blood vessels within the brain, in longitudinal and transverse section. A sheath of astrocytic end-feet wraps around the vessel and, in vessels larger than capillaries, its investment of pial meninges. Vascular endothelial cells are joined by tight junctions and supported by pericytes; perivascular macrophages lie outside the endothelial basal lamina.
Blood-brain barrier and blood-CSF barrier

- The blood-brain barrier develops during embryonic life but may not be fully completed by birth.
- There are certain areas of the adult brain where the endothelial cells are not linked by tight junctions, which means that a free exchange of molecules occurs between blood and adjacent brain.
- Most of these areas are situated close to the ventricles and are known as circumventricular organs.
- Elsewhere, unrestricted diffusion through the blood-brain barrier is only possible for substances that can cross biological membranes because of their lipophilic character. Lipophilic molecules may be actively re-exported by the brain endothelium.
Circumventricular organs

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<tr>
<th>Organ</th>
<th>Location</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>Vascular organ of the lamina terminalis (VOLT)</td>
<td>Vascular loops in the rostral wall of the third ventricle (lamina terminalis); rudimentary in humans</td>
<td>Secretes the regulatory hormones somatostatin, lulliberin, and motilin; contains cells sensitive to angiotensin II; is a neuroendocrine mediator</td>
</tr>
<tr>
<td>Subfornical organ (SFO)</td>
<td>Fenestrated capillaries between the interventricular foramina and below the fornices</td>
<td>Secretes somatostatin and lulliberin from nerve endings; contains cells sensitive to angiotensin II; plays a central role in the regulation of fluid balance (&quot;organ of thirst&quot;)</td>
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<tr>
<td>Subcommissural organ (SCO)</td>
<td>Borders on the pineal body; overlies the epithalamic commissure at the junction of the third ventricle and cerebral aqueduct</td>
<td>Secretes glycoproteins into the aqueduct that condense to form the Reissner fiber, which may extend into the central canal of the spinal cord; blood-brain barrier is intact; function is not completely understood</td>
</tr>
<tr>
<td>Area postrema (AP)</td>
<td>Paired organs in the floor of the caudal end of the rhomboid fossa, richly vascularized</td>
<td>Trigger zone for the emetic reflex (absence of the blood-brain barrier); atrophies in humans after middle age</td>
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