"Blood Supply of Brain and Spinal Cord (Part 1/2)"

》 Arteries of the Brain

- Main Arteries: Brain is supplied by two internal carotid and two vertebral arteries.

- Subarachnoid Space: These four arteries lie within this space, with branches forming the circle of Willis on the brain's inferior surface.

"Internal Carotid Artery"

》 Origin:

- Begins at bifurcation of common carotid artery, often showing a dilation known as the carotid sinus.

》 Path:

- Ascends neck, enters skull via carotid canal in the temporal bone.

- Passes horizontally through cavernous sinus, emerges medially at anterior clinoid process by perforating dura mater

- Enters subarachnoid space by piercing arachnoid mater, then curves to lateral cerebral sulcus.

》 Division:

- Ends by splitting into anterior and middle cerebral arteries.

> Cerebral Portion Branches

1) Ophthalmic Artery:

• Origin:

- Originates as internal carotid exits cavernous sinus.

• Path:

- Enters orbit through optic canal below optic nerve.

• Supplies:

- Eye, orbital structures, and terminal branches supply frontal scalp, ethmoid and frontal sinuses, dorsum of the nose.

2) Posterior Communicating Artery:

• Origin:

- Small vessel originating near internal carotid's terminal bifurcation.

• Path:

- Runs posteriorly above oculomotor nerve, joining posterior cerebral artery.

• Function:

- Forms part of the circle of Willis.

3) Choroidal Artery:

• Origin:

- Small branch close to internal carotid's terminal bifurcation.

• Path:

- Runs posteriorly near optic tract, enters inferior horn of lateral ventricle, ending in choroid plexus.

• Supplies:

- Small branches to crus cerebri, lateral geniculate body, optic tract, and internal capsule.

> Anterior Cerebral Artery

- Smaller Terminal Branch of internal carotid.

• Path:

- Runs forward and medially above optic nerve, enters longitudinal fissure.

• Connections:

- Joined to opposite anterior cerebral artery by anterior communicating artery.

• Course:

- Curves over corpus callosum, finally anastomoses with posterior cerebral artery.

• Cortical Supply:

- Medial surface of cerebral cortex up to parieto-occipital sulcus.
-2.5 cm strip on adjoining lateral surface.
- Supplies leg area of precentral gyrus.

• Central Branches:

- Pierce anterior perforated substance.
- Supply lentiform nucleus, caudate nuclei, and internal capsule.

> Middle Cerebral Artery

- Largest Branch of internal carotid.

• Path:

- Runs laterally in lateral cerebral sulcus.

• Cortical Supply:

- Entire lateral hemisphere surface except narrow strip supplied by anterior cerebral artery.

- Does not supply occipital pole and inferolateral surface (supplied by posterior cerebral artery).

- Supplies entire motor area except leg area.

• Central Branches:

- Enter anterior perforated substance.
- Supply lentiform nucleus, caudate nuclei, and internal capsule.

"Vertebral Artery"

• Origin:

- Branch of the first part of the subclavian artery.

• Path:

- Ascends neck via transverse foramina of the upper six cervical vertebrae.

- Enters skull through foramen magnum, pierces dura mater and arachnoid to reach the subarachnoid space.

- Runs upward, forward, and medially along the medulla oblongata.

- Joins the opposite vertebral artery at the lower pons to form the basilar artery.

》 Branches of the Cranial Portion

1) Meningeal Branches:

- Small branches that supply bone and dura in the posterior cranial fossa.

2) Posterior Spinal Artery:

- May arise from the vertebral or posterior inferior cerebellar artery.

- Descends on the posterior spinal cord surface, close to the posterior roots of spinal nerves.

- Reinforced by radicular arteries entering through intervertebral foramina.

3) Anterior Spinal Artery:

- Formed by contributions from each vertebral artery near termination.

- Descends on the anterior medulla oblongata and spinal cord within the pia mater along the anterior median fissure.

- Reinforced by radicular arteries.

4) Posterior Inferior Cerebellar Artery (PICA):

- Largest branch, passes between medulla and cerebellum.

• Supplies:

- Inferior surface of cerebellar vermis.
- Central nuclei of the cerebellum.
- Inferior cerebellar hemisphere surface.
- Medulla oblongata.
- Choroid plexus of the fourth ventricle.

5) Medullary Arteries:

- Small branches that supply the medulla oblongata.

》 Basilar Artery

• Formation:

- Union of the two vertebral arteries.

• Path:

- Ascends in a groove on the anterior pons.

• Division:

- At the upper border of the pons, divides into two posterior cerebral arteries.

> Branches of the Basilar Artery

1) Pontine Arteries:

- Numerous small vessels that penetrate and supply the pons.

2) Labyrinthine Artery:

- Long, narrow artery accompanying the facial and vestibulocochlear nerves through the internal acoustic meatus.

- Supplies the internal ear; often a branch of the anterior inferior cerebellar artery.

3) Anterior Inferior Cerebellar Artery (AICA):

- Passes posteriorly and laterally.

• Supplies:

- Anterior and inferior parts of the cerebellum, with a few branches to the pons and upper medulla oblongata.

4) Superior Cerebellar Artery:

- Originates near basilar artery termination.

- Winds around the cerebral peduncle.

• Supplies:

- Superior cerebellar surface, pons, pineal gland, and superior medullary velum.

5) Posterior Cerebral Artery:

- Curves laterally and backward around the midbrain.

- Joined by the posterior communicating branch of the internal carotid artery.

• Cortical Supply:

- Inferolateral and medial surfaces of the temporal lobe.

- Lateral and medial surfaces of the occipital lobe, including the visual cortex.

• Central Supply:

- Parts of the thalamus, lentiform nucleus, midbrain, pineal gland, and medial geniculate bodies.

• Choroidal Branch:

- Enters the inferior horn of the lateral ventricle to supply the choroid plexus.

- Also supplies the choroid plexus of the third ventricle.

"Circle of Willis"

- Lies in the interpeduncular fossa at the base of the brain.

• Formed by anastomosis of:

- Two internal carotid arteries
- Two vertebral arteries

• Contributing arteries:

- Anterior communicating
- Anterior cerebral
- Internal carotid
- Posterior communicating
- Posterior cerebral
- Basilar arteries

• Function:

- Allows blood distribution to both cerebral hemispheres from internal carotid or vertebral arteries.

- Cortical and central branches supply brain substance.

- Variations in artery sizes are common; absence of one or both posterior communicating arteries reported.

"Arteries to Specific Brain Areas"

》 Corpus Striatum and Internal Capsule: Supplied by:

- Medial and lateral striate central branches of the middle cerebral artery.

- Central branches of anterior cerebral artery supply remainder.

» Thalamus: Supplied mainly by branches of:

- Posterior communicating
- Basilar
- Posterior cerebral arteries

» Midbrain: Supplied by:

- Posterior cerebral
- Superior cerebellar
- Basilar arteries

» Pons: Supplied by:

- Basilar
- Anterior inferior
- Superior cerebellar arteries

» Medulla Oblongata: Supplied by:

- Vertebral
- Anterior and posterior spinal
- Posterior inferior cerebellar
- Basilar arteries

》 Cerebellum: Supplied by:

- Superior cerebellar
- Anterior inferior cerebellar
- Posterior inferior cerebellar arteries

"Nerve Supply of Cerebral Arteries"

- Rich supply of sympathetic postganglionic nerve fibers from superior cervical sympathetic ganglion.

- Stimulation causes vasoconstriction of cerebral arteries.

• Local blood flow mainly controlled by concentrations of:

- Carbon dioxide
- Hydrogen ions
- Oxygen

- Increase in carbon dioxide and hydrogen ions, decrease in oxygen tension, leads to vasodilatation.

"Veins of the Brain"

- No muscular tissue; very thin walls; no valves.

- Emerge from brain, lie in subarachnoid space, pierce arachnoid mater and dura to drain into cranial venous sinuses.

"External Cerebral Veins"

》 Superior Cerebral Veins:

- Pass upward over lateral surface of cerebral hemisphere; empty into superior sagittal sinus.

》 Superficial Middle Cerebral Vein:

- Drains lateral surface of cerebral hemisphere; runs inferiorly in lateral sulcus; empties into cavernous sinus.

» Deep Middle Cerebral Vein:

- Drains insula; joined by anterior cerebral and striate veins to form basal vein; joins great cerebral vein, draining into straight sinus.

"Internal Cerebral Veins"

- Formed by union of thalamostriate vein and choroid vein at interventricular foramen.

- Run posteriorly in tela choroidea of third ventricle; unite beneath splenium of corpus callosum to form great cerebral vein, emptying into straight sinus.

"Veins of Specific Brain Areas"

» Midbrain: Drained by veins opening into basal or great cerebral veins.

» Pons: Drained by veins opening into basal vein, cerebellar veins, or neighboring venous sinuses.

» Medulla Oblongata: Drained by veins opening into spinal veins and neighboring venous sinuses.

» Cerebellum: Drained by veins emptying into great cerebral vein or adjacent venous sinuses.

"Brain Capillaries"

- Capillary blood supply greater in gray matter than white matter.

- Greater metabolic activity in neuronal cell bodies of gray matter compared to nerve processes in white matter.

- Blood-brain barrier isolates brain tissue from the body.

- Formed by tight junctions between endothelial cells in capillary beds.

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"Cerebral Circulation"

- Blood flow delivers oxygen, glucose, and nutrients; removes carbon dioxide, lactic acid, and metabolic by-products.

》 Supplied by:

- Two internal carotid arteries
- Two vertebral arteries

- Blood supply to half of the brain comes from internal carotid and vertebral arteries on that side; streams meet in the posterior communicating artery without mixing.

- If occlusion occurs in internal carotid or vertebral artery, blood compensates by moving across the point to maintain flow.

- Arterial circle allows blood flow across the midline during occlusion.

- Streams from vertebral arteries remain separate on the same side of the basilar artery.

》 Anastomoses and Pressure Factors

- Cerebral arteries anastomose at the circle of Willis and via surface branches but do not further anastomose within brain substance.

- Arterial blood pressure is crucial for driving blood through the brain.

》 Opposed by:

- Raised intracranial pressure
- Increased blood viscosity
- Narrowed vascular diameter

- Cerebral blood flow remains constant despite general blood pressure changes.

》 Autoregulation occurs:

- Lowering cerebral vascular resistance when arterial pressure decreases.

- Rising vascular resistance when arterial pressure increases.

- Autoregulation ineffective at very low arterial blood pressure levels.

》 Cerebrovascular Resistance and Regulation

- Diameter of cerebral blood vessels significantly contributes to cerebrovascular resistance.

- Innervated by sympathetic postganglionic nerve fibers but play little role in cerebrovascular resistance control in normal humans.

》 Most powerful vasodilators:

- Increased carbon dioxide or hydrogen ion concentration.

- Reduced oxygen concentration causes vasodilatation.

》 Local Blood Flow Increase

- Increase in neuronal activity results in local blood flow increase (e.g., viewing an object increases oxygen and glucose consumption in visual cortex).

- Local increases in carbon dioxide and hydrogen ions trigger further blood flow increase.

》 Measurement of Cerebral Blood Flow

- Cerebral blood flow can be measured via intracarotid injection or inhalation of radioactive krypton or xenon.

- Normal cerebral blood flow: approximately 50 to 60 mL/100g of brain tissue per minute.

"Spinal Cord Arteries"

》 Arterial Supply: Spinal cord supplied by:

- Two posterior spinal arteries
- One anterior spinal artery

• Structure:

- Longitudinal arteries reinforced by small segmental arteries entering the vertebral canal through intervertebral foramina.

• Anastomoses:

- Vessels form anastomoses on the cord's surface, supplying both white and gray matter.

》 Posterior Spinal Arteries

> Origin:

- Arise directly from vertebral arteries inside the skull or indirectly from posterior inferior cerebellar arteries.

- Run along the posterior surface of the spinal cord near the posterior nerve roots.

> Function:

- Supply the posterior third of the spinal cord.

> Vulnerability:

- Smaller in upper thoracic region.

- First three thoracic spinal segments at risk for ischemia if segmental or radicular arteries are occluded.

》 Anterior Spinal Artery

> Origin:

- Formed by the union of two arteries originating from vertebral arteries inside the skull.

> Course:

- Descends on the anterior surface of the spinal cord within the anterior median fissure.

> Function:

- Supplies the anterior two-thirds of the spinal cord.

> Vulnerability:

- May be very small in upper and lower thoracic segments.

- Fourth thoracic and first lumbar segments at high risk for ischemic necrosis if segmental or radicular arteries are occluded.

》 Segmental Spinal Arteries

> Location:

- Enter the vertebral canal at each intervertebral foramen, reinforcing posterior and anterior spinal arteries.

> Origin:

- Branches from deep cervical, intercostal, and lumbar arteries.

> Function:

- Segmental arteries form anterior and posterior radicular arteries, accompanying respective nerve roots.

- Additional feeder arteries enter and anastomose with spinal arteries.

> Great Anterior Medullary Artery of Adamkiewicz:

- Arises from the aorta at lower thoracic or upper lumbar levels, typically from the left.

- Major blood supply for the lower two-thirds of the spinal cord.

"Spinal Cord Veins"

》 Structure:

- Six tortuous longitudinal veins.

》 Drainage:

- Veins drain into internal vertebral venous plexus, communicating superiorly with brain veins and venous sinuses within the skull.

Circle of Willis