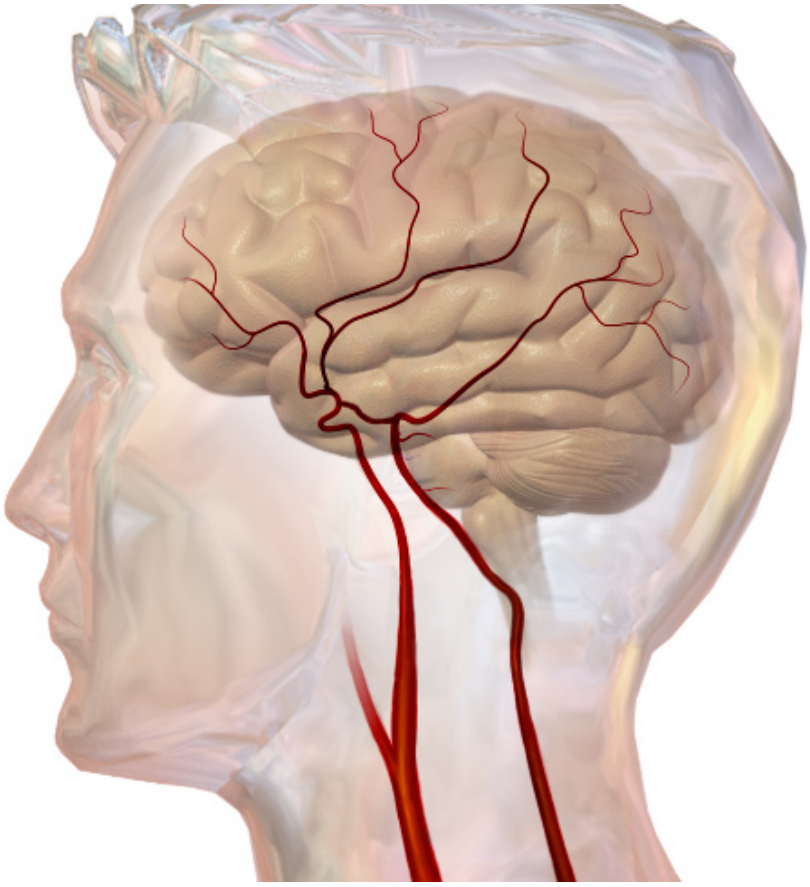
Special Circulations of the Cardiovascular System — Cerebral, Coronary and Cutaneous Circulation

See online here

Blood flows through the body in a complex circulatory system supplying even the most complex structures, like brain and heart, in the cerebral and coronary circulation respectively. The skin as the outermost border of the organism requires special conditions of the cutaneous circulation, owing to the external temperature.



Coronary Circulation

The blood vessels which supply the **cardiac muscles** constitute the **coronary circulation**.

The arteries supplying oxygenated blood to the cardiac muscles are known as the **coronary arteries**. There are two main coronary arteries: **right coronary artery** and **left coronary artery**.

The veins which carry deoxygenated blood away from the heart are called the **cardiac veins**. These include the **great cardiac vein**, the **anterior cardiac vein**, the **small cardiac vein**, the **posterior cardiac vein,** and the **middle cardiac vein.**

The coronary arteries are **autoregulated** this means that when they are fully patent, they adjust the supply of blood according to myocardial demand. These, however, are the **end arteries** hence the only source of oxygen and nutrients to the heart muscles.

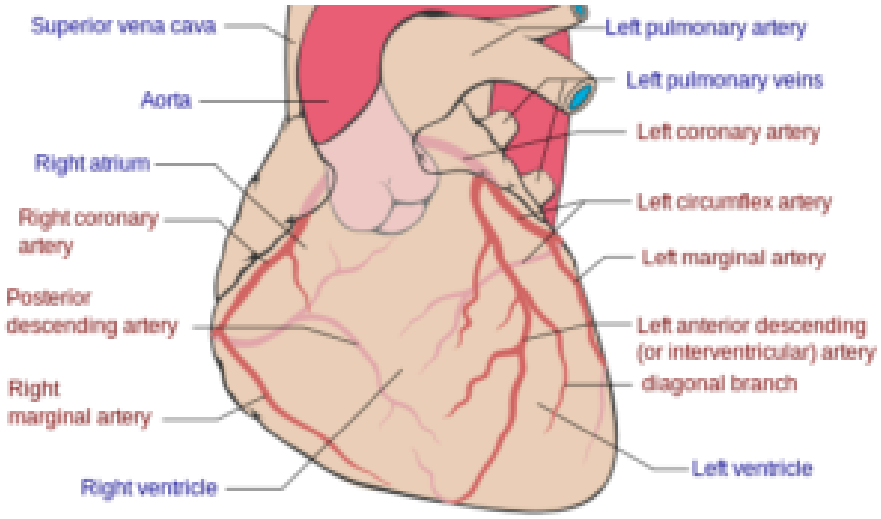


Image: "The arterial supply of the heart (anterior view)." by Patrick J. Lynch, medical illustrator derivative work: Fred the Oyster (talk) adaption and further labeling: Mikael Häggström – Coronary.pdf. License: CC BY-SA 3.0

Two coronary arteries arise from the root of the aorta, just before it exits the left ventricle.

The aorta has three sinuses which are :

- The anterior aortic sinus that gives the right coronary artery (RCA)
- The left posterior aortic sinus that gives the left coronary artery (LCA)
- The right posterior aortic sinus does not give any artery.

However, in some subjects the two arteries may arise as one trunk or an extra third branch is known as the posterior coronary artery may be seen. The arteries which remain on the surface of the heart and follow the sulci are called **epicardial coronary arteries**, as shown in the figures.

The **left coronary artery** supplies blood to the **left atrium**, **left ventricle,** and interventricular **septum**. It gives off two main branches as follows:

- The left circumflex artery (LCX)
- The anterior interventricular artery or left anterior descending artery (LAD)

The **left circumflex artery** follows the coronary sulcus pathway on the left side of the heart. It then fuses with the branches of the right coronary artery.

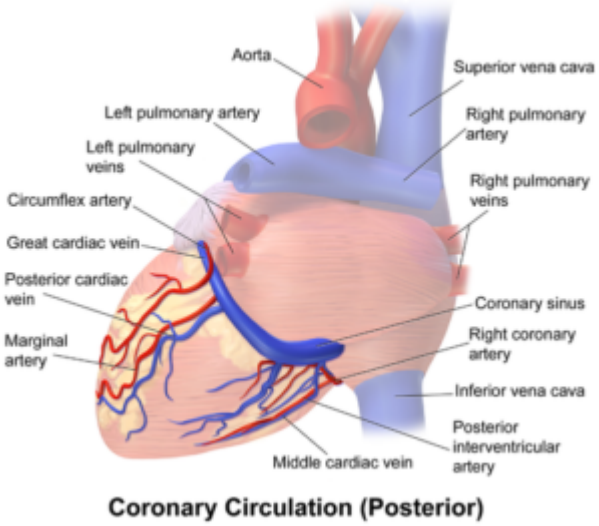


Image: "Coronary circulation viewed from posterior." by Blausen.com staff. "Blausen gallery 2014". Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010. ISSN 20018762. – Own work. License: CC BY 3.0

The **anterior interventricular artery**, also known as the **left anterior descending artery**, follows the route of interventricular sulcus where it gives off several branches which anastomose with the posterior interventricular artery.

The **right coronary artery** supplies blood to the **right atrium**, **right ventricle**, **conductive system** of the heart and some area of the **left ventricle**. It gives off the following branches:

- Marginal branches
- Posterior interventricular artery or posterior descending artery.

The anastomosis occurring in the coronary circulation is referred to as **an anatomical anastomosis.** These arteries do not supply blood efficiently if one of them is blocked by an atheroma. The three anastomoses occurring are:

- Branches of the anterior interventricular artery anastomose with the posterior interventricular artery.
- The circumflex artery anastomoses with the right coronary artery in the atrioventricular groove.
- The septal branches of both right and left coronary artery anastomose in the interventricular septum.

The **great cardiac vein** receives tributaries from the **left atrium** and **both ventricles**. It begins at the apex and ascends along the anterior longitudinal sulcus.

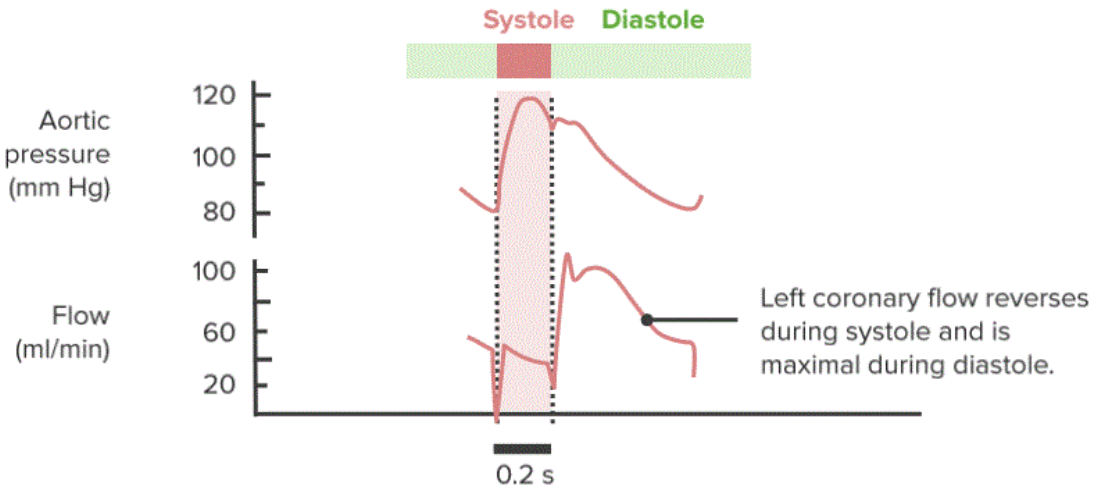
The **middle cardiac vein** also begins at the apex of the heart and ascends in the posterior longitudinal sulcus.

The **anterior cardiac vein** drains blood from the right ventricle and opens into the right atrium.

The **small cardiac vein** drains blood from the posterior portion of the right atrium and ventricle.

All the cardiac veins except the anterior cardiac vein drain into coronary sinus as shown in the figures.

When the coronary arteries develop an **atheroma** in them, it leads to the decreased blood supply to the cardiac muscles. In such cases, when the oxygen demand exceeds, it results in left-sided chest pain called **angina**. If the coronary artery is completely blocked, the area of the heart supplied by that particular artery undergoes infarction, often referred to as **myocardial infarction** or **heart attack** in layman language. These lesions can be visualized in echocardiography or deduced from electrocardiography findings.



"Coronary Blood Flow During Contraction and Relaxation" Image created by Lecturio

The effect of ventricular contraction of Coronary Blood Flow is that the contracting myocytes collapse vessels. Arterial blood is forced backward toward aorta. During contraction, there are reductions of blood flow, but during relaxation, there is engorgement with the overall effect being an increase in coronary blood flow.

Cerebral Circulation

Cerebral circulation comprises of the vessels supplying the brain. The brain receives approximately **750 ml** of blood each minute which is **15%** of the cardiac output.

The arterial supply of the brain is divided into two categories :

- The anterior circulation from the internal carotid artery system.
- The posterior cerebral circulation from the vertebral-basilar circulatory system.

The **anterior cerebral circulation** supplies blood to the anterior portion of the brain. It comprises of the following arteries:

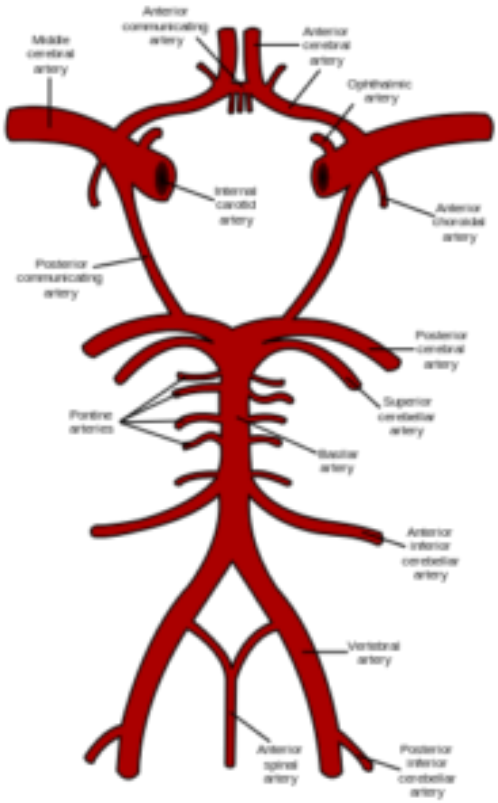


Image: “Schematic representation of the circle of Willis, arteries of the brain and brain stem.” by Rhcastilhos – Gray519.png, License: Public Domain

The **right and left internal carotid arteries** are the branches of the **common carotid artery**. Each internal carotid artery gives off an **anterior cerebral artery branch** and continues as the **middle cerebral artery** as shown in the figure.

The **anterior cerebral artery** supplies blood to the **frontal lobe** and the **superior medial portion of the parietal lobe**. The **anterior cerebral artery syndrome** is a result of blockage of the anterior cerebral artery. The symptoms include behavioral changes, motor and sensory weakness of the lower leg and foot on the contralateral side.

The **anterior communicating artery** connects the two anterior cerebral arteries as shown in the diagram.

The **middle cerebral artery** supplies a **major portion of the hemisphere** except for the part of the cerebrum supplied by the anterior cerebral artery. Deep branches also supply the **basal ganglia**. **Middle cerebral artery syndrome** occurs as a result of occlusion of the middle cerebral artery. It results in contralateral loss of motor and sensory sensations of the face and arm. Damage to the dominant hemisphere results in **aphasia**, as **Broca’s and Wernicke’s areas** are also supplied by the middle cerebral artery.

The **posterior cerebral circulation** supplies the **occipital lobes of the brain**, the **medulla,** and the **brain stem**. The arteries forming the posterior cerebral circulation are as shown below:

The **vertebral arteries** arising from the **subclavian artery** fuse to form the **basilar artery** in the cranium. It gives off two **posterior inferior cerebellar artery** branches which supply the cerebellum. Occlusion of the posterior inferior cerebellar artery results in **lateral medullary syndrome**.

The **basilar artery** supplies the **midbrain and the cerebellum**. It gives off the following branches:

- The posterior cerebral artery supplies the **occipital lobe**.
- The superior cerebellar artery supplies the **superior half of the cerebellum** and a portion of the **midbrain**.
- The **anterior inferior cerebellar artery** supplies the **cerebellum**. **Lateral pontine syndrome** occurs as a result of occlusion of the anterior inferior cerebellar artery.
- The **pontine arteries** are small branches arising from the main trunk of the basilar artery. These arteries supply the **pons** and the adjacent areas of the brain.

The **posterior communicating artery** connects the posterior cerebral artery to the middle cerebral artery and the internal carotid artery.

Venous drainage of the brain

The venous drainage of the brain consists of a superficial system of **dural sinuses** lying between the periosteum and the meningeal layer of the dura mater. The deep system consists of traditional veins inside the deep structures of the brain.

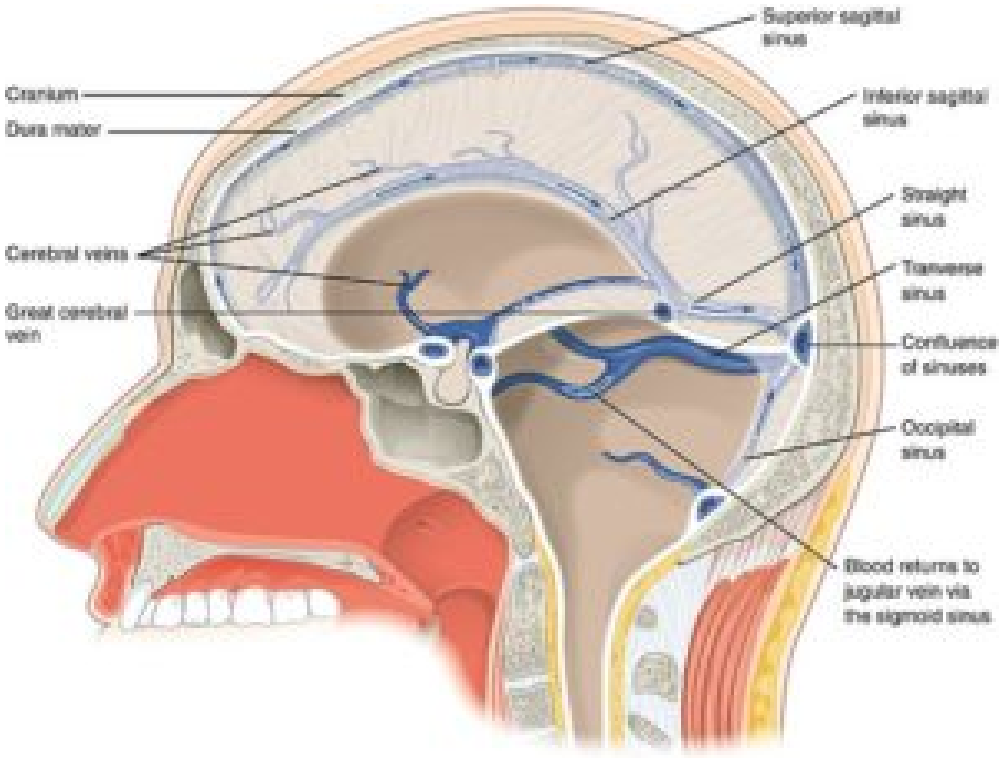


Image: "The dural sinuses of the brain." by OpenStax – https://cnx.org/contents/FPtK1zmh@8.25:fEI3C8Ot@10/Preface. License: CC BY 4.0

The dural venous sinuses are valve-less vessels which ultimately drain into the **internal jugular vein**. The inferior sagittal sinus and the great cerebral vein unite to form the straight sinus.

The **superior sagittal sinus**, the **straight sinus**, the **transverse sinus,** and the **occipital sinus** converge at the **confluence of sinuses** as shown in the figure beside.

The **sigmoid sinus** is a continuation of the **transverse sinus** and drains into the **internal jugular vein**.

The **cavernous sinus** is found on either side of the **sella turcica**. It drains the blood from the ophthalmic veins as shown in the figure below. The blood then drains into the **internal jugular vein** via the **superior and inferior petrosal sinuses**.

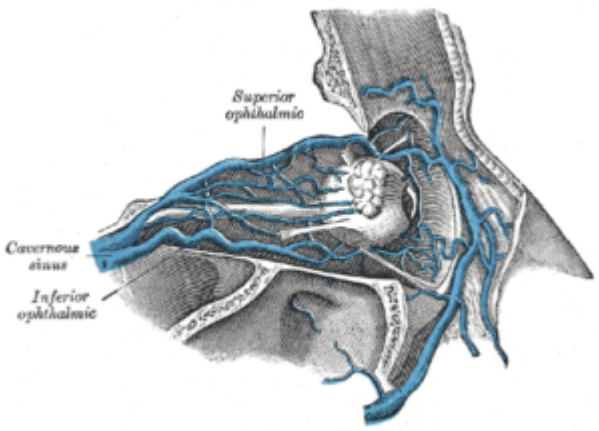


Image: "The cavernous sinus." by Henry Vandyke Carter, Henry Gray (1918) Anatomy of the Human Body. Bartleby.com: Gray's Anatomy, Plate 572. License: Public Domain

The veins of the brain lie within the brain structures. They are further categorized into a superficial and deep system.

The **superficial venous system** consists of:

- The **superficial cerebral vein**, which drains into the **superior sagittal sinus**.
- The **superficial middle cerebral vein**, which drains into the **cavernous sinus** or the **transverse sinus** after draining the lateral surface of the cerebral hemispheres. **Superior anastomotic vein** connects the **superficial middle cerebral vein** to the cavernous sinus while the **inferior anastomotic vein** connects the superficial middle cerebral vein to the transverse sinus.
- Inferior cerebral vein drains into the **cavernous and transverse sinuses** after receiving blood from the inferior surface of the cerebral hemispheres.

The **deep venous system** consists of:

- **Subependymal veins**, which, after receiving blood from the medullary veins, drain into the dural sinuses.
- The **medullary veins**, which drain into the **subependymal veins.**
- The **great cerebral vein**, also known as the **vein of Galen**, which receives blood from the **cerebrum** and drains into the straight sinus.

Cutaneous Circulation

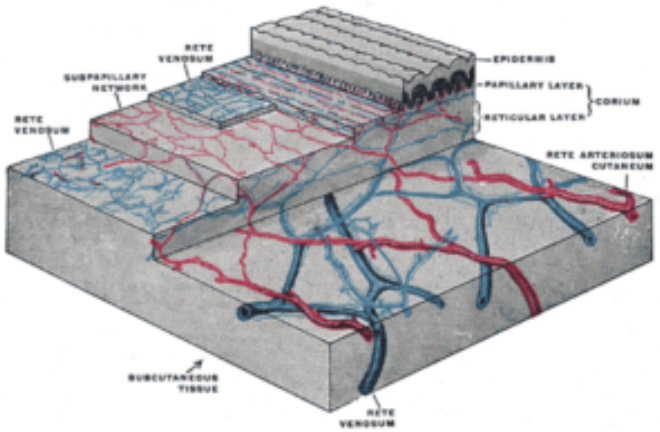


Image: "The cutaneous circulation." by Henry Vandyke Carter, Henry Gray (1918) Anatomy of the Human Body. Bartleby.com: Gray's Anatomy, Plate 942. License: Public Domain

The needs of the skin are minimal and as such the blood supply is mainly via arteriovenous anastomosis as opposed to supplying by arterioles. The **epidermis** of the skin does not contain any arterioles or arteries to supply blood. Nutrients and waste products travel through simple diffusion from the underlying skin layers. The **dermis** consists of two regions – the **papillary region** and the **reticular region**.

The **papillary region** is the superficial layer and as the name suggests consists of papillary projections into the epidermis. The projections contain a network of blood capillaries. It is composed of areolar connective tissues.

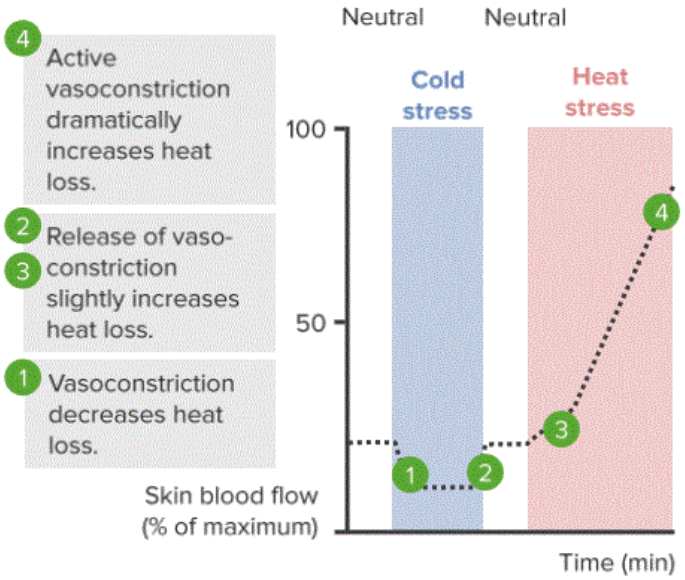
The **reticular region** lies deeper to the papillary region and is composed of dense connective tissues made up of collagen, elastic and reticular fibers. This layer is comparatively thicker than the papillary layer.

The network of capillaries in the papillary region is derived from the arteries of the reticular region. Similarly, these arteries drain into veins present in the deeper layer. The arteries are called **rete arteriosum** and the veins are called **rete venosum**. The blood supply of the skin is shown in the figure.

As the skin is a **thermoregulatory organ**, the blood supply to the skin depends largely upon the internal body temperature and the external environment. For instance, if the external temperature is low, the brain sends sympathetic signals to the skin vessels. This causes **vasoconstriction** of the arterioles to prevent blood flow to the superficial layers of skin and to preserve heat loss.

Similarly, if the external temperature is high, the arterioles of the skin are **dilated**. This is to allow more blood flow to the superficial layers of the skin and loss of heat via the skin.

Non-glabrous systemic responses



“Cutaneous Circulation” Image created by Lecturio

Sympathetic vasoconstrictor

- Tonically active but can be increased
- Norepinephrine (α1- & α2-AR)
- Adrenergic co-released neuropeptide Y

Active vasodilation

- Not solely acetylcholine (ACh) mediated
- Might be cholinergic co-released
- Nitric oxide (NO) is involved but not the mediator

References

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Notes