

Anatomy and Function of the Dural Venous Sinuses

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The dural venous sinuses (DVS) are venous blood reservoirs located between the 2 layers of the dura mater. The absence of lymphatic drainage in the brain places the venous outflow system means that the DVS is critically important. This article provides an overview on dual venous sinuses and then focuses on arachnoid granulations, tributaries, and the drainage patterns.



Dural Venous Sinuses (DVS)

The dura mater (Latin for “tough mother”) with its varied reflections segregates the brain into **structural compartments**. The dura mater has 2 layers: the inner or **meningeal** layer, and the outer **periosteal or endosteal** layer.

These layers fit snugly into each other in almost all locations except for certain avenues, where they split to accommodate the **venous channels**. These reservoirs are the DVS, which convene blood from the meninges, **calvarium**, and the brain to seep into the **jugular veins** at the base of the skull.

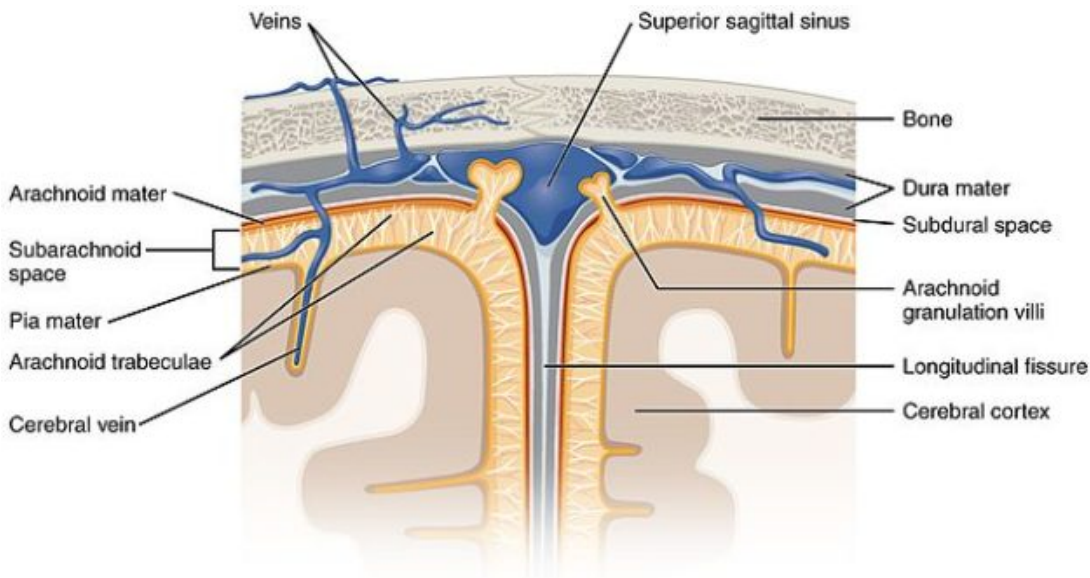


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The venous drainage of the brain does not follow the arteries, however. The brain also does not possess a **lymphatic system**.

Distantly akin to the lymphatics, the brain has **Virchow-Robin spaces**, the **perivascular pia mater-lined fluid cisterns** that convey fluid from neuronal cell bodies to the cervical lymph nodes. These are, however, extremely diminutive, and the brain relies on the venous system for cerebrospinal fluid absorption (CSF) and the complete clearance of neuronal, chemical, and metabolic waste.

There are many ways to classify the DVS. A few salient ones are tabulated as follows:

Paired	Unpaired
Superior petrosal sinus	Straight
Sigmoid sinus	Occipital
Cavernous sinus	Anterior intercavernous
Transverse sinus	Posterior intercavernous
Sphenoparietal sinus	Inferior sagittal
Inferior petrosal sinus	Basilar venous plexus
Middle meningeal	Superior sagittal
Petrosquamous	

Group	Superior group	Inferior group
Components	Superior sagittal sinus, inferior sagittal sinus, occipital sinus, sigmoid sinus, transverse sinus, straight sinus	Basal plexus, sphenoparietal sinus, superior and inferior petrosal sinus, cavernous sinus
Drainage expanse	As the predominant system, its enclave includes the majority of brain parenchyma. Through the torcular confluence of herophili, it ultimately empties into the jugular vein via the transverse and sigmoid sinuses.	This group drains the basal and medial surfaces of the brain and the orbits. The system opens into the sigmoid sinus and jugular vein.

The DVS have endothelium-lined walls composed of dura mater. They are **valveless** and lack the usual organization of the vessel wall into tunica intima, media, and albuginea.

Most DVS are triangular in shape, with an upward-turned base. They are traversed by **synechia** and have longitudinal ridges known as **chordae Willisii** along the luminal surface. The chordae have a potential role in **the regulation of laminar flow** and the **preclusion of venous reflux into cortical veins**.

The significant individual dural venous sinuses can be summarized as follows:

Superior sagittal sinus (SSS)

The SSS is situated along the superior border of falx cerebri, from foramen caecum of the crista galli en route to the inner surface of the frontal sagittal face of the parietal and occipital bones to the confluence of the sinuses.

Arachnoid granulations are most numerous along the sagittal sinus. They facilitate CSF drainage and absorption.

The **vein of Trolard**, also known as the **superior anastomotic vein**, connects the **superficial middle cerebral vein** to the SSS.

The SSS drains the **anterior corpus callosum, medial hemispheres, and cingulate gyrus**. Occasionally, drainage of the nasal fields via connecting veins makes **nasal and facial infections** a potential provenience for **SSS thrombosis**.

Inferior sagittal sinus

Also known as the **longitudinal inferior sinus**, the inferior sagittal sinus begins at the junction of the anterior and middle 3rd of the falx cerebri and extends along the entire length of the lower border.

Angiographic location of the inferior sagittal sinus marks the **anterior midline of the brain**. Early filling or displacement of the same has localizing value.

The inferior sagittal sinus drains the medial and deep aspects of the cerebral hemispheres.

Transverse sinus

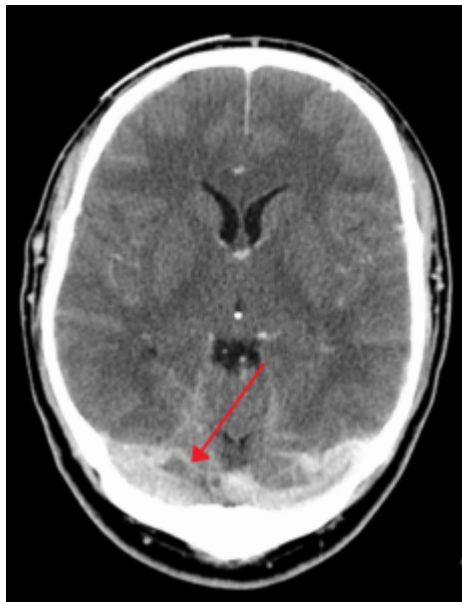


Image: "A dural venous sinus thrombosis of the transverse sinus. Greater on the right than left."
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Also known as **lateral sinuses**, these paired structures lie in the confines of the **tentorium cerebelli** and extend from the internal occipital protuberance to the base of the **petrous temporal bone**.

Usually, the SSS continues as the **dominant larger right transverse sinus** and the inferior sagittal sinus flows into the left transverse sinus, but **the anatomical variation** is the norm.

The **vein of Labbe**, or **inferior anastomotic vein**, connects the **superficial middle cerebral vein** to the transverse sinus. It drains the **temporal lobe**, **posterior cingulate gyrus**, and the **corpus callosum**.

Sigmoid sinus

Named after their characteristic "S"-shaped turn as they traverse to the **jugular veins**, these paired sinuses display **immense anatomic variation** in formation, course, and dominance. They represent **extensions of the transverse sinus**. The transition to the **internal jugular vein** occurs at the **jugular foramen**.

The junction of the sigmoid sinus and transverse sinus is marked externally by **asterion**, which forms an important surgical landmark for **posterior fossa surgeries**.

It drains the **posterior cranial fossa** and **posterior aspect of the calvarium** and serves as the **penultimate sinus** before the jugular veins.

Intercavernous Sinuses

The anterior and posterior intercavernous sinuses are transverse venous channels communicating with the cavernous sinuses across the **sellar diaphragm**.

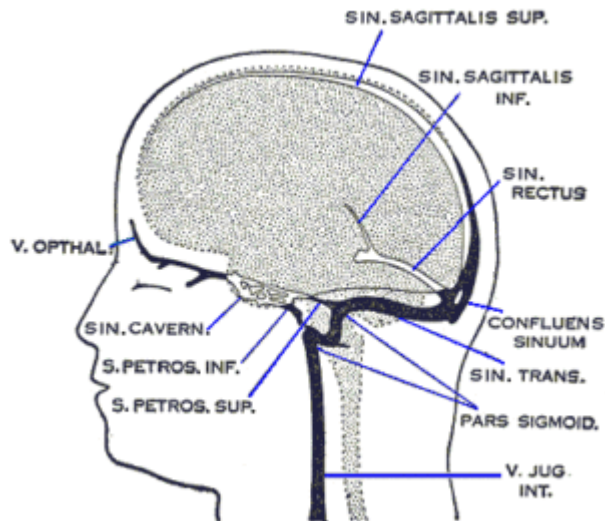
Straight or Tentorial Sinus

The inferior sagittal sinus joins the **great cerebral vein of Galen** to form the sinus rectus, also known as the **straight sinus**. At the internal occipital protuberance, it continues into the left transverse sinus.

Occipital sinus

Enclosed in the leaflets of the **falx cerebelli**, this is the **smallest of all sinuses**. It communicates with the **internal vertebral plexus**, sigmoid sinus, and the **confluence**.

Superior petrosal sinus



[Image](#): "Revised diagram of cranial sinuses (in the human head) from Gray's Anatomy plate #488" by User:Wikid77 (clarifying Gray's image) - Derivative of Wikimedia Image:Gray488.png. License: Public Domain

Lodged in the **petrous temporal bone's groove**, the superior petrosal sinus travels from the **cavernous sinus** to each side of the transverse sinus.

Confluence of sinuses

Also known as **torcular herophili** (for Herophilos, the Greek anatomist), the confluence is the depot for communication between the 4 major sinuses, namely the superior sagittal sinus, occipital sinus, and the corresponding transverse sinuses.

Arachnoid Granulations

Arachnoid granulations are **arachnoid membrane projections** into the DVS that facilitate **CSF drainage** from the subarachnoid spaces into the venous system. Evidence has confirmed the role of arachnoid granulations as **1-way valves** to prevent reverse reflux from venous lakes to the **subarachnoid space**.

They are usually located along the **lateral venous lacunae** of the superior sagittal sinus, followed by the transverse sinus. There are 3 consistent venous lacunae on each side of the SSS: the **frontal**, the **parietal**, and the **occipital lacunae**.

The arachnoid granulations comprise arachnoid projections at the base with **collagenous stroma, trabeculae, and interlaced conduits**. The collagenous core is surmounted by an apical cap of arachnoid cells. The cap cells of the arachnoid membrane are the harbingers of **meningiomas**. They simulate filling defects in the sinuses and may erroneously lead to a **diagnosis of sinus thrombosis**. The distinction lies in their classic location near draining tributaries and their round, well-defined morphological appearance.

Miniature-sized granulations are called **villi**.

Named after the Italian anatomist Antonio Pacchioni, **calcified granulations** are called **Pacchionian bodies**. Occasionally, arachnoid granulations are called Pacchioni's granulations.

Granular fovea are impressions of arachnoid granulations on the undersurface of the overlying bone.

Tributaries of the Dural Venous Sinuses

The major groups of veins that communicate with the DVS are as follows.

Meningeal veins

The meningeal veins intermingle to form a **plexus in the endosteal layer of the dura** and in the potential space between it and the **periosteum** of the inner table of the **calvarium**. They peregrinate between the DVS internally and the **pterygoid plexus** after exiting the skull. Along with the **diploic veins**, they amalgamate into the lateral venous lacunae in the DVS.

Emissary veins

These veins are frequently seen in the parasagittal aspect of the SSS and around the sigmoid sinus. They are situated at the interface between the **extracranial veins**, DVS, **meningeal veins**, and the **diploic veins**.

The key emissary veins can be summarized as follows:

Emissary vein	Communication
Occipital emissary vein	Between the torcular sinus and occipital scalp veins
Veins in the cribriform region	Connecting the SSS and veins of nasal mucosa
Parietal emissary vein	Between the SSS and scalp veins through the parietal foramen
Mastoid emissary vein	Between the sigmoid sinus and occipital veins or the posterior auricular veins

Diploic veins

Situated in the **diploe**, these **endothelial-lined, large, thin-walled, venous lakes** connect the internal meningeal veins and DVS with extracranial veins. They are concentrated in the **cancellous bones**. The frontal vein communicating between the supraorbital vein and the SSS, and the anterior temporal diploic vein tending to the **sphenoparietal sinus** are a few examples.

Bridging veins from the dural venous sinuses to the cerebral and cerebellar cortical veins

Intermediate anastomotic veins

The 4 important anastomotic veins are:

- Vein of Trolard
- Vein of Labbe
- Vein of Rolando
- Sylvius (Sylvian) vein

The tributaries of the major DVS can be summarized as follows:

Dural venous sinus	Tributaries
Sigmoid sinus	Mastoid and condylar emissary vein, cerebellar veins, and internal auditory vein
Transverse sinus	Inferior cerebellar veins, superior petrosal sinus, inferior cerebral veins, anastomotic veins, and diploic veins
Superior sagittal sinus	Parietal emissary veins, superior cerebral veins, scalp veins, cavernous sinus through superior anastomotic veins, meningeal veins, veins of the frontal sinus, diploic veins

Inferior sagittal sinus	Veins draining the limbic lobe (cingulate gyrus), medial frontoparietal lobe and genu of the corpus callosum, deep cerebral veins
Straight sinus	Superior cerebellar veins, a few tributaries from the falx cerebri
Superior petrosal sinus	Cerebellar, inferior cerebral, and tympanic veins

Drainage of the Dural Venous Sinuses

The DVS system is a gigantic, organized plexus of venous cisterns meant to enable proficient venous outflow from the brain to the internal jugular veins.

The drainage pattern of the major dural venous sinuses can be summarized as follows:

Sinus	Drains into
Superior sagittal sinus	Right transverse sinus
Inferior sagittal sinus	Straight sinus
Straight sinus	Left transverse sinus
Sphenoparietal sinuses	Cavernous sinuses
Occipital sinus	Confluence of sinuses
Transverse sinus	Sigmoid sinus
Sigmoid sinus	Internal jugular vein

Applied Anatomy

- Venous sinus thrombosis occurs as a result of systemic diseases or various infections.
- The cavernous sinus can become infected through various routes and foci, resulting in thrombosis. Infection from the area of the face that is formed by the 2 corners of the mouth and the bridge of the nose can spread to the cavernous sinus and infect it.
- **Cavernous sinus syndrome** involves the cavernous sinus along with cranial nerves, internal carotid artery, and sympathetic plexus because of their association; this gives rise to a set of clinical manifestations.
- **Carotid-cavernous fistula** is an abnormal communication between the cavernous sinus and carotid arteries and branches.
- **Tolosa-Hunt syndrome** is ophthalmoplegia (weakness of eye muscles) caused by nonspecific infection of the cavernous sinus and superior orbital fissure.

Summary

The DVS are enclosed in the 2 layers of the dura mater. They drain the **brain parenchyma**, communicate with extracranial veins, and ultimately merge to form the internal jugular veins.

Arachnoid granulations are projections of the arachnoid penetrating the dural envelope of the DVS in order to facilitate CSF drainage from the subarachnoid spaces into the venous lacunae. Their morphological advantage as 1-way valves helps prevent reflux.

The **tributaries** communicate with cerebral veins, extracranial veins, and the DVS. There are meningeal veins, diploic veins, emissary veins, bridging veins, and intermediate anastomotic channels. **Anatomical variation** is common.

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