Anatomy and Function of the Dural Venous Sinuses

Dural venous sinuses are venous blood reservoirs contained between the two layers of the dura mater. The absence of lymphatic drainage in the brain places the venous outflow system on a pedestal of prime importance. Following a prologue to dural venous sinuses, this article focuses on arachnoid granulations, tributaries and the drainage pattern of the venous sinuses.

Dural Venous Sinuses (DVS)

The dura mater (Latin: tough mother) with its varied reflections segregates the brain into structural compartments. There are two layers of the dura mater, the inner or meningeal layer and the outer, i.e., periosteal or endosteal layer.

These layers snugly fit each other in almost all locations but for certain avenues, where they split to accommodate the venous channels. These reservoirs are the dural venous sinuses, which convene blood from the meninges, calvarium and the brain to finally seep into the jugular veins at the base of the skull.
Defying the norm, the venous drainage of the brain does not follow the arteries. 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**, which 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 CSF absorption and clearance of neuronal, chemical and metabolic waste in a profound manner.

There are myriad ways of classifying the DVS. A few salient ones are tabulated as follows:

<table>
<thead>
<tr>
<th>Paired</th>
<th>Unpaired</th>
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</thead>
<tbody>
<tr>
<td>Superior petrosal sinus</td>
<td>Straight</td>
</tr>
<tr>
<td>Sigmoid sinus</td>
<td>Occipital</td>
</tr>
<tr>
<td>Cavernous sinus</td>
<td>Anterior intercavernous</td>
</tr>
<tr>
<td>Transverse sinus</td>
<td>Posterior intercavernous</td>
</tr>
<tr>
<td>Sphenoparietal sinus</td>
<td>Inferior sagittal</td>
</tr>
<tr>
<td>Inferior petrosal sinus</td>
<td>Basilar venous plexus</td>
</tr>
<tr>
<td>Middle meningeal</td>
<td>Superior sagittal</td>
</tr>
<tr>
<td>Petrosquamous</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Superior group</th>
<th>Inferior group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td>Superior sagittal sinus, inferior sagittal sinus, occipital sinus, sigmoid sinus, transverse sinus, straight sinus</td>
<td>Basal plexus, sphenoparietal sinus, superior and Inferior petrosal sinus, cavernous sinus</td>
</tr>
<tr>
<td>Drainage expanse</td>
<td>Being the predominant system, its enclave is inclusive of the majority of brain parenchyma. Through the torcular confluence of Herophii, it ultimately empties into the jugular vein en route the transverse and sigmoid sinuses.</td>
<td>This group drains the basal and medial surfaces of the brain and the orbits. This system opens into the sigmoid sinus and jugular vein.</td>
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</tbody>
</table>

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

Most of the DVS are triangular in shape with the base turned upwards. They are traversed by **synechiae** 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 **preclusion of venous reflux into cortical veins**.
A short description of the significant individual dural venous sinuses can be summarized as follows:

**Superior sagittal sinus (SSS)**

It 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.

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

**Inferior sagittal sinus**

Also known as the **longitudinal inferior sinus**, it ensues at the junction of the anterior and middle third 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.” by James Heilman, MD – Own work. License: CC BY-SA 4.0*
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 superior sagittal sinus continues as the dominant larger right transverse sinus, and the inferior sagittal sinus flows into the left transverse sinus, but the anatomical variation is rather the norm.

The vein of Labbe, or the 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 foramen jugulare.

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.

**Sinus intercavernosi**

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

**Sinus rectus**

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 is commonly appreciated in pediatrics. It communicates with the internal vertebral plexus, sigmoid sinus, and the confluence.

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

Confluence of sinuses

Also known as torcular Herophili in reverence of Herophilos, the Greek anatomist, the confluence is the depot for communication between the four major sinuses, namely the superior sagittal sinus, occipital sinus and the corresponding transverse sinuses.

Arachnoid Granulations

These are arachnoid membrane projections into the DVS, which facilitate CSF drainage from the subarachnoid spaces into the venous system. Evidence endorses the role of arachnoid granulations as one-way valves to prevent reverse reflux from venous lakes to the subarachnoid space.

The most frequent location is along the lateral venous lacunae of the superior sagittal sinus, followed by transverse sinus. There are three 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 an amateurish 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 termed as villi.

Named after the Italian anatomist Antonio Pacchioni, calcified granulations are termed as Pacchioni bodies. Occasionally, arachnoid granulations are entitled the eponym 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:

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 few prominent emissary veins can be summarized as follows:

<table>
<thead>
<tr>
<th>Emissary vein</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occipital emissary vein</td>
<td>Between the torcular sinus and occipital scalp veins</td>
</tr>
<tr>
<td>Veins in the cribiform region</td>
<td>Connecting the SSS and veins of nasal mucosa.</td>
</tr>
<tr>
<td>Parietal emissary vein</td>
<td>Between the SSS and scalp veins through the parietal foramen</td>
</tr>
<tr>
<td>Mastoid emissary vein</td>
<td>Between the sigmoid sinus and occipital veins or the posterior auricular veins</td>
</tr>
</tbody>
</table>

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 few prototypes.

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

Intermediate anastomotic veins

The four 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:

<table>
<thead>
<tr>
<th>Dural venous sinus</th>
<th>Tributaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigmoid sinus</td>
<td>Mastoid and condylar emissary vein, cerebellar veins and</td>
</tr>
<tr>
<td></td>
<td>internal auditory vein</td>
</tr>
</tbody>
</table>
Drainage of the Dural Venous Sinuses

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

For easy registration, the drainage pattern of the major dural venous sinuses can be summarized as follows:

<table>
<thead>
<tr>
<th>Sinus</th>
<th>Drains into</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior sagittal sinus</td>
<td>Right transverse sinus</td>
</tr>
<tr>
<td>Inferior sagittal sinus</td>
<td>Straight sinus</td>
</tr>
<tr>
<td>Straight sinus</td>
<td>Left transverse sinus</td>
</tr>
<tr>
<td>Sphenoparietal sinuses</td>
<td>Cavernous sinuses</td>
</tr>
<tr>
<td>Occipital sinus</td>
<td>Confluence of sinuses</td>
</tr>
<tr>
<td>Transverse sinus</td>
<td>Sigmoid sinus</td>
</tr>
<tr>
<td>Sigmoid sinus</td>
<td>Internal jugular vein</td>
</tr>
</tbody>
</table>

Applied Anatomy

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

Summary

The dural venous sinuses are enclosed in the two 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 dural venous sinuses with the purpose to facilitate CSF drainage from the subarachnoid spaces into the venous lacunae. Their morphological advantage as one-way valves helps in preventing reflux.

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

**Review Questions**

The correct answers can be found below the references.

1. **Which sinus does not drain into the torcular Herophili?**
   
   A. Occipital sinus  
   B. Cavernous sinus  
   C. Transverse sinus  
   D. Sigmoid sinus

2. **Choose the false statement regarding the arachnoid granulations:**
   
   A. They are present in the superior sagittal sinus.  
   B. They regulate CSF absorption in the dural venous sinuses.  
   C. They are projections of arachnoid mater into the venous sinuses.  
   D. They are pathological granulations of the arachnoid mater, seen in granulomatous diseases.

3. **Choose the correct pair:**
   
   A. Transverse sinus to straight sinus  
   B. Straight sinus to sphenoparietal sinus  
   C. Occipital sinus to the confluence of sinuses  
   D. Transverse sinus to inferior petrosal sinus

**References**


DeJong’s textbook of Neurology.

Youman’s textbook of Neurosurgery.


Tutorials in Endovascular Neurosurgery and Interventional Neuroradiology. By James Vincent Byrne

Anand’s Human Anatomy for Dental Students.

**Correct answers:** 1B, 2D, 3C

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