Anatomy and Clinical Relevance of the Cavernous Sinus

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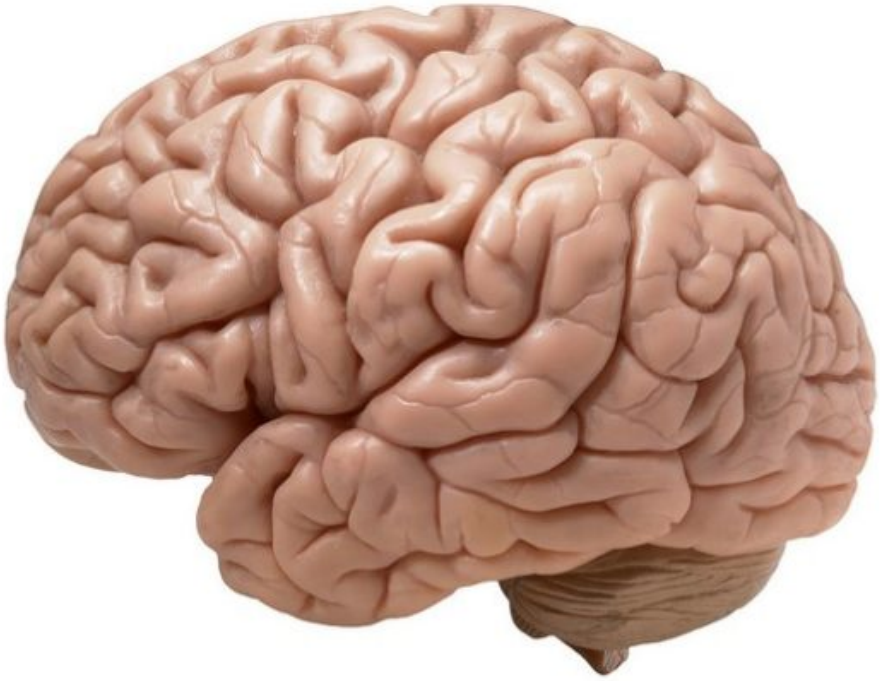
The cavernous sinus is one of the most important dural venous sinuses located between the endosteal dura and meninges. The roof of the sinus is formed by the inner layer of the meningeal dura, which is continuous with the diaphragma sellae covering the pituitary gland.



Overview

The roof of the sinus is attached anteriorly to the anterior and middle **clinoid processes** and posteriorly to the **tentorium** where it connects to the posterior clinoid process.

The floor of the sinus is formed partly by the **periosteum** of the greater wing of the **sphenoid and endosteal dura mater**.

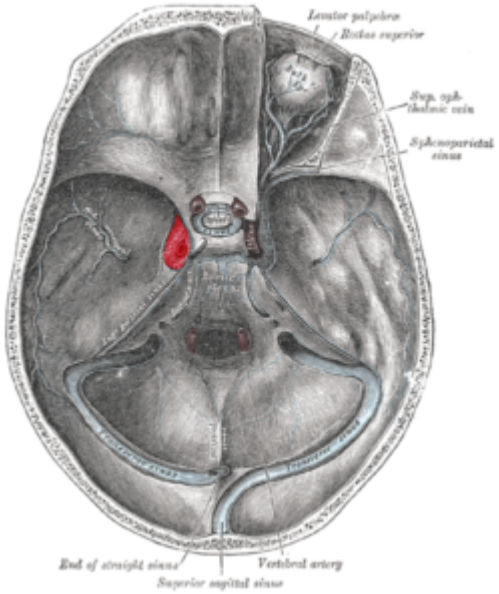


Image: Cavernous sinus. By: Mikael Häggström at English Wikipedia, Gray570.png. License: Public domain.

The lateral and medial walls are formed by the **meningeal dura**.

The interior of the sinus is separated into caverns or spaces by **trabeculae**. These trabeculae are less prominent in the living organism than in cadavers. The sinus is called cavernous due to its **cavernous appearance in cadavers,** where its cavity collapses and the nerves and arachnoid granulations in its walls encroach into the cavity (see image).

The cavernous sinus is a **true dural venous sinus** and not a venous plexus. It is clinically important because of its location, its close relationship to several **cranial nerves** and the **internal carotid artery,** and the complex of veins without valves that drain from and to the paired cavernous sinuses.

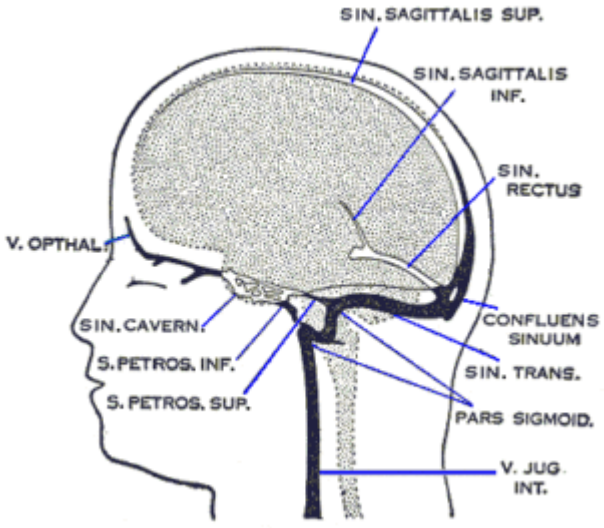


Image: Revised diagram of cranial sinuses (in the human head) from Gray's Anatomy plate #488. By: Wikid77 (clarifying Gray's image), derivative of Wikimedia Gray488.png. License: Public domain.

Location and Anatomy

The cavernous sinus is located in the **middle cranial fossa**, on either side of the **sella turcica** or **pituitary fossa** and the body of the **sphenoid** at the base of the skull. Usually, the paired cavernous sinuses are situated superolateral to the **sphenoid** or the **posterior ethmoid sinuses** and posterior to the **optic chiasma** (see image).

The sinuses have an **irregular shape** and each sinus is formed within layers of the dura (see image). Normally, the lateral wall can be either concave or straight and is formed by the **visceral dural mater**.

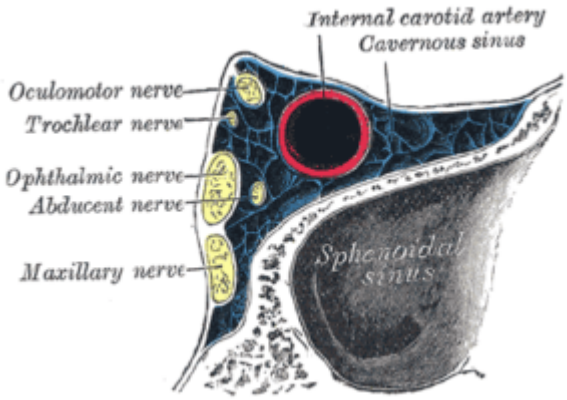


Image: Oblique section through the right cavernous sinus. By: Henry Vandyke Carter, Henry Gray (1918) *Anatomy of the Human Body*. Bartleby.com: Gray's Anatomy, plate 786. License: Public domain.

Spatial relations

Several cerebral, vascular, and osseous structures surround the cavernous sinus from all sides.

Anterior: superior orbital fissure

Posterior: CN VI and apex of the petrous temporal bone

Superior: internal carotid artery, optic tract, and optic chiasma

Lateral: medial aspect and uncus of the temporal lobe

Medial: body of the sphenoid and sella turcica

Contents

The **internal carotid artery** (ICA) enters the posterior inferior aspect of the cavernous sinus, forming the cavernous part of the artery. It then travels horizontally anteriorly within the sinus.

Once it reaches the anterior wall of the sinus, the ICA traverses vertically upward toward the roof of the sinus and exits to form the cerebral part. It gives rise to two branches

within the sinus: the **meningohypophyseal branch** and the **inferolateral branch**. IThis part of the internal carotid artery is the only artery that is surrounded by a **network of veins**.

Sympathetic nerves around the carotid plexus arise from the **superior cervical ganglion** and surround the cavernous part of the ICA.

The **abducent nerve, or sixth cranial nerve (CN VI),** traverses the sinus inferolateral to the ICA and exits by entering the superior orbital fissure anteriorly. It innervates the **lateral rectus muscle** once it reaches the orbit.

The **oculomotor nerve, or third cranial nerve (CN III),** is the most superior nerve in the lateral wall of the sinus. As it reaches the anterior wall of the sinus, it divides into superior and inferior branches, which pass through the **superior orbital fissure**. CN III and the sympathetic plexus around the ICA innervate the **levator palpebrae superioris**, **inferior oblique**, and the **superior, medial, and inferior recti muscles of the orbit**.

The **trochlear nerve, or fourth cranial nerve (CN IV),** lies in the lateral wall of the sinus, below CN III. It exits through the anterior wall of the sinus and enters the superior orbital fissure. It supplies the **superior oblique muscle in the orbit**.

The **ophthalmic nerve** and **maxillary nerve** are branches of the **trigeminal nerve, or fifth cranial nerve (CN V).** They lie below CN IV in the lateral wall of the cavernous sinus. The ophthalmic branch exits via the superior orbital fissure, while the maxillary nerve exits the sinus via the **foramen rotundum**.

In **obese patients** and patients taking **corticosteroids**, fatty deposits may occasionally be seen within the cavernous sinus.

Connections

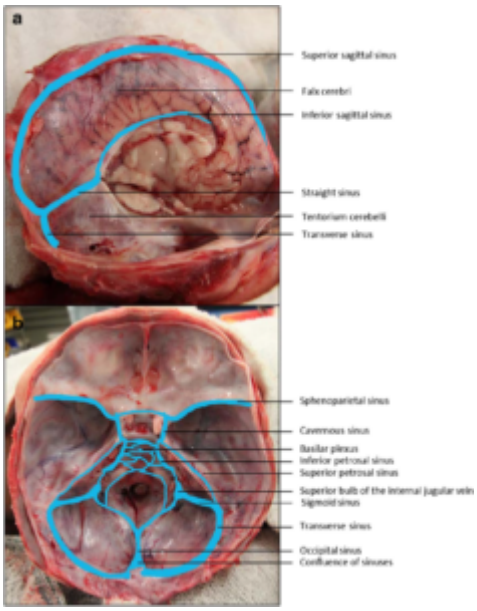


Image: “Dural venous sinuses” by Emma C. Cheshire, Roger D. G. Malcomson, Shiju Joseph, Asif Adnan, David Adlam, Guy N. Rutty. License: CC BY 4.0

The cavernous sinus connects to the rest of the dural venous sinuses through many veins

and anatomical spaces (e.g., receive cerebrospinal fluid from the subarachnoid space). Several tributaries from the cerebral cortex drain into the cavernous sinus, which then drains into other venous sinuses eventually reaching the superior vena cava.

Tributaries or incoming veins:

- Superficial middle cerebral vein
- Inferior cerebral vein from the temporal lobe
- Intercavernous sinus, which connects the cavernous sinuses on either side
- Inferior and superior ophthalmic veins (which drain the facial veins) from the orbit
- Sphenoparietal sinus from the **meninges**
- Central retinal vein, which may drain into the superior ophthalmic vein
- Tributary of the middle meningeal vein, which may drain into the **pterygoid plexus** or sphenoparietal or cavernous sinus

The cavernous sinus drains through the:

- Venous plexus around the ICA to the **basilar venous plexus**
- Superior petrosal sinus to the sigmoid sinus
- Inferior petrosal sinus to the **internal jugular veins**
- Emissary veins, passing through various foramina in the skull base, (eg, foramen ovale, foramen lacerum, sphenoidal foramen)

As the superior ophthalmic veins and the other complex of veins do not have valves, the **blood flow is bidirectional,** depending on the pressure gradients. The cavernous sinus receives blood via this bidirectional route and therefore **infections** from the mid face, nose, paranasal sinuses, orbits, tonsils, and even the middle ear can easily spread to it.

Clinical Relevance

Cavernous Sinus Thrombosis

Cavernous sinus thrombosis (CST) was first described in 1831 by Bright. It is a late complication of infection in the dangerous (central) area of the face (eg, furuncle on the nose, dental caries) or paranasal sinuses. CST is a medical emergency requiring urgent management, with a high incidence of morbidity and mortality.

With the advent of **broad-spectrum antimicrobial drugs**, the incidence of CST has significantly decreased. The infection may cause **thrombosis within the facial veins;** when the clot breaks off and travels to the cavernous sinus, it can cause CST.

As well, due to the close relationship of the cavernous sinus to the paranasal sinuses, orbit, complex of veins, cranial nerves, internal carotid artery, and meninges, and the absence of valves in the veins draining to and from the cavernous sinus, **infection from draining tissues** can result in CST.

The condition is characterized by edema of the eyelids, conjunctiva, and paralysis of the cranial nerves closely related to the cavernous sinuses.

Common organisms involved in CST include ***Staphylococcus aureus***, ***Streptococcus pneumococcus***, **gram-negative bacteria**, **anaerobes,** and fungi such as ***Rhizopus*** and ***Aspergillus***.

Diagnosis of CST is done clinically and confirmed with either **computed tomography**

(CT) scan or **magnetic resonance imaging with magnetic resonance venogram**, which is the study of choice.

Treatment consists of **empirical broad-spectrum antibiotics** with **corticosteroids** to reduce edema. **Surgery** may be required to drain/clean infected material from the paranasal sinuses. Delay in diagnosis and treatment is associated with **high morbidity and mortality**. Patients who survive may have **a visual impairment or cranial nerve deficits**.

Cavernous Sinus Syndrome

The **pituitary gland** is located in a fossa between the two cavernous sinuses. As **pituitary tumors** grow, they can expand toward and then compress the cavernous sinus. This can lead to cavernous sinus syndrome (CSS), which is characterized by **ophthalmoplegia** (paralysis of CN III, IV, and VI), **loss of sensation** in the region of the ophthalmic and maxillary nerves, and **Horner's syndrome** due to compression of the sympathetic plexus around the internal carotid artery.

CSS can also be caused by **tumors** extending from the nasopharynx, pituitary, or metastasis, or even following CST.

Carotico-Cavernous Fistula

Carotico-cavernous fistula (CCF) is formed via an unnatural direct communication between the cavernous sinus and the ICA traversing through it. This direct fistula is formed due to either trauma or rupture of an **aneurysm**.

Arterial dissection, **collagen vascular diseases** such as Ehler-Danlos syndrome, and **fibromuscular dysplasia** can also cause CCF.

Among other symptoms, patients may present with pulsatile proptosis; orbital congestion; chemosis; corneal exposure; diplopia; paralysis of CN III, IV, and VI; and retinopathy. **CT angiography** is the test of choice.

Usually, these fistulae resolve spontaneously. **Persistent symptomatic fistulae** require treatment, which consists of **steroids in the acute phase** to reduce edema followed by definitive surgery.

Endovascular approaches with obliteration of the fistula and restoration of arterial and venous flow lead to resolution of the fistula.

Triangular Space Approach

In 1965, Parkinson described a triangular space **between the ophthalmic and trochlear nerves** that can be used to approach lesions near the cavernous part of the ICA. With the advent of radiosurgery and endovascular surgery, this direct approach through the triangular space is rarely required, however.

If **endovascular surgery** or **occlusion of carotico-cavernous fistula** fails, then direct surgery through this space may be necessary. As well, in the case of certain tumors such as **meningiomas, schwannomas, pituitary adenomas, and chondromas**, access to the tumors can be gained through this triangle.

References

Ten Triangles around Cavernous Sinus for Surgical Approach via ncbi.nlm.nih.gov

Cavernous sinus via wikipedia.org

Cavernous Sinus Thrombosis via medscape.com

Definition of Cavernous sinus via medicinenet.com

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Notes