

Cavernous sinuses

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Question 1

The **cavernous sinuses** are one of several drainage pathways for the brain that sits in the middle. In addition to receiving venous drainage from the brain, it also receives tributaries from parts of the face.

The left and right cavernous sinuses communicate by through the anterior and posterior intercavernous sinuses. The cavernous sinus drains to the superior and inferior petrosal sinuses, which then join the sigmoid sinus.

The cavernous sinuses are 1 cm wide cavities that extend a distance of 2 cm from the most posterior aspect of the **orbit** to the **petrous part of the temporal bone**. They are bilaterally paired collections of venous plexuses that sit on either side of the sphenoid bone. Although they are not truly trabeculated cavities like the corpora cavernosa of the penis, the numerous plexuses, however, give the cavities their characteristic sponge-like appearance. It is **roofed** by an inner layer of **dura mater** that continues with the diaphragma sellae that covers the superior part of the pituitary gland. The roof of the sinus also has several other attachments. Anteriorly, it attaches to the anterior and middle **clinoid processes**, posteriorly it attaches to the **tentorium** (at its attachment to the posterior clinoid process). Part of the periosteum of the greater wing of the sphenoid bone forms the floor of the sinus. The body of the sphenoid acts as the medial wall of the sinus while the lateral wall is formed from the visceral part of the dura mater.

The cavernous sinus contains the internal carotid artery and several cranial nerves. Abducens nerve (CN VI) traverses the sinus lateral to the internal carotid artery. The remainder of the cranial nerves pass through the lateral wall of the carotid sinus, and from superior to inferior they are:

Oculomotor nerve (CN III)

Trochlear nerve (CN IV)

Trigeminal nerve (CN V) - ophthalmic and maxillary divisions.

Internal carotid artery

In addition to the thin walled veins that traverse the cavernous sinus, a lone arterial vessel also uses the area as a conduit. The **internal carotid artery** (a branch of the common carotid artery) – along with its postganglionic **sympathetic plexus** from the superior cervical ganglion – gains access to the cavernous sinus posteriorly. As the petrous part of the internal carotid artery leaves the **carotid canal**, it curves vertically and superiorly above foramen lacerum to enter the cavernous sinus. Here the artery is also referred to as the **cavernous part**.

Within the sinus, the internal carotid artery travels anteriorly, in a horizontal manner until it

reaches the anterior limit of the sinus. Here it curves vertically and superiorly to exit the sinus through its roof and become the **cerebral part** of the internal carotid artery. It is noteworthy that the cavernous part of the internal carotid artery is the only arterial vessel that is completely surrounded by venous networks.

Abducent nerve

There are also other non-vascular structures that utilize the cavernous sinus as a pathway to their points of supply. Five cranial nerves (CN) use this pathway to gain access to their points of innervation. The first to be discussed is the **abducent nerve (CN VI)**. This motor nerve leaves the pons and gains access through the posterior part of the sinus after passing the apical portion of the petrous temporal bone. It has also been known to access the cavernous sinus by way of the petrosal sinus, adjacent to the clivus.

Within the cavernous sinus, it takes an inferolateral course, relative to the internal carotid artery. It exits the sinus by way of the **superior orbital fissure** to gain access to the orbit, where it innervates the lateral rectus muscle of the eyeball.

Oculomotor nerve

The other nerves travelling through the cavernous sinus do so between the endothelial lining and the dura mater of its lateral wall. The most superior of the four nerves in the lateral wall is the **oculomotor nerve (CN III)**. At the posterior aspect of the roof of the cavernous sinus, the free and attached edges of tentorium cerebelli form a space through which CN III enters the lateral wall of the sinus. It takes an anterior, inferomedial course (relative to the other nerves in the lateral wall) towards the anterior extremity of the sinus.

Here it bifurcates into its **superior and inferior rami** that pass through the superior orbital fissure. Along with **sympathetic fibers** from the internal carotid plexus, CN III provides motor supply to inferior oblique, levator palpebrae superioris, and the inferior, medial and superior recti muscles.

Trochlear nerve

The smallest of the cranial nerves, the **trochlear nerve (CN IV)**, enters the posterior aspect of the cavernous sinus after leaving the posterior part of the brainstem and decussating with the same nerve from the opposite side. It continues anteriorly in the lateral wall of the cavernous sinus, inferior to CN III and passes through the superior orbital fissure at the anterior aspect of the sinus. Once in the orbit, CN IV has the responsibility of innervating the **muscles of the eyeball** that are responsible for inferolateral motions.

Trigeminal nerve

Finally, two of the three branches of the **trigeminal nerve (CN V)** pass through the cavernous sinus. Prior to entering the cavernous sinus, the proximal portion of the nerve lies in Meckel's cave, where it forms the trigeminal ganglion. After leaving the cave, the **mandibular division (CN V3)** courses inferiorly to pass through foramen ovale (without entering the cavernous sinus).

The other two branches, the **ophthalmic** and the **maxillary (CN V1 and CN V2, respectively)**, travel through the lateral wall of the sinus. Both take courses inferior to CN III and CN IV, however, CN

V2 is the most inferior of them all. Both CN V branches in the sinus travels horizontally. CN V2 leaves the sinus via foramen rotundum, while the three branches of CN V1 exit the cranial fossa via the superior orbital fissure. CN V1 and CN V2 are purely sensory and supply specific regions of the face.

Relations

There are numerous structures surrounding the cavernous sinus that are noteworthy. Medially, the sinus is adjacent to the lateral walls of the **pituitary fossa** with the pituitary gland, the sphenoid bone and its air sinus. The cerebral part of the **internal carotid artery** courses superiorly. Laterally, the medial aspect of the **temporal lobe** of each hemisphere lies adjacent to the sinus. And posteriosuperiorly, the **uncus** of the temporal lobe has a relation to the sinus.

The cavernous sinus is an unconventional venous system in the sense that it does not have a unidirectional flow of blood. Owing to the fact that there are no valves in the sinus and its connected veins, the direction of blood flow is dependent on venous pressure. The veins that communicate with the cavernous sinus are:

Superior ophthalmic vein

Inferior ophthalmic vein

Superficial middle cerebral vein

Middle meningeal vein

Hypophyseal veins

Superior ophthalmic vein

The cavernous sinus generally has five venous tributaries. The **superior ophthalmic vein** receives blood from the ethmoidal, nasofrontal, vorticosae (drains the ocular choroid), and central retinal veins. It drains into the anterior part of the sinus via the superior orbital fissure.

Inferior ophthalmic vein

The **inferior ophthalmic vein** collects blood from the eyelids, lacrimal sac, and some vorticosae contributions, as well as the anterior floor and medial wall of the orbit. In addition to draining to the cavernous sinus, it also drains to the pterygoid plexus.

Superficial middle cerebral vein

At the point where the internal carotid artery emerges, the **superficial middle cerebral vein** pierces the roof of the sinus. Here, it drains blood from the cortices that are adjacent to it as it courses through the lateral sulcus.

Middle meningeal vein

Finally, branches of the **middle meningeal vein** may join the **sphenoparietal sinus** on its way to the cavernous sinus. Before piercing the roof of the sinus, it travels along the edge of the lesser wing of the sphenoid between the layers of dura mater.

Hypophyseal veins

Additionally, **efferent hypophyseal veins** of both the adenohypophysis and neurohypophysis drain to the cavernous sinus.

Intercavernous sinuses and drainage

The left and right cavernous sinuses communicate by way of the **anterior and posterior intercavernous sinuses**. These vessels travel anteriorly and posteriorly (respectively) around the infundibulum of the pituitary gland, deep to the diaphragma sellae, between the layers of dura mater.

The cavernous sinus in turn drains to the **superior and inferior petrosal sinuses**. Both sinuses join the sigmoid sinus, which then becomes the internal jugular vein. The internal jugular vein meets with the subclavian vein to become the left (or right) brachiocephalic vein.

Clinical significance

Carotid-cavernous fistula

Head trauma resulting in rupture of the cavernous part of the **internal carotid artery** can produce what is known as a carotid-cavernous fistula. A pulsating exophthalmos can result as the venous pressure in the sinus would increase and reverse the flow of blood in the ophthalmic veins.

Cavernous sinus thrombosis

The sinus also has communicating branches from the sin of the face. Particularly in the '**danger area**' (at the nasolabial crease and at the crease between the ala of the nose and the cheek), an infection can spread to the cavernous sinus, which can result in a cavernous sinus thrombosis. This condition can result in **internal strabismus** (crossed eyes) if the CN VI is damaged, **doubled vision** while looking downward if CN IV was damaged, or **ophthalmoplegia** (paralysis or weakness in muscles of movement of the eye).

Question 2

Discuss the walls of the nose

The lateral wall of the nasal cavity is a region of the nasopharynx essential for humidifying and filtering the air we breathe in nasally.

Here we can find a structure called **agger nasi**. The agger nasi is also referred to as the 'nasoturbinal concha' or 'nasal ridge.' It can be described as a small mound or ridge found in the lateral side of the nasal cavity. The structure is located midway along the anterior aspect of the

middle nasal concha. An abnormally enlarged form may restrict the drainage of the frontal sinus by obstructing the frontal recess area.

Contents

1. Nasal septum

Bones and cartilages

The **anterior nasal aperture** is simply the area where the anterior bony aspects of both the maxilla and the nasal bone terminate and form an opening into the cartilaginous nasal vestibule. The structure is also referred to as the piriform aperture.

Three cartilages contribute to the nasal septum:

lesser alar cartilages are paired cartilages suspended in the fibro-fatty tissue that forms the lateral aspect of the nostril. The structures lie free from the other cartilages and provide the nostril with stability and form.

greater alar cartilages are paired cartilages that form part of the antero-superior nostril as well as the nasal tip. The structures give the tip of the nose stability and flexibility and are a crucial element of the cartilaginous apparatus of the nose.

lateral nasal cartilages are structures that articulate inferiorly with the greater alar cartilages and superiorly with the anterior nasal aperture formed by both the nasal bone superiorly and for a short part of its border with the perpendicular plate of the ethmoid bone. These structures form the cartilaginous part of the bridge of the nose and form in conjunction with the greater alar cartilages, the major structural appearance of the nose.

2. Nasal conchae

We can find 3 types of nasal conchae in the nasal cavity. Those are:

A. inferior nasal concha. It is the longest and broadest of the conchae and is formed by an independent bone (of the same name, inferior concha). The concha is covered by a mucous membrane that contains large vascular spaces and is one of the three that work to both humidify and clear the air that passes into the nasopharynx.

B. superior and middle nasal conchae arise from the perpendicular plate of the ethmoid bone. The middle nasal concha is found in between the superior and inferior nasal concha and plays a role in humidifying and clearing inspired air of micro-particles such as dirt. The superior nasal concha is a bony shelf located above the middle nasal concha and below the sphenoidal recess. Similar to the middle nasal concha the superior concha is itself part of the ethmoid bone.

Associated structures

The **nasal surface of the maxilla** forms the antero-lateral part of the bony nasal cavity. It is located inferior to the nasal bone and gives rise in part, to the inferior nasal concha. The **sphenopalatine foramen** is found in the posterior most region of the nasal cavity, at the

back of the middle meatus. The foramen is formed by the processes on the superior border of the palatine bone, and the under surface of the sphenoidal body, which form a foramen. It connects the nasal cavity to the pterygopalatine fossa, and thus transmits the sphenopalatine artery and vein as well as the superior nasal and nasopalatine nerves.

The **medial plate of the pterygoid process** is an inferior projection of the sphenoid bone. The plate forms a laterally pointing hook like process at its most inferior point, known as the pterygoid hamulus. The tensor veli palatine muscle glides around this structure. The lateral surface of the medial plate forms the medial border of the pterygoid fossa, and the medial surface forms the lateral boundary of the choana of the adjacent nasal cavity

Limn nasi

The **limn nasi** is approximately 10mm in length and is defined as the boundary between the nasal cavity proper and the vestibule. It is relatively wide and superficial anteriorly but gradually narrows as it extends posteriorly towards the anterior region of the middle concha. It lies upon the upper edge of the lateral crus of the greater alar cartilage and detached pieces of cartilage may take part in its formation.

The **inferior nasal meatus** lies beneath the inferior nasal concha and the lateral nasal wall. It is broader in front than behind and extends the entire length of the lateral wall of the nose and the anterior third contains the termination of the nasolacrimal or 'tear' duct. This opening is covered by a mucosal valve known as Hassner's valve. The **middle nasal meatus** is located above the inferior and below the middle nasal concha. It is also part of the ethmoidal complex as it drains the maxillary, frontal and anterior ethmoidal sinuses. The **superior meatus** is located below the superior nasal concha and drains the posterior ethmoidal air cells.

The **sphenoethmoidal recess** is a small cleft like pocket located above the superior nasal concha and drains the sphenoid sinus. The sphenoethmoidal recess is a space found superior to the superior turbinate bone and drains the sphenoidal sinus as well as some of the **ethmoidal sinuses**. The frontal sinuses are situated between the brow ridges and lie between the two layers of the frontal bone. They are unlikely to be symmetrical and are not usually involved in sinusitis.

The **sphenoidal sinus** is contained within the body of the sphenoid bone itself. There is a great deal of variation in the shape and size of this sinus between individuals. The sinus drains into the sphenoethmoidal recess which is located superior to the choana. The main expansion of their size occurs during puberty and they perform a similar function to the other sinuses.

The **nasal vestibule** is the visible part of the internal nasal cavity from an external view. The vestibule is maintained by the greater and lesser alar cartilages and contains small hairs which trap dirt and small particles during inspiration. The vestibules are lined by stratified squamous epithelium, and are separate from the nasal cavity proper, which is lined with respiratory epithelium.

3. Nasal skeleton

Ethmoid bone

The ethmoid bone is located on the roof of the nose between the two orbits and is lightweight and spongy. It has **three parts**:

cribriform plate which is pierced by fibres of the olfactory nerve;

ethmoidal labyrinth which consists of numerous thin walled hollow cavities;

perpendicular plate which forms part of the posterior nasal septum and gives rise to the superior and middle nasal conchae.

The bone **articulates** with many others including the frontal and sphenoid bone as part of the neurocranium, and the nasal and lacrimal bones anteriorly as well as the maxilla inferolaterally and the vomer and inferior nasal concha inferiorly. The bone also forms the deep medial part of the orbit.

Frontal bone

The frontal bone overlies the frontal lobe of the brain and lies anteriorly forming the brow, forehead and one third of the anterior scalp. The bone contains the frontal sinus, which in sinusitis and nasal infections can become filled with fluid. The bone **articulates** with the bones forming the calvaria as well as the zygomatic bone inferolaterally and the nasal and maxilla bones anteroinferiorly.

Lacrimal bone

The lacrimal bone is the smallest bone of the face and forms part of the posterior nasal skeleton. The bone has a crest known as the 'sulcus lacrimalis' on its lateral surface. This crest gives rise to the aptly named lacrimal part of the orbicularis oculi muscle.

The anterior inner margin of the bone **articulates** with the frontal process of the maxilla and the upper part of the fossa contains the lacrimal sac, which drains into the nasolacrimal duct. The superior portion articulates with the frontal bone. The **inferior border** of the bone is divided by the lower edge of the posterior lacrimal crest into an anterior and posterior part. The posterior articulates with the orbital plate of the maxilla, and the anterior extends through a descending process which forms part of the canal for the nasolacrimal duct as well as articulating with the lacrimal process of the inferior nasal concha. The posterior portion of the bone is smooth and forms part of the medial wall of the orbit.

Nasal bones

The paired nasal bones form the bridge of the nose and with the frontal process of the maxilla laterally and the nasal process of the frontal bone superiorly. The inner surface is grooved by the passage of the nasociliary nerve.

The surface of the bone is convex anteriorly and is covered by both the compressor naris and procerus muscle. The bone articulates distally with the cartilages of the nose, namely the lateral cartilages and inferiorly with the quadrangular cartilage of the nasal septum in the midline. It also articulates posteroinferiorly in the midline with the perpendicular plate of the

ethmoid bone

Palatine bones

The palatine bones are paired 'L' shaped bones consisting of a perpendicular and horizontal plate. They are situated at the posterior part of the nasal cavity between the pterygoid process of the maxilla and the sphenoid.

Three protruding processes can also be found, namely the **pyramidal process** directed posterolaterally which can be found between the two parts and the orbital and sphenoidal processes.

The bones form the posterior part of the **hard palate** and form the floor of the nasal cavity and articulate with the maxillae anteriorly. The **greater and lesser palatine foramina** transmit the greater and lesser palatine nerves and blood vessels respectively. The greater palatine foramen is larger and more lateral than the lesser.

Sphenoid bone

The **sphenoid bone** is a wedge-like, complex bone with many articulations. It is one of the seven bones to form the orbit and also forms part of the mid lateral surface of the skull, anterior to the temporal bone. The bone forms the floor of the **middle cranial fossa** and contains numerous foramina for the passage of cranial nerves. The median portion of the bone contains the **sella turcica** or 'Turkish saddle' which resembles a four poster bed with its paired anterior and posterior clinoid processes. The pituitary gland sits in the sella turcica. In life, a layer of dura covers this space and its contents. The bone also possesses two greater and two lesser wings. The greater wings curve backward and laterally to articulate with the petrous portion of the temporal bone. The orbital surface of the great wings forms the lateral wall of the orbit.

The superior surface contains many **foramina** including which transmit different nerves and blood vessel:

superior orbital fissure which transmits the oculomotor nerve; trochlear and abducens nerves; and V1 (ophthalmic) branch of the trigeminal nerve.

optic canal transmits the optic nerve.

foramen rotundum found below the fissure transmits V2 (maxillary nerve) branch of the trigeminal nerve.

foramen ovale transmits V3 (mandibular nerve) branch of the trigeminal nerve.

foramen spinosum found posterolaterally like the point on an exclamation mark, allows entry of the middle meningeal artery (a branch of the maxillary artery which is the seventh branch of the external carotid artery).

The three branches of the trigeminal nerve branch at the trigeminal ganglion in the '**Meckel's cave**' found on the ridge of the middle and posterior cranial fossae. Dura covers the cavernous

sinus, which contains the internal carotid artery travelling forwards as well as cranial nerves 3, 4, v1, v2 and 6. The region of the greater wing that extends from the body to the spine provides in its medial half the anterior margin of the foramen lacerum.

Clinical notes

Sinusitis

Sinusitis is an inflammation of the different sinuses found in the head. That type of inflammation may result in different symptoms including:

plugged nose;

nasal mucus;

and pain in the facial region.

When we talked about the frontal bone we saw that it overlies the frontal lobe of the brain and lies anteriorly forming the brow, forehead and one third of the anterior scalp. The bone contains the frontal sinus, which in sinusitis and nasal infections can become filled with fluid.