Orbital Vascular Anatomy

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Glossary

Anastomosis – The collateral communication between blood vessels. They enlarge to facilitate compensatory blood flow when one of the vessels is obstructed.

Fistula – An abnormal communication between an artery and vein.

A thorough knowledge of the vascular anatomy in the orbit and periorbital tissues is critical for understanding alterations due to disease as well as avoiding these vessels during surgery in and around the orbit. The complexity and interindividual variability of the vessel anatomy is quite significant, and thus understanding the possible differences between orbits is particularly important for ensuring maximum preservation of blood supply and limiting bleeding within the orbit during surgical procedures.

The first major branch of the internal carotid, the ophthalmic artery, is the source of most of the orbital blood supply, with minor contributions from the external carotid circulation. Branching patterns of the ophthalmic artery may vary widely, but common patterns have been identified. Its distal branches form important anastomoses with the external carotid circulation that can sustain orbital blood flow in pathologic conditions involving the internal carotid artery (ICA). The orbital venous system is even more variable than the orbital arteries. Unlike the vasculature in most areas of the human body, the orbital arteries and veins do not run in parallel. Generally, the superior and inferior ophthalmic veins drain orbital blood into the cavernous sinus posteriorly. The orbital venous system is valveless, so alternative drainage can occur through veins that connect to the facial veins anteriorly and the pterygoid venous system inferiorly.

Arterial Blood Supply

The ophthalmic artery provides the major blood supply to the orbit. It is the first major branch of the ICA. Branches of the ophthalmic artery anastomose with distal branches of the external carotid artery (ECA), creating important connections between the internal and external carotid circulations (Figure 1). The orbital arterial supply will be described first from the internal carotid contributions followed by the external carotid contributions. The most common anatomical configurations will be emphasized with discussions of common variants.

Internal Carotid Artery

At the upper limit of the thyroid cartilage, the common carotid artery bifurcates into the ICA and ECAs. The ICA ascends the neck without branching and enters the skull base through the carotid canal, an opening in the petrous portion of the temporal bone. The ICA runs anteromedially through the carotid canal, continuing through the foramen lacerum to emerge in the posterior cavernous sinus. The ICA winds through the cavernous sinus forming an elongated S shape referred to as the carotid siphon. From its entrance into the posterior cavernous sinus, the ICA travels slightly superiorly and then anteriorly before turning abruptly superiorly and piercing the dural roof of the cavernous sinus, just medial to the anterior clinoid process of the sphenoid bone. The carotid siphon then curves posteriorly, and then anterosuperiorly to reach the inferolateral optic nerve. Within the cavernous sinus, the ICA consistently gives off a meningohypophyseal trunk, which supplies the intracavernous oculomotor, trochlear, and abducens nerves, as well as portions of the pituitary gland. The artery of the inferior cavernous sinus and the capsular arteries are more variable intracavernous ICA branches.

The first major intradural branch of the ICA is the ophthalmic artery, which arises just distal to the carotid siphon. In 10% of cases, the ophthalmic artery actually arises from the ICA within the cavernous sinus external to the dura. Rarely, the external carotid circulation contributes to the ophthalmic artery’s origin. The most common variant origin arises from the middle meningeal artery (MMA) either as a single trunk or from two separate ICA and MMA trunks. Isolated descriptions also exist of ophthalmic arteries arising from the middle cerebral artery, the anterior cerebral artery, the posterior communicative artery, and the basilar artery.

Usually, the ophthalmic artery arises from the anterior wall of the ICA inferior to the optic nerve. It then runs anterolaterally inferior to the optic nerve to enter the optic canal, running with the optic nerve. Multiple small arteries arise from the ICA near the origin of the ophthalmic artery. These arteries supply the pituitary infundibulum, the intracranial portion of the optic nerve, and the...
optic chiasm. Distal to the ophthalmic artery, the ICA gives off the posterior communicating and anterior choroideal arteries to form the anterior circle of Willis. The terminal branches of the ICA are the anterior and middle cerebral arteries that supply blood to the brain parenchyma.

**Ophthalmic Artery**

The ophthalmic artery provides the major blood supply to the orbit. It is the first major branch of the ICA. Distal branches of the ICA form important anastamotic connections with the external carotid circulation that can provide collateral blood flow to the orbit. Branches of the ophthalmic artery are extremely variable, but common patterns have been identified. The ophthalmic artery will be described in three parts: (1) intracranial, (2) intracanalicular, and (3) intraorbital. The most common branching patterns will be discussed here along with common variants.

**Intracranial**

The intracranial segment of the ophthalmic artery describes the length of the vessel from its branch point off the internal carotid until it enters the optic canal. This portion of the ophthalmic artery is usually subdural (85%) and intimately associated with the ICA and the inferior aspect of the optic nerve. These structures are often linked by fibrous connective tissue. The average length of the intracranial ophthalmic artery is 2.6 mm, but can be as long as 7 mm. Typically, there are no branches off this arterial segment.

**Intracanalicular**

The intracanalicular ophthalmic artery runs in the optic canal, inferior to the optic nerve until it emerges in the orbit. The artery gradually pierces the dura surrounding the intraorbital optic nerve to enter the subdural space. Thus, within the optic canal, the artery becomes physically separated from the optic nerve by a dural barrier. The intracanalicular ophthalmic artery sends small branches to the intracanalicular optic nerve through fibrous bands connecting the dura to the optic nerve. Traumatic injury to the optic canal can tear these fibrous bands, interrupting the blood supply to the optic nerve and causes ischemic damage. Rarely, the ophthalmic artery enters the orbit through a separate bony canal.

**Intraorbital**

The extreme variability of the ophthalmic artery and its branches becomes evident in its intraorbital course. Hayreh has done the most comprehensive anatomical
descriptions of the ophthalmic artery. While their systematic dissections never revealed any identical intraorbital branching patterns of the ophthalmic arteries, they identified common patterns associated with whether the intraorbital ophthalmic artery crosses superior or inferior to the optic nerve.

The intraorbital ophthalmic artery can be divided into three segments (Figure 2). The first part begins at the orbital apex and is attached by loose connective tissue and fat to the inferior aspect of the optic nerve as it courses anteriorly along the inferolateral margin. The artery then crosses to the medial orbit. The point at which the artery turns medially to cross superior (83%) or inferior (17%) to the optic nerve is called the angle and marks the division between the first and second intraorbital ophthalmic artery segments. The second segment of the ophthalmic artery is defined as the length of artery that crosses the optic nerve from lateral to medial. It is only loosely connected to the dural nerve sheath. The vertical position of this arterial segment with respect to the optic nerve determines which arterial branching pattern will commonly be seen. The division between the second and third parts of the ophthalmic artery is called “the bend.” This is a well-defined point on the superiomedial aspect of the optic nerve, where the ophthalmic artery turns to head anteromedially through the orbit. Distal to “the bend,” the ophthalmic artery loses its intimate association with the optic nerve and is anchored to the medial orbital wall by the ethmoidal vessels. This arterial segment is quite tortuous, allowing the ophthalmic artery to withstand ocular movement without compromising blood supply. It heads medially and passes anterosuperiorly between the

![Figure 2](image-url)
medial rectus and superior oblique muscles. It runs inferior to the trochlea before its terminal branches emerge from the superiomedial orbital angle, midway between the medial palpebral ligament and the superior orbital margin (Figure 3).

Branching patterns of the intraorbital ophthalmic artery are extremely variable. In Hayreh's systematic study of 59 human orbits, no identical ophthalmic artery branching patterns were seen. The main pattern distinction depends on whether the second segment of the ophthalmic artery crosses superior or inferior to the optic nerve and can be traced to varying patterns in fetal arterial development. As the ophthalmic artery develops, a vascular ring forms around the optic nerve. Typically, the larger dorsal portion of the vascular ring persists, while the ventral portion regresses, resulting in the ophthalmic artery crossing superior to the optic nerve 83% of the time. When the dorsal segment of the fetal vascular ring regresses, the ophthalmic artery crosses inferior to the optic nerve.

While the variability of the intraorbital branching pattern of the ophthalmic artery cannot be overemphasized, the most common branching patterns based on order of origin are outlined in Table 1. The following descriptions of the intraorbital ophthalmic arterial branches are organized topographically by the ocular, orbital, and extraorbital blood supplies.

### Table 1

<table>
<thead>
<tr>
<th>Order of origin</th>
<th>Crossing pattern of ophthalmic artery</th>
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<tbody>
<tr>
<td>Superior to the optic nerve (83%)</td>
<td>Inferior to the optic nerve (17%)</td>
</tr>
<tr>
<td>1 Central retinal</td>
<td>Lateral posterior ciliary</td>
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<tr>
<td>2 Lateral posterior ciliary</td>
<td>Central retinal</td>
</tr>
<tr>
<td>3 Lacrimal</td>
<td>Medial muscular</td>
</tr>
<tr>
<td>4 Muscular to superior rectus and/or levator</td>
<td>Medial posterior ciliary</td>
</tr>
<tr>
<td>5 Posterior ethmoid</td>
<td>Lacrimal</td>
</tr>
<tr>
<td>6 Supraorbital</td>
<td>Muscular to superior rectus and/or levator</td>
</tr>
<tr>
<td>7 Medial posterior ciliary</td>
<td>Posterior ethmoid</td>
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<tr>
<td>8 Medial muscular</td>
<td>Supraorbital</td>
</tr>
<tr>
<td>9 Muscular to superior oblique and medial rectus</td>
<td>Muscular to superior oblique and medial rectus</td>
</tr>
<tr>
<td>10 Anterior ethmoid</td>
<td>Anterior ethmoid</td>
</tr>
<tr>
<td>11 Medial palpebral</td>
<td>Medial palpebral</td>
</tr>
<tr>
<td>Terminal Dorsal nasal</td>
<td>Dorsal nasal</td>
</tr>
<tr>
<td>Terminal Supratrochlear</td>
<td>Supratrochlear</td>
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### Ocular Branches

The ocular branches include the central retinal artery, the anterior ciliary arteries, the lateral and medial posterior ciliary arteries, and small collateral branches to the optic nerve. The central retinal artery is typically the first branch of the ophthalmic artery. It runs along the inferior aspect of the optic nerve before piercing the optic nerve sheath 5–15 mm posterior to the globe. Once the artery has entered the neural sheath, it makes its way to the
center of the optic nerve substance, supplying blood to the surrounding nerve as it courses toward the optic nerve head where its terminal branches divide to supply the inner retina. The central retinal artery is the sole blood supply to the inner two-thirds of the retina. The terminal branches of the central retinal artery are end arteries, meaning that a proximal occlusion will completely cut off blood supply to that portion of the retina. More distal occlusions can lead to segmental retinal ischemia.

The number of posterior ciliary arteries is variable. They typically arise as two to three trunks that divide into multiple short ciliary arteries and a medial and lateral long posterior ciliary artery that extend from the ophthalmic artery to the posterior globe. Up to five posterior ciliary artery branches have been described. The short ciliary arteries pierce the sclera near the optic nerve and directly supply the choroidal vessels that nourish the outer one-third of the retina. They form the anastomotic circle of Zinn and Haller, adjacent to the optic nerve that feeds the optic disc. In approximately 15% of the population, the short posterior ciliary arteries give off one or more cilioretinal arteries to supply the inner two-thirds of the macula in addition to the central retinal artery. When present, the cilioretinal artery can provide collateral circulation to the macula in a central retinal artery occlusion. The medial and lateral long posterior ciliary arteries run toward either side of the globe along the horizontal meridian, passing between the choroid and the sclera to anastomose with the anterior ciliary arteries. It supplies the ciliary muscle, iris, and part of the choroid.

**Orbital Branches**

The orbital branches of the ophthalmic artery include the lacrimal artery, extraocular muscular arteries, and small branches that supply the orbit periosteum and areolar tissue. The lacrimal artery typically branches from the second part of the ophthalmic artery between "the angle" and "the bend." It runs along the lateral orbital wall above the superior border of the lateral rectus muscle with the lacrimal nerve to supply the lacrimal gland. The lacrimal artery gives off the recurrent meningeal, zygomatic, and lateral palpebral arteries. The recurrent meningeal artery exits the orbit through the superior orbital fissure and anastomoses with branches of the MMA, connecting the internal and external carotid circulations. The lateral palpebral arteries supply the lateral eyelids and conjunctiva.

Multiple muscular arteries arise from the ophthalmic artery branches to supply the extraocular muscles. The lateral and medial muscular branches are the most prominent, and provide the major extraocular muscle blood supply. The lateral muscular artery typically arises from the second segment of the ophthalmic artery and supplies the lateral rectus, superior rectus, superior oblique, and levator palpebrae superioris. The medial muscular branch typically arises from the third segment of the ophthalmic artery medial to the optic nerve to supply the medial and inferior rectus, and the inferior oblique. After running the length of the muscle, the muscular branch in each rectus muscle gives off two anterior ciliary arteries, except for the lateral rectus that typically contributes only one, which run in the rectus tendons before piercing the sclera near the limbus to anastomose with the posterior ciliary arteries to supply anterior segment structures and choroid. Interruption of anterior ciliary blood flow can lead to a rare, but well-defined complication of strabismus surgery: anterior segment ischemia. This has typically been reported when three to four rectus muscles are removed during strabismus surgery, but has been reported in cases involving fewer muscles in patients with underlying predispositions to orbital ischemia. Anterior segment ischemia is more common in vertical muscle surgery, most likely because collateral flow from the long posterior ciliary arteries along the equator of the globe can compensate for lateral and medial anterior ciliary blood flow.

**Extraorbital Branches**

The extraorbital branches include the anterior and posterior ethmoidal arteries, the supraorbital artery, the medial palpebral artery, and the terminal ophthalmic artery branches: the dorsal nasal and supratrochlear arteries. The posterior and anterior ethmoidal arteries typically arise from the third segment of the ophthalmic artery and course through the orbital orbit before passing through the posterior and anterior ethmoidal canals, respectively, into the ethmoid air cells. The presence of the posterior ethmoidal artery is variable. Hayreh reported absence of the posterior ethmoidal artery in 15% of specimens where the ophthalmic artery crosses under the optic nerve, and 19% of ophthalmic arteries that cross over the optic nerve. In the majority of cases, however, the posterior ethmoidal artery runs between the superior oblique muscle and thelevator muscles. It enters the posterior ethmoidal canal with the posterior ethmoidal nerve to supply blood to the posterior ethmoidal air cells, the meninges of the anterior cranial fossa, and the upper nasal mucosa.

The anterior ethmoidal artery is larger and more consistent than its posterior counterpart. It runs between the superior oblique and medial rectus and passes through the anterior ethmoidal canal with the anterior ethmoidal nerve to supply the anterior and middle ethmoidal air cells, the frontal sinus, and the anterior cranial fossa dura. Nasal branches supply skin on the lateral wall of the nose.

The supraorbital artery typically arises off the second portion of the ophthalmic artery. It joins the supraorbital nerve as is courses anterosuperiorly through the medial orbit. The supraorbital artery emerges on the face through the supraorbital notch or foramen to supply the levator
The facial artery supplies blood to oral, pharyngeal, and mid-lower facial structures. It is a very tortuous vessel, which allows it to withstand movement during speaking and chewing. The facial artery branches off the ECA near the angle of the mandible. It dives deep to the posterior belly of the digastric and stylohyoid muscles and enters a groove on the posterior aspect of the submandibular gland. The facial artery then emerges on the face, crosses superiorly over the body of the mandible to the angle of the mouth, and ascends lateral to the nose to terminate as the angular artery in the medial canthal region. The angular artery has an anastomotic connection with the dorsal nasal artery, a terminal branch of the ophthalmic artery off the ICA to connect the internal and external carotid circulations.

The superficial temporal artery is one of the two terminal ECA branches. It arises from the ECA within the substance of the parotid gland posterior to the neck of the mandible and ascends the scalp, anterior to the ear. Within the parotid gland, the superficial temporal artery gives off the transverse facial artery, which supplies the parotid gland and duct and the masseter muscle. The superficial temporal artery then ascends to cross above the posterior zygomatic process where it gives off two branches: (1) the middle temporal artery that supplies the temporalis muscle and (2) the zygomatic artery that supplies the orbicularis oculi muscle before anastomosing with the lacrimal and palpebral branches of the ophthalmic artery. Within 2–5 cm of crossing the zygomatic process, 90% of superficial temporal arteries split into a frontal and parietal branch. Anomalous patterns exist in approximately 10% of the population, with the most common variant being an additional frontal branch. Other variations include an additional parietal branch, a more proximal branch point off the superficial temporal artery, or no branching at all. The frontal branch supplies the facial muscles, skin, and pericranium of the anterior scalp and anastomoses with the supraorbital artery. The posterior branch anastomoses with the posterior auricular and occipital arteries to supply the posterior scalp.

The maxillary (internal maxillary) artery is the larger terminal ECA branch that supplies the deep structures of the face and sends intracranial branches to the dura and trigeminal ganglion. The artery can be split into three sections: (1) mandibular, (2) pterygoid, and (3) pterygopalatine. The mandibular portion of the maxillary artery runs anteriorly between the mandibular ramus and the sphenomandibular ligament insertion. It gives off the anterior tympanic, deep auricular, and middle meningeal arteries (MMA).

The MMA provides the largest dural blood supply. It ascends between the external pterygoid muscle and the sphenomandibular ligament and passes through the foramen spinosum in the sphenoid bone to enter the cranium. Blunt head trauma can result in MMA rupture leading to an epidural hematoma. Orbital branches of the MMA pass through the superior orbital fissure to anastomose with the laterial artery and/or other ophthalmic artery tributaries. Occasionally, the ophthalmic artery originates from one of these orbital MMA branches. Additional anastomoses between the internal and external carotid circulations may exist between small branches off the MMA that anastomose with the meningeohypophyseal trunk within the cavernous sinus.

The pterygoid portion of the maxillary artery does not typically contribute blood supply to the orbit. It ascends the external surface of the medial pterygoid muscle medial to the ramus of the mandible, making its way
anteriorly, and entering the pterygoid fossa. It gives off branches to the pterygoid, masseter, and buccinator muscles as well as deep branches to the temporalis muscle and pericranium.

The pterygopalatine portion of the maxillary artery lies in the pterygopalatine fossa. It gives off six major branches: (1) the posterior superior alveolar artery, (2) the infraorbital artery, (3) the descending palatine artery, (4) the artery of the pterygoid canal, (5) a pharyngeal branch, and (6) the sphenopalatine artery. The infraorbital artery runs along the infraorbital groove and canal with the infraorbital nerve, where it gives off branches to the inferior oblique and inferior rectus muscles and anastomoses with the lacrimal and the third segment of the ophthalmic artery. This artery emerges on the face through the infraorbital foramen and ascends toward the medial canthal region to anastomose with the angular branch of the facial artery and the dorsal nasal artery off the internal carotid.

Venous Drainage

The orbital veins are extremely complex and variable. The exact number and configuration of the orbital veins are controversial because of their high variability. Unlike venous systems throughout the rest of the body, the orbital veins do not parallel the orbital arteries. One exception is the superior ophthalmic vein, which has a similar course to the ophthalmic artery. The superior and inferior ophthalmic veins represent the principal drainage systems of the orbit (Figure 4). Variably present orbital veins include the middle and medial ophthalmic veins and various collaterals that interconnect the superior and inferior orbital venous systems. Primary drainage is to the cavernous sinus; however, various interconnections also exist with the facial veins and the pterygoid plexus. The orbital veins are valveless, allowing pressure-dependent drainage through these alternative routes.

The superior ophthalmic vein is the largest and most consistently present orbital vein. Its diameter ranges from 2 mm to 1 cm. The superior ophthalmic vein is formed by the confluence of the supraorbital and angular veins near the superomedial orbital rim. The supraorbital vein enters the orbit and runs along the orbital roof superior to the trochlea. The angular vein pierces the orbicularis oculi muscle and enters the orbit through an opening in the orbital septum to join the supraorbital vein, just posterior to the trochlea in the anteromedial orbit. Various superior ophthalmic vein roots have been described, including a singular root formed by the convergence of the supraorbital and angular veins anterior to the trochlea.

The course of the superior ophthalmic vein is relatively constant compared to the rest of the orbital veins. In general, it follows the ophthalmic artery through the orbit. From the superomedial orbital angle, the superior ophthalmic vein enters the orbital cone near the medial border of the superior rectus muscle. It runs within the intraconal adipose tissue, crossing inferior to the superior rectus at the muscle's lateral border. The superior ophthalmic vein then runs posteriorly along the lateral aspect of the superior rectus before exiting the orbit through the superior orbit.

Figure 4 The orbital venous system. The orbital veins are highly variable; however, the superior and inferior ophthalmic veins are relatively constant. The inferior ophthalmic vein frequently empties into the superior ophthalmic vein prior to exiting the orbit through the superior orbital fissure to enter the cavernous sinus. Adapted from Gray’s Anatomy, 20th edition, copyright expired.
orbital fissure and emptying into the cavernous sinus. The medial palpebral, superior vortex, anterior ethmoidal, lacrimal, central retinal, muscular, and inferior ophthalmic veins, typically, all drain into the superior ophthalmic. The muscular veins are often the most variable orbital veins; however, the veins from the superior rectus and superior oblique muscles consistently drain into the superior ophthalmic vein (Figure 5).

While there is some debate regarding the course and existence of the inferior orbital vein, most investigators agree that the venous drainage of the inferior orbit begins as a diffuse venous plexus on the orbital floor that receives venous blood from the inferior eyelid, lacrimal sac, inferior extraocular muscles, and the inferior vortex veins. When present, the inferior orbital vein typically arises from the posterior inferior venous plexus in the mid-orbit and runs posteriorly between the inferior rectus muscle and the optic nerve. In the posterior orbit, the inferior orbital vein commonly runs along the lateral border of the inferior rectus, before heading superiorly to join the superior ophthalmic vein, prior to its exiting the orbit through the superior orbital fissure into the cavernous sinus. The inferior orbital vein can also enter directly into the cavernous sinus without converging with the superior ophthalmic vein.

Inconstant orbital veins include the middle and medial ophthalmic veins. The middle ophthalmic vein drains the inferior orbit and runs between the superior and inferior ophthalmic veins in the posterior orbit before emptying into the superior ophthalmic vein. The medial ophthalmic vein arises from the angular vein or anterior superior ophthalmic vein. When present, the medial ophthalmic vein runs along the medial orbital wall and empties either into the superior ophthalmic vein or directly into the cavernous sinus. Cheung and McNab found that the medial ophthalmic vein consistently empties into the superior ophthalmic vein. The medial ophthalmic vein has been reported to connect the medial collateral, ethmoidal, and medial muscular veins to the superior ophthalmic vein through a venous loop.

Multiple, variable collateral veins typically connect the superior and inferior venous systems. Cheung and McNab described only medial and lateral collateral veins. Henry described anterior, medial, lateral, and posterior collateral veins that were also found identified by Brismar to be present in 91%, 97%, 72%, and 19% of individuals, respectively, based on orbital phlebography. A collateral branch that drains to the pterygoid plexus is another common variant.

The central retinal vein drains blood from the retina and intraorbital optic nerve. It runs with the central retinal artery within the substance of the optic nerve. It exits the optic nerve sheath 8–15 mm posterior to the globe and typically passes directly through the superior orbital fissure into the cavernous sinus. It can also join the superior or inferior ophthalmic veins within the orbit. Hayreh found that the central retinal vein runs within the surrounding dura after exiting the optic nerve. An optic nerve sheath meningioma involving the dura containing the central retinal vein gradually occludes it, which may cause development of the characteristic retinociliary collateral veins that are indicative of optic nerve sheath meningiomas.

The cavernous sinuses are paired venous plexuses situated just lateral to the sella turcica on the superior aspect of the sphenoid bone. They receive the majority of orbital venous blood. Each cavernous sinus extends from the superior orbital fissure anteriorly to the apex of the petrous portion of the temporal bone posteriorly. Each cavernous sinus is approximately 3 cm long, 1 cm wide, and 0.5 cm high. Superiory, the cavernous sinus is bordered by the anterior and posterior clinoid processes. The floor of the cavernous sinus contains the foramen lacerum, foramen ovale, and foramen rotundum.

The cavernous sinus receives venous blood from the orbit and drains posteriorly through the superior and inferior petrosal sinuses. It is the primary drainage reservoir for the orbital veins; however, the absence of valves in
the cavernous sinus and the orbital veins allows for alternative pressure-dependent drainage through the facial veins or pterygoid plexus. This is a potential path for facial infections to spread into the cavernous sinus and throughout the dura. Venous drainage into the cavernous sinus varies depending on the highly variable orbital venous configurations. The superior ophthalmic vein consistently drains through the superior orbital fissure. The inferior ophthalmic vein and the inconstant orbital veins variably drain into the superior ophthalmic vein, or directly into the cavernous sinus.

Contents of the Cavernous Sinus

The ICA runs through the medial cavernous sinus surrounded by a web of sympathetic fibers. The abducens nerve runs through the lateral cavernous sinus. Within the lateral wall of the sinus, from superior to inferior, lies the oculomotor nerve (CN III), trochlear nerve (CN IV), and the ophthalmic (CN V1) and maxillary (CN V2) divisions of the trigeminal nerve (Figure 6).

Clinical Correlate: Orbital Vascular Pathology

Arterial and Venous Occlusions

While the anastomoses between the internal and external carotid circulations can often compensate for a gradual compromise in orbital blood flow, acute interruptions in ocular blood flow can have clinically significant visual consequences.

Figure 6  Contents of the cavernous sinus. The cavernous sinus is a venous network that serves as the primary drainage for orbital venous blood. The internal carotid artery, the oculomotor nerve, the trochlear nerve, abducens nerve, and the ophthalmic and maxillary divisions of the trigeminal nerve all run through the cavernous sinus. Adapted from Gray’s Anatomy, 20th edition, copyright expired.

Transient monocular vision loss, or amaurosis fugax, results when blood flow in the central retinal artery, ophthalmic artery, or ciliary arteries is compromised. Common etiologies include embolic occlusion, vasospasm, and giant cell arteritis (GCA). Atherosclerotic disease proximal to the affected artery can cause an ocular transient ischemic attack (TIA) when cholesterol emboli released from an atherosclerotic lesion transiently occlude an ophthalmic vessel, or when a severely stenotic proximal vessel results in hypoperfusion. Carotid emboli from atrial fibrillation, valvular heart disease, or atrial myxoma can cause the same obstructions but typically results in permanent occlusion.

Embolic occlusion of the central retinal artery (CRAO) or one of its branches (BRAO) typically resolves over time, but even transient ischemic retinal injury may result in permanent visual loss in the affected retinal areas. CRAO may result in peripheral field loss with spared central visual acuity if the cilioretinal arteries are spared. Granulomatous inflammation can also cause CRAO and BRAO. Furthermore, vasculitis of the short posterior ciliary arteries can result in arteritic anterior ischemic optic neuropathy (AION).

Occlusion of the central retinal vein (CRVO) or its branches (BRVO) causes loss of vision when venous congestion inhibits retinal capillary blood flow. Patients typically present with acute blurry vision and segmentally distributed intraretinal hemorrhages on examination. CRVO is associated with glaucoma, hypertension, diabetes mellitus, and cardiovascular disease. The strong association with atherosclerotic disease can be explained by the common sheath shared by the central retinal artery and vein, allowing easy compression the central retinal vein.

Cavernous Carotid Artery Aneurysm

ICA aneurysms within the cavernous sinus may present with visual complaints due to compression of the cranial nerves III, IV, and/or VI. Aneurysms can become quite large (>2 cm) before symptoms begin. If the aneurysm extends through the roof of the cavernous sinus into the subarachnoid space, there is a risk of subarachnoid hemorrhage. Aneurysmal involvement of the ophthalmic artery is also possible, putting the orbital circulation at risk. Treatment of these aneurysms involves coiling or ICA ligation to cause thrombosis within the aneurysm.

Carotid–Cavernous Sinus Fistula

A direct connection between the ICAs within the cavernous sinus can lead to the formation of a fistula between the ICA and venous cavernous sinus (Figure 7). Carotid–cavernous
sinus fistulas (CCFs) can be traumatic or spontaneous, rapid or insidious. The fistula between arterial and venous blood disrupts the orbital pressure gradient and causes a reversal of venous blood flow through the orbital veins. Signs and symptoms of a CCF include chemosis, eyelid edema, proptosis, ophthalmoplegia, and arterialization of the conjunctival vessels (Figures 8 and 9), diplopia secondary to oculomotor, trochlear, or abducens nerve palsy, and an audible orbital bruit (the sound of turbulent blood flow heard by the patient or by a clinician with a stethoscope). Approximately 50% of CCFs with low-velocity blood flow will close spontaneously and may not require any intervention. In the presence of a neuro-ophthalmologic deficit or posterior venous drainage, coils can be placed in the cavernous sinus to occlude the fistula (Figure 7).

**Cavernous Sinus Thrombosis**

Infectious cavernous sinus thrombosis results from the progression of facial infections through the facial vein or pterygoid plexus to the cavernous sinus through the superior ophthalmic vein. Sinus and dental infections can also extend into the cavernous sinus. Signs and symptoms include fever, orbital congestion, lacrimation, conjunctival edema, swelling, proptosis, and ophthalmoparesis from compression of the abducens, oculomotor, or trochlear nerves. Progression of thrombosis to the rest of the cerebral venous sinuses can result in increased intracranial pressure and stroke. Treatment includes antibiotics,
anticoagulation, systemic steroids, and possibly surgery. Noninfectious cavernous sinus thrombosis can result from hypercoagulable states, including polycythemia, sickle cell crisis, and paroxymal nocturnal hemoglobinuria. However, the overwhelming majority of these are infectious.

Orbital Surgical Surface Anatomy

Dacryocystorhinostomy

Abnormal tearing, or epiphora, occurs when the nasolacrimal duct is obstructed and tears cannot drain normally from the lacrimal sac to the inferior meatus inferior to the inferior nasal turbinate. Obstruction can be congenital or acquired through recurrent dacrocystitis or canaliculitis, dacrolithiasis, trauma, malignancy, or underlying nasal pathology. Surgical repair with dacryocystorhinostomy (DCR) creates a new direct connection between the lacrimal sac and the nasal mucosa for drainage. DCR approach can be external or endoscopic. Both techniques must take care to avoid the angular artery, which lies beneath the obicularis oculi muscle, 6–8 mm medial of the inner canthus and 5 mm anterior of the lacrimal sac.

Temporal Artery Biopsy

Giant cell arteritis (GCA) is a systemic vasculitis that can lead to rapid, irreversible blindness if left untreated. Classic symptoms include headache, scalp tenderness, and jaw claudication. Definitive diagnosis requires temporal artery biopsy. The superficial temporal artery is easily accessible for biopsy as it lies just under the skin while ascending the temporal region and anterior scalp. In cases where the ipsilateral ICA is occluded, collateral flow through the ECA occurs. Resection of the temporal artery in such cases may result in a stroke. Prior to biopsy, the vessel is compressed by hand and the patient is observed for focal neurologic deficits. A positive biopsy reveals lymphocyte, macrophage, and giant cell infiltration of the arterial wall. A negative biopsy does not rule out the possibility of disease.

See also: Ischemic optic neuropathy (00287); The Bony Orbit: Bony Anatomy and Orbital Fracture (00270); The Bony Orbit: Orbital Imaging (00271); Extraocular Muscles: Extraocular Muscle Anatomy (00274); Cranial Motor Nerves and Autonomic Innervation (00285).

Further Reading

Abstract:
A thorough knowledge of the vascular anatomy in the orbit and periorbital tissues is critical for understanding alterations due to disease as well as avoiding these vessels during surgery in and around the orbit. The complexity and interindividual variability of the vessel anatomy is quite significant. Understanding the possible differences between the vascular patterns within individual patient orbits is particularly important for ensuring maximum preservation of blood supply and limiting bleeding within the orbit during surgical procedures. In addition, it allows for better treatment of vascular-related abnormalities that affect the globe and orbit.

Keywords: Anterior ethmoidal artery; Inferior ophthalmic vein; Internal carotid artery; Lacrimal artery; Ophthalmic artery; Superior ophthalmic vein

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