

Introduction

Many ophthalmic procedures, such as cataract extraction, corneal transplants, trabeculectomy, lid surgery, and even vitrectomy or repair of a detached retina, can be performed safely in an outpatient setting, using regional anesthesia and mild sedation. The number of outpatient ophthalmic procedures will increase as health-care costs are contained and the population continues to age, local anesthesia is becoming the ideal technique for most types of ophthalmic procedures, patient comfort, safety and low complication rates are the essentials of local anesthesia. peribulbar block is a safe and inexpensive technique with advantage of providing efficient anesthesia with good lid and globe kinesis, it's also effective in the treatment of postoperative pain, it has become a common practice to use polypharmacy approach to enhance the onset and increase the duration of the block. Local anesthetics are agents that reversibly block action potentials at the level of the sodium channels, thereby interrupting axonal conduction. Local anesthetics actions are nonspecific: they work on any nerve with a functioning sodium channel.

Knowledge of the structural components of local anesthetics will aid in better understanding how these interesting compounds work. Local anesthetics are composed of a lipophilic/hydrophobic group (an aromatic ring) connected by an amide or ester intermediate chain to a hydrophilic or ionizable group (a secondary or tertiary amine). Those compounds with highly lipophilic/hydrophobic moieties are more potent, more long lasting, and more toxic. This appears to be related to the site of action on the nerve cell membrane.

Adjuvants to local anesthetics are used to improve the quality of local anesthesia (speeds the onset, shorten the duration, decrease the need for post operative analgesia) for example: vasoconstrictors such as epinephrine. Hyaluronidase, sodium bicarbonate, clonidine, opioids, atracurium added to lidocaine bupivacaine mixture of peribulbar block, magnesium sulphate

Magnesium sulphate has been used for many years as an adjuvant to local anesthetics in intrathecal and epidural blocks. Magnesium is the fourth most prevalent cation in the body and activates approximately 300 enzyme systems, including many involved in energy metabolism. [because the biological basis for its potential antinociceptive effect is promising.

These effects are primarily based on physiological calcium antagonism, that is voltage-dependent regulation of calcium influx into the cell, and noncompetitive antagonism of N-methyl-D-aspartate (NMDA) receptors.

Safe, comfortable and effective akinesia and analgesia of the eye can be obtained using peribulbar block; that is, local anesthetic is injected outside the muscle cone. Complications occur at a very low rate, including; brain-stem anesthesia, retrobulbar hemorrhage, atrophy of optic nerve, spread to anesthetic to contralateral orbit. Disadvantages of peribulbar blocks include large injected volumes, slower onset, possible globe perforation, myotoxicity of anesthetic on inferior rectus muscle causing vertical diplopia.

Anatomy

Anatomical Classification:

The eye will be divided into 2 sections: extraocular (ie, structures outside of the globe) and the ocular (ie, the globe and intraocular structures) (*Moore and Keith, 2010*).

A- Extraocular Structures:

Several structures exist within the category of extraocular structures, including the orbit, extraocular muscles, conjunctiva, the lacrimal system, and eyelids. The functions associated with these structures include protection and lubrication.

- **Orbit:**

The orbit, which protects, supports, and maximizes the function of the eye, is shaped like a quadrilateral pyramid, with its base in plane with the orbital rim. Seven bones conjoin to form the orbital structure, as shown in the image below.



Figure (1): The 7 bones that contribute to the structure of the right orbit

The orbital process of the frontal bone and the lesser wing of the sphenoid form the orbital roof. The orbital plate of the maxilla

joins the orbital plate of the zygoma and the orbital plate of the palatine bones to form the floor. Medially, the orbital wall consists of the frontal process of the maxilla, the lacrimal bone, the sphenoid, and the thin lamina papyracea of the ethmoid. The lateral wall is formed by the lesser and greater wings of the sphenoid and the zygoma.

The orbits are aligned so that the medial walls are parallel and the lateral walls are perpendicular. The arc from medial to lateral wall in each orbit is 45°. Lines dropped through a central anterior-to-posterior axis of each orbit bisect at a 45° angle. The floor is two-thirds the depth of the orbit (**Moore and Keith, 2010**).

The average dimensions of the orbit are as follows:

- Height of orbital margin - 40 mm
- Width of orbital margin - 35 MM.
- Depth of orbit - 40-50 mm
- Interorbital distance - 25 mm
- Volume of orbit - 30 cm³

The superficial bony orbit is defined by the orbital margin, which is rectangular with rounded corners. The margin is discontinuous at the lacrimal fossa. The supraorbital notch (seen in the image below) is within the supraorbital rim and is closed to form the supraorbital foramen in 25% of individuals. The supratrochlear notch is medial to the supraorbital notch.

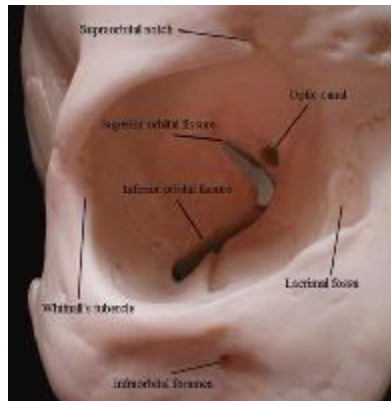


Figure (2): This image of the right orbit shows superficial landmarks, optic canal, and superior and inferior orbital fissures.

The trochlea is a cartilaginous ring that supports the superior oblique muscle. The trochlea attaches to the periorbita within the fovea trochlearis along the superior-medial orbit. The infraorbital foramen is located 10 mm inferior to the zygomaxillary suture. Laterally, the orbital rim is marked by the Whitnall tubercle, which is 10 mm inferior to the zygomaticofrontal suture. The tubercle is the site of attachment of the lateral canthal tendon (*Doxanas and Anderson, 1984*).

- Orbital fissures and optic canal:

The orbit has a volume of 30 mL, measures 4 cm horizontally and 3.5 cm vertically, and has a depth (anteroposteriorly) of 4.5 cm. Associated with the orbit are foramina and fissures (Table 1 below), which are important in transmitting nerves, arteries, and veins. The primary function of the orbit is to protect the eye from physical injuries (*Clemente and Gray, 1985*).

Table (1): Contents of Orbital Foramens and Fissures

Orbital Foramens and Fissures	Nerve(s)	Artery(ies)	Vein(s)	Others Structures
Supraorbital foramen	Supraorbital nerve (from frontal branch of cranial nerve V1)	Supraorbital		
Superior orbital fissure	1. Lacrimal branch of CN V1 2. Frontal branch of CN V1 3. Superior and inferior branches of oculomotor nerve (CN III) 4. Trochlear (CN IV) 5. Nasociliary branch of CN V1 6. Abducent (CN VI) 7. Sympathetic root ganglion		Superior ophthalmic	
Inferior orbital fissure	1. Infraorbital branch of CN V2 2. Zygomatic branch of CN V2	Infraorbital	Pterygoid plexus with inferior ophthalmic	
Optic canal	1. Optic (CN II) 2. Sympathetic fibers from internal carotid plexus	Ophthalmic		
Anterior ethmoidal foramen	Anterior ethmoidal	Anterior ethmoidal	Anterior ethmoidal	
Posterior ethmoidal foramen	Posterior ethmoidal	Posterior ethmoidal	Posterior ethmoidal	
Zygomatic foramen	Zygomatic branch of CN V2	Zygomatic		
Lacrimal fossa				Lacrimal gland
Fossa for lacrimal sac				Lacrimal sac - nasolacrimal duct

- Ethmoid arteries:

The anterior and posterior ethmoid foramina lie in the medial wall of the orbit along the frontoethmoidal suture line. The anterior and posterior ethmoid arteries pass through these foramina and are important surgical landmarks. The arteries mark the level of the cribriform plate and the relationship of the anterior cranial fossa to the orbits. The ethmoid arteries mark the superior limit for osteotomies during medial maxillectomy.

The distance from the orbital rim to the anterior ethmoid artery is approximately 20-25 mm. The distance between the anterior and posterior ethmoid arteries averages 12 mm, with a range of 8-19 mm. The optic ring averages 6 mm from the posterior ethmoid artery, with a range of 5-11 mm. Knowledge of these distances safely guides the surgeon along the medial orbital wall (*Doxanas and Anderson, 1984*).

- Infraorbital foramen:

The infraorbital sulcus crosses the floor of the orbit and carries the infraorbital artery, infraorbital vein, and infraorbital nerve from the inferior orbital fissure to the infraorbital foramen. Clinically, the infraorbital foramen provides a route of spread for infection or maxillary tumors to the orbit and the skull base. The surgeon must avoid injury to the infraorbital neurovascular bundle when performing a midface degloving approach. (*Clemente CD, Gray H; 1985*)

• **Lacrimal System:**

- Lacrimal gland

The lacrimal system produces, distributes, and drains tears. Tears are produced by the lacrimal gland and multiple accessory glands. The lacrimal gland is divided into the orbital lobe and the palpebral lobe by the lateral horn of the levator aponeurosis. The lacrimal gland is oriented in the superior-temporal region of the orbit and lies in the fossa glandular lacrimalis. The palpebral lobe can be seen by everting the upper lid where it extends to within a few millimeters of the tarsus. The ducts of the orbital lobe traverse the palpebral lobe before opening into the fornix.

The gland can be recognized by its pink-grey color and glandular surface. Although the gland appears to have a capsule, this is really a combination of surrounding connective tissue insertions. The lacrimal nerve, a branch of the ophthalmic division of cranial nerve V (CN V), provides sensory innervation to the lacrimal gland (*Tasman and Jaeger, 2007*).

- Tear drainage:

Tears are drained via a conduit of tubes along the medial angle of the eye. The system is composed of paired lacrimal papillae, puncta, and canaliculi that connect to form the common canaliculus, lacrimal sac, and nasolacrimal duct. The common canaliculus inserts into the lacrimal sac at an angle to produce the valve of Rosenmüller. This valve prevents reflux of tears into the canalicular system. The tears are stored in the lacrimal sac and then drain through the nasolacrimal duct that opens into the inferior meatus of the nasal cavity. The nasolacrimal duct is just anterior and lateral to the uncinate process and can be injured in endoscopic sinus surgery (*Tasman and Jaeger, 2007*).

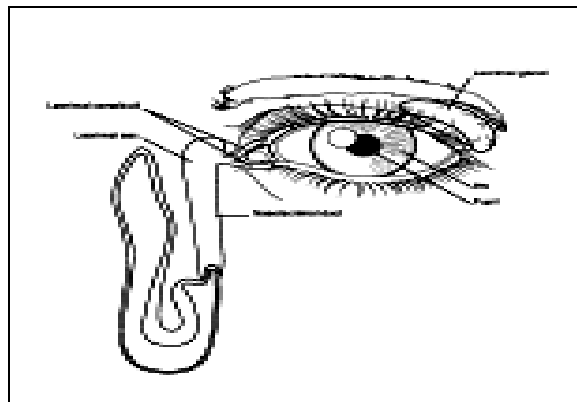


Figure (3): Eye and lacrimal duct, anterior view.

- **Connective Tissue Planes:**

The contents of the orbit are separated and supported by multiple connective tissue planes. The detailed anatomy of these connective tissue structures is complicated and beyond the scope of this article. In general, the connective tissue boundaries can be divided into 4 main units as follows: ***(Heufelder and Spitzweg, 1999)***.

- The bulbar fascia (ie, Tenon fascia) surrounds and protects the globe posteriorly from the limbus, and the extraocular muscles penetrate the bulbar fascia to insert on the globe; the fascia provides a barrier between the globe and the retrobulbar fat, allowing free motion of the globe.
- Multiple connective tissue septa extend from the globe to the periorbita like spokes on a wheel; these septa are located 360° around the globe, stabilizing the globe centrally within the orbit but having enough laxity to allow free movement of the globe
- Each extraocular muscle has an individual connective tissue sheath; as the sheaths progress anteriorly toward the globe, they fuse to form a confluent muscle sheath, with connective tissue struts extending medially and laterally from the respective muscle sheaths to form the medial and lateral check ligaments
- The orbital structures are contained within the periosteal lining of the orbit, which can be elevated in surgery to expose the bony orbit; by keeping the periosteum intact, the surgeon can work in the anterior orbit without injuring the orbital contents.

- **Extraocular Muscles:**

Each orbit contains 6 extraocular muscles that function together to move the eye: 4 rectus muscles (ie, superior, inferior, lateral, medial) and 2 oblique muscles (ie, superior, inferior). Another muscle, the levator palpebrae, functions to elevate the upper lid.

The actions of each of the extraocular muscles are as follows:

- Medial rectus - Adduction
- Lateral rectus - Abduction
- Superior rectus - Elevation, adduction, intorsion
- Inferior rectus - Depression, adduction, extorsion
- Inferior oblique - Extorsion, elevation, abduction
- Superior oblique - Intorsion, depression, abduction

The origin of the 4 rectus muscles is the common ring tendon (annulus of Zinn) at the orbital apex. The rectus muscles insert on the sclera anterior to the equator. The insertions of the rectus muscles are not equidistant from the limbus. The imaginary line connecting the insertions of the 4 rectus muscles is known as the Spiral of Tillaux.

Unlike the rectus muscles, the origin of the superior oblique is the sphenoid bone and has a long (10 + 10 mm) tendinous insertion. It inserts superior and temporal to the posterior pole and is covered by the superior rectus. The origin of the inferior oblique is the maxilla and has a muscular insertion temporal and inferior to the geometric posterior pole and covers the inferior rectus (*Tasman and Jaeger, 2007*).

Multiple medical conditions can cause hypertrophy of the extraocular muscles, with clinical presentation of proptosis, diplopia, and orbital pain. Trokel and Hilal showed that exophthalmos of

Graves disease was the most common cause of extraocular muscle hypertrophy. Graves disease was the cause in 65.6% of cases, while carotid cavernous fistula caused 17.1%, pseudotumor (Figure 4) caused 10%, and orbital tumor caused 7.1% of cases of extraocular muscle hypertrophy.



Figure (4): Coronal computed tomography (CT) scan of the orbits of a 35-year-old woman that demonstrates a mass in the left orbit that obliterates superior and medial structures of the orbit, compared with normal structures in right orbit. The mass also involves the left ethmoid sinuses. The histologic diagnosis of this mass was orbital pseudotumor (*Trokel and Hilal, 1979*).

Graves ophthalmopathy has been linked to thyroid-stimulating hormone and a factor that causes increased deposition of mucopolysaccharides into orbital fat. Malignant exophthalmos is most commonly associated with Graves disease, but it can be caused by other endocrine disorders (*Heufelder and Spitzweg, 1999*).

Exophthalmos can lead to corneal abrasion, chemosis, ophthalmoplegia, and retinal venous congestion. Several procedures have been developed that involve removing a portion of the bony orbit to decompress the orbital contents.

- **Innervation of the Orbit:**

The innervation of the orbit can be divided into 4 functional components: general somatic efferent (extraocular muscles), general somatic afferent (sensory), general visceral efferent (autonomic), and

special sensory afferent (vision). The general somatic efferents include the motor division of the oculomotor nerve (CN III), the trochlear nerve (CN IV), and the abducens nerve (CN VI).

- Oculomotor nerve

The oculomotor nerve (CN III) pierces the dura at the lateral posterior clinoid process, courses through the lateral aspect of the cavernous sinus, and enters the inferior portion of the supraorbital fissure. Within the cavernous sinus, the nerve divides into superior and inferior branches. The superior branch supplies the superior rectus muscle and the levator palpebrae superioris, while the inferior branch passes through the annulus of Zinn to supply the medial rectus, inferior rectus, and inferior oblique. The inferior branch also carries preganglionic parasympathetic fibers to the ciliary ganglion.

- Trochlear nerve

The trochlear nerve (CN IV) travels through the cavernous sinus and enters the orbit through the superior orbital fissure outside of the annulus of Zinn. The trochlear nerve innervates the superior oblique muscle.

- Abducent nerve

The abducens nerve (CN VI) has a long, tortuous intracranial course. The nerve passes along the clivus and through the inferior petrosal sinus at the junction of the petrous portion of the temporal bone and occipital bone. The nerve bends over the petrous ridge and passes inferior to the petroclinoid ligament. It then travels through the Dorello canal, lateral to the carotid artery and medial to the trigeminal ganglion. The abducens nerve enters the orbit through the superior orbital fissure within the annulus of Zinn and innervates the lateral rectus. The relatively long

intracranial course of the abducens nerve makes it susceptible to injury secondary to trauma, tumor, aneurysm, and infection.

- Trigeminal nerve

The trigeminal nerve, which supplies general sensory innervation to the orbit and surrounding structures, originates at the lateral and ventral portion of the pons. The nerve enters the Meckel cave, which is formed by a split in the dura along the petrous temporal bone in the middle cranial fossa. The trigeminal ganglion rests in the Meckel cave posterior and lateral to the cavernous sinus and the internal carotid artery.

The surgeon must be aware of the oculocardiac reflex when manipulating the contents of the orbit. The reflex arc can cause bradycardia, hypotension, and nausea when pressure is applied to the globe or when the extraocular muscles are stretched. The reflex is triggered by afferent fibers of the trigeminal nerve, which synapse with visceral motor nucleus neurons of the vagal nerve in the reticular formation of the brainstem. When applying pressure to the globe during surgery, notify the anesthesiologist of potential changes in the patient's hemodynamic status.

- Ophthalmic and other nerves:

The ophthalmic branch extends from the trigeminal ganglion and passes through the cavernous sinus to the orbit via the superior orbital fissure.

Within the orbit, the ophthalmic nerve branches into the lacrimal, frontal, and nasociliary nerves. The lacrimal nerve innervates the lacrimal gland and accepts postganglionic parasympathetic fibers. The parasympathetic fibers travel from the lacrimal nucleus in the

pons via the nervus intermedius to the greater superficial petrosal nerve, to the vidian nerve, to the sphenopalatine ganglion, to the zygomatic branch of the maxillary nerve, to the zygomaticotemporal nerve, and to the lacrimal nerve, to innervate the lacrimal gland.

The frontal branch splits to form the supraorbital and supratrochlear nerves that exit the orbit at the superior orbital rim and innervate the eyebrow and scalp. The nasociliary branch enters the orbit through the annulus of Zinn (as shown in the image below) and then gives off short and long ciliary nerves to the globe. The long ciliary nerves carry sympathetics from the superior cervical ganglion responsible for dilatation of the pupil. The short ciliary nerves pass through the ciliary ganglion and do not synapse. A branch of the nasociliary nerve runs along the medial orbital wall and gives off the posterior and anterior ethmoid nerves, which innervate the mucosal lining of the ethmoid sinuses and part of the nasal cavity.

The infratrochlear nerve is also a branch of the nasociliary nerve and provides sensory innervation to the medial lower lid, side of nose, conjunctiva, and lacrimal sac.

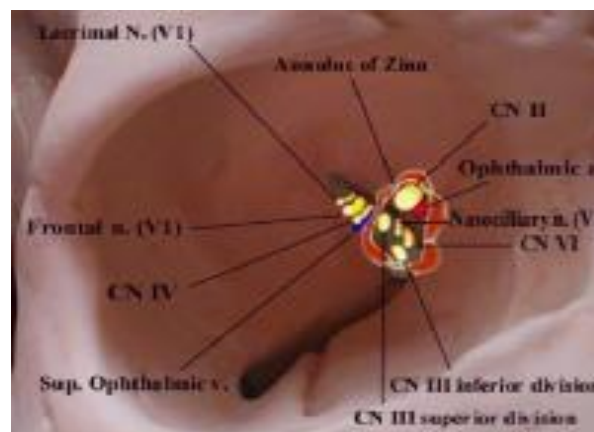


Figure (5): Diagram of right orbit that shows the relationship of entering nerves and vessels to the annulus of Zinn.

The maxillary division of the trigeminal nerve leaves the middle cranial fossa through the foramen rotundum and enters the pterygopalatine fossa. Within the fossa, it branches into purely sensory infraorbital, zygomatic, and posterior superior alveolar nerves. The infraorbital nerve travels along the infraorbital sulcus and exits the infraorbital foramen. The zygomatic nerve divides into the temporal and facial branches. The posterior superior alveolar nerve primarily innervates the teeth.

The optic nerve extends from the optic chiasm to enter the orbit through the optic canal. The intraorbital portion of the optic nerve is 30 mm in length and 4 mm in diameter. The optic nerve is covered by dura, arachnoid, and pia from the sclera to the canal, where the dura is continuous with the periosteum of the orbit (*Tasman and Jaeger, 2007*).

- **Vascular Supply of the Orbit:**

- Ophthalmic artery and its branches:**

An anastomosing network of vessels derived from the internal and external carotid artery systems supplies the orbit. The major arterial supply to the orbit is the ophthalmic artery, the first major branch of the internal carotid artery. The ophthalmic artery originates from the internal carotid as it exits the cavernous sinus. The ophthalmic artery courses on the inferior aspect of the optic nerve and enters the orbit through the optic canal. The artery gives off many branches with a significant amount of variability. In general, the branches of the ophthalmic artery can be divided into 3 groups of vessels (ie, ocular, orbital, extraorbital), based on their target organs.