6 Complications of Ophthalmic Regional Anesthesia

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Administering anesthesia blocks for ophthalmic surgery was, in the past, the exclusive domain of the ophthalmologist; however, more and more anesthesiologists are now performing these blocks worldwide. Anesthesiologists now routinely perform many ophthalmic blocks at eye clinics or surgery centers and most of them have expertise that is equal or superior to that of the average ophthalmologist. When anesthesiologists perform ophthalmic blocks, it is advisable to communicate with the ophthalmologist about the relevant anatomy of the eye in question.

Training of the Ophthalmic Regional Anesthesiologist

Sound knowledge of orbital anatomy, ophthalmic physiology, and the pharmacology of anesthesia and ophthalmic drugs are prerequisites before embarking on orbital regional anesthesia techniques; such information should then be augmented by training in techniques obtained in clinical settings from practitioners with wide experience and knowledge in the field.[1] Neophytes go through an obligatory "learning curve," the gradient of which can be greatly reduced by exposure to expert instruction and supervision.[2] Cadaver dissection is an excellent means of gaining the necessary anatomic knowledge of the orbit.[3]

Optimal Management of Patients Undergoing Ophthalmic Regional Anesthesia

The advantages of regional anesthesia easily surpass those of general anesthesia, in terms of safety, efficacy, and patient comfort. All patients require a thorough preoperative assessment, including history and physical examination with open communication with the patients about risks and potential complications of the procedure. Each patient is expected to provide a list of all current medications to ensure that essential therapy is continued through the perioperative period and to minimize the risk of drug interactions. Laboratory and radiologic investigations are ordered only when indicated and appropriate to the management of the case.[4] The majority of patients presenting for ophthalmic surgery are elderly and many of them have hypertension, coronary artery disease, chronic obstructive pulmonary disease, diabetes, and obesity, which present additional challenges to the operating team. Every effort

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must be made to have patients in the best possible medical condition before surgery. Most ophthalmic surgery is elective, therefore there is ample opportunity to optimize patients' medical conditions in advance.

The monitoring requirements for ophthalmic anesthesia/surgery, in the awake patient, are no different than those required for procedures being performed under general anesthesia.[5] The elderly require less sedation at the time of surgery than do young patients, and take the discomforts of life "in their stride." If sedation is required, it must be prescribed judiciously and in small increments so that the patient will be comfortable yet remain alert, calm, and cooperative. The advantages of regional anesthesia can be quickly negated with excessive use of sedation.[6] A recent multicenter study confirmed that intravenous anesthetic agents administered to reduce pain and anxiety are associated with an increased incidence of side effects and adverse medical events.[7] Incomplete regional anesthesia is best managed with block supplementation until complete; to operate in the presence of obvious block failure is to subject the patient to an unpleasant and stressful experience. It is hazardous and inappropriate to use intravenous sedation to cover up for gross block inadequacy.

In cataract surgery, a precise axial length measurement of the eye is usually available because it is required for intraocular lens diopter power calculation. It is of the utmost importance to know the axial length of the eye in advance of needle placement to reduce the risk of globe perforation in those patients with longer-than-average axial lengths.

Complications of Ophthalmic Regional Anesthesia

Hemorrhage

Retrobulbar hemorrhages vary in severity. Some are of venous origin and spread slowly. Signs of severe arterial hemorrhage are a rapid and taut orbital swelling, marked proptosis with immobility of the globe, and massive blood staining of the lids and conjunctiva.[8] Serious impairment of the vascular supply to the globe may result.[9] More usually, however, an excellent surgical outcome can be achieved.[10,11] Bleeding can be minimized and confined by rapid application of digital pressure over a gauze pad applied to the closed lids, and by constant vigilance and keen observation of the patient immediately after needle withdrawal. The incidence of serious retrobulbar bleeding is reported to be in the range of 1%–3% in one article[12] and as 0.44% in a series of 12,500 cases.[13] Gentle and smooth needle insertion without pivotal or slicing movement is less likely to cause bleeding.[12,13] A strong argument can be made in favor of using small-gauge, disposable needles as opposed to larger-gauge needles,[14–16] on the grounds that if a vessel is perforated, the amount of bleeding that occurs is reduced and less precipitous because of a smaller tear in the vessel. Furthermore, patients tolerate smaller-gauge needles and usually do not experience pain or require sedation during needle placement.

Blood vessels are smaller in the anterior orbital region than in the posterior region. In the interest of avoiding hemorrhage, sites that are relatively avascular are preferred for needle placement. The inferior temporal quadrant and directly nasally in the compartment that is on the nasal side of the medial rectus muscle[17] are recommended. The superior nasal quadrant of the orbit should be avoided because the end vessels of the ophthalmic arterial system are located there, as is the complex trochlear mechanism of the superior oblique muscle. Because orbital blood vessels are largest in the posterior orbit, deep needle placement must be avoided if at all possible (see next section).

Brainstem Anesthesia

The most likely situation that may warrant cardiopulmonary resuscitation in ophthalmic regional anesthesia is brainstem anesthesia, which is a form of central nervous system (CNS) toxicity.[18] Brainstem anesthesia is not caused by increasing levels of local anesthetics in the systemic circulation (including CNS) but by direct spread of local anesthetic to the brain from the orbit, along submeningeal pathways (Figure 6-1). The usual doses of local anesthetics used for eye surgery do not result in plasma levels of local anesthetic that result in systemic toxicity.

Brainstem anesthesia is reported to occur in 1 in 350–500 intraconal local anesthesia injections.[18] Typically, the patient first describes symptoms within 2 minutes of the orbital injection. Frequently, the zenith is reached at 10–20 minutes and resolves over 2–3 hours. Because this is a potential complication on each occasion that orbital blocks are performed, patients should not be draped for surgery until 15 minutes have elapsed after completion of the block, otherwise identification and corrective treatment may be dangerously delayed. Ophthalmic regional anesthesia should not be performed in any location unless all the necessary monitoring and resuscitation equipment is immediately available.[8,15,19–22] The clinical picture of brainstem anesthesia is protean in manifestation,[23] producing signs that vary from mild confusion through marked shivering or convulsant behavior,[24] bilateral brainstem nerve palsies (including motor nerve blocking to the contralateral orbit with amaurosis),[25,26] dysarthria,[27] or hemi-, para-, or quadriplegia, with or without loss of consciousness, to apnea with marked cardiovascular instability.[18,28–30] Treatment of these differing manifestations of central spread includes reassurance, ventilatory support with oxygen, intravenous fluid therapy, and pharmacologic circulatory support with vagolytics, vasopressors, vasodilators, or adrenergic blocking agents as appropriate and as dictated by close monitoring of the vital signs.

Much is known about prevention of this syndrome. Unsöld and coworkers[31] in 1981 revealed the danger of the elevated, adducted globe, as advocated by Atkinson[32] during inferior temporal needle placement. This position places the optic nerve closer to the advancing needle. They demonstrated, using computed tomography studies in the fresh cadaver, that with the globe in primary gaze, the optic nerve is less vulnerable. Avoidance of deep penetration of the orbit in any technique is advisable both to prevent this and other serious block complications. Katsev et al.[33] advised that maximum penetration from the orbital rim should not exceed 31 mm. Modern

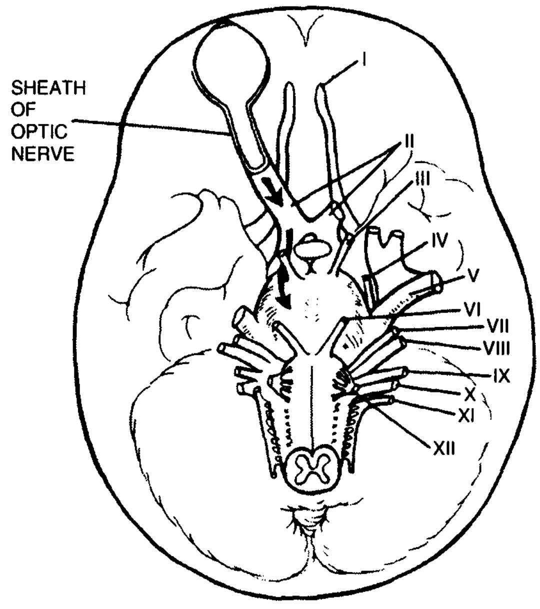

FIGURE 6-1. Illustration of the base of the brain and the pathway for spread of local anesthetics inadvertently injected into the subarachnoid space surrounding the optic nerve. Note that this pathway includes the cranial nerves, pons, and midbrain. (Reprinted from Javitt et al.[21] Copyright 1987, with permission from the American Academy of Ophthalmology.)

techniques avoid deep orbital placement and instead promote accurate injection at limited orbital depth and recommend increasing the volume of injectate in order to achieve critical blocking concentration at the apex.

Globe Penetration and Perforation

The ability to detect subtle changes in tissue densities during needle advancement is a vital part of safe regional anesthesia; it is an acquired skill that requires experience and ongoing practice.[34] Needle advancement within the confines of the orbit is essentially a blind procedure and has the potential for serious complications. In view of the many eye block procedures performed annually, the incidence of globe perforation is low; however, even rare complications become significant.[33] The Atkinson "up and in" globe positioning[30] has been discredited. During inferior temporal needle insertion with the globe elevated and adducted, the optic nerve is brought closer to the needle tip and the macular area is more exposed to damage.[19,29,31,34] Optic nerve sheath penetration, optic nerve trauma, and ocular penetration or perforation by the needle may result. The posterior pole of the globe is endangered, particularly in the ovoid globes of myopic patients.[14] In patients with gross myopia (axial length greater than 29 mm), there is a higher incidence of staphyloma usually located inferior to the posterior pole of the globe; single medial canthal blockade[17] is safer in these patients rather than inferior temporal placement.[35] Many serious complications are avoided by having patients direct their eyes in primary gaze position during needle placement and subsequent injection. In the literature, there was a considerable lobby for the use of dull needles to reduce the incidence of bleeding and of ocular penetration.[36–38] The superiority of blunt- over sharp-tipped needles in reducing these complications has not been demonstrated in a controlled trial.[39] Tactile discrimination is progressively reduced with increasing needle size; the increased resistance caused by a blunt needle is not appreciated because of the necessarily greater preload.[14] To avoid scleral penetration (entrance wound only) or perforation (entrance and exit wounds), the importance of block technique and needle type are stressed. "The equator of the globe, with the eye in the primary position, is the greatest diameter in the coronal plane. Any needle entering the orbital region anteriorly must be directed in such a manner as to avoid encountering the sclera. Only by accurately judging the position of the equator can a needle be inserted in safety."[1] Penetration or perforation of the eye using larger dull needles causes more serious damage than when fine disposable needles are used.[40] The use of blunt-tipped needles does not protect against penetration and perforation.[40,41] Blunt-tipped needles are painful for the patient and require sedation during insertion, whereas fine disposable needles cause much less discomfort and sedatives are usually not required during insertion. The use of blunt-tipped, wider-gauge needles should be abandoned.[42]

Although there are proponents of both intraconal and periconal techniques, safe anesthesia can be accomplished using either method; likewise, serious complications can arise with either technique if performed incorrectly. A faster onset of anesthesia is achieved when blocking within the muscle cone.[15,43] Approximately 10% of peribulbar blocks are considered failures because they do not provide adequate ocular analgesia.[44] Chemosis is more common with periconal blocks.[45] Although it is possible to achieve effective blocks with small-volume injection at the apex of the orbit,[46] the risks are too great. Needles should never be advanced beyond 31 mm as measured from the orbit rim[33] nor should a needle advancing from an inferior temporal entry be allowed to cross the midsagittal plane of the eye (Figure 6-2).[14] All needles used for intraconal and periconal insertion should be orientated tangentially to the globe with the bevel opening faced toward the globe.[15,47] If a tangentially aligned needle contacts the sclera, globe penetration is less likely to occur than a needle approaching at a greater angle. All needles in the orbit are potentially hazardous in the wrong hands; careful supervision and training in technique have great relevance in the avoid-

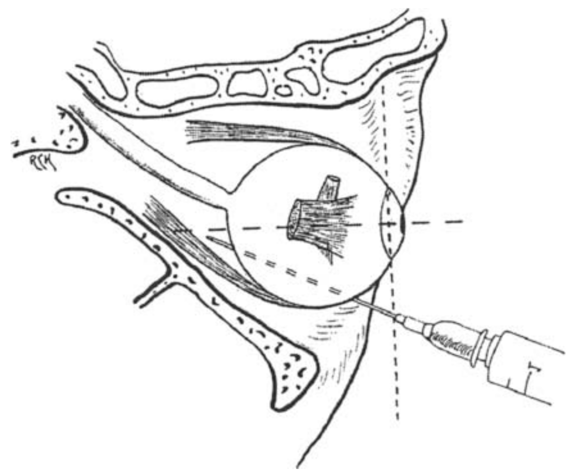

FIGURE 6-2. Globe in primary gaze. Fine dashed line indicates the plane of the iris; coarse dashed line indicates the midsagittal plane of the eye and the visual axis through the center of the pupil. The optic nerve lies on the nasal side of the midsagittal plane of the eye. Note how the temporal orbit rim is set back from the rest of the orbit rim at or about the globe equator, making for easy needle access to the retrobulbar compartment. A 31-mm needle is advanced beyond the equator of the globe, and then directed toward an imaginary point behind the macula, being careful not to cross the midsagittal plane of the eye. In a globe with normal axial length as illustrated here, when the needle/hub junction has reached the plane of the iris, the tip of the needle lies 5–7 mm beyond the hind surface of the globe. (From Gimbel Educational Services, with permission.)

ance of serious complications.[1] Techniques requiring multiple needle placements are associated with an increased incidence of complications when compared with a single or reduced number of injections.

The author, with an experience of more than 33,000 retrobulbar (intracone) blocks, routinely uses and recommends a percutaneous approach from a more lateral inferior temporal entry point than frequently practiced[48] after preliminary local anesthesia of the skin (Figure 6-3).[49] By using a percutaneous entry, patients with narrow palpebral fissures, and those with excessive blinking strength, present no problem.

Ocular penetration or perforation is more likely in patients with elongated myopic eyes. Patients presenting for retinal detachment or refractive surgery (such as laser in situ keratomileusis) have a higher propensity of longer globes than patients having cataract surgery. In myopic patients, the incidence may be as high as 1 in 140.[50] This complication has been reported with both the intraconal and the periconal methods. Nonakinetic anesthesia methods have been developed (see below), partly to avoid the serious complications associated with needle blocks. The diagnosis of penetration may be suspected in the presence of hypotony, poor red reflex, vitreous hemorrhage, and "poking through sensation"[51]; however, more than 50% of iatrogenic needle penetrations of the globe go unrecognized at the time of their occurrence.[52] The patient may report marked pain at the time of the penetration,[53] particularly if the anesthetic is inadvertently injected intraocularly. Funduscopy confirms the diagnosis, if the media are sufficiently clear. Cases involving retinal tears only, with minimal blood-staining of the vitreous, can be managed with laser photocoagulation, cryotherapy, or on occasion observation only. When so much blood is present that the fundus is not visible early vitrectomy may be indicated. Without surgical intervention, vitreous hemorrhage after penetrating injury frequently leads to proliferative vitreoretinopathy with resultant detachment of the retina. Once retinal detachment is diagnosed, whether associated with clear or cloudy media, prompt surgical treatment is indicated. The appropriate management of scleral penetration and perforation is complex and often

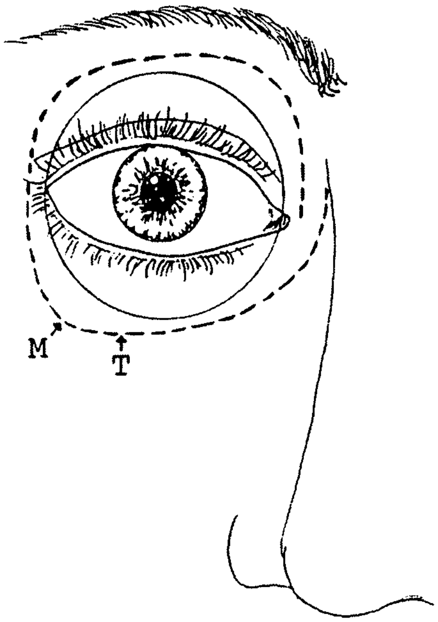

FIGURE 6-3. The outline of the globe is superimposed on a template of the orbit rim. The traditional inferior block injection site ("T") is just inside the orbit rim at the junction of the medial two-thirds and lateral third of the inferior orbital rim. The author's modified injection site ("M") is just inside the orbit rim at the junction of the inferior and lateral orbital rims. Injection at the modified site is best done percutaneously, the entry point on the skin being 4–5 mm inferior to the lateral canthus. (From Gimbel Educational Services, with permission.)

drawn out over some weeks involving difficult judgment calls on the part of the ophthalmologist.[54]

Ocular explosion associated with orbital blockade has been described.[55,56] This is a devastating complication with catastrophic visual outcome. It typically occurs in deeply sedated patients, after unrecognized ocular penetration, associated with the use of excessive force of local anesthetic injection. To date, eight cases have been described in the literature. There is a strong argument here to avoid deep sedation. Patients who are fully alert experience severe pain in these circumstances. The precautions described above, if followed, should greatly reduce the likelihood of this complication.

Myotoxicity

Prolonged extraocular muscle malfunction may follow regional anesthesia of the orbit.[15,57,58] Diplopia and ptosis are common for 24–48 hours postoperatively when long-acting local anesthetics have been used in large volume. However, when this persists for days or weeks, or fails to recover, it may be evidence of toxic change within muscle. In those patients in whom muscle recovery is delayed more than 6 weeks, 25% turn out to be permanent. It is indeed a complication of the greatest magnitude for a patient to have an excellent optical result and end up with devastating diplopia because the eyes are misaligned. Studies of the myotoxicity of local anesthetics have been published.[59–61] Higher concentrations of local anesthetic agents are more likely to result in myotoxicity.[61] A common cause of prolonged muscle malfunction, whatever concentration has been used, is intramuscular injection.[59,61–63] The etiologies of these muscle malfunctions, however, include not only local anesthetic myotoxicity,[59–61] but also surgical trauma, inappropriately placed antibiotic injection,[64] and ischemic contracture of the Volkmann's type after trauma or hemorrhage.[65] Increasing age is associated with poor recovery from anesthesia-induced muscle damage.[66] It is imperative to have a good three-dimensional knowledge of the anatomy of the orbit and its contents to accurately place injections. Of particular note are the number of articles indicating damage to the inferior rectus muscle,[58,62–65] likely caused by inadequate elevation of the needle tip from the orbit floor during attempted intracone placement (Figure 6-4). By meticulous attention to detailed placement of anesthetic needles and with precise knowledge of the anatomy of the six extraocular muscles, the incidence of muscle damage/malfunction can be eliminated. Aiming the retrobulbar needle "midway between the inferior and lateral rectus muscles" to gain clear entry into the intraconal space, avoiding trauma to the inferior rectus muscle is stressed.[65] Extraocular muscles are more easily avoided by using a fully inferior temporal orbital entry point for the retrobulbar injection (Figure 6-3).[48] This more lateral entry point for the retrobulbar block allows for easy and safe access to the intraconal space, because the temporal orbit rim is set back from the rest of the orbit rim. Inferior oblique muscle injury and trauma to its motor nerve by regional anesthesia injection have been reported.[66] Less frequently affected are the superior oblique,[67] the medial rectus,[17] and the lateral rectus muscles.[68] A persistent strabismus may be caused by contracture of an antagonist muscle reacting to an initial temporary paresis of its agonist muscle.[69] For additional information on this topic, please refer to Chapter 5.

Globe Ischemia

The risk imposed on the blood supply of the globe from retrobulbar hemorrhage has been discussed above.

In intraocular surgery, it is considered advantageous if the intraocular pressure is low and pressure fluctuations are kept to a minimum.[70] In a previous era, it was considered particularly important to maintain a "soft eye" in the avoidance of complications, particularly suprachoroidal hemorrhage.[71] Phacoemulsification techniques, which require a smaller surgical incision, are associated with smaller swings in intraocular pressure than the older intracapsular or extracapsular methods. After completion of regional anesthetic blocks, mechanical orbital decompression devices[72–75] are frequently used to promote ocular hypotony and a reduction in vitreous volume,[76] especially when larger volumes of orbital injectate have been used (as in periconal blocks). Because blood flow to the retina, choroid, and optic nerve depend on the balance between the intraocular pressure and the mean local arterial blood pressure,

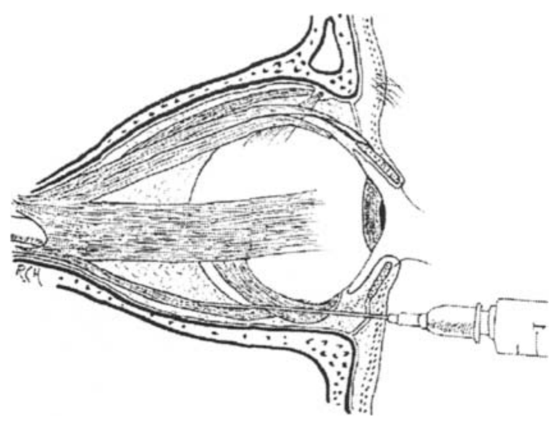

FIGURE 6-4. A straight 31-mm needle being advanced from the inferotemporal quadrant in an attempt to enter the intraconal space has failed to adequately clear the orbit floor. The needle tip has entered the belly of the inferior rectus muscle. Hemorrhage into the muscle with subsequent fibrosis, or intramuscular injection of local anesthetic with subsequent myotoxicity, may result in prolonged or permanent imbalance between the superior and inferior rectus muscles and vertical diplopia. (From Gimbel Educational Services, with permission.)

it is possible for these devices to induce global ischemia.[77,78] In the presence of significant local arterial disease, orbital hemorrhage, or in patients with glaucoma, vascular occlusion may result.[79] It may be prudent to omit epinephrine from the anesthesia injectate in these cases.[14,43]

Optic Nerve Damage

Injection at the orbital apex, as was advocated in the distant past,[46] has the potential of frank optic nerve injury (Figure 6-5). The needle length introduced beyond the orbital rim for both intraconal and periconal injections should not exceed 31 mm to assuredly avoid damage to the optic nerve in all patients.[33] In the execution of orbital blocks, it is possible for the needle tip to enter the optic nerve sheath and produce not only brainstem anesthesia, as described above, but also tamponade of the retinal vessels within the nerve and/or the small vessels supplying the nerve itself either by the volume of drug injected or by initiating intrasheath hemorrhage.[12,16,80–82] Even without trauma to the optic nerve, the increased orbital pressure of retrobulbar hemorrhage may tamponade its small nutrient vessels, explaining those cases of profound visual loss in which the findings of retinal vascular occlusion were not seen and late optic atrophy developed.[8,79] Preexisting small vessel disease such as is seen in diabetes mellitus may increase the likelihood of this complication.

Other Nerve Injury

It is possible for autonomic,[83,84] sensory, or motor nerves[61] in the orbit to be traumatized by a needle. The motor nerve to the inferior oblique muscle may be damaged by a needle entering insufficiently lateral (Figure 6-6) with resultant diplopia.[66]

Therapeutic Misadventures (Including Systemic Toxicity)

Orbital injections of depot steroid medications and antibiotics are frequently used at the time of ophthalmic surgery for their antiinflammatory and antiinfective properties. The anesthesiologist may be asked to administer such agents and should be aware of the risks involved. Their inadvertent injection into the vitreous has serious implications.[85–91] In delivering steroids and antibiotics in a planned extraocular location, it is important to aspirate before injection to check for inadvertent intravascular needle-tip placement. There are many reports of retinal, ciliary, and choroidal arterial embolism of these medications, often with irreversible vision deterioration.[92–94] Intraocular antibiotics are used to treat established endophthalmitis and are being increasingly used prophylactically in its prevention. The preparation of the special concentration

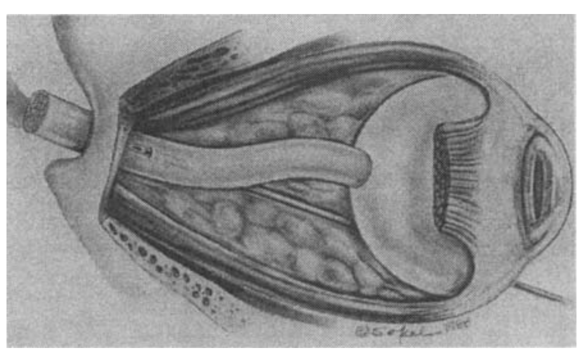

FIGURE 6-5. Injections into the deep orbit may perforate the optic nerve or injure other important structures, including vessels, tightly packed at the apex. (Reprinted from Katsev et al.[33] Copyright 1989, with permission from the American Academy of Ophthalmology.)

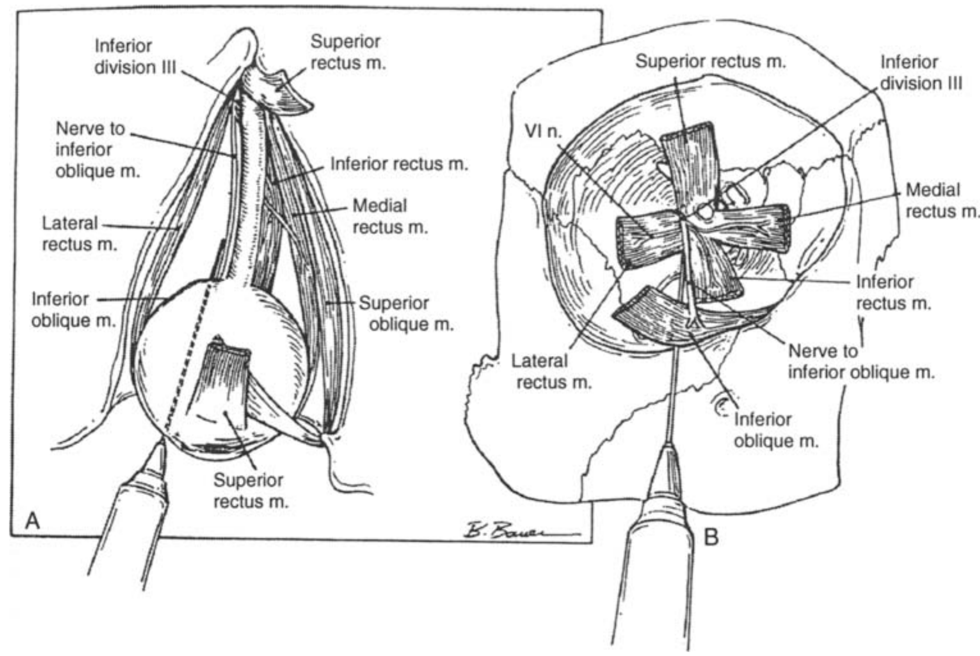

FIGURE 6-6. Right orbit. **(A)** View from above. **(B)** View from in front with the globe removed. Observe the proximity of the needle path to the inferior oblique muscle belly, its motor nerve, and the lateral border of the inferior rectus muscle. One or more of these three structures can be damaged by a traditionally placed retrobulbar needle. (Reprinted from Hunter et al.[66] Copyright 1995, with permission from the American Academy of Ophthalmology.)

required must be done correctly and is probably best delegated to a pharmacist so as to avoid devastating and irreversible retinotoxic iatrogenic damage.[95]

The incidence of systemic toxicity with local anesthetics is related to total dose given, vascularity of site of injection, drug used, speed of injection, and whether epinephrine has been used as an additive to delay systemic release. The amount of local anesthesia agent required to be effective in ophthalmic anesthesia is relatively small in comparison with regional anesthesia requirements for most other types of surgery, so systemic toxicity is unlikely. Unintentional intravenous injection of the total mass of local anesthetic required for an eye block if given rapidly may result in systemic toxicity with the usual target organs being those with the more excitable membranes, namely, the CNS and myocardium. Aspirating before injection and injecting slowly reduces the likelihood of this complication. Inadvertent intraarterial injection of local anesthetics with retrograde flow to the cerebral circulation may result in an acute grand mal seizure.[96,97]

Seventh Nerve Block Complications

An isolated facial nerve block is rarely necessary in modern ophthalmic practice. Complications associated with blocking of the main trunk of the facial nerve at the base of the skull have been reported.[98,99] In these cases, patients experienced difficulty swallowing and respiratory obstruction related to unilateral vagus, glossopharyngeal, and spinal accessory nerve blockade. For facial blockade at this site, it is prudent to inject no deeper than 12 mm and to avoid hyaluronidase in the injectate.[99,100] Bilateral facial nerve block is not recommended.[101]

Allergy

True allergy to local anesthetics is extremely rare.[102] Allergic reactions are almost exclusively confined to the ester-linked drugs. The breakdown product of the esters, paraaminobenzoic acid, is thought to trigger an allergic reaction in certain individuals. Reaction with preservatives, such as methylparabens, in multidose vials is possible; hence, it may be better to use preservative-free vials where a history of the problem exists.[103] A myasthenia-like response to various agents including local anesthetics has been reported[104] and also two well-documented cases of true allergy to amide drugs have been reported.[105,106]

Alternative Methods of Ophthalmic Anesthesia

Ongoing reports of the rare but serious complications of intraconal anesthesia stimulated editorials and reintroduced the concept of alternative nonakinetic methods of regional anesthesia for ophthalmic surgery.[107,108] These fall into three groups: subconjunctival (perilimbal)[107,109–112]; injection of local anesthetic by needle or cannula within Tenon's capsule[113–116]; and solely topical corneoconjunctival anesthesia.[117–119] With these methods, the surgeon encounters a varying degree of muscle action affecting the globe and lids, and sensitivity of intraocular contents (particularly the iris and ciliary muscle with solely topical anesthesia).[109] A systematic search of the literature concluded that retrobulbar block provided better pain control than topical anesthesia.[120]

Anticoagulants and Antiplatelet Therapy

It has been common practice in surgery, including ophthalmic, to reduce or discontinue anticoagulant therapy for some days before an operation. Whereas this action may be appropriate for more major ophthalmic surgical procedures, such as scleral buckling, its advisability for the cataract surgery patient has been questioned.[121,122] Discontinuation of anticoagulant medication may result in thrombotic complications such as cerebral vascular accident, pulmonary embolism, and death.[123] In two reports, the minor hemorrhagic complications associated with continuance of anticoagulants had no long-term effects on visual acuity.[124,125] This implies that the risk of stopping anticoagulants for this type of surgery is probably greater than any risk imposed by their continuance. A recent publication reviews the current literature.[126] Patients receiving antiplatelet therapy may also continue their drugs through cataract surgery if medical reasons dictate.[127]

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