Complications in Ophthalmic Anesthesiology
Stanley W. Stead

The ophthalmic patient is at a particular risk from anesthesia. Patients submitted for ophthalmic surgery represent the extremes of age: the very young and the very old. As such, the underlying medical condition of the patient may be compromised, as well as the patient's response to pharmacological agents may be exaggerated. Frequently, these patients are receiving medications for their ophthalmic needs that may have significant impact on anesthetic management and coexisting disease.

Mortality

There is a variety of data on mortality associated with anesthesia in ophthalmic surgery from the 1960 to 1970s (Table 1).1-5 Mortality varied from 0.06% to 0.16%, regardless of whether the patient received local or general anesthesia. However, this data is obsolete because these studies represent a different level of preoperative preparation, type of anesthesia, and quality of intraoperative monitoring by anesthesia personnel from what is practiced today. There are no current large-scale epidemiological studies to evaluate anesthesia risk in ophthalmic surgery population. Nevertheless, the observations of Quigley's in 1974 still apply today: the morbidity associated with ophthalmic anesthesia is: nausea, vomiting, retrobulbar hemorrhage, perforation, and loss of vitreous. Mortality rates for ophthalmic anesthesia remain less than those for general surgery.6

Today, much of ophthalmic surgery is performed under monitored anesthesia care (MAC), that is local anesthesia with conscious sedation. Mortality data associated with the administration of various types of anesthetics has been evaluated in several venues. In one survey, the risk of death from intravenous sedation is reported as 1 in 340,000 cases compared with 1 in 324,000 for general anesthesia in patients having dental anesthesia in a dentist's office.7 In a 1984 study by the Federated Ambulatory Surgery Association, the complications were correlated to anesthetic technique. The complications associated with local anesthesia and sedation exceeded that of general anesthesia or regional block.8 In a recent study of 100,000 anesthetics, MAC was associated with the highest rate of mortality, 2.1%, even though an anesthesiologist was in attendance.9 Unfortunately, specific data on agents, doses, and events were lacking. In a closed-claims analysis of 14 cases of cardiac arrest in healthy patients under spinal anesthesia, the intraoperative use of sedation was a recurring pattern of management.10

Morbidity from Coexisting Disease States

Of patients undergoing ophthalmic surgery, 65% are older than age 65. In this geriatric population there is considerable preexisting disease. Hypertension is present in 47% of patients, renal disease in 31%, coronary artery disease in 27%, history of myocardial infarction in 19%, chronic obstructive lung disease in 14%, diabetes in 9%, liver disease in 9%, heart failure in 8%, and cerebral vascular accidents in 6%.11 While not all of these patients have morbidity associated with their ophthalmic procedures, it is interesting to note that these same disease states contribute to postoperative morbidity.

Wu and Schachat reported on the need to transfer patients from the ophthalmology service to another medical service after ophthalmic surgery.12 During the 2-year study period, 0.7% of patients experienced medical conditions that required transfer to a medical service. Of these patients, 70% were more than 50 years old. The most common reasons for transfer were cardiac-related conditions: angina, electrocardiographic changes, and congestive heart failure (26%). Un-
Table 1. Mortality, Anesthesia, and Ophthalmic Surgery

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Occurrences</th>
<th>Cases Reviewed</th>
<th>% Mortality With General Anesthesia</th>
<th>% Mortality With Local Anesthesia</th>
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<td>Petruska et al</td>
<td>1962-71</td>
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<td>Hallerman and Ruger</td>
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</table>

controlled blood sugar in diabetics represented 19% of the transfers. Acute renal failure caused 11% of the transfers. Coagulation abnormalities, stroke, and uncontrolled hypertension (each at 7%) represented the remainder of nonophthalmic causes. Only one case was transferred because of an adverse reaction to an anesthetic administration. This data underscores that coexisting disease in the ophthalmic patient remains an important cause for morbidity associated with ophthalmic surgery.

MORBIDITY FROM THE SYSTEMIC EFFECTS OF OPHTHALMIC DRUGS

Ophthalmic medications administered in the perioperative period are sufficiently potent to have systemic effects. Ocular drugs applied topically can act as readily as if administered intravenously. Although the medication is absorbed slowly from the conjunctival sac, much more rapid absorption can occur via the mucosal surfaces reached through the nasolacrimal duct. Systemic absorption may be enhanced in a diseased or postsurgical eye.

Phenylephrine

Phenylephrine is used as a mydriatic. There is little increase in mydriasis when ophthalmic solutions with concentrations greater than 5% are used. Significance complications have been reported with 10% phenylephrine because a single drop of 10% solution may contain 5 mg of the drug. Complications seen include myocardial infarction, hypertension, reflex bradycardia, and cardiac dysrhythmias.

Epinephrine

Topical application of 2% epinephrine solution to the eye causes a decrease in aqueous secretion and improves outflow, both which act to reduce intraocular pressure (IOP) in open-angle glaucoma. Complications include hypertension, tachycardia, dysrhythmias, and fainting. Because a single drop of 2% epinephrine contains 0.5 to 1.0 mg, it is reasonable to expect systemic complications to occur. Despite these concerns, intraocular epinephrine administered during halothane anesthesia seems to be without significant cardiac effects.

β-Adrenergic Antagonists

β-adrenergic antagonists are used in the treatment of glaucoma. This class of medication acts to reduce aqueous humor secretion, with minimal effects on aqueous outflow. Pupillary size is not affected. Patients may complain of lightheadedness, fatigue, disorientation, and may show a general depression of central function. Excessive dosage of β-adrenergic antagonists may lead to cardiovascular dysfunction including bradycardia, palpitations, syncope, increase in heart block and congestive heart failure. While rare, exacerbation of asthma while on timolol has also been reported. Particular caution should be exercised with neonates receiving timolol eye drops because apnea has been reported.

Apraclonidine

Apraclonidine is a relatively new α2-adrenergic agonist that has found a role as a topical antiglaucoma medication. Like epinephrine, it causes a decrease in aqueous formation and improves aqueous outflow, both of which act to reduce IOP. Systemic absorption may cause significant sedation and drowsiness. Hypotension is a possible complication, but has not been re-
ported. However, acute withdrawal from long-term therapy may result in rebound hypertension.

**Echothiophate Iodide**

Echothiophate iodide is a long-acting anticholinesterase drug still used to treat glaucoma. The pupil is constricted and aqueous drainage is increased. Its duration of action is 4 to 6 weeks, and 3 weeks after the cessation of treatment with echothiophate iodide, plasma cholinesterase activity remains at 50% of normal. If a patient receives succinylcholine, a relative overdose of succinylcholine is possible with prolonged apnea. Careful titration of succinylcholine with the use of a peripheral nerve stimulator will avoid prolonged apnea. Ester local anesthetics (procaine and chloroprocaine) may be significantly prolonged. Amide type local anesthetics may be a better choice for regional anesthesia.

**Muscarinic Agonists**

Muscarinic agonists are given to cause prolonged mydriasis. A drop of atropine 1% solution contains 0.2 to 0.5 mg of drug. One drop of 0.5% scopolamine contains 0.2 mg of the drug. Systemic reactions have been seen in both young and elderly patients after the administration of topical ocular atropine or scopolamine. These reactions are manifested by tachycardia, flushing, thirst, dry skin, and in elderly patients, agitation. Central nervous system excitement and agitation can be treated with incremental doses of physostigmine 0.15 mg/kg, intravenously.

**Acetazolamide**

The carbonic anhydrase inhibition of acetazolamide interferes with the formation of the aqueous humor and lowers IOP. Aside from a metabolic acidosis with depletion of sodium and potassium, long-term therapy may result in dyspepsia. Given acutely, the patient may show an acute decrease in blood pressure. Caution should be exercised in patients with renal disease, dehydration, and sodium or potassium depletion.

**Anticoagulants**

The use of anticoagulants is not a contraindication to local anesthesia or to ophthalmic surgery. The risk of stopping the anticoagulants for ophthalmic surgery is probably greater than their continuance. Proper positioning of small, fine needles in avascular areas of the orbit can allow safe regional anesthesia.

**COMPLICATIONS BY TYPE OF ANESTHETIC ADMINISTERED**

The American Society of Anesthesiologists (ASA) closed-claims analysis of 73 claims for eye injury identified two subgroups of claims. Corneal abrasion was the most common single injury. The severity of the injury was low, the mechanism of injury was unclear. Patient movement during ophthalmic surgery was the second most common complication. When movement occurred, blindness was common. Because the data was taken from the closed-claim database, it is impossible to determine the incidence of blindness from movement during ophthalmic surgery. However, it is clear that anesthesiologists bear the responsibility for patient immobility during ophthalmic surgery under general anesthesia. When procedures are performed under topical or regional anesthesia, both ophthalmologist and anesthesiologist must work together to ensure a quiet surgical field.

Ophthalmic procedures are commonly performed under local anesthetic nerve block and MAC. Anesthesiologists, in conjunction with surgeons, have introduced new, improved pharmacological agents and noninvasive monitors into the operating room. The use of MAC is increasing in frequency, particularly in ophthalmic surgery. Administration of MAC may be more complex and is potentially more dangerous than general anesthesia in which the patient’s airway is secured with an endotracheal tube, the lungs are ventilated, supplemental oxygen is administered, and invasive monitoring is used. Patients are now commonly provided with MAC, often in remote areas, with the mistaken belief that a MAC anesthetic incurs less risk than a general anesthetic.

There is a progressive loss of consciousness from conscious sedation to deep sedation and finally to general anesthesia. It is important to define the desired level of sedation of the patient. A degree of safety is implied when a state of conscious sedation is achieved compared with deep sedation or general anesthesia. It might be assumed that the degree of care provided to pa-
tients under conscious sedation could be less intense or less thorough, but the opposite is true. Moving from a state of consciousness to deep sedation is a dose-dependent continuum that also depends on patient response. The dividing line between consciousness and unconsciousness may be subtle. There is the risk of synergistic interactions between sedative and analgesic drugs.

Conscious sedation is defined as the following: “Minimally depressed level of consciousness that retains the patient’s ability to independently and continuously maintain an airway and respond appropriately to physical stimulation and verbal command, produced by a pharmacological or nonpharmacological method, or combination of both.”22 In contrast, during deep sedation, patients are unconscious and not easily aroused. This is accompanied by a partial or complete loss of protective airway reflexes. It is in this setting that respiratory arrests and other untoward events occur. It is important to understand that deep sedation is really general anesthesia, with its attendant risks.

MAC is properly accomplished under conscious sedation. In this state, the patient’s mood is altered, with the patient being conscious and cooperative. Airway reflexes are intact and respiration is spontaneous. Traditionally, this sedation provided only minimal analgesia and amnesia, newer agents can add considerable analgesia and amnesia. In this manner, patients enjoy perioperative comfort, a short recovery room stay, and rare complications.

Most patients, adequately medicated can undergo extensive surgery under MAC. Indications for MAC anesthesia are cooperative patients, a surgical procedure with a limited surgical field, amenable to topical or local anesthesia, the ability to communicate with the patient, and finally patient preference. General anesthesia is indicated when the patient is unable to cooperate (children, adults with mental or psychological deficits). In lengthy procedures (>3 hours) or procedures that do not lend themselves to local anesthesia, general anesthesia is the preferred technique. Sometimes general anesthesia is forced, such as after an intravascular or subarachnoid injection of local anesthesia. Of course, some patients (or ophthalmologists) prefer a general anesthetic. When the health of the patient does not preclude general anesthesia, it should be considered a reasonable alternative to MAC anesthesia. Surgical outcome is markedly influenced by the quality of anesthesia. Inadequate regional blocks require supplementary blocks, rather than increased sedation.

**Topical**

Topical anesthesia is becoming increasingly popular for cataract surgery. The single largest complication from topical anesthesia occurs when the patient is unable to cooperate or tolerate the pressure sensations associated with the surgery. Rather than increasing the level of sedation, these patients should be converted to regional anesthesia.

Local anesthetic applied topically seems to have little consequence to the corneal epithelium. However, if local anesthetics enter the anterior chamber of the eye, there is a significant increase in corneal thickness and opacification may result. In a study in rabbits, four topical anesthetics, lidocaine 4%, proparacaine 0.5%, bupivacaine 0.75%, and tetracaine 0.5% were compared with saline when 0.2 mL was injected into the anterior chamber of the eye. All four anesthetics showed an increase in corneal cloudiness after 1 day, with some resolution in 7 days. This study indicated that caution should be exercised when topical anesthetics are placed on an open eye.23

**Regional**

Regional anesthesia is the most common form of ophthalmic anesthesia. Complications arising from regional anesthesia may be systemic, or limited to the orbit and its contents. The time course is variable: some complications arise immediately whereas in others it is delayed. Complications may be directly related to the local anesthetics and method of administration, whereas other complications occur in combination with operative trespass.

Regional anesthesia of the eye has two goals: anesthesia of the globe and surrounding structures and akinesia. Accordingly, two injections are commonly administered. A facial nerve block is performed to provide periorbital motor blockade. Orbital anesthesia and akinesia is accomplished by the deposition of local anesthesia in
OPHTHALMIC COMPLICATIONS

the orbit, with either a retrobulbar or peribulbar approach.

Facial Nerve Block Complications

The facial nerve may be blocked at several points after exiting from the base of the skull as the stylomastoid foramen. The Nadbath block is performed by using a short length (0.5 in) small gauge needle to deposit 5 mL of local anesthetic near the stylomastoid foramen. Disturbances of swallowing and respiratory difficulties have been reported when the vagus, glossopharyngeal, or spinal accessory nerves have been affected. 2.26 In fact, if the local anesthesia tracks inferiorly down the neck, a Horner’s syndrome can result with great discomfort to the patient. Several cases have reported permanent facial nerve paralysis when longer needles and hyaluronidase were used. 27 The O’Brien procedure of facial nerve block deposits local anesthesia anterior to the tragus of the ear. Again, facial nerve damage was associated with longer needles and the use of hyaluronidase. 28 Some clinicians advocate the use of a single injection of a large volume of local anesthesia into the orbit to provide periorbital muscle akinesia.

Inadvertent Subarachnoid Anesthesia

Central nervous system depression after retrobulbar nerve block has been reported for over a century. However, in the last decade, the number of reported cases has greatly increased. Classically, the patient has received a retrobulbar block. Several minutes later there is a decreased sensorium noted in the patient with drowsiness. This may culminate in apnea 10 to 15 minutes later.

The mechanism of retrobulbar blocks progressing to brain stem anesthesia is still subject to debate. Interestingly, the dural sheath covering the intraorbital portion of the optic nerve is not impervious to anesthetics. It has been shown radiologically that communication is possible from the subdural space of the optic nerve to the optic chiasm, and subsequently to the subarachnoid space surrounding the pons and midbrain. 29 Typically, puncture of the optic nerve sheath by needles provides an entry for local anesthetics into the subarachnoid space. Suggestions have been made that the use of bupivacaine as well as larger volumes of local anesthetic may increase the incidence of central spread, although there is no data to support this assertion. Several large series of retrobulbar blocks estimate the incidence to be 0.3% to 0.8%. 30,31

The possibility of subarachnoid anesthesia must be considered whenever there is an unexplained onset of sensorial changes in the ophthalmic patient. 32 Any change in sensorium should alert the clinician to the possibility of central spread of the block. The most common single early finding is that the contralateral pupil is areflexic and dilated. 33 If the patient is conscious, temporary blindness (amaurosis) may be reported. There may be mild confusion or shivering. Patients may complain of dyspnea or difficulty in catching their breath. As symptoms progress, there can be brain stem or cranial nerve palsies. Sometimes nausea and vomiting predate the progression. “Total spinals” have been reported with hemiplegia, paraplegia, or quadriplegia, or loss of consciousness. Patients may have symptoms of excitement followed by frank convulsions. Apnea with cardiovascular collapse has been reported. 34-36

Treatment of central spread should begin immediately. Positioning the patient in a recumbent, but head up position, may delay or reduce the spread of the local anesthetic. Supplemental oxygen should be administered and preparations for securing the airway (as always) should be readily available. In animal studies, direct application of local anesthetics, may have significant effects on myocardial function. 37,38 Commonly, there is profound vasodilatation and bradycardias. Alternately, hypertension, tachycardias, and pulmonary edema have been reported, presumably from the respiratory arrest and resultant hypoxemia. Supportive treatment is indicated and recovery can be expected in 2 to 3 hours. The optic nerve has not been examined after a case of brain stem anesthesia, and there have been no cases of obvious optic nerve trauma, such as optic neuropathy or nerve sheath hemorrhage after subarachnoid anesthesia. In fact, in cases of optic nerve trauma from a needle, the clinical picture differs from subsheath bleeding and central spread was not reported. 39

Prevention of this syndrome is dependent on proper positioning of the needle during retrobul-
bar block and the gaze of the eye. When the globe is adducted and elevated during inferotemporal needle placement, the optic nerve is placed in closer proximity to the advancing needle. When the globe is in the primary gaze, the nerve is less vulnerable. The needle should not penetrate more than 31 mm from the orbital rim. If resistance is present the needle should be withdrawn and relocated before injection.

**Optic Nerve Trauma**

Optic nerve injury after injection of local anesthetics may occur with compromise of the blood supply of the globe. In many of these cases, ultrasonography or computed axial tomography scans indicated a dilated optic nerve sheath, suggesting an intrasheath injection. Fundoscopic examination reveals an injected retina and white patches associated with retinal veins around the disk or macula. Surgical decompression of the optic nerve sheath may be indicated.

**Ocular Penetration and Perforation**

Clinicians differentiate penetration and perforation of the globe. Penetration refers to needle entry through the sclera of the globe, whereas perforation indicates both entry and exit from the globe with a needle. These types of complications are most common in the myopic, elongated globes. Patients presenting for retinal detachment repair and radial keratotomy surgery tend to have longer globes than patients requiring cataract surgery. A particularly high-risk group are myopic patients with staphyloma. The incidence of penetration or perforation depends greatly on the type of ophthalmic block. Large series of peribulbar blocks report no penetration or perforation, while case reports abound. Series comprised of both peribulbar and retrobulbar or retrolbulbar blocks alone report a range between 0.075% to 0.1%. The use of large, dull needles probably decreases the incidence of penetration, but if penetration does occur, the severity of bleeding will be worse. The use of small, fine needles is probably justified because if a vessel is perforated, the rent will be smaller, and the amount of bleeding will be subsequently less.

A retrobulbar hemorrhage should be suspected with a stained conjunctiva and proptotic globe. IOP should be determined and ophthalmoscopy performed to examine retinal circulation. Treatment is directed towards reducing orbital compartment pressure, thus reducing IOP and mini-
imizing the effects on retinal circulation. Classically, osmotic diuretics have been advocated. In many centers, lateral canthotomy is routinely used to acutely decompress the globe and reduce IOP. In the case of extensive bleeding, orbital decompression may be indicated. As noted above, needles should be inserted in the more avascular parts of the orbit. The apex of the orbit contains the major vessels, making this the highest risk area. A rent in one of the retinal vessels has the potential of endangering retinal circulation.

In some cases of retrobulbar hemorrhage, retinal vascular occlusion was not seen, but late optic nerve atrophy has developed. This is thought to be from tamponade of the nutrient vessels of the optic nerve from the increased orbital pressure. Retinal vascular occlusion has been reported in patients with the absence of retrobulbar hemorrhage after retrobulbar injection of local anesthesia in patients with vascular or bleeding disorders. Presumably the injection of local anesthetic compressed the retinal artery.

Minor Bleeding

Minor bleeding after retrobulbar or peribulbar injections ranges from 1% to 2.75%. The vessels in the anterior orbit are smaller than those in the posterior orbit. Consequently, these minor retrobulbar or peribulbar hemorrhages manifest themselves as subconjunctival bleeding and lid ecchymosis. Lid ecchymosis can be particularly troubling to patients because of its cosmetic appearance. Placement of the injections in the relatively avascular portions of the orbit minimizes the possibility of bleeding. The most avascular regions of the orbit are at the inferotemporal quadrant, the superotemporally quadrant at the lateral limbus, and on nasal side of the medial rectus muscle.

Intravascular Injection

Penetration of the vessels of the orbit can also result in an intravascular injection. Intra-arterial injection can result in retrograde arterial flow of the local anesthetic. The sudden presence of large amounts of local anesthetic centrally, are very similar to those seen with central spread of local anesthesia. Often the patient will comment on a metallic taste in the mouth, followed by excitement, loss of consciousness, and frank seizures. A large local anesthetic dose may result in cardiovascular collapse. Prevention is predicated on careful aspiration of needle before injection and immediate cessation if blood is present. Slow injections of local anesthetic decrease the chance for retrograde arterial flow and may decrease the concentration of local if retrograde flow occurs.

Prolonged Extraocular Muscle Malfunction

Investigators have detailed the myotoxicity of local anesthetics. Myotoxicity of local anesthetics on extraocular muscles in the orbit has been reported. Higher concentrations of local anesthetics seem to be related to myotoxicity, as well as the presence of epinephrine. Typically, this myotoxicity presents as diplopia and ptosis 24 to 48 hours postoperatively. The most common cause is direct intramuscular injection of local anesthetic. If there has been no nerve damage, function normally returns in 2 to 3 weeks. When recovery is delayed more than 6 weeks, there is a 25% chance of permanent damage. This syndrome can be prevented by avoiding the extraocular muscles and nerves during injection.

Orbital Decompression Devices

Some physicians apply manual compression to the to assist the spread of local anesthesia after ophthalmic nerve blocks. Manual compression, or a mechanical compression device (such as a Honen’s) may also be applied on the globe to produce a “soft eye” (decrease IOP) before eye surgery. Compression has been used with great safety over a number of years, however, persistent case reports can be found implicating orbital decompression as the cause of postoperative ptosis and more importantly, impairing retinal circulation. When compression on the globe is used, the pressure exerted should be substantially below diastolic pressure to ensure that vascular impairment does not occur.

Postoperative ptosis is a complication that can be seen both after ophthalmic and nonophthalmic surgery. After ophthalmic surgery, it can be caused by edema of the upper lid from local anesthesia, pressure applied to the globe or orbital rim either by a lid speculum or by a face mask.
Corneal Injury

Corneal injury is the more common complication of both nonophthalmic and ophthalmic surgery with a reported incidence of 44% in the unprotected eye. In the case of nonophthalmic surgery, it is associated with failure to seal the eyelids (with or without ointment) until the patient has returned to consciousness. In the case of ophthalmic surgery, the patient who has undergone a local anesthetic block is at particular risk. The cornea is insensitive in the postoperative period. Additionally, lacrimal gland function may be suppressed by either local or general anesthesia, making the cornea more susceptible to damage. When lid function is impaired, the operated eye should be patched until sensation and motor functions return.

Oculocardiac Reflex

The oculocardiac reflex (OCR) is caused by traction on the extraocular muscles, manipulation of the globe, or an increase in IOP. It is most commonly described as occurring during eye muscle surgery, but it is prevalent during retinal detachment repair and enucleation. The OCR manifests itself not just by bradycardia, but by bigeminy, ectopic beats, nodal rhythms, atrioventricular block, and asystole. The dysrhythmias persist as long as the stimuli is present.

The afferent pathway of the OCR is via the ciliary ganglion to the ophthalmic division of the trigeminal nerve, through the gasserian ganglion to the sensory nucleus V in the fourth ventricle. The efferent pathway is exclusively through the vagus nerve. It is the vagus innervation to the abdominal viscera that causes nausea and vomiting, along with the cardiac manifestations.

Alexander reported that 90% of patients experienced the oculocardiac reflex during traction of the extraocular muscles. The reported incidence of cardiac dysrhythmias varies between 32% to 82%. However, the oculocardiac reflex has also been observed after retrobulbar block and retrobulbar hemorrhage.

Diagnosis of the OCR relies on continuous monitoring of the electrocardiogram on all ophthalmic surgery patients. Treatment varies based on the severity of the reflex. If the reflex manifests itself as bradycardia or infrequent ectopic beats, and the patient remains hemodynamically stable, no treatment may be justified. If the dysrhythmias become significant, cessation of the surgical stimuli is indicated. Often the procedure may proceed after a brief pause. The OCR tires easily and usually there is little or no OCR after this brief pause. When the OCR is severe, treatment with anticholinergics (glycopyrrolate or atropine) is indicated. Caution must be exercised with large doses of atropine because frequently more severe, prolonged dysrhythmias may result.

Suprachoroidal Hemorrhage

Choroidal hemorrhage is possible when the pressure in the eye is transiently elevated during intraocular procedures. Systemic hypertension (diastolic > 110 mm Hg) is a contraindication to intraocular surgery. Any maneuver that suddenly causes a rapid rise in intraocular pressure such as coughing, sneezing, straining, or Valsalva’s maneuver can cause a choroidal bleed.

GENERAL ANESTHESIA

Nausea and Vomiting

Postoperative nausea and vomiting are the most common complications associated with outpatient general anesthesia, and may result in delayed discharge from the hospital. Intractable vomiting has been found to be the most common anesthetic-related cause for unanticipated overnight admission. The risk of pulmonary aspiration of gastric contents in the early postoperative period is increased with the occurrence of vomiting. Although uncommon, hypokalemia, hypochloremia, hyponatremia, alkalosis, and dehydration because of severe postoperative vomiting may also occur.

Many factors have been shown to increase the incidence of postoperative nausea and vomiting. Among these factors are patient characteristics, surgical site, duration of anesthesia, as well as anesthetic agents and techniques used. The use of preoperative, intraoperative, and postoperative antiemetics have been reported to have varying degrees of success in the prevention of postoperative nausea and vomiting. Side effects of the commonly used centrally acting antiemetics include excessive sedation and extrapyramidal reactions. The efficacy and side effects of these...
agents vary and may be related to the dosage and
timing of administration. Among surgeries
associated with an increased incidence of postop-
erative nausea and vomiting, ophthalmic proce-
dures are particularly problematic. The incidence
of postoperative nausea and vomiting in pediatric
patients undergoing strabismus surgery has been
found to be as high as 85%. Propofol has become the drug of choice in
ambulatory settings and is becoming increasingly
popular in pediatric anesthesia. Whether propofol
has intrinsic antiemetic properties or not is un-
clear, but it seems in some studies that those
patients who receive propofol rather than potent
inhalation agents for the same procedure have
less nausea and vomiting. As nausea and vom-
iting after strabismus surgery is common, the use
of propofol in this setting has been studied. In a
study by Watcha et al. the incidence of emesis
in the group receiving propofol alone was 23%
compared with 50% in those who received the
standard regimen of halothane/N₂O/droperidol. Other studies have corroborated these findings.
A prominent feature of recovery from propofol
anesthesia is the absence in the early recovery
period of a "hang over" effect commonly seen
with the use of halogenated agents. Some studies
have also shown shortened recovery times and
earlier discharge times for both adults and chil-
dren.

Postoperative nausea and vomiting remain a
tremendous challenge to both anesthesiologist
and ophthalmologists. Classic antiemetic agents
(atropine, chlorpromazine, metaclopramide, dro-
peridol) have not been able to eliminate nausea and
vomiting from ophthalmic patients. Higher dosages
of these classic agents have greater efficacy, but
the higher doses often result in undesirable side
effects such as extrapyramidal symptoms, sedation,
dry mouth, and urinary retention. Recent work has
shown that, in children undergoing pediatric stra-
bismus surgery, higher doses of droperidol greatly
reduce postoperative emesis without increasing
side effects. In addition, a new class of antiemetic
has become available. 5HT-3 antagonists (ondan-
setron, tropisetron, granisetron) were developed for
nausea and vomiting associated with chemotherapy.
They have also shown effectiveness in de-
creasing vomiting associated with pediatric strabis-
mus surgery. These new agents have minimal side
effects to limit their use.

Pulmonary Embolus

Pulmonary embolism remains the chief cause
of postoperative ophthalmic surgery death. As
reported by Kaplan and Reba, pulmonary embol-
ism is particularly a problem with long proce-
dures (retinal and oculoplastic surgery) in the
elderly. The pulmonary embolism is thought to be from a leg deep venous thrombosis. Pneumatic
leg compression devices for deep venous throm-
bosis prophylaxis should be considered in all
ophthalmic surgery cases under general anesthe-
sia that are expected to last 3 hours or longer.

Intraocular Pressure

IOP is the tension exerted on the contents of
the globe. It is kept relatively constant by the
balance between the production and drainage of
aqueous humor. IOP is normally 16 ± 5 torr.
There are normal minor fluctuations in IOP:
changes caused by body position (+1 torr su-
pine), diurnal rhythm (2 to 3 torr), blood pressure
oscillations (1 to 2 torr), and respiration (deep
inspiration decreases IOP by 5 torr). Excessive
increases in IOP interfere with choroidal and reti-
nal blood supply as well as corneal metabolism,
potentially causing retinal ischemia and corneal
opacification. Decreased IOP or hypotony, in-
creases the risk for retinal detachment and vitre-
ous hemorrhage.

Because choroidal vessels of the eye act much
as intracranial vessels it is useful to think of anes-
thetic effects on IOP as almost identical to anes-
thetic effects on intracranial pressure. Choroidal
vessels constrict with hyperventilation and cause
a decrease in IOP. Hypoventilation (or hypercar-
bia) cause vasodilatation and an increase in IOP.
Similarly, hypoxia may contribute to increased
IOP through vasodilatation of intraocular vessels.
The most severe increases in IOP are usually
caused by blockage of aqueous outflow by acute
venous congestion. Any straining, bucking,
breath holding, or obstructed airway during the
induction or emergence of general anesthesia will
increase venous congestion in the ophthalmic
veins and therefore increase IOP. A mild cough
can increase IOP by 30 to 40 torr. Endotracheal
intubation is also a potent stimulus increasing
IOP. External pressure from face mask, fingers,
orbital tumors, contraction of the orbicularis
oculi muscle, or retrobulbar hemorrhage will also increase IOP.

Drugs used during anesthesia generally decrease IOP by 10% to 30%. There are two notable exceptions: ketamine and succinylcholine. Ketamine produces a moderate increase in IOP. Most of this increase in IOP can be explained by increased blood pressure. Succinylcholine causes an increase in IOP that has been ascribed to the contraction of the extraocular muscles leading to compression of the globe. Concern has been expressed that this contraction would extrude globe contents in a patient with an open globe injury. Kelley and colleagues studied patients undergoing elective enucleation and compared IOP after the administration of succinylcholine between the normal eye and the diseased eye that had all extraocular muscles detached. A no difference between the two eyes was found in baseline or peak intraocular pressure. However, both eyes showed a precipitous increase in IOP, leading the investigators to conclude that extraocular muscle contraction does not contribute to the increase in IOP after succinylcholine. Regardless of the cause, it is prudent to avoid succinylcholine when a patient with an open globe presents for anesthesia. Currently available rapid-acting, nondepolarizing neuromuscular agents have obviated the need for succinylcholine in these situations.

Intravitreal Gas and Nitrous Oxide

It is important to recognize the danger of using nitrous oxide when intravitreal gas is administered. To provide internal tamponade of the retina after reattachment, intravitreal gas bubble (SF₆ or C₃F₈) replaces some or all of the vitreous. Nitrous oxide is extremely soluble and will diffuse rapidly into the insoluble intravitreal gas, causing a rapid expansion of the volume and pressure of the bubble. Typically the volume of the vitreous is 4 mL and the sclera of the globe is relatively rigid. In a case where vitreous was replaced by 0.5 mL of SF₆ in the presence of 75% nitrous oxide, the intravitreal bubble expanded and caused an increase in IOP from 17 torr to 39 torr. Such a large increase in IOP impairs retinal circulation. When the nitrous oxide is discontinued, there is a precipitous decrease in IOP which may be detrimental to the retinal repair. Computer modeling of gas solubilities has determined that if nitrous oxide is discontinued 15 minutes before the injection of intravitreal gas, there are minimal effects on gas bubble size. When air or gas remains in the eye, nitrous oxide should be avoided. It is important to understand that similar hazards exist in air transport of patients with intravitreal gas because the aircraft cabin is pressurized for an altitude of about 2,000 m above sea level.

CONCLUSION

Anesthetic complications in ophthalmic surgery can be minimized with careful attention to the preoperative preparation of the patient, appropriate monitoring, selection of an appropriate anesthetic technique, and precise administration of the anesthetic. Access to the patient, the airway, the infusion site, and the monitor probes is very limited. Practitioners of ophthalmic anesthesia need to be knowledgeable of both anesthesiology and ophthalmology. Communication between the anesthesiologist and ophthalmologist is critical to the proper management of the ophthalmic patient.

Complications from regional anesthesia can be minimized by the study of the pertinent anatomy, comprehensive training in performing the blocks, proper positioning of the patient, use of disposable needles of the appropriate gauge and length, precise placement of the needles in avascular areas, and appropriate volumes and concentrations of local anesthetics. Safe regional anesthesia requires not only personnel trained in its use, but those trained in recognizing the complications.

Intravenous sedation is an important adjunct to topical and regional anesthesia. Significant complications can arise from the inappropriate use of conscious sedation to provide analgesia and akinesia from a poorly performing regional anesthetic. There is no indication for deep sedation during regional anesthesia. If regional anesthesia is inadequate, regional supplementation or conversion to a general anesthetic is indicated.

Complications from general anesthesia are similar to complications seen in other types of surgery. Preoperative screening minimizes the risk from coexisting disease. Careful attention is needed to ensure that patients receiving general anesthesia have anesthetic agents and adjuncts
selected that have minimal ophthalmic effects. Modification of anesthetic technique may be needed to provide optimal surgical repairs.

REFERENCES

8. FASA Special Study I. Federated Ambulatory Surgery Association, Alexandria, Virginia, 1985