Chapter 84

Anesthesia for Eye Surgery

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Acknowledgment: The editors and the publisher would like to thank Dr. Anil Patel, who was a contributing author to this topic in the prior edition of this work. It has served as the foundation for the current chapter.

Key Points

- Understanding ocular anatomy and physiology and the systemic effects of ophthalmic medications is essential to preparing an appropriate anesthesia plan.
- Pressure on the globe or any orbital contents can result in a trigemino-vagal or oculocardiac reflex with bradycardia, atrioventricular block, or even asystole.
- The blood supply to the retina is governed by the ocular perfusion pressure, which is determined by the arterial blood pressure and the intraocular pressure (IOP).
- Sufficient concentrations of inhaled anesthetics decrease IOP, whereas ketamine and succinylcholine can increase IOP.
- Sudden increases in IOP in the setting of open globe injury can lead to vitreous loss and blindness.
- Complications of retrobulbar block include retrobulbar hemorrhage, increased IOP, intraarterial injection with convulsions, and subarachnoid injection via the optic nerve sheath with respiratory arrest.
- Nitrous oxide should be avoided for 15 minutes before the insertion of intraocular gas. Nitrous oxide must be avoided for 7 to 45 days after use, or until the gas bubble is resorbed.
- True ophthalmic emergencies, such as chemical burns and central retinal artery occlusions, must be treated within minutes to avoid permanent vision loss. Open globe injuries and other urgent procedures can be scheduled after appropriate NPO status.
- Eye compression from a facemask or positioning can lead to central retinal artery occlusion.

Ocular Anatomy

The eye is a sphere measuring approximately 24 mm in diameter. It sits in the pyramidal bony orbit. The wall of the globe has three layers: the sclera, the uveal tract, and the retina.

The sclera is the outermost layer. It is the tough, fibrous white of the eye. The transparent cornea is the anteriormost part of the sclera. Most of the focus power of the eye is from the curvature of the cornea.

The middle layer, the uveal tract, has three structures: the choroid, the iris, and the ciliary body. The choroid is a layer of blood vessels located posteriorly. Bleeding in this layer is one cause of intraoperative expulsive hemorrhage. The pigmented iris controls light entry with muscle fibers that change the size of the pupil. Sympathetic stimulation dilates the pupil by causing iris dilator muscles to contract, whereas parasympathetic stimulation causes miosis, or pupillary constriction, by causing the iris sphincter muscles to contract. The ciliary body lies just behind the iris; it produces aqueous humor. Ciliary muscle fibers adjust the focus by releasing tension on the suspensory fibers, or zonules, of the lens. Opacification of the lens causes a cataract. Uveitis is an inflammatory condition of these structures (iris, choroid, and ciliary body).

The innermost eye layer is the retina. Light stimulates retinal photoreceptors to produce neural signals that the optic nerve carries to the brain. There are no capillaries in the retina; the choroid layer provides the retina with oxygen. Retinal detachment from the choroid layer compromises the retinal blood supply and is a major cause of vision loss. The retinal layer ends approximately 4 mm behind the iris. The area between the limbus of the cornea and the retina is called the pars plana. Because there is no retinal layer there, it is a safe entrance site for vitrectomy procedures.

The center of the eye is filled with vitreous gel. This thick fluid has attachments to blood vessels and the optic nerve. Traction of the vitreous on the retina is a cause of
retinal detachment. Scarring, bleeding, or opacification of the vitreous is treated by vitrectomy.

The extraocular muscles move the globe within the orbit. They arise from a fibrous ring near the apex of the orbit and insert on the sclera. The six extraocular muscles lie within a cone behind the eye surrounding the optic nerve, ophthalmic artery and vein, and ciliary ganglion.

The eyelids have an outer layer of skin, a muscle layer, a tarsal plate of cartilage, and a layer of conjunctiva. The conjunctiva is a mucous membrane that lines the inner eyelids and covers the globe up to the corneal-scleral junction.

The lacrimal gland sits in the superior temporal orbit. It releases tears across the surface of the globe. Tears drain via the puncta near the medial canthus of the eyelids. Tears flow through the canaliculi to the lacrimal sac and duct, to drain into the nasopharynx.

The ophthalmic artery provides most of the blood supply to the orbital structures. It is a branch of the internal carotid artery, close to the circle of Willis. The superior and inferior ophthalmic veins drain directly into the cavernous sinus.

Cranial nerves (CN) innervate the ocular structures. The optic nerve (CN II) carries the neural signals from the retina. The oculomotor (CN III), trochlear (CN IV), and abducens (CN VI) control the extraocular muscles. Touch and pain sensation is carried via the trigeminal nerve (CN V). Sensation to the upper lid is via the maxillary nerve. Sensation to the upper lid is via the frontal branch of the trigeminal nerve. The nasociliary branch of the ophthalmic nerve sends sensory fibers to the medial canthus, lacrimal sac, and ciliary ganglion.

The ciliary ganglion provides sensory innervation to the cornea, iris, and ciliary body. Parasympathetic fibers originate from the oculomotor nerve (CN III) and synapse in the ciliary ganglion before supplying the iris sphincter muscle. Sympathetic fibers originate from the carotid plexus and travel through the ciliary ganglion to innervate the dilator muscle of the iris. Local anesthetic blockade of the ciliary ganglion produces a fixed, mid-dilated pupil.

The facial nerve (CN VII) exits the base of the skull from the stylomastoid foramen. It supplies motor innervation to the orbicularis muscle via the zygomatic branch. Local anesthetic block of the facial nerve can prevent lid squeezing.

The reflex may be seen more often with procedures under topical anesthesia. Retrobulbar block is not uniformly effective, however, at preventing the reflex. Orbital injections can trigger the response. The response is exacerbated by hypercapnia or hypoxemia.

In the event of arrhythmia, the anesthesiologist first should ask the surgeon to stop manipulations. The ventilatory status is assessed. If significant bradycardia persists or recurs, intravenous atropine is administered in 7-μg/kg increments. Rarely, severe bradycardia or asystole occurs. Although chest compressions might be required to allow the atropine to circulate, usually the heart rhythm returns to normal with cessation of manipulation alone. The response fatigues with repeated stimulation.

Pretreatment with intravenous atropine or glycopyrrolate can be effective. Pretreatment may be indicated in patients with a history of conduction block, vasovagal responses, or β-blocker therapy.

**INTRAOCULAR PRESSURE**

The blood supply to the retina and optic nerve depends on the intraocular perfusion pressure.  This perfusion pressure is defined as the difference between the mean arterial pressure and the intraocular pressure (IOP). High IOP impairs the blood supply, leading to a loss of optic nerve function. After an incision in the globe is made, factors that would increase IOP can cause prolapse and loss of intraocular contents; this can cause permanent vision loss.

The globe is a relatively noncompliant compartment. The volume of the internal structures is fixed except for aqueous fluid and choroidal blood volume. The quantity of these two factors regulates IOP.

Two thirds of the aqueous fluid is actively secreted by the ciliary body by a sodium-pump mechanism. One third comes from passive filtration through vessels on the iris. Aqueous fluid is produced at a rate of 2 μL/min. Aqueous fluid flows over the lens and through the pupil to bathe the inner corneal endothelium. It then enters the angle of the anterior chamber to flow through the trabecular meshwork to the canal of Schlemm. The canal of Schlemm is continuous with channels to the episcleral veins. IOP is primarily regulated by the resistance at the trabecular meshwork. Normal pressure is 10 to 20 mm Hg.

Impairment of aqueous drainage at any point can elevate the IOP. Sclerosis of the trabecular meshwork is believed to cause the chronic pressure elevation in open-angle glaucoma. Closed-angle glaucoma occurs when there is an obstruction to aqueous drainage from closure of the anterior chamber angle. This happens from peripheral iris swelling or anterior displacement. Patients with a preexisting narrow angle may be predisposed to this condition. The acute increase in pressure causes severe pain and is an ophthalmologic emergency.

Changes in choroidal blood volume can increase IOP rapidly. Hypercapnia causes choroidal congestion. Coughing, straining, or vomiting can increase IOP to 30 to 40 mm Hg. Endotracheal intubation can cause similar increases. These increases are transient and are relatively innocuous in a closed eye. In an open eye, such...
as after traumatic injury or during cataract surgery, these increases can lead to loss of intraocular contents, hemorrhage, and permanent vision loss.6
Extrinsic compression of the eye also increases the IOP. A normal blink increases the IOP by 10 mm Hg. A forceful lid squeeze can increase IOP to more than 50 mm Hg.7 A poorly placed anesthesia mask can put enough pressure on the eye to reduce blood flow to zero.
Deep inhaled or intravenous (e.g., propofol) anesthesia causes a dose-related reduction in IOP by 30% to 40%.8 Opioids have little effect. Usual doses of atropine do not cause a significant increase in IOP, even in patients with open-angle glaucoma. Ketamine can cause a modest increase in IOP.
 Intravenous succinylcholine causes IOP to increase by 6 to 12 mm Hg9; this lasts for 5 to 10 minutes. The use of succinylcholine for induction of anesthesia in cases of open-globe injury with full stomach has been controversial. Loss of vitreous in patients from succinylcholine has not actually been reported.

**OPHTHALMOLOGIC DRUGS**

Ophthalmologic drugs are systemic medications. Eye drops can have systemic effects and important drug interactions with anesthetics. Acetazolamide is a carbonic anhydrase inhibitor and is used for the treatment of glaucoma to decrease chronically increased IOP. It also induces an alkaline diuresis that can result in potassium depletion. Patients taking acetazolamide should have electrolytes checked preoperatively. Atropine eye drops can cause tachycardia, dry skin, fever, and agitation.10 Overdose can be treated with incremental doses of physostigmine.

Echothiophate is a topical anticholinesterase drug used to maintain miosis in the treatment of glaucoma. Systemic absorption leads to total body inhibition of plasma cholinesterase. Subsequent administration of succinylcholine can cause prolonged muscle paralysis (see Chapter 34).11 Inhibition of the metabolism of ester-type local anesthetics may predispose a patient to local anesthetic toxicity. Echothiophate is a long-acting. A return toward normal enzyme activity can take 4 to 6 weeks after discontinuation of the drug.

Mannitol is an osmotic diuretic that causes a decrease in IOP lasting 5 to 6 hours. Patients who receive mannitol during surgery may need a urinary catheter to avoid overdistention of the bladder. Mannitol causes an increase in the circulating blood volume, which can lead to congestive heart failure in patients with poor ventricular function.

Phenylephrine is an α-adrenergic agonist applied topically to dilate the pupil. Systemic absorption of the 10% solution is associated with severe hypertensive reactions.12 The 2.5% concentration is safer, but can exacerbate hypertension in some patients.

Pilocarpine and acetylcholine are cholinergic drugs used to constrict the pupil and can cause bradycardia and acute bronchospasm.

Timolol maleate is a topical β-blocker used for the treatment of glaucoma. Systemic absorption causes β-blockade, with possible bradycardia, bronchospasm, or exacerbation of congestive heart failure.13 These concerns are especially important in patients with severe chronic obstructive pulmonary disease.

Tamsulosin hydrochloride (Flomax) has selective α1-adrenoceptor antagonistic properties and binds for a long period to nerves to the iris dilator muscle, affecting iris dilation and leading to complications in cataract surgery. The iris remains floppy even after a 7- to 28-day interruption of the tamsulosin regimen.14

**PREOPERATIVE EVALUATION** *(see Chapter 38)*

Eye surgery is the most common surgery in the elderly (see Chapter 80). In 2005, the Medicare program paid for nearly 3 million claims for cataract surgery. These outpatient procedures are quick and do not involve blood loss or significant postoperative pain. They are not minor procedures, however; ophthalmic surgery can be a major life event. Establishing a professional relationship reduces anxiety and helps the patient prepare for surgery. Giving information to the patient is just as important as getting information from the patient. An informed patient is more calm, comfortable, and cooperative. The patient needs to know what to expect.

Patients undergoing eye surgery can be a high-risk group. Adults tend to be older. Most patients have other risk factors, such as diabetes, hypertension, and atherosclerosis.15 Cataracts are a marker for increased mortality in the Nurses’ Health Study.16 Yet, ophthalmic surgery is still low risk. Mortality after eye procedures is more infrequent than for the general surgical population. Backer and colleagues17 found that eye surgery did not pose the risk of myocardial reinfarction seen with general surgical procedures. Patients’ chronic diseases have less effect on outcome with these procedures. In a study of unanticipated hospital admissions after outpatient ophthalmic surgery, age and American Society of Anesthesiologists (ASA) physical status were not significant factors.18

There is controversy regarding the best preoperative management. Some clinicians say that because cataract extraction is a low-stress procedure with no blood loss, no preoperative evaluation is needed. Publication of a large, multicenter trial showed no effect of preoperative blood tests and electrocardiogram on postoperative outcome.19 Another opinion is that every patient must receive a full evaluation to include every possible test, to detect every possible finding, to institute every possible therapy, and to delay as long as possible, so that the patient can be in the best possible condition and have the lowest possible risk. The appropriate approach is likely in between these two approaches. Appropriate preoperative medical consultation is important. A study of malpractice litigation in cataract surgery found that medical consultation accounted for 16% of the liability; this compared with 17% attributed to either local or general anesthesia.20

Risk cannot be ignored. Neither should we reduce every risk to the lowest conceivable minimum. The anesthesiologist’s goal is to prepare the patient to present an acceptable risk at surgery. Acceptable risk is determined by the medical care team with the informed consent of
The patient. If a patient's condition would indicate inpatient admission for medical treatment, or if a reversible condition would likely lead to a perioperative complication, the risk is unacceptable.

The goal is to develop guidelines that would encourage consistency of care and minimize disruption to patients and the operating room. The following guidelines are presented after review of literature and published guidelines (see Chapters 38 and 80).

**PATIENT HISTORY**

Previous hospitalizations and surgical procedures are reviewed. Allergies and drug sensitivities are noted. Latex allergy should be addressed specifically. A current list of medications is obtained. Patient factors that could influence anesthetic management include dementia, deafness, language difficulty, restless legs syndrome, obstructive sleep apnea, tremors, dizziness, and claustrophobia. A preoperative patient questionnaire can be very helpful. A thorough review of the patient history helps with perioperative planning and establishing a physician-patient relationship.

**PHYSICAL EXAMINATION**

Check for signs of major cardiac or pulmonary conditions and problems. Particular attention should be paid to positioning issues, such as severe scoliosis or orthopnea (see Chapter 41).

**LABORATORY STUDIES**

No routine screening tests have been shown to improve outcome. Yet, laboratory studies should be determined based on the results of the history and physical examination. Generally, the tests that a patient needs before ophthalmic procedures are the same tests a patient would require at a routine examination if surgery were not planned. Tests are chosen when the results are likely to change management. Urgent medical management is obtained for results reaching critical limits. Indications for laboratory studies and critical results are as follows:

- **Electrocardiogram**: New chest pain, decreased exercise tolerance, palpitations, near-syncope, fatigue, or dyspnea; tachycardia, bradycardia, or irregular pulse on examination
- **Critical results**: Signs of acute ischemia or injury, malignant arrhythmia, complete heart block, atrial fibrillation that is new, or heart rate more rapid than 100 beats/minute
- **Serum electrolytes**: History of severe vomiting or diarrhea, poor oral intake, changes in diuretic management, or arrhythmia
- **Critical results**: Sodium less than 120 mEq/L or greater than 158 mEq/L; potassium less than 2.8 mEq/L or greater than 6.2 mEq/L
- **Urea nitrogen**: Signs or symptoms of renal decompensation
- **Critical result**: Greater than 104 mg/dL
- **Serum glucose**: Polydipsia, polyuria, or weight loss
- **Critical results**: Less than 46 mg/dL or greater than 480 mg/dL
- **Hematocrit/hemoglobin**: History of bleeding, poor oral intake, fatigue, decreased exercise tolerance, or tachycardia
- **Critical results**: Hematocrit less than 18% or greater than 61%; hemoglobin less than 6.6 mg/dL or greater than 19.9 mg/dL

**OPHTHALMIC EVALUATION**

Visual acuity of both eyes should be noted. Patients with poor vision in the nonoperative eye face much greater potential functional loss. These patients have a higher anxiety level. If the patient is to be patched overnight, the physician should anticipate the increased need for postoperative assistance for a temporarily blind patient.

The axial length of the globe should be assessed. When ultrasound measurements are available, the axial length should be noted. If no ultrasound is available, a myopic patient likely has an increased axial length. If a posterior staphyloma is present, the risks of injection anesthesia may be dramatically increased. Preoperative glaucoma history, increased IOP, and increased axial length are important risk factors for suprachoroidal hemorrhage. The risk can be reduced with intense control of intraoperative heart rate and arterial blood pressure. Preoperative softening of the globe with a compression device also may decrease risk.

**CARDIOVASCULAR EVALUATION**

The American Heart Association and American College of Cardiology published guidelines for perioperative cardiovascular evaluation for noncardiac surgery.**21** Ophthalmic procedures, such as cataract extraction, are specifically identified as low-risk procedures. For these procedures, evaluation is focused on patients with major clinical predictors of risk. These major predictors and the evaluation of the patient are reviewed in Chapters 38 and 39.

**HYPERTENSION**

Hypertension is a common problem in ophthalmic patients. Severe hypertension can lead to perioperative complications (see Chapter 39). Degrees of hypertension have been defined. Stage 3 of severe hypertension is defined as a systolic blood pressure of 180 mmHg or more or a diastolic blood pressure of 110 mmHg or more. Elective procedures in patients with sustained stage 3 hypertension should be delayed until after 2 weeks of antihypertensive therapy.

**PULMONARY CONSIDERATIONS**

Ophthalmic procedures generally require that the patient lie flat comfortably and quietly. If the patient cannot lie flat, or if there is intractable cough, a perioperative complication is more likely. Preoperative risk reduction strategies include cessation of cigarette smoking, treatment of airflow obstruction with bronchodilators or steroids, and administration of antibiotics for respiratory infections.
Patients should be assessed for sleep apnea. Intravenous sedation is often contraindicated in these patients. For some patients, treatment with a mild stimulant such as caffeine can be helpful in keeping them awake and cooperative during a procedure.

ENDOCRINE CONSIDERATIONS (Also see Chapter 39)

Diabetes mellitus is common in patients undergoing ophthalmic surgery. An early morning start for surgery is desirable to lessen the disturbance to the patient’s usual daily routine. Severe hyperglycemia and hypoglycemia should be avoided. A fasting blood glucose measurement should be checked preoperatively. Insulin therapy should be used, if needed, to maintain blood glucose at 150 to 250 mg/dL. The potential for autonomic neuropathy needs to be considered, especially when elevating the patient from the supine position.

Patients undergoing long-term steroid therapy generally do not require “stress-dose” steroid treatment for ophthalmic surgery. The patient should be given his or her normal steroid dose on the day of surgery. The physician should be alert to the occasional patient who might require additional glucocorticoid perioperatively. Unexpected hypotension, fatigue, and nausea may be signs of a patient who needs additional steroid.

ANTICOAGULATION

Many patients undergoing ophthalmic surgery take anticoagulants. Perioperative management of anticoagulants involves weighing the relative risks of thrombotic against possible hemorrhagic complications. Either of these results can be devastating to the patient. In a study of more than 19,000 cataract procedures, the incidence of hemorrhagic and thrombotic complications was infrequent.22

The risk of thrombotic complications depends on the following:

1. The indication for anticoagulation. Serious complications from arterial thromboembolic disease, such as atrial fibrillation or valvular heart disease, are much more common than complications from venous disease, such as deep vein thrombosis.
2. The risk factors for thromboembolism, especially if and when the patient had a previous episode of thromboembolism.

The risk of hemorrhagic complications depends on the following:

1. The degree of anticoagulation.
2. The hemorrhagic potential of the surgical procedure. Serious hemorrhagic complications are most probable in orbital and oculoplastic surgery; of intermediate probability in vitreoretinal, glaucoma, and corneal transplant surgery; and least likely in cataract surgery.

A consensus is developing that cataract surgery can be performed safely while maintaining patients receiving warfarin. For intermediate-risk procedures, such as some glaucoma surgeries, stopping warfarin intake for 4 days preoperatively is indicated. For high-risk cases for hemorrhage or thrombosis, conversion from warfarin to heparin may be required.

ANESTHETIC TECHNIQUES

REGIONAL TECHNIQUES

Eye surgery usually requires immobility (or akinesia) of the eye and profound anesthesia of the surgical site. Any discomfort during the procedure can be magnified by the patient’s anxiety and fear of possible vision loss.23 Various regional anesthetic techniques have been developed that satisfy the requirements of ophthalmologic surgery and are generally reliable and safe. Discomfort and anxiety are associated with many of these blocks, and so are rare but severe complications. Supplementation with intravenous sedation and continuous patient monitoring are frequently preferred.24,25 Intravenous sedation also may be associated with an increased incidence of medical events.26

Regional anesthesia has several advantages over general anesthesia (see Chapters 57 and 89). The local block gives significant postoperative analgesia. Nausea and vomiting are infrequent. The patient can return to ambulation faster. Most patients meet recovery discharge criteria at the end of surgery, and can bypass a stay in the postanesthesia care unit.

An intravenous infusion is started. Arterial blood pressure, electrocardiogram, and oxygen saturation monitors are placed. Supplemental oxygen is administered with nasal prongs. A foam wedge is placed to keep the knees flexed to prevent lower back pain. An air blower is often placed with the outlet on the chest to eliminate carbon dioxide and oxygen buildup under the drapes and to prevent claustrophobia.

An intravenous administration of midazolam (0.5 to 1 mg), fentanyl (12.5 to 50 μg), and propofol (30 to 50 mg) provides excellent amnesia and sedation for the placement of the blocks. This author omits midazolam and fentanyl in patients with limited cognitive reserve resulting from stroke or mild dementia. For local anesthesia, we use a 1:1 ratio of bupivacaine 0.75% and lidocaine 2% without epinephrine.27 Hyaluronidase is added to speed tissue penetration. Hyaluronidase can also be important in preventing anesthetic-related damage to the extraocular muscles.28 A human recombinant brand (Hylenex) is commercially available.

FACIAL NERVE BLOCKS

A facial nerve block is performed when complete akinesia of the eyelids is desired.29 Three methods for the eyelid block are as follows:

1. Modified van Lint block: The needle is placed 1 cm lateral to the orbital rim, and 2 to 4 mL of anesthetic is injected deep on the periosteum just lateral to the superolateral and inferolateral orbital rim. The disadvantages of this block include discomfort, proximity to the eye, and common postoperative ecchymoses.
2. O’Brien block: The mandibular condyle is palpated inferior to the posterior zygomatic process and anterior to...
the tragus of the ear as the patient opens and closes the jaw. The needle is inserted perpendicular to the skin approximately 1 cm to the periosteum. As the needle is withdrawn, 3 mL of anesthetic is injected.

3. Nadbath-Rehman block: A 12-mm, 25-gauge needle is inserted perpendicular to the skin between the mastoid process and the posterior border of the mandible. The needle is advanced its full length, and after careful aspiration, 3 mL of anesthetic is injected as the needle is withdrawn. This blocks the entire trunk of the facial nerve. The patient should be told to expect a lower facial droop for several hours postoperatively. The major disadvantage to this block is the proximity of the injection to important structures, such as the carotid artery and the glossopharyngeal nerve.

RETROBULBAR BLOCK

The retrobulbar block provides excellent akinesia and anesthesia of the eye. A 3-cm, 23- to 25-gauge blunt Atkinson needle is recommended to protect against ocular perforation. The needle is placed at the junction of the inferior and lateral walls of the orbit just above the inferior orbital rim. The needle is advanced its full length, and after careful aspiration, 3 mL of anesthetic is injected as the needle is withdrawn. This blocks the entire trunk of the facial nerve. The patient should be told to expect a lower facial droop for several hours postoperatively. The major disadvantage to this block is the proximity of the injection to important structures, such as the carotid artery and the glossopharyngeal nerve.

POSTERIOR PERIBULBAR BLOCK

To prevent retrobulbar hemorrhage, posterior peribulbar anesthesia has become more popular. A blunt, 23-gauge, 7/8-inch Atkinson needle is placed at the junction of the middle and lateral thirds of the lower lid just above the inferior orbital rim; 1 mL of local anesthetic is put just below the orbital septum, 3 mL at the equator, and 2 mL posterior outside the muscle cone. If no bulging is noted at the superior nasal lid area, a second injection of 2 to 3 mL is administered inferonasally. Disadvantages of the technique include a longer onset time (9 to 12 minutes) and lower incidence of complete akinesia. Globe perforation from peribulbar injection has been reported.

SUB-TENON BLOCK

To avoid the complications of sharp needles, a technique was developed using a blunt cannula under the fascia of Tenon. Various lengths of cannulas have been used. Using topical anesthesia with sedation, a speculum is placed to retract the lids. A 2- to 3-mm spot of cautery can be made 5 mm from the limbus in the inferonasal or inferolateral quadrant. A 2-mm snip is made in the conjunctiva with blunt dissection through the fascia of Tenon. A blunt cannula is directed under fascia of Tenon posteriorly, but not beyond the equator of the globe, with injection of 1 to 3 mL of local anesthetic. A small degree of conjunctival edema is often seen. Analgesia is usually excellent.

TOPICAL ANESTHESIA

Cataract surgery can be performed using topical anesthesia alone. This technique arose with the increase in popularity of small incision surgery and phacoemulsification. Topical anesthesia avoids the potential complications associated with retrobulbar and peribulbar injections. In addition, patients have the most rapid visual rehabilitation, with improved vision almost immediately after the procedure. Disadvantages of the technique include the potential for eye movement during surgery, increased patient anxiety, and discomfort from the microscope light. Tetracaine 0.5% and lidocaine 4% have been used successfully. Two drops of tetracaine are given initially. Approximately three more doses of tetracaine or lidocaine are applied every 5 minutes just before surgery.

Appropriate patient selection is crucial. A confident, calm, and cooperative patient usually does well. A nervous, hypersensitive patient may be a better candidate for another technique. Photophobic patients, those with small pupils, or the requirement of a large incision are other problems that may occur.

GENERAL ANESTHESIA

The choice of general versus regional anesthesia is made based on the duration of surgery, the relative risks and benefits of each technique for the patient, and patient preference. Neither technique has been shown to be safer.

In the past, regional anesthesia had an advantage of greatly reduced postoperative nausea and vomiting. With
the advent of shorter-acting general anesthetics and non-opioid analgesia, the incidence of nausea and vomiting has decreased dramatically. Droperidol has been used frequently as an antiemetic, although late postoperative anxiety can occur in some individuals. Ondansetron may be as effective with fewer side effects. A comparison of memory function in patients after general anesthesia or local anesthesia with sedation showed no advantage to either technique.38

The goals of general anesthesia include a smooth endotracheal intubation, stable IOP, avoidance of severe oculocardiac reflexes, a motionless field, and smooth emergence. These goals can be accomplished with inhaled volatile anesthesia, balanced opioid anesthesia, or intravenously administered anesthetics, with or without muscle relaxants. The laryngeal mask airway (LMA) can be used for ophthalmologic surgery and may be associated with less coughing on emergence. Because of the inaccessibility of the airway during the surgery, and the risk of laryngospasm or aspiration of gastric contents, LMA should be used only by anesthesia providers who are highly skilled in the technique. In some cases, the LMA may be more appropriate for extraocular surgery.

Nitrous oxide presents a special problem in some vitreoretinal procedures.39 In the technique called fluid-gas exchange, the surgeon injects an intravitreal air bubble to tamponade the retina against the wall of the globe. Sulfur hexafluoride is a poorly soluble gas used to prolong the resorption of intravitreal air bubbles. Nitrous oxide diffuses and causes bubble expansion, with the potential for dangerous increases in IOP. Nitrous oxide should be shut off for 15 minutes before placing the sulfur hexafluoride bubble and should be avoided for 7 to 10 days thereafter.

This problem is potentially worse with a relatively newer drug, perfluoropropane (C3F8), because this drug can persist for weeks. In this case, nitrous oxide should be avoided for at least 1 month, or until the bubble is resorbed. If a patient presenting for nonophthalmic surgery has a history of a recent retinal procedure, it is critical to establish whether the patient has an intravitreal gas bubble before using nitrous oxide. Otherwise, blindness can result.

ANESTHESIA FOR PEDIATRIC OPHTHALMOLOGIC PROCEDURES

Anesthesia for pediatric eye surgery can be considered a subspecialty of its own (see also Chapter 93).40 Small children may require examination under anesthesia. Intramuscular ketamine sometimes can be a good choice; it can be used when intravenous access may be problematic. Some ophthalmologists prefer ketamine because it does not reduce IOP as barbiturates, and deep levels of inhaled anesthetics do.

The most common eye surgery in children is for strabismus, or misalignment of the eyes. There is generally no severe postoperative pain, but nausea and vomiting are significant 50% to 80% of the time without treatment. Droperidol 5 to 75 μg/kg seems to decrease nausea and vomiting significantly without undue delay of discharge. Ondansetron has similar effects without sedation. If forced ductal testing is used to assess the muscle tightness, the surgeon should be notified if succinylcholine is used. Succinylcholine causes a tonic increase in eye muscle tone, which resolves in approximately 20 minutes.

Strabismus is a common condition, and most children are otherwise healthy. There is a more frequent incidence of strabismus in trisomy 21 or Down syndrome, cerebral palsy, and hydrocephalus. Malignant hyperthermia and myotonic dystrophy are associated with strabismus. Myotonic dystrophy also occurs in patients with ptosis and cataracts.

Cataracts can be seen in children with Pierre-Robin syndrome and phenylketonuria. Patients with Marfan syndrome have a frequent incidence of subluxation or dislocation of the lens. Aniridia, the congenital absence of the iris, is associated with Wilms tumor and hypertension. Congenital glaucoma also occurs with Sturge-Weber syndrome and with seizures and angiomas of the mouth and larynx. Pediatric ophthalmologic conditions associated with congenital syndromes are summarized in Table 84-1.
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**Intracapsular Cataract Extraction**

Intracapsular cataract extraction is the total removal of the opaque lens with the lens capsule. It can be done with a cryoprobe. Intracapsular cataract extraction is performed in selected cases of lens subluxation, dislocation, or a lens containing a foreign body.

**Extracapsular Cataract Extraction**

Extracapsular cataract extraction refers to the removal of the lens, while leaving the posterior lens capsule and zonules intact. A rim of the anterior capsule also is preserved; this provides an excellent location for an intraocular lens implant.

**PHACOEMULSIFICATION**

Phacoemulsification refers to the use of ultrasonic vibration of fragments of the lens with simultaneous irrigation and aspiration. This technique allows for very small incisions. New techniques are bringing the use of the femtosecond laser for the initial steps of creating corneal incisions, capsulotomy, and fragmenting the lens. Because use of the laser requires patient cooperation and because supplemental oxygen is contraindicated, these parts of the procedure are generally done under local anesthesia.

**GLAUCOMA PROCEDURES**

Glaucoma is a general term for diseases of the eye characterized by an increase in IOP.

**FILTRATION PROCEDURES**

Trabeculectomy is a surgical excision of the trabecula to increase the drainage of aqueous humor. Baerveldt and Ahmed devices are glaucoma drainage implants that shunt aqueous fluid out of the eye to drain under the conjunctiva of the orbit.

**PROCEDURES FOR THE CORNEA**

**Penetrating Keratoplasty**

A corneal transplant is done to replace an optically poor, infected, or traumatized cornea. Control of IOP and avoidance of patient movement are especially important in these open-globe procedures.

**Lamellar Keratoplasty**

Instead of a full thickness corneal graft, a layer of the corneal donor is used. A gas bubble can be used to hold the graft in place to adhere to the patient’s cornea. In Figure 84-1, intraoperative ocular coherence tomography

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**TABLE 84-1 OCULAR MANIFESTATIONS AND PEDIATRIC SYNDROMES**

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<th>Ocular Manifestation</th>
<th>Pediatric Syndrome</th>
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<td>Strabismus</td>
<td>Trisomy 21</td>
<td>Retinal hemorrhage</td>
<td>Acquired immunodeficiency syndrome (AIDS)</td>
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<td>Cerebral palsy</td>
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shows how after placement of the corneal graft, the eye is pressurized to cause the graft to adhere.

**Radial Keratotomy**
A series of incisions is made in the cornea in a spikelike manner to change the shape of the cornea to correct myopia.

**Pterygium Excision**
A pterygium is an abnormal fold of membrane in the interpalpebral fissure. An excision is generally performed when the abnormal tissue impinges on the cornea, affecting vision, or for cosmetic improvement.

**VITREORETINAL SURGERY**

**Retinal Cryotherapy**
A cryoprobe is used for prophylaxis of certain retinal breaks and tears. This technique is used in some patients with retinal tumors and vascular malformations.

**Repair of Retinal Detachment**
Retinal reattachment involves localizing all tears and holes, creating chorioretinal adhesions, and scleral buckling with silicone belts around the globe to pull the sclera in to support the retina.

**Vitrectomy**
Vitrectomy is the surgical extraction of the contents of the vitreous chamber and their replacement with a physiologic solution. A posterior vitrectomy is indicated for the removal of foreign bodies, to repair retinal detachments, to remove membranes and media opacities, and to alleviate vitreous traction on the retina. These procedures may be prolonged. Many patients have diabetes or severe chronic hypertension, which can influence the conduct of anesthesia (see Chapter 39).

**OCULOPLASTIC SURGERY**
Most oculoplastic surgery is performed with local infiltration anesthesia. Some longer, more invasive procedures require general anesthesia.

**Ectropion Repair**
Ectropion usually results from the effects of aging on the eyelid. Other causes include mechanical or congenital lid pathology. The eyelid is turned outward.

**Entropion Repair**
Involutional entropion usually results from aging. The eyelid is inverted or turned inward.

**Ptosis Repair**
Ptosis, or drooping of the upper eyelid, can be congenital (dystrophy of the levator muscle) or acquired from aging or trauma.

**Blepharoplasty**
Blepharoplasty is plastic surgery of the eyelids to remove redundant tissue that is obstructing vision, or for improved appearance.

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Figure 84-1. Intraoperative optical coherence tomography cross sections in a patient undergoing Descement stripping automated endothelial keratoplasty (DSAEK) immediately after delivery and unfolding of the donor graft (A). After elevation of the intraocular pressure, the size of the gap is decreased (B, C). After sweeping maneuver, there is no interface gap (D). (Courtesy William J. Dupps.)
Chapter 84: Anesthesia for Eye Surgery

DACRYOCYSTORHINOSTOMY

Dacryocystorhinostomy refers to the formation of a communication channel between the lacrimal sac and the nasal cavity. This is performed for congenital or acquired nasolacrimal duct obstruction. It usually requires general anesthesia.

ORBITAL SURGERY

Most orbital surgery is performed using general anesthesia. If the surgery is anterior, local anesthesia can be used. Examples of orbital surgery include the following:

- Repair of blowout fracture
- Drainage of orbital abscess
- Decompression of the optic nerve
- Exenteration of the orbit for malignancy

OPHTHALMOLOGIC EMERGENCIES

Most urgent ophthalmologic procedures do not need to be performed on an emergency basis. This is important because the anesthetic plan must consider the NPO (nil per os, nothing by mouth) status and general medical condition of the patient. This does not apply to true eye emergencies. In these rare conditions, therapy should be started within minutes. Other urgent ophthalmologic conditions can start within 1 to several hours, without a change in outcome.

True Emergencies

Therapy should be started within minutes for chemical burns of the cornea and central retinal artery occlusion.

Urgent Situations

Therapy should be started in 1 to several hours. Urgent situations include open-globe injuries, endophthalmitis, acute narrow-angle glaucoma, acute retinal detachment, corneal foreign body, and lid laceration.

Semiurgent Situations

Therapy should be started within days, but sometimes can be rescheduled for several weeks. Semiurgent situations include ocular tumors, blowout fractures of the orbit, congenital cataract, and chronic retinal detachment.

Open Globe and Full Stomach

A patient with eye trauma presents a challenge to the anesthesia provider. The dilemma is to protect the patient from pulmonary aspiration of stomach contents and to protect the eye from acute changes in IOP, which could cause vitreous loss, retinal detachment, and blindness. A rapid-sequence induction of anesthesia provides rapid control of the airway, but succinylcholine causes a modest increase in IOP. Of course, intubating the trachea during light anesthesia or inadequate neuromuscular blockade can cause large increases in IOP, which needs to be avoided. Attentiveness to neuromuscular monitoring can confirm the adequacy of neuromuscular blockade (see Chapters 34 and 53). Regional anesthetic techniques can also be performed. Factors to consider include the following:

- **Size of the perforation:** Small punctures have higher resistance to vitreous loss with changes in IOP.
- **Pulmonary status:** Patients with decreased functional residual capacity become rapidly hypoxic making a more rapid technique preferable.
- **NPO status:** What is the magnitude of the pulmonary aspiration of gastric contents risk?
- **Length of procedure:** If the surgery is short, and a large dose of nondepolarizing neuromuscular blocker is used, can the block be reversed (see Chapter 35) or will postoperative mechanical ventilation occur?

ANESTHESIA-RELATED EYE INJURIES

Anesthesia providers must be aware of possible ocular damage during anesthesia and surgery (see Chapter 41). If a patient emerges from a general anesthetic complaining of vision impairment, an emergency may exist because of the possibility of central retinal artery occlusion. When using a facemask, care must be taken to avoid applying undue pressure to the eye. Systemic hypotension and anemia also can be contributing factors in vision loss.

A second potential complication is corneal abrasion. General anesthesia decreases basal tear production. Proper eye care with taping of lids with or without an ocular lubricant provides protection. If a patient emerges from general anesthesia with eye pain or a foreign body sensation, the patient must be observed continually to ensure improvement. If left untreated, corneal abrasions can progress to form corneal ulcers.

Complete references available online at expertconsult.com.

REFERENCES

References

22. Lai F, Sutton B, Nicholson G: Comparison of l-bupivacaine 0.75% and lidocaine 2% with bupivacaine 0.75% and lidocaine 2% for peribulbar anaesthesia, Br J Anaesth 90:512-514, 2003.