Chapter

31 OPHTHALMOLOGY AND OTOLARYNGOLOGY

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In addition to the usual anesthetic issues, surgical procedures of the head and neck present unique anesthetic challenges. Isolation from the surgical field physically places the anesthesia provider at a distance from the airway and hampers access to the patient. In addition to common anesthetic problems, the region's extensive parasympathetic innervations predispose patients to intraoperative bradycardia and asystole. Ophthalmic and otolaryngologic procedures require smooth induction of and emergence from anesthesia. This is especially important because coughing and "bucking" increase venous and intraocular pressure, which may negatively impact surgical outcome.

OPHTHALMOLOGY

Ophthalmic procedures are among the most commonly performed surgical procedures worldwide. More than 2 million cataract operations are performed nationally each year. Most eye procedures are considered an uncommon risk for perioperative complications; however, ophthalmic patients are often at greater risk during surgery because typically they include the elderly (also see Chapter 35), who frequently have multiple concomitant medical issues, or pediatric patients (also see Chapter 34), who may be premature or have associated syndromes.[1] Additionally, most operations are conducted on an ambulatory basis (also see Chapter 37), emphasizing the importance of preoperative evaluation (also see Chapter 13).

Most ophthalmologic procedures are performed via monitored anesthesia care (MAC) and some form of regional or topical eye anesthetic.[2] Aside from intraoperative analgesia and akinesia, advantages of ophthalmic regional blocks include suppression of the oculocardiac reflex (OCR) and provision of postoperative pain management. An understanding of regional block techniques and management of their complications is requisite. General anesthesia is reserved for operations of prolonged duration, more invasive orbital procedures, and for patients unable to remain relatively still such as neonates, infants, and children (also see Chapter 34).

Anesthetic drugs and maneuvers may affect ocular dynamics and surgical outcomes, and ophthalmic medications can cause adverse anesthesia reactions or may significantly impact systemic physiology. Appreciation of factors affecting intraocular pressure (IOP) and vigilance vis-à-vis the OCR are critical.

Intraocular Pressure

Adequate pressure within the eye serves to maintain refracting surfaces, corneal contour, and functionally correct vision. IOP is primarily derived from a balance between aqueous humor production and drainage. Aqueous humor is actively secreted from the posterior chamber's ciliary body and flows through the pupil into the anterior chamber where it is admixed with aqueous passively produced by blood vessels on the iris's forward surface. After washing over the avascular lens and corneal endothelium, aqueous humor filters through the spongy trabecular meshwork into the canal of Schlemm tubules at the base of the cornea. From there, it exits the eye into episcleral veins and ultimately to the superior vena cava and right atrium. Therefore, any obstruction of venous return from the eye to the right side of the heart can increase IOP. Lesser factors that influence IOP include force transmitted to the globe by contraction of the orbicularis oculi or extraocular muscles as well as hardening of the lens, vitreous, and sclera that can occur with aging (also see Chapter 35).

IOP ranges between 10 and 22 mm Hg in the intact normal eye. Typically, there is a 2 to 5 mm Hg diurnal variation. Small transient changes occur with each cardiac contraction as well as with eyelid closure, mydriasis, and postural changes. These changes are normal and have no bearing on the intact eye. A sustained increase in IOP during anesthesia, however, has the potential to produce acute glaucoma, retinal ischemia, hemorrhage, and permanent visual loss.

Factors That Influence Intraocular Pressure

Venous congestion resulting from obstruction at any point from the episcleral veins to the right atrium may cause substantive increase of IOP. Prior to induction of anesthesia, Trendelenburg positioning or presence of a tight cervical collar can increase intraocular blood volume, dilate orbital vessels, and inhibit aqueous drainage. Straining, retching, or coughing during induction of anesthesia will markedly increase venous pressure and can readily precipitate an increase in IOP of 40 mm Hg or more. Should this occur while the globe is open during surgery, such as during corneal transplant, loss of vitreous, hemorrhage, and expulsion of eye contents may lead to permanent damage to the eye or even blindness. Arterial hypertension can transiently increase IOP, but has much less impact than perturbations of venous drainage. External compression on the globe by a tightly applied face mask, laryngoscopy, and tracheal intubation also elevate IOP, but placement of a supraglottic airway has minimal impact. Hypoxemia and hypoventilation can increase IOP. Hyperventilation and hypothermia have the opposite effect.

Anesthetic Drugs and Intraocular Pressure

Inhaled and most intravenous anesthetics produce dose-related reductions in IOP. Although the exact mechanisms are not known, IOP is probably reduced by a combination of central nervous system depression, diminished aqueous humor production, enhanced aqueous outflow, and relaxation of extraocular muscles. There is controversy surrounding the effect of ketamine on IOP. Although ketamine may not increase IOP, it does cause rotatory nystagmus and blepharospasm, making it a less than ideal anesthetic for eye surgery.

In the absence of alveolar hypoventilation, nondepolarizing neuromuscular blocking drugs decrease IOP via relaxation of the extraocular muscles. In contrast, succinylcholine produces an increase of about 9 mm Hg in 1 to 4 minutes after intravenous administration with a subsequent diminution to baseline within 7 minutes. The increase in IOP is probably due to several mechanisms, including tonic contraction of extraocular muscles, relaxation of orbital smooth muscle, choroidal vascular dilation, and aqueous outflow-impeding cycloplegia. Pretreatment with a small dose of a nondepolarizing neuromuscular blocking drug, lidocaine, β-blocker, or acetazolamide may attenuate the increase in IOP associated with induction of anesthesia with succinylcholine, direct laryngoscopy, and endotracheal intubation. However, this approach for induction of anesthesia is rarely used.

Ophthalmic Medications

Systemic absorption of topical ophthalmic drugs from either the conjunctiva or via drainage through the nasolacrimal duct onto the nasal mucosa can produce untoward side effects. These drops include acetylcholine, anticholinesterases, cyclopentolate, epinephrine, phenylephrine, and timolol (Table 31.1). Phospholine iodide (echothiophate) is a miosis-inducing anticholinesterase that profoundly interferes with metabolism of succinylcholine. Prolonged paralysis following a single dose of succinylcholine may ensue. Phenylephrine drops are available in concentrations of 2.5% and 10%. Systemic absorption via the nasolacrimal duct of 10% phenylephrine drops can induce transient malignant hypertension. Parenteral administration of a long-acting antihypertensive drug may result in untoward

Table 31.1 Drugs Administered to Ophthalmic Surgery Patients

Ophthalmic Indication	Drug	Mechanism of Action	Systemic Effect
Miosis	Acetylcholine	Cholinergic agonist	Bronchospasm, bradycardia, hypotension
Glaucoma (increased intraocular pressure)	Acetazolamide	Carbonic anhydrase inhibitor	Diuresis, hypokalemic metabolic acidosis
	Echothiophate	Irreversible cholinesterase inhibitor	Prolongation of succinylcholine's effects Reduction in plasma cholinesterase activity up to 3-7 weeks after discontinuation Bradycardia, bronchospasm
	Timolol	β-Adrenergic antagonist	Atropine-resistant bradycardia, bronchospasm, exacerbation of congestive heart failure; possible exacerbation of myasthenia gravis
Mydriasis, ophthalmic capillary decongestion	Atropine	Anticholinergic	Central anticholinergic syndrome (*mad as a hatter*, delirium, agitation; *hot as a hare*, fever; *red as a beet*, flushing; *dry as a bone*, xerostomia, anhidrosis) Blurred vision (cycloplegia, photophobia)
	Cyclopentolate	Anticholinergic	Disorientation, psychosis, convulsions, dysarthria
	Epinephrine	α-, β-Adrenergic agonist	Hypertension, tachycardia, cardiac dysrhythmias; epinephrine paradoxically leads to decreased intraocular pressure and can also be used for glaucoma
	Phenylephrine	α-Adrenergic agonist, direct-acting vasopressor	Hypertension (1 drop, or 0.05 mL, of a 10% solution contains 5 mg of phenylephrine)
	Scopolamine	Anticholinergic	Central anticholinergic syndrome (see atropine earlier)

hypotension following resolution of the short-acting phenylephrine. Some systemic ophthalmic drugs, such as glycerol, mannitol, and acetazolamide, may also produce untoward side effects.

Oculocardiac Reflex

The OCR is a sudden profound decrease in heart rate in response to traction on the extraocular muscles or external pressure on the globe. There is a wide range of reported incidence, varying from approximately 15% to 80%. This reflex occurs more commonly in young patients. The reflex arc has a trigeminal nerve afferent limb that generates an efferent vagal response that may precipitate a variety of dysrhythmias including junctional or sinus bradycardia, atrioventricular block, ventricular bigeminy, multifocal premature ventricular contractions, ventricular tachycardia, and asystole.

The OCR is most often encountered during strabismus surgery but can occur during any type of ophthalmic surgery. OCR may also occur while performing an eye regional anesthetic nerve block. Hypercarbia, hypoxemia, and light planes of anesthetic depth augment the incidence and severity of OCR.

Prompt removal of the instigating surgical stimulus frequently results in rapid recovery. Unrelenting tension may induce cardiac arrest, so heart rate must be continuously monitored during eye regional block and surgery. At the first sign of dysrhythmia, surgery must stop and all pressure on the eye or traction on eye muscles discontinued. The ventilatory status and depth of anesthesia should be reassessed. The reflex may extinguish itself after a few minutes; it also can be abated by administration of a parasympatholytic drug such as atropine or glycopyrrolate. The OCR can also be eradicated by inserting a regional anesthetic eye block, thereby abolishing its afferent arc. Paradoxically, placement of a regional block can induce the OCR.

The prophylactic use of intramuscular anticholinergics for adult ophthalmic surgery patients is not effective. In fact, tachycardia following atropine or glycopyrrolate may have significant consequence for geriatric patients with history of cardiac disease (also see Chapter 25). In children (also see Chapter 34), who are more dependent on heart rate to maintain cardiac output, prophylactic intravenous administration of atropine (0.01 to 0.02 mg/kg) or glycopyrrolate may be prudent just prior to commencing eye surgery.

Preoperative Assessment

Patients having eye surgery are often at the extremes of age—ranging from premature babies with retinopathy to the elderly. Hence, special age-related considerations such as altered pharmacokinetics and pharmacodynamics

Box 31.1 Goals for Anesthesia Management of Ophthalmic Surgery

Safety
Analgesia
Akinesia (when indicated)
Control of intraocular pressure
Avoidance of the oculocardiac reflex
Awareness of possible drug interactions
Awakening without coughing, nausea, or vomiting

apply (also see Chapters 13 and 35). The elderly, pediatric patients with various syndromes, and premature infants frequently have multiple comorbid conditions. Preoperative evaluation is vital, but routine laboratory testing is not appropriate. For cataract surgery in particular, routine testing is associated with a significant increase in health care spending.[3] Physician assessment and judgment determine the need for indicated laboratory testing.[4] Cessation of antiplatelet/anticoagulant drugs prior to eye surgery is controversial.[5] The risk of intraocular bleeding versus the risk of perioperative stroke, myocardial ischemia, and deep venous thrombosis must be assessed.[6]

One of the most important preoperative assessments is the likelihood of patient movement during surgery. Inability to remain supine and relatively still during intraocular surgery with MAC result in eye injury and have devastating long-term visual consequences.[7]

Anesthetic Options

Anesthetic options for most ophthalmic procedures include general anesthesia, retrobulbar (intraconal) block, peribulbar (extraconal) anesthesia, sub-Tenon block, and topical analgesia (see Box 31.1). Often, there is minimal exposure to regional anesthetic eye block techniques during anesthesia training, creating a reluctance to perform such blocks. Professional societies dedicated to teaching safe ophthalmic regional anesthesia can provide valuable instruction.[8] Site of surgery errors is more common for eye procedures than all other surgeries (except dental and digital). Of prime importance is confirmation of the correct eye (i.e., right versus left) immediately prior to anesthesia and surgery.

Needle-Based Ophthalmic Regional Anesthesia

The anatomic foundation of needle-based eye blocks rests upon the concept of the orbital cone. This structure consists of the four ocular rectus muscles extending from their origin at the apex of the orbit to the globe anteriorly. These muscles and their surrounding connective tissue form a compartment behind the globe akin to the brachial plexus sheath in the axilla.

A retrobulbar block is performed by inserting a steeply angled needle from the inferotemporal orbital rim into this muscle cone such that the tip of the needle is behind (retro) the globe (bulbar).[9] A more descriptive term is intraconal block (Fig. 31.1).[10] Injection of a small volume of local anesthetics into this compartment will produce rapid onset of akinesia and analgesia.

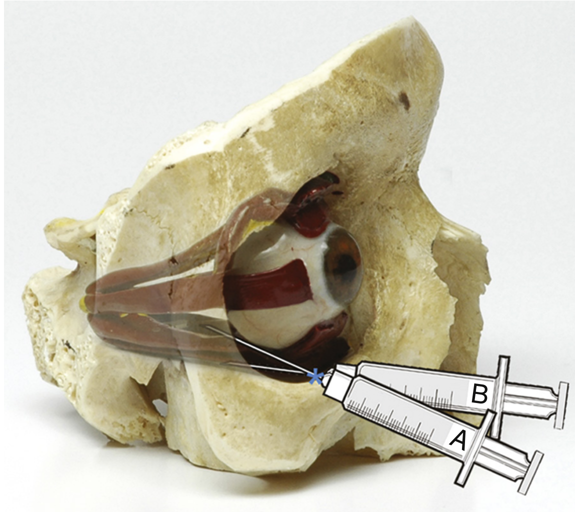

Fig. 31.1 Needle-based regional anesthesia for ophthalmic surgery. (A) An intraconal (retrobulbar) block is placed deeper and is more steeply angled. (B) An extraconal (peribulbar) block is shallower and minimally angled. Asterisk indicates needle entry point. A portion of the lateral orbital rim is removed. (Model courtesy of Dr. Roy Hamilton.)

The boundary separating the intraconal from extraconal space is porous, and thus local anesthetics injected outside the muscle cone diffuse inwardly. A peribulbar block can be achieved by directing a minimally angled needle to a shallow depth such that the tip remains outside the cone (see Fig. 31.1). This extraconal block is theoretically safer because the needle is not directed toward the apex of the orbit; hence the needle tip is ultimately situated further from key intraorbital structures. This distance minimizes the potential for optic nerve trauma, optic nerve sheath injection, orbital epidural, and brainstem anesthesia. Complications of needle-based eye blocks are listed in Box 31.2. Because extraconal block local anesthetics are injected at a farther distance from the nerves, larger volumes and more time for diffusion of the local anesthetic are needed. Thus, intraconal versus extraconal anesthesia is somewhat analogous to subarachnoid versus epidural anesthesia in terms of volume, onset, and density of block.

Altered physiologic status following an ophthalmic anesthetic block has important implications. Differential diagnosis includes oversedation, brainstem anesthesia, and intravascular injection of local anesthetic (Table 31.2). Abrupt onset of seizure activity is characteristic of intravascular injection. Convulsions are typically of brief and limited duration. Brainstem anesthesia

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Box 31.2 Complications of Regional Anesthesia for Ophthalmic Surgery

Superficial or retrobulbar hemorrhage
Elicitation of the oculocardiac reflex
Puncture of the globe
Intraocular injection
Optic nerve trauma
Seizures (intravenous injection of local anesthetic solution)
Brainstem anesthesia (spread of local anesthetic to the brainstem causing delayed-onset loss of consciousness, respiratory depression, paralysis of the contralateral extraocular muscles)
Central retinal artery occlusion
Blindness

Table 31.2 Differential Diagnosis of Altered Physiologic Status After Regional Anesthesia for Ophthalmic Surgery

Alteration	Oversedation	Brainstem Anesthesia	Intravascular Injection
Loss of consciousness	±	+	+
Apnea	±	+	±
Cardiac instability	±	+	±
Seizure activity	Ø	Ø	+
Contralateral mydriasis	Ø	±	Ø
Contralateral eye block	Ø	±	Ø

+, Likely; ±, may or may not be present; Ø, not present.

may have a gradual latency of onset and persist for 10 to 40 minutes, or longer. Patients must be continuously monitored following anesthetic eye blocks for signs of oversedation, brainstem anesthesia, and intravascular absorption of local anesthetics.

Branches of the facial nerve that innervate the eyelid's orbicularis oculi muscle are blocked by the larger volume of local anesthetic used with extraconal injection. This prevents eyelid squeezing and is a distinct advantage during corneal transplantation. An intraconal block requires a separate facial nerve injection to limit blepharospasm.

Cannula-Based Ophthalmic Regional Anesthesia

Ophthalmic anesthesia can also be achieved by instilling local anesthetics through a blunt cannula into the space between the globe's rigid sclera and sub-Tenon capsule (Fig. 31.2).[11] The capsule consists of fascia that envelops the eye, providing a smooth friction-free interface in which to rotate. Anteriorly, it originates near the limbal margin where it is fused to the conjunctiva. As the capsule extends posteriorly, it surrounds the eye, with portions reflected onto the extraocular muscles. Local anesthetics injected into the sub-Tenon space block cranial and ciliary nerves that penetrate the capsule as well as the optic nerve posteriorly.

Anesthesia Management of Specific Ophthalmic Procedures

Retina Surgery

The globe's posterior inner wall is lined by the retina, sensory tissue that converts incoming light into neural output and, ultimately, vision. The densely packed macula near its center provides fine detailed vision. Perfusion comes from the choroid layer situated between the sclera and the retina. The retina may break or detach from the choroid leading to ischemia and compromised vision. Diabetics and people with myopia are at particular risk. Surgical options include combinations of scleral buckle, vitrectomy, laser, cryotherapy, and injection of intravitreal gas.

Preoperative evaluation of patients with diabetes and coexisting comorbid conditions (also see Chapter 13) is important, and appropriate changes should be made to ensure that these patients are in optimal medical condition for surgery. Sudden death during retina surgery can occur due to venous air embolism introduced into the choroid blood flow during the air/fluid exchange portion of vitrectomy. Retina surgery is often prolonged and associated with more extensive manipulation of the eye, therefore requiring general anesthesia or dense regional anesthetic block with MAC. Perfluorocarbons such as sulfur hexafluoride (SF6) and C_3F_8 are inert, relatively insoluble gases that are injected to internally tamponade the retina onto the choroid. Resorption can take 10 to 28 days depending on which drug is selected. As nitrous oxide is over 100-fold more diffusible than SF6, it can expand the size of the gas bubble, increase IOP, and potentially cause retinal ischemia and permanent loss of vision.[12] Nitrous oxide should be discontinued 20 minutes prior to gas injection or omitted altogether.

Glaucoma

Glaucoma is commonly characterized as a sustained increase in IOP that leads to diminished perfusion of the optic nerve and eventual loss of vision. Various forms of glaucoma exist, each presenting with differing degrees of IOP variation. Terminology can be confusing, resulting in several classifications: acquired versus congenital, high-IOP versus normal-pressure, acute versus chronic, and open- versus narrow- or closed-angle. Angle-closure (acute) glaucoma occurs when the angle between the iris and cornea narrows and obstructs outflow. Open-angle (chronic) glaucoma results from sclerosis of trabecular

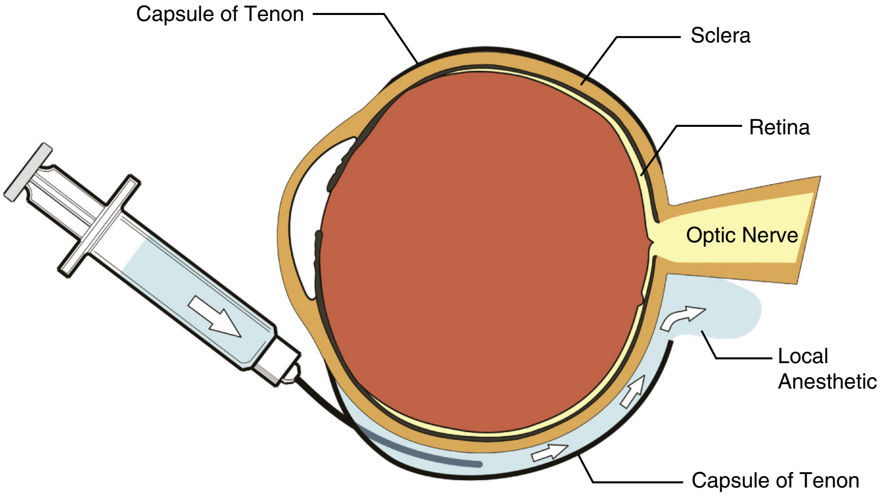

Fig. 31.2 Sub-Tenon block. Local anesthetic is infused via a cannula into the potential space between Capsule of Tenon and the sclera, ultimately arriving at the optic nerve.

meshwork and impaired aqueous drainage. Outflow is improved with constriction of the pupil by miotic drugs. Administration of atropine drops into the eye produce mydriasis and are contraindicated. Intravenous atropine on the other hand is minimally absorbed by the eye and should be used when indicated during anesthesia. Infantile glaucoma may readily progress to blindness, making early surgery more urgent. Congenital glaucoma is often a component of many syndromes, several of which have important anesthesia implications.

Many adult glaucoma procedures can be managed with regional anesthesia and MAC. General anesthesia is a requisite for pediatric glaucoma cases. Anesthesia implications include (1) avoiding mydriasis by continuing all miotic drops, (2) understanding the interactions of antiglaucoma medications and anesthetics (see Table 31.1), and (3) preventing increases in IOP associated with induction, maintenance, and emergence from anesthesia.

Strabismus Surgery

Strabismus surgery is performed to correct misalignment of extraocular muscles and realign the visual axis. Most patients are pediatric (also see Chapter 34). Special considerations include (1) frequent incidence of intraoperative OCR, (2) potential increased risk for malignant hyperthermia, and (3) marked prevalence of postoperative nausea and vomiting (PONV).

Nausea and Vomiting

The incidence of PONV following strabismus surgery varies widely but has been quoted as high as 85% (also see Chapter 39). PONV is the most common reason for pediatric inpatient admission after outpatient surgery and is probably a vagal-mediated response to surgical manipulation of extraocular muscles. Multimodal antiemetics with differing mechanisms of action may be more effective than individual medications for those patients at most risk of PONV following eye surgery.

Malignant Hyperthermia

Strabismus is a neuromuscular disorder that can be associated with other myopathies. The frequency of masseter muscle spasm after succinylcholine is fourfold greater than baseline. Suspect malignant hyperthermia if hypertension, tachycardia, hypercarbia, and increasing temperature occur.

Traumatic Eye Injuries

Eye injury occurs as a result of penetrating or blunt trauma. The anesthesia plan must balance specific risks. Increased IOP due to a tightly applied face mask, laryngoscopy, and endotracheal intubation, or due to coughing or bucking, can cause extrusion of globe contents and jeopardize vision. Additionally, in emergency situations, the patient may be nonfasting and at risk of aspiration of gastric contents upon induction of general anesthesia. Control of the airway can be achieved with a rapid-sequence induction of anesthesia including succinylcholine; however, succinylcholine can also cause a transient increase in IOP.[13] Awake endotracheal intubation may be appropriate for patients with difficult airways; however, the resultant increases in IOP can be disastrous. The risks of succinylcholine or awake intubation on IOP must be weighed against the dangers imposed by a full stomach or difficult airway.

The anesthesia provider should ask the ophthalmologist if the operative repair can be delayed until the stomach is considered safe. If not, then proceed after careful evaluation to rule out other issues. Administer appropriate drugs to decrease gastric acidity and volume. Place the patient in slight reverse Trendelenburg position and avoid any maneuvers that may increase IOP. If no airway problems are anticipated, consider a modified rapid-sequence induction of anesthesia with a large dose of a nondepolarizing neuromuscular blocking drug (e.g., rocuronium, 1.0 mg/kg). If succinylcholine is selected, the IOP and systemic hypertension following laryngoscopy/intubation can be moderated by intravenous lidocaine, opioids, or a small pretreatment dose of nondepolarizing neuromuscular blocker prior to induction of anesthesia. Regional anesthesia may be an option for select injuries and patients at greater risk from general anesthesia.[14]

Postoperative Eye Issues

Corneal Abrasion

The most common cause of postoperative eye pain after general anesthesia is corneal abrasion. It manifests with conjunctivitis, tearing, and foreign body sensation. Damage may be mechanically incurred by dangling ID tags, the anesthesia mask, drapes, and other objects. During general anesthesia, abrasion may also occur because of the loss of the blink reflex, the drying effects of exposure to air, and diminished tear production. Preventive measures include gently taping the eyelids shut during mask ventilation, endotracheal intubation, and thereafter. Ointments may cause allergic reaction or blurred postemergence vision. Protective goggles may be best. Antibiotic ointment and patching the eye usually result in healing of corneal abrasions within a day or two.

Acute Glaucoma

Acute glaucoma is also painful. Presence of a mydriatic pupil may be diagnostic. This is an urgent matter calling for consult with an ophthalmologist. Intravenous mannitol or acetazolamide can decrease IOP and relieve pain.

Postoperative Visual Loss

Painless loss of vision after surgery may be due to ischemic optic neuropathy (ION) or brain injury. Both are rare events. Risk is more frequent with spine surgery in the prone position and cardiac surgery.[15] Consultation with an ophthalmologist is mandatory as early funduscopic examination may aid in diagnosis.

OTOLARYNGOLOGY

Ear, nose, and throat (ENT) surgery can make the airway fairly inaccessible and is commonly referred to as *field avoidance*. Preoperative planning with the surgeon and nursing staff is essential.[16] There is a distinct possibility of encountering a difficult airway because of anatomic factors, surgical issues, or underlying disease. Attention should be directed to the establishment and firm anchoring of an endotracheal airway. The endotracheal tube (ETT) should be manually supported during patient repositioning such as turning of the head because movement can result in endobronchial intubation, tube occlusion, cuff leaks, disconnections, or even frank dislodgement of the ETT and inadvertent extubation. Prior to surgical preparation or placement of drapes, the neck position should be reassessed, and susceptible pressure points padded. During surgery, the airway may be compromised by often undetected bleeding, edema, or surgical manipulation. The use of posterior pharyngeal packs can minimize the risk of aspiration of gastric contents. Operating room (OR) personnel should be alerted to their placement, and there must be confirmation of the complete removal of all packs prior to extubation of the trachea.

Special Considerations for Head and Neck Surgery

The Difficult Airway (Also See Chapter 16)

All airway concerns should be addressed with surgical colleagues prior to patient entry into the OR. Supplementary equipment must be readied in anticipation of a possible difficult airway, and expert assistance should be immediately available. Modified techniques to secure the airway include use of videolaryngoscopy, fiberoptic bronchoscopy, or even performance of a tracheostomy under local anesthesia. The placement of tracheal retention sutures with tracheostomy can facilitate recapture of airway access should it become compromised during or after surgery. Procedures within the airway can produce significant edema resulting in acute obstruction. In the postoperative period these patients may need to remain tracheally intubated, or, if extubated, they may require treatment with humidified oxygen or nebulized bronchodilators.

Laryngospasm

The laryngospasm reflex is mediated through vagal stimulation of the superior laryngeal nerve. Abrupt intense, prolonged closure of the larynx with compromise of ventilation can occur upon instrumentation of the endolarynx, with blood or foreign body presence, and with inadequate depth of anesthesia. If the airway is completely obstructed, the anesthesia provider may be unable to ventilate the patient despite an adequate mask fit. The ensuing hypercarbia, hypoxia, and acidosis elicit an autonomic sympathetic response producing hypertension and tachycardia. A temporal reduction in brainstem firing to the superior laryngeal nerve eventually causes relaxation of the vocal cords. In small children even brief laryngospasm is particularly perilous as peripheral oxygen saturation decreases precipitously as a result of a small functional residual capacity and relatively high cardiac output (also see Chapter 34). Prompt recognition and intervention are essential. Treatment modalities include the administration of 100% oxygen via positive-pressure face mask ventilation, placement of an oral/nasal airway, and deepening of anesthesia with intravenously administered anesthetics. Small doses of succinylcholine (0.25 to 0.5 mg/kg) and tracheal intubation may be necessary in refractory cases. The likelihood of encountering laryngospasm may be reduced with use of intravenous or topical lidocaine (4% lidocaine spray) prior to laryngoscopy and endotracheal intubation.

Upper Respiratory Infections

Patients, especially children, scheduled for elective ENT surgery may present with an unresolved upper respiratory infection (URI) predisposing to airway hyperreactivity. They are at enhanced risk of intraoperative breath-holding, desaturation, and postoperative croup.[17] Postponing surgery for uncomplicated pediatric URI is controversial and may not be required for brief nonairway ENT procedures such as myringotomy and tube placement (also see Chapter 34).

Epistaxis

After massive epistaxis, patients are often anxious, hypovolemic, and hypertensive. Rehydration and reassurance are essential. Because blood is being continuously swallowed, these patients are considered at high risk for regurgitation and aspiration of gastric contents and are managed accordingly. A large-bore peripheral intravenous cannula is vital because some blood loss is occult, and hypotension or continued hemorrhage is likely after induction of anesthesia.

Obstructive Sleep Apnea (Also See Chapter 13)

Obstructive sleep apnea (OSA) is characterized by upper airway obstruction and disordered breathing patterns during sleep. Symptoms include snoring, headache, sleep disturbance, daytime somnolence, and personality changes. Polysomnography (sleep study) establishes the diagnosis and severity of the disorder but is not routinely performed. Pediatric patients may have behavior and growth disturbances as well as poor school performance (also see Chapter 34). Patients are often obese with short, thick necks and large tongues. These factors contribute to difficult airway management during mask ventilation, direct laryngoscopy, tracheal intubation, and extubation.[18] Patients with OSA are exquisitely sensitive to the effects of hypnotics and narcotics and may require prolonged recovery room stay.

Airway Fires

Airway fires are a direct patient hazard and source of medical litigation. Three elements are needed for the creation of a fire in the OR:

1. Heat/source of ignition (laser or electrosurgical unit)
2. Fuel (paper drapes, ETT, or gauze swabs)
3. Oxidizer (O_2, air, or N_2O)

The danger of an airway fire is not limited to general anesthesia. It may also occur during face and neck procedures conducted under MAC because electrocautery is used in close proximity to an open source of oxygen, such as nasal cannula.[19]

Anesthesia Management of Specific Otolaryngology Procedures

Ear Surgery

There are several points to consider for anesthesia and ear surgery:

Nitrous Oxide

Nitrous oxide is more soluble than nitrogen in blood and diffuses into air-filled cavities quicker than nitrogen diffuses out. The ensuing increased middle ear pressure may be problematic, including potential dislodgement of tympanoplasty grafts. Furthermore, acute discontinuation of high concentrations of nitrous oxide markedly decreases cavity pressure and may cause serous otitis. Nitrous oxide should be avoided or used in moderate concentration (<50%) and discontinued approximately 15 to 30 minutes prior to graft application.

Facial Nerve Monitoring

The surgeon may elect to use a facial nerve monitor to prevent accidental incision of facial nerve branches during surgery. Complete paralysis by neuromuscular blocking drugs can inhibit facial nerve monitor function. The use of neuromuscular blocking drugs should be curtailed to small doses or to only succinylcholine. Also, use of a neuromuscular monitor can be used to confirm a response to train-of-four stimulation of a peripheral nerve and absence of full paralysis prior to surgical dissection in the middle ear (also see Chapter 11).

Epinephrine

Epinephrine is frequently injected during ear microsurgery to decrease bleeding and improve the visual field. Systemic uptake may precipitate tachydysrhythmias. Hence, epinephrine concentration should be limited to a 1:200,000 solution.[20] Other means to control bleeding include moderate reverse Trendelenburg (head-up) positioning to decrease venous congestion and the use of volatile anesthetics to decrease systolic arterial blood pressures within an acceptable range. The use of vasoactive drugs and controlled hypotension is controversial.

Emergence

Head and neck manipulation during the application of bandages at the conclusion of surgery produces movement of the ETT and airway irritation. Coughing and bucking increase venous pressure, which can lead to graft disruption or acute bleeding. In the patient with an uncomplicated airway, extubation of the trachea at a deep plane of anesthesia may be beneficial.

Postoperative Nausea and Vomiting (Also See Chapter 39)

As a result of manipulation of the vestibular apparatus, PONV is common after middle ear surgery. Factors that may exacerbate PONV include anesthetic technique (use of nitrous oxide and narcotics), inadequate rehydration, and postoperative movement. The extent of prophylactic measures taken to prevent PONV is guided by a graded risk analysis.[21] Prophylactic interventions may include use of one or more antiemetics including corticosteroid, 5-HT_3-receptor antagonist, neurokinin-1 receptor antagonist, scopolamine patch, low-dose propofol, and gastric decompression. Scopolamine may cause confusion and probably should not be used in geriatric patients.

Myringotomy and Tube Insertion

Myringotomy and tube insertion is performed for children with disorders of the middle ear who have a history of repeated ear infections with unsatisfactory response to antibiotic therapy. There may be residual inflammation of the middle ear and upper airway irritability. An inhaled induction and maintenance of anesthesia with ventilation via a face mask is preferred for this brief procedure. Postoperative pain is minimal, so premedication may not be needed and may result in residual postoperative sedative effects (also see Chapter 34).

Tonsillectomy and Adenoidectomy

Most patients undergoing this procedure are young and healthy. Common surgical perioperative issues include airway obstruction, bleeding, cardiac arrhythmias, and croup (postextubation airway edema). Patients frequently have obstruction of the upper airway, which only becomes apparent during sleep (OSA). In general, a comprehensive history and physical examination are sufficient for a preoperative workup, but any history of sleep-disordered breathing, obesity, or a bleeding diathesis warrants further investigation. Sedative premedication is best avoided for children with OSA, obesity, intermittent airway obstruction, or significant tonsil hypertrophy.

In young children, an inhaled induction of anesthesia is preferred because preoperative establishment of an intravenous line may be difficult or traumatic. An intravenous line can be started once the child is anesthetized. Loss of pharyngeal muscle tone upon induction of anesthesia may lead to airway obstruction. Continuous positive airway pressure may relieve the problem. Placement of a cuffed preformed curved oral ETT optimizes field visualization and decreases the likelihood of accidental extubation of the trachea (Fig. 31.3). An air leak at 20 cm H_2O peak airway pressure reduces the probability of tissue edema, a critical factor for pediatric patients who have narrower airway diameters than adults. A precordial stethoscope is useful to monitor breath sounds because ETT dislodgement can occur with movement of the head or mouth gag. The supraglottic area is occasionally packed with gauze to protect against aspiration. Prior to extubation of the trachea, the pack must be removed and the stomach should be decompressed. Tracheal extubation can be performed when the child is fully awake and actively responsive. Some anesthesia providers perform tracheal extubation when the patient is still anesthetized in order to minimize coughing and laryngospasm related to the presence of the ETT.

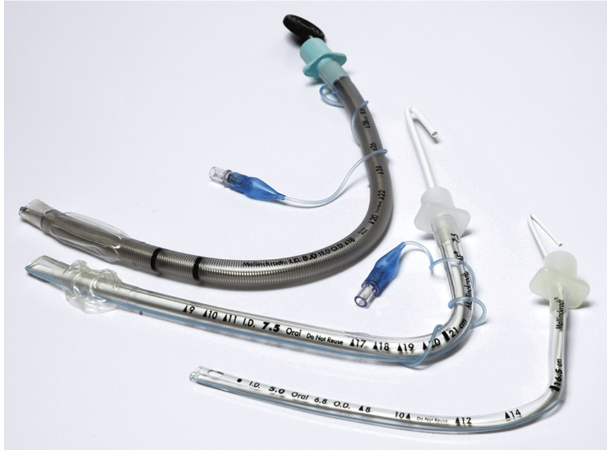

Fig. 31.3 Armored and cuffed preformed curved oral endotracheal tubes.

Intravenous dexamethasone may decrease edema and postoperative pain as well as PONV. Postoperative airway obstruction can occur for a variety of reasons ranging from secretions or blood on the vocal cords to a retained pharyngeal pack. Airway obstruction occasionally produces negative-pressure pulmonary edema. This manifests when the patient breathes against a closed glottis creating a marked negative intrathoracic pressure. This pressure is transmitted to interstitial tissue and promotes flow of fluid from the pulmonary circulation into the alveoli. Young children (younger than 4 years old) are susceptible to airway obstruction as late as 24 hours postoperatively and may benefit from prolonged postoperative monitoring.

Bleeding Tonsils After Tonsillectomy and Adenoidectomy

The family's expectation is that a patient undergoing tonsillectomy will have a complete and uncomplicated procedure and anesthesia. Yet, serious complications can occur. Hemorrhage after tonsillectomy normally occurs within a few hours of surgery and presents with expectoration of red blood, repeated swallowing, tachycardia, and PONV.[22] Blood loss is often underestimated because it is mostly swallowed. Intravenous fluid administration is critical prior to corrective urgent surgery. Patients are considered to have a full stomach, so precautions are taken during induction of anesthesia to avert regurgitation and pulmonary aspiration of blood and gastric contents. Features of a rapid-sequence induction of anesthesia include application of cricoid pressure (Sellick maneuver) until correct ETT positioning is confirmed, administration of intravenous anesthetics and neuromuscular blocking drugs in quick succession, and presence of a working suction catheter at the head of the table.

Epiglottitis (Also See Chapter 34)

Acute epiglottitis is an infectious disease caused by *Haemophilus influenzae* type B, most often affecting children between 2 and 7 years of age.[23] There is often a history of sudden onset of fever and dysphagia. Symptomatic progression from pharyngitis to airway obstruction and respiratory failure can be rapid (within hours). The child with epiglottitis appears agitated, drools, and leans forward holding the head in an extended position. Exhaustion may result from labored breathing against an almost fully occluded airway.

Direct visualization of the glottis should not be attempted because stimulation of the patient and struggling may result in complete airway obstruction. Anesthesia commences only when all emergency airway equipment is open and readied, with a surgeon adept at rigid bronchoscopy and tracheostomy present. An inhaled induction of anesthesia maintaining spontaneous ventilation is preferred. Atropine may be given to avoid bradycardia and to dry secretions. The edematous airway necessitates use of a small ETT. Because the degree of airway narrowing is unpredictable a range of ETT sizes should be available. In the event of any difficulty, the surgeon should intervene and secure the airway with a rigid bronchoscope or establish a surgical airway.

Foreign Body in Airway

Tracheal aspiration of a foreign body is an emergency, especially in the pediatric population (also see Chapter 34). Clinical manifestations include sudden dyspnea, dry cough, hoarseness, and wheezing. Mutual cooperation between the anesthesia provider and surgeon is vital to avoid inadvertent distal displacement of the foreign body and complete airway obstruction.

Removal of the foreign body is achieved either via direct laryngoscopy or rigid bronchoscopy, without application of positive airway pressure.[24] The surgeon should be present and ready to perform emergency cricothyrotomy or tracheostomy in the event of complete airway occlusion. Total intravenous anesthesia maintaining spontaneous respiration avoids exposing OR personnel to volatile anesthetics. Postoperatively, the patient should breathe humidified oxygen and remain under close observation for airway edema.

Nasal and Sinus Surgery

Nasal surgery is performed for either cosmetic or functional purposes. Common surgical operations include polypectomy, septoplasty, functional endoscopic sinus surgery, and rhinoplasty. Patients having nasal surgery often also have significant nasal passage obstruction, which may hinder ventilation via face mask. Furthermore, nasal polyps are associated with allergy and reactive airway disease. The nose's rich vascular supply can result in substantial intraoperative blood loss that may be undetected as blood trickles backward into the pharynx. Many nasal procedures can be performed under regional anesthesia and sedation.

The anterior ethmoidal and sphenopalatine branches of the trigeminal nerve provide sensory innervation to the nasal septum and lateral walls. Topical anesthesia is achieved by packing the nose with 4% cocaine pledgets, which are left in situ for 15 minutes. The advantages of using cocaine include production of topical anesthesia, vasoconstriction of vascular tissue, and shrinking of the mucosa. Because cocaine's disadvantages include altered sensorium and deleterious cardiovascular effects, it is frequently replaced by a "pseudococaine" solution of a different local anesthetic mixed with a vasoconstrictor.[25] Anesthesia can be supplemented by submucosal local anesthetic infiltration. When general anesthesia is chosen, the airway should be secured with a cuffed ETT. A posterior pharyngeal pack can prevent aspiration of gastric contents and decrease PONV due to swallowed blood. Extubation of the trachea should be performed only on return of protective airway reflexes.

Endoscopic Surgery

Endoscopy includes esophagoscopy, bronchoscopy, laryngoscopy, and microlaryngoscopy (with or without laser surgery). Airway evaluation is performed for a variety of pathologic conditions, ranging from foreign body, gastroesophageal reflux, and papillomatosis to tumors or tracheal stenosis. The compromised and symptomatic airway needs careful preoperative assessment. Airway issues should be discussed with the surgeon, and preoperative investigations such as analysis of arterial blood gases, flow-volume loops, radiographic studies, or magnetic resonance imaging may be warranted.

A proactive airway management plan is necessary. Consideration must be given to a fiberoptic endotracheal intubation in an unsedated patient if doubts exist about the efficacy of successful mask ventilation and direct laryngoscopy. Sedative premedication should be cautiously considered in the presence of upper airway obstruction. Administration of an anticholinergic drug will diminish secretions and facilitate airway visualization. If the patient exhibits stridor or inspiratory retractions, airway obstruction probably exists. Although rarely done, a tracheostomy under local anesthesia can be performed.

Techniques can be employed to provide oxygenation and ventilation during endoscopy. The trachea can be intubated with a small-diameter pediatric ETT, but these

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Fig. 31.4 Sanders injector apparatus uses high-flow oxygen insufflations through a small-gauge catheter placed in the trachea.

Box 31.3 Operating Room Precautions for Laser Surgery

Preoperative Period

1. Arrange surgical drapes to avoid accumulation of combustible gases (O_2, N_2O).
2. Allow time for flammable skin preparations to dry.
3. Moisten gauze and sponges in vicinity laser beam.

Intraoperative Period

1. Alert surgeon and OR personnel about ignition risk.
2. Assign specific roles to each OR member in case of fire.
3. Use appropriate laser-resistant ETT.
4. Reduce inspired O_2 to minimal values (monitor Spo_2).
5. Replace N_2O with air.
6. Wait a few minutes after steps 3 to 5 before activating laser.

ETT, Endotracheal tube; *OR*, operating room; *Spo_2*, oxygen saturation measured by pulse oximetry.

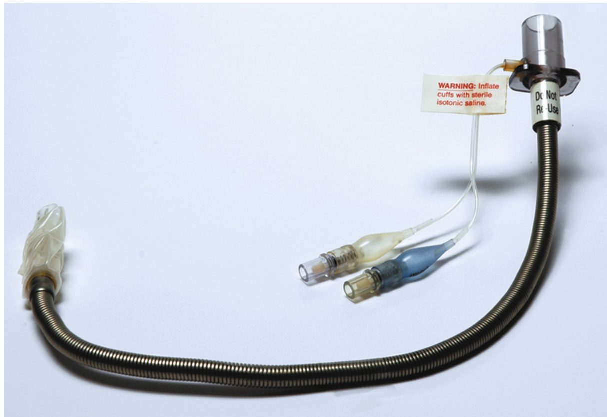

Fig. 31.5 Laser endotracheal tube—stainless steel.

tubes are frequently too short for use in adults and offer high resistance to flow. Because an ETT impairs visualization of the posterior commissure, a technique using high-flow oxygen insufflations through a small-gauge catheter placed in the trachea is useful (Fig. 31.4).[26] Another alternative is a manual jet ventilator, which attaches to a side port of the laryngoscope. High-pressure oxygen (30 to 50 psi) is delivered during inspiration and concomitantly entrains air into the trachea via the Venturi effect. This technique carries risk of pneumothorax and pneumomediastinum from rupture of alveolar blebs.

An adequate degree of masseter relaxation is required for introduction of a suspension laryngoscope by the endoscopist. Even though a succinylcholine infusion provides the necessary relaxation, a phase II neuromuscular blockade can result, which often cannot be rapidly terminated (also see Chapter 11).

Laser Surgery

Laser (light amplification by stimulated emission of radiation) surgery affords precision in targeting lesions, provides hemostasis, causes minimal tissue edema, and promotes rapid healing. Its physical properties depend on the medium used to create the beam. Laser is used in the treatment of vocal cord papillomas, laryngeal webs, and resection of subglottic occlusive tissue. The use of a small-diameter ETT is necessary for maximum exposure.[27] Laser energy can cause retinal damage, and can produce a laser plume of toxic fumes, which has potential to transmit disease. An efficient smoke evacuator and special masks are necessary because small particles are readily inhaled. The patient's eyes should be taped, and OR personnel must wear protective eyeglasses.

The greatest danger during laser surgery is ETT fire (also see Chapter 48), as described earlier, so suitable precautions should be taken (Box 31.3). Flexible stainless steel laser-resistant tubes are available for the specific type of laser employed (Fig. 31.5). In order to dissipate heat and detect cuff rupture, the tube cuff should be filled with saline and an indicator dye. Although polyvinylchloride tubes are flammable, they may be modified with a metallic tape wrap. Nonetheless, they may retain a risk of ignition and can reflect the laser beam onto nontargeted tissue. The tissue adjacent to the surgical field should be protected with moist packing. Postoperatively, patients should be monitored for laryngeal edema.

Neck Dissection Surgery

Neck dissection may be complete, modified, or functional. Anatomically, the structures principally involved are (1) the sternocleidomastoid muscle, (2) cranial nerve XI, and (3) the internal and external jugular veins and carotid artery. Frequently, neck dissection is performed for removal of a tumor and may also involve partial or total glossectomy. Patients with such tumors may have a history of tobacco and alcohol abuse. Pulmonary disease is likely and is an indication for a preoperative pulmonary evaluation.

In many cases, the neck dissection may be bilateral, and a tracheostomy may be performed to maintain a patent airway. Upper airway management may be difficult in these patients, especially if there is a history of radiation treatment of the larynx and pharynx or if a mass is present in the oral cavity. Neuromuscular

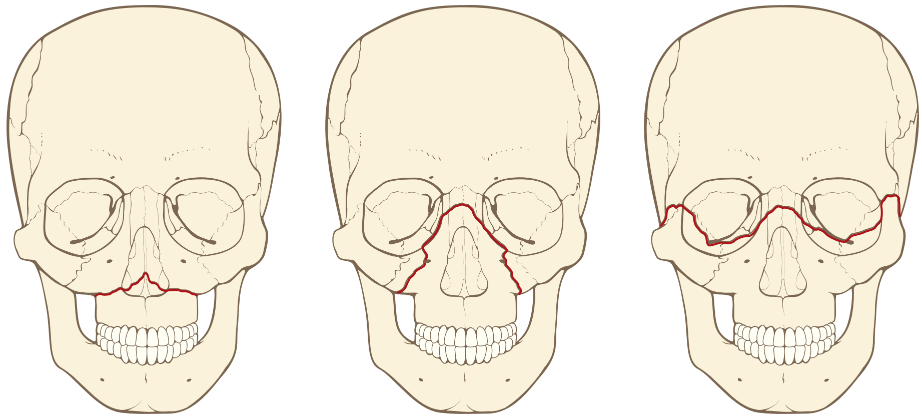

Fig. 31.6 Facial injuries and the LeFort fracture classification. (From Myer CM. Trauma of the larynx and craniofacial structures: airway implications. *Paediatr Anaesth.* 2004;14:103-106, used with permission.)

blocking drugs are avoided or the dose is markedly decreased if neuromonitoring is used. Traction or pressure on the carotid sinus can provoke prolongation of the QT interval, bradydysrhythmias, and even asystole. Treatment consists of early detection, cessation of surgical stimulus, and administration of atropine. The carotid sinus reflex can be blocked with local anesthetic infiltration. During dissection, open veins carry risk of venous air embolism.

Postoperative Complications

In the postoperative period the anesthesia provider should be aware of potential nerve injuries. Damage to the recurrent laryngeal nerve can cause vocal cord dysfunction and, if bilateral, results in airway obstruction. The phrenic nerve also traverses through the operative field, and injury to it can result in paralysis of the ipsilateral hemidiaphragm. Pneumothorax can also occur in the postoperative period. Excessive coughing or agitation can result in hematoma formation and airway compromise. If tracheostomy is not performed as part of the procedure, the patient should be monitored closely for signs of laryngeal or upper airway obstruction (also see Chapter 39).

Thyroid and Parathyroid Surgery

Thyroid storm may be encountered in a patient who has inadequately controlled hyperthyroidism. It manifests with signs of massive catecholamine release including tachycardia, hypertension, and diaphoresis. Intraoperative anesthesia considerations again focus on airway management. Surgical manipulation of the head and neck can occlude a standard ETT, so an armored ETT may be beneficial (see Fig. 31.3). Airway obstruction after thyroid or parathyroid surgery can be caused by bleeding from the operative site compressing the trachea. Emergency measures include prompt incision and opening of the wound to release the accumulated hematoma. Surgical trauma to one or both recurrent laryngeal nerves can manifest as postextubation hoarseness or stridor. Some surgeons use electromyography (EMG) to monitor recurrent laryngeal nerve integrity, using a special ETT and EMG monitor. Parathyroid injury or removal may cause hypocalcemia with clinical signs of tetany, cardiac dysrhythmias, and laryngospasm.

Parotid Surgery

The parotid gland may be excised in toto or surgery may be limited to the superficial portion of the gland. Because the parotid is traversed by the facial nerve, nerve function can be monitored with a facial nerve monitor in order to circumvent surgical trauma.[28] The facial nerve may need to be sacrificed during radical parotidectomy and reconstructed with a graft from the contralateral greater auricular nerve (branch of the superficial cervical plexus). Nasotracheal intubation is appropriate if a mandibular resection is planned.

Facial Trauma

Facial fractures are characterized by the LeFort classification of maxilla fractures (Fig. 31.6).[29] A LeFort I fracture extends across the lower portion of the maxilla but does not continue up into the medial canthal region. A LeFort II fracture also extends across the maxilla, but at a more cephalad level, and it continues upward to the medial canthal region. A LeFort III fracture is a high-level transverse fracture above the malar bone and through the orbits. It is characterized by complete separation of the maxilla from the craniofacial skeleton. Orotracheal intubation is necessary when intranasal damage is a possibility. In orthognathic surgery, LeFort fractures are created for cosmetic repair.

QUESTIONS OF THE DAY

1. What are the effects of different airway management techniques (e.g., face mask ventilation, direct laryngoscopy, tracheal intubation, or supraglottic airway placement) on intraocular pressure?
2. What are the potential systemic side effects of ophthalmic medications?
3. What are the clinical manifestations of the oculocardiac reflex (OCR)? What are the options for managing OCR?
4. A patient who received a retrobulbar block prior to eye surgery develops decreased level of consciousness. What are the potential causes, and what is the appropriate management?
5. A patient is undergoing retinal surgery with general anesthesia. The surgeon plans injection of an intravitreal gas bubble. What are the anesthetic implications?
6. An adult patient who sustained a traumatic eye injury requires urgent surgery. The patient recently ingested a large meal. What are the options for anesthesia management that address both the risk of aspiration and visual loss?
7. What measures can be taken to reduce the risk of airway fire during laser surgery of the vocal cords and trachea?
8. A patient is undergoing neck dissection and laryngectomy. What are the implications for intraoperative anesthesia management? What postoperative complications should be anticipated?

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