OCULAR TRAUMA

Ocular trauma is one of the most preventable causes of visual impairment in the world. Children and adolescents account for a disproportionate share of ocular trauma. Penetrating eye injuries occurred in 34% of children under the age of 15 years old. Boys between 11 and 15 years old are the most vulnerable; compared with girls, they are injured in a ratio of approximately 4 to 1.

Penetrating eye injuries in children cause long-term morbidity, and are of considerable socioeconomic importance. The list of clinical circumstances and the various possible sharp objects that can be implicated in causing ocular trauma are endless. Most injuries in children are related to rough sports and projectiles, including toys, guns, darts, sticks, stones, and airguns. Traumatic interruption of the ocular cavity threatens vision by the direct effect of the injury itself, the loss of intraocular contents, or the introduction of toxic material into the ocular chamber with consequent infection.

A clear understanding of the physiologic functioning of the visual apparatus and the possible mechanism of the injury, the recognition of the signs of injury, and prompt and efficient management help to reduce the chance of a bad visual outcome after ocular trauma in children. The protective reflexes of the eye do little to limit the extent of penetrating trauma. The bony orbit can protect the eye only from posterior and oblique injuries; a sharp, projectile object entering the area in the orbital rim still can pierce the globe. The presence of disruption, laceration, or
puncture of the orbital bones or the eyelid indicates penetrating ocular injury, and must be investigated thoroughly. Lacerations involving just the conjunctiva are not significant. The choroid, which is the highly vascular coat lying between the sclera, retina, and vitreous, can be penetrated by blunt and sharp trauma with resultant subconjunctival, subretinal and vitreous hemorrhage. The category and extent of the injury are considered equally when predicting visual outcome after trauma. 

**TERMINOLOGY**

Knowledge of ophthalmic terminology is important in expediting patient care through enhancement of communication among physicians, and figures prominently in the decision-making process by the anesthesiologist during the preoperative evaluation and intraoperative care of the patient.

*Laceration* is defined as a defect in the cornea or sclera caused by a sharp object, such as a knife, scissors, glass shard, or high-velocity missile. Laceration of the globe must be suspected when ocular symptoms are related to guns or explosion.

*Orbital hemorrhage* is defined as bleeding into the orbital space behind the globe and orbital septum, and can be caused by blunt and penetrating eye injuries.

*Rupture of the globe* refers to disruption of the sclera or cornea from indirect forces or agents of blunt trauma, including low-velocity missiles (e.g., from an airgun injury).

*Perforation* implies that the injury has traversed the full thickness of the sclera or cornea and has entered the intraocular cavity.

*Double perforation* describes an injury that enters the eye, traverses the intraocular cavity, and exits through the sclera opposite the entry point. Double perforations involve the anterior and the posterior walls of the eye, and have the worst overall prognosis.

**TYPES OF INJURIES**

The following are types of injuries:

- Corneal and conjunctival lacerations
- Scleral rupture
- High-velocity injuries
- Intraocular foreign bodies
- Ruptured globe

Severe trauma, even when blunt, can cause lacerations of the cornea, conjunctiva, and sclera and can lead to a ruptured globe. High-velocity objects can cause lacerations, and can rupture when they strike the eye. Smaller, sharper, and faster objects may cause less ocular damage.
Larger, slower, and more blunt objects have more disruptive force on the eye, and can cause scleral rupture and disorganization of intraocular contents. Intraocular foreign bodies may be organic or inorganic. Organic foreign bodies, such as wood, may be difficult to remove; and the left-over fragments may lead to infection. Organic material, iron, copper, aluminum, magnesium, and poor-quality plastic are also toxic to the eye. Inorganic foreign bodies, such as glass, stainless steel, high-quality plastic, and stone, are essentially inert, cause minimal reaction, and may be left alone unless they cause symptoms.

Penetrating injuries may introduce bacteria or fungi into the intraocular cavity, resulting in endophthalmitis with devastating consequences for vision. These injuries usually occur from objects such as a tree branch or splinters from a dirty tool. The friction-generated heat from the high velocity-objects tends to sterilize the objects before they enter the eye.

**INTRAOCULAR PRESSURE**

Normal intraocular pressure ranges from 15 to 20 mm Hg, and is maintained by means of a balance between the secretion of the aqueous by the ciliary body and its outflow through the canal of Schlemm. This pressure is kept constant by the volume of the aqueous humor, vitreous, and vascular volume in the intraocular space. Most inhalational anesthetics decrease intraocular pressure in direct proportion to the inspired concentration of the drug. Although not well defined, the mechanism is believed to be caused by relaxation of the ocular muscle tone and depression of the ocular centers in the diencephalons, midbrain, and hypothalamus.

Although choroidal blood flow maintains constancy of the intraocular pressure over a range of perfusion pressures (mean arterial pressure minus intraocular pressure), a sudden increase in blood pressure increases the intraocular pressure by causing changes in the choroidal blood flow. Below a systolic pressure of 85 to 90 mm Hg, however, a marked reduction of intraocular pressure occurs. Controlled arterial hypotension maintains a reduction in intraocular pressure. An increase in central venous pressure by flexion of the head, a Valsalva maneuver, coughing, bucking, and straining causes marked increases in the intraocular pressure that are greater than those caused by an increase in arterial pressure. An increase in arterial CO₂ tension increases intraocular pressure, and a decrease in arterial CO₂ tension decreases intraocular pressure. Deep inspiration may reduce the intraocular pressure by 5 mm Hg. Although coughing may increase the intraocular pressure by as much as 40 mm Hg, the intraocular pressure returns to normal in 30 seconds after the coughing has ceased. If the eye has sustained an open injury, however, extrusion of the intraocular contents already may have oc-
Intraocular pressure rises markedly with pressure on the eye, contraction or contracture of the extraocular muscles, contraction of the orbicularis oculi muscle, eyelid closure, and venous congestion of the orbital veins.²

Etomidate, when used as a bolus or for total intravenous anesthesia, has been shown to reduce intraocular pressure markedly.¹⁸ Thiopental reduces intraocular pressure in normal⁶ and glaucomatous eyes.³ Ketamine produces a small increase in intraocular pressure.²¹ Although sizable decrease (25%) in intraocular pressure was demonstrated in children who received intramuscular ketamine, the associated blepharospasm and nystagmus make it unsuitable for ophthalmic surgery.⁴

Succinylcholine produces a 7- to 12-mm Hg increase in intraocular pressure.¹¹,¹⁷ The increase is rapid in onset, maximal in 1 to 2 minutes, and lasts for 5 to 6 minutes.⁴ Rocuronium is a new steroidal, nondepolarizing neuromuscular blocking drug with a short onset time, intermediate duration of action, few reported side effects,¹⁰,¹⁹ cardiovascular stability, and a lack of histamine release, even with large doses.⁷ Rocuronium is an attractive alternative to succinylcholine when rapid endotracheal intubation is necessary, qualifying its incorporation into many emergency management protocols.¹⁰

**DIAGNOSIS**

The following are components of the diagnosis:

- Clinical examination
- Slit-lamp examination
- Plain radiographs
- CT scanning
- MR imaging

The clinical examination of injured children is always a challenge. It is performed with the help of the parent or an assistant, who holds the child, or with use of sedation. All children who have eyelid injuries should be examined closely for foreign bodies or organic contamination, and visual acuity should be documented even if it is only a gross estimate of vision.

Corneal abrasions are detected by instilling fluorescein dye and by inspecting the cornea with a blue-filtered light.

Orbital radiographs are useful for demonstrating bony trauma and the number and shape of radio-opaque foreign bodies. The CT scan then is used to delineate their relationship to the globe. In the case of a ruptured globe, the CT scan may reveal air in the globe. MR imaging should never be used to rule out the presence of a metallic foreign body because its movement in the magnetic field may cause further damage to the surrounding intraocular structures.
PREOPERATIVE EVALUATION

A detailed history regarding the mechanism and time of injury to the eye should be taken. Information about medications, allergy to medications, and the time of the most recent consumption of food and drink is elicited in view of preparing for possible surgery under general anesthesia. As with all trauma cases, priority is given to any associated abdominal, thoracic, or cerebral trauma; and the patient is stabilized before considering any repair of the ocular injury.

All trauma involving the face should be suspected of having the potential for ocular involvement. Penetrating eye injury may go undiagnosed because of severe facial injury or multiorgan injury. The difficulty arises when children, conscious and in pain, may not cooperate with a detailed evaluation of the traumatized eye. If there is any concern about the possibility of a penetrating injury, no pressure is applied to the eye because it may cause extrusion of the intraocular contents. The patient is maintained under constant observation so that there is no pulling, pressing, or scratching of the injured eye. The traumatized eye is covered with a soft, sterile dressing that does not put pressure on the eye.

CLINICAL PRESENTATION

Patients who have sustained penetrating eye injury present with various symptoms.

Patients with conjunctival lacerations may complain of slight redness of the affected eye, mild irritation, foreign body sensation, and possible mild blurring of vision. If the damage is limited only to the conjunctiva, the vision usually is unaffected. Children with larger lacerations, rupture, or perforation may cry hysterically, and may complain of pain in the affected eye, bleeding, and nearly complete loss of vision. While trying to wipe the child's tears, the parent may notice some intraocular contents, such as pigmented uveal tissue or jelly-like vitreous substance, on the child's eyelid or cheek.

Scleral rupture can be caused by forceful blunt trauma. Vitreous hemorrhage, even in the absence of external abnormalities, may signal scleral rupture. Scleral rupture also is suspected when there is hematoma of the conjunctiva because the hematoma may arise from disruption of the sclera and the choroids with hemorrhage into the subconjunctival space. Ruptures located near the cornea may cause collapse of the iris, lens, uvea, or vitreous.

PREMEDICATION

Premedication is indicated in this group of children, even in those children less than 1 year old, because it is almost impossible to keep them calm and stop them from scratching and pulling on any dressing.
that may have been applied to the eye at the accident scene. Anxiety, pain, and crying must be controlled adequately to prevent an increase in intraocular pressure with extrusion of the intraocular contents. These children benefit from heavy sedation and an antiemetic so that they are brought drowsy or well asleep to the operating suite. The choice of premedication is predicated on the sedative, hypnotic, amnesic, anticholinergic, and antiemetic effects. Premedics in the benzodiazepine and butyrophenone groups serve the purpose. Oral midazolam, 0.5 mg/kg, confers sedation and amnesia, and allows the establishment of intravascular access in preparation for the rapid-sequence induction of anesthesia.

**MONITORING**

Adequate monitoring is essential in view of the lack of access to the patient’s airway once the surgical drapes are applied. Standard monitoring includes ECG, an esophageal stethoscope, pulse oximetry, end-tidal CO\(_2\) tension, noninvasive blood pressure, and a temperature probe. Invasive arterial monitoring and a urinary catheter to monitor the urine output are required when there is accompanying major trauma.

**ANESTHETIC MANAGEMENT**

Most children require heavy sedation or general anesthesia for the performance of an adequate eye examination, even to make a clinical diagnosis, because the child usually is terrified by the whole incident. The parents are also anxious about the possible outcome, and cannot provide adequate comfort to the crying child. Several problems must be addressed before embarking on the induction of anesthesia in these challenging patients who present under varied and stressful circumstances. The straining, coughing, and vomiting associated with general anesthesia can increase intraocular pressure with disastrous consequences. The main concerns for the anesthesiologist are to control intraocular pressure and to prevent extrusion of the intraocular contents, including the iris, lens, and vitreous, at the time of the induction of anesthesia or incision into the anterior chamber of the eye to retrieve a foreign body or evacuate a hematoma.

The considerations for anesthetic management include the following:

1. The need to control intraocular pressure to prevent extrusion of global contents
2. The possibility of a full stomach and consequent risk for aspiration
3. The maintenance of a well-relaxed patient for a lengthy operative repair
Control of intraocular pressure is crucial to the optimal management of open-eye injury. Skillful anesthetic management can enhance the outcome for the pediatric patient with penetrating eye injury associated with prolapse of the intraocular contents. Any maneuver, such as crying, coughing, vomiting, or intubating the trachea under light anesthesia or inadequate relaxation, should be avoided to prevent a rise in intraocular pressure and extrusion of the contents of the eye.

An open eye in the presence of a full stomach mandates that the induction of anesthesia and airway control be managed in rapid sequence. Barbiturates and nondepolarizing relaxants reduce intraocular pressure, and are the combination of choice for the emergency repair of an open-eye injury. The patient is preoxygenated; thiopental, 4 to 6 mg/kg (i.e., if blood pressure permits), and rocuronium, 0.6 mg/kg, are given; cricoid pressure is maintained; and the trachea is intubated quickly. The presence of bilateral breath sounds is confirmed, and the endotracheal tube is well secured. Because most inhalational drugs decrease intraocular pressure, they are useful for maintenance of anesthesia. Adjuvant drugs may prove useful. Intravenous droperidol confers antiemesis; H₂ receptor antagonists, cimetidine and ranitidine, increase gastric pH and reduce gastric acid production; and metoclopramide promotes gastric emptying.

POSTOPERATIVE CARE

At the conclusion of the operation, the stomach is suctioned and the trachea is extubated when the patient is fully awake. The patient is transferred to the postanesthesia care unit, and is monitored until complete recovery is achieved. The patient receives antibiotics to reduce the risk of endophthalmitis.

SUMMARY

Anesthesia for pediatric eye emergencies is predicated on prevention of a rise in intraocular pressure and avoidance of extrusion of the intraocular contents in the setting of a full stomach. Sedation or general anesthesia is frequently necessary for adequate examination of the eye.

References


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