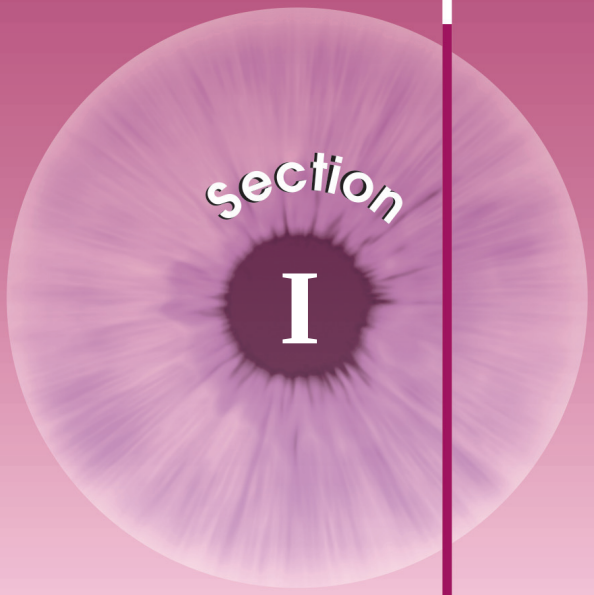
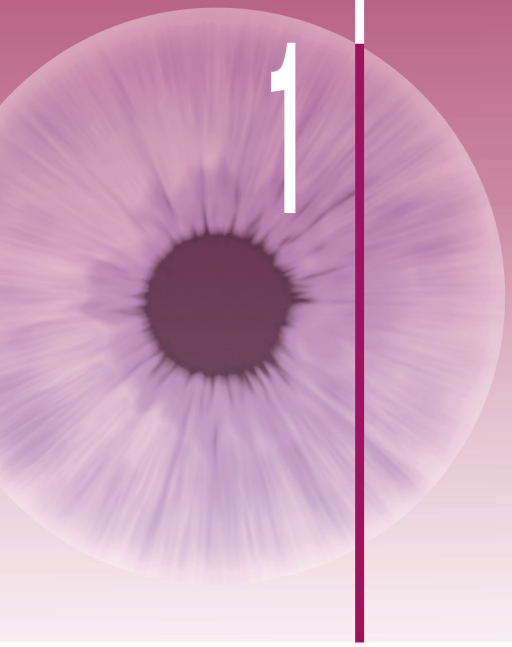


Ocular Injuries: General Considerations



1 OCULAR TRAUMA: CLASSIFICATION AND TERMINOLOGIES

INTRODUCTION

PATTERN OF OCULAR INJURIES

Pattern of ocular injuries tends to vary from one location to another and is affected by the activities of residents in a given location. Many eye injuries are related to sports, agriculture, occupation, exposure to hazards and are caused by a variety of objects used in different settings. In addition, in this era of high-speed traffic and rapid industrialization, the incidence of injuries involving the eye is also increasing. Despite the fact that the eyes represent only 0.27% of the total body surface area and 4% of the face, these are the third most common organs affected by injuries after the hands and feet. In general, trauma is an important cause of ocular morbidity.

OCULAR TRAUMA AND BLINDNESS

Ocular trauma is an avoidable cause of blindness and visual impairment. Worldwide there are approximately 1.6 million people blind from eye injuries, 2.3 million bilaterally visually impaired and 19 million with unilateral visual loss. As a matter of fact, ocular trauma is the commonest cause of unilateral blindness. Younger age and male gender are the most common subjects of ocular trauma. Various studies have reported that approximately one-half of patients who present to an eye emergency department are cases of ocular trauma.

GROUPING OF OCULAR INJURIES

Grouping of ocular injuries, in general, can be done comprehensively as below (Fig. 1.1):

I. Isolated ocular injuries
- Mechanical injuries
- Non-mechanical injuries.

II. Ocular injuries associated with other injuries

III. Etiological grouping

MECHANICAL INJURIES

Incidence of mechanical injuries is increasing in general in this era of high-speed traffic and industrialization, like any other part of the body, eyes are also not exempted from these injuries; in spite of the fact that they are well protected by the lids, projected margins of the orbit, the nose and a cushion of fat from behind.

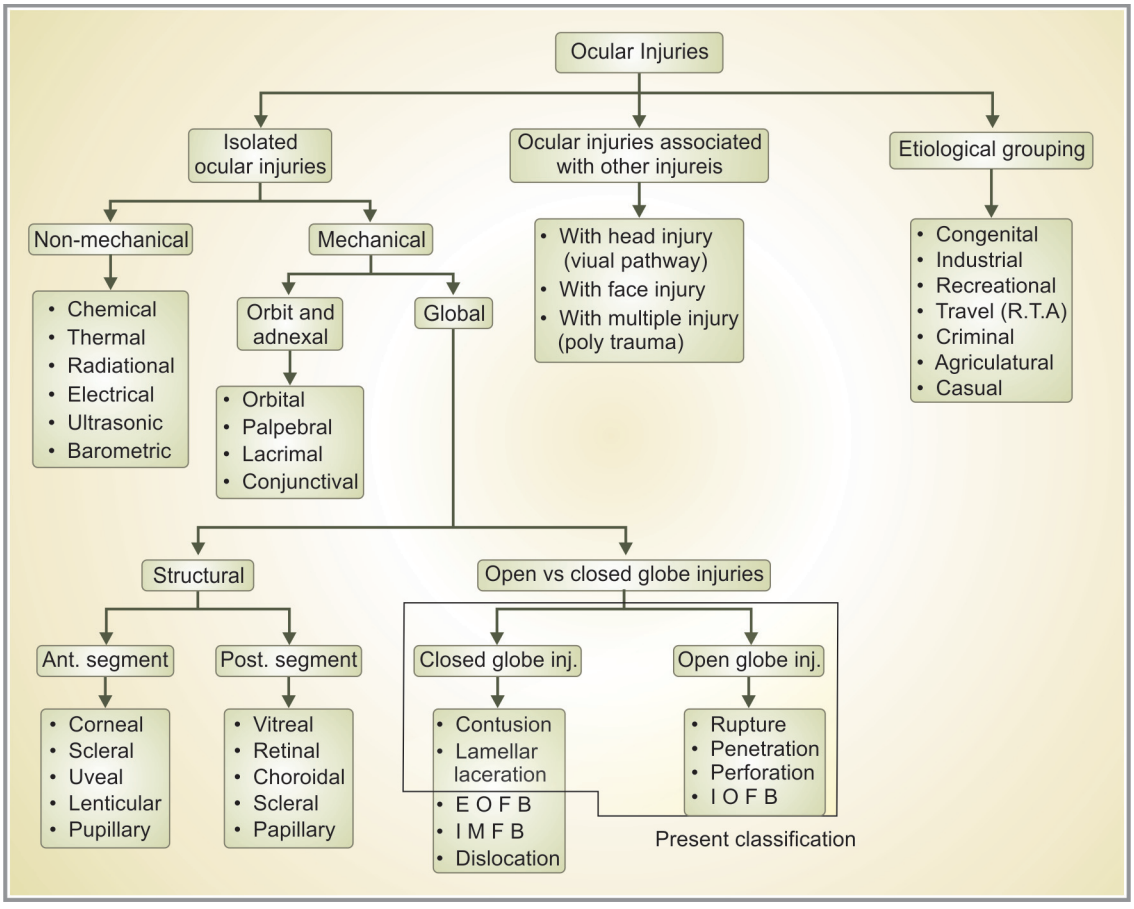


Fig. 1.1 *Comprehensive grouping of ocular injuries*

Mechanical ocular injuries can be discussed under following headings:

- Extraocular foreign bodies
- Blunt trauma
- Open globe injuries
- Sympathetic ophthalmitis

OCULAR TRAUMA: TERMINOLOGY, CLASSIFICATION AND SCORING

BIRMINGHAM EYE TRAUMA TERMINOLOGY

For individuals to communicate and understand each other, one requires a language which is both universally recognized and accepted. In a similar manner, to prevent misinterpretation of facts relating to eye injuries ophthalmologists require terms with unambiguous definitions. In many series and reports, different terms were being used interchangeably for the same ocular injury. This prevented ophthalmologists from establishing a set protocol to manage ocular trauma.

The Birmingham Eye Trauma Terminology (BETT) laid down the terminology of mechanical ocular injuries to overcome this ambiguity. Kuhn and coworkers based on their experience came up with this terminology to categorize eye injuries. This terminology, i.e. BETT was endorsed by various professional associations, such as the American Academy of Ophthalmology, International Society of Ocular Trauma and World Eye Injury Registry amongst others. The Birmingham Eye Trauma Terminology considers certain basic criteria which are looked for in an ideal terminology system.

- Includes all types of ocular injuries.
- Each type of injury is clearly defined.

- The same ocular injury cannot be described by different terms.
- The tissue of injury is mentioned along with the type of injury.

Eyewall

Though the wall of the eyeball comprises three coats; only the integrity of the external shell made of sclera and cornea needs to be broken for an injury to convert from closed globe to an open globe. Hence, the term eyewall is limited to this outer coat of the eye (sclera and cornea).

Terminologies for mechanical globe injuries

Terminologies for mechanical globe injuries modified from Birmingham Eye Trauma Terminology (Fig. 1.2) are as below:

I. **Closed globe injury** is the one in which eyewall (sclera and cornea) does not have a full thickness wound but there is intraocular damage. It includes contusion and lamellar laceration.

1. ***Contusion*** refers to the closed globe injury resulting from blunt trauma. Damage may occur at the site of impact or at a distant site.

2. ***Lamellar laceration*** is a closed globe injury characterized by a partial thickness wound of the eyewall caused by a sharp object or blunt trauma.

II. **Open globe injury** is associated with a full thickness wound of the sclera or cornea or both. It includes rupture and laceration of eyewall.

1. ***Rupture refers*** to a full thickness wound of eyewall caused by the impact of blunt trauma. The wound occurs due to markedly raised intraocular pressure by an inside out injury mechanism.

2. ***Laceration*** refers to a full thickness wound of eyewall caused by a sharp object. The wound occurs at the impact site by an outside in mechanism. It includes penetrating and perforating injuries.

i. *Penetrating injury* refers to a single laceration of eyewall caused by a sharp object which traverses the coats only once.

ii. *Perforating injury* refers to two full thickness lacerations (one entry and one exit) of the eyeball caused by a sharp object or missile. The two wounds must have been caused by the sameagent (earlier known as double perforation)

iii. *Intraocular, foreign body injury* is technically a penetrating injury associated with retained intraocular foreign body. However, it is grouped separately because of different clinical implications.

OCULAR TRAUMA CLASSIFICATION SYSTEMS

A standardization of ocular trauma classification was carried out by a group of 13 ophthalmologists, who reviewed the trauma classification systems in ophthalmology and reports on the characteristics and outcomes of eye injuries. They came up with a classification system with standardized

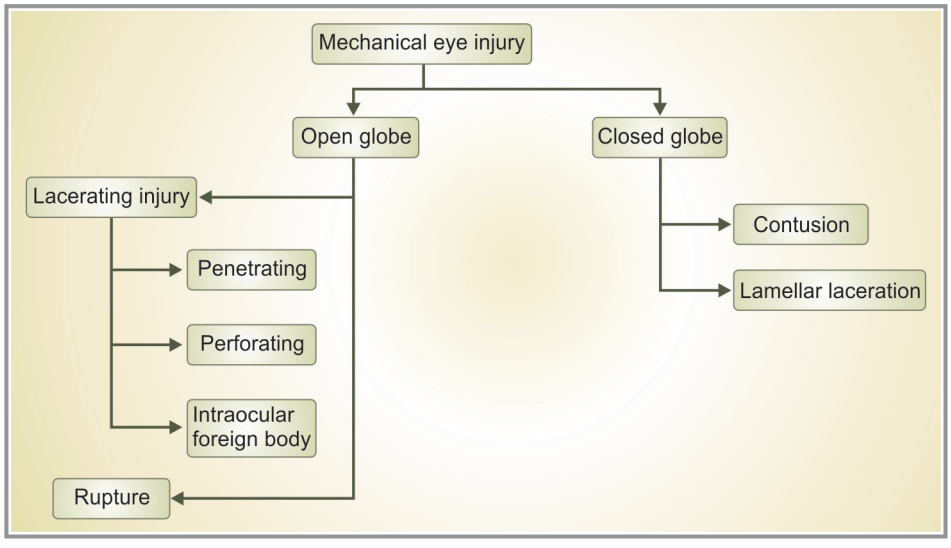


Fig. 1.2 *Birmingham eye trauma terminology*

nomenclature and prognostic indicators that need to be evaluated upon initial presentation.

The classification takes into account four variables—type, grade, zone and presence or absence of RAPD. These variables can be discerned at the initial examination or at the time of primary repair, forceful evaluation should never be attempted, lest the intraocular contents prolapse out.

System for classifying open globe injuries

Type of injury

a. Rupture
b. Penetrating
c. Intraocular foreign body
d. Perforating
e. Mixed

Grade (visual acuity at presentation)

i. ≥ 20/40
ii. 20/50 to 20/100
iii. 19/100 to 5/200
iv. 4/200 to PL+
v. Absence of light perception

Pupillary response

a. Relative afferent pupillary defect (RAPD) present in the injured eye
b. No RAPD in the injured eye

Zone (Fig. 1.3)

1. Cornea and limbus
2. Limbus to 5 mm posterior into the sclera
3. Posterior to 5 mm from the limbus

(The posterior most opening in the eyeball is considered.)

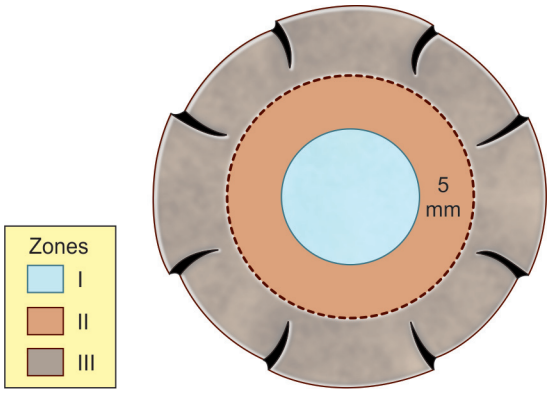


Fig. 1.3 *Zones of the eyeball as per the ocular trauma classification*

System for classifying closed globe injuries

Type

1. Contusion
2. Lamellar laceration
3. Superficial corneal foreign body
4. Mixed

Grade (visual acuity at presentation)

i. ≥ 20/40
ii. 20/50 to 20/100
iii. 19/100 to 5/200
iv. 4/200 to PL+
v. Absence of light perception

Pupillary response

a. RAPD present in the injured eye
b. No RAPD in the injured eye

Zone

1. *External*, limited to bulbar conjunctiva, sclera and cornea.
2. *Anterior segment* includes structures of anterior segment along with pars plicata and the lens apparatus.
3. *Posterior segment* incluldes all internal structures posterior to posterior lens capsule.

(The posterior most structure showing evidence of structural alteration is taken into consideration.)

OCULAR TRAUMA SCORE

The patient's perspective in the scenario of ocular trauma should be borne in mind. Their leading questions "How much is the damage?" or "How much chance is there of recovery?" although cannot be determined in a single value; however, a probable idea or prognostication can be given from the ocular trauma score (OTS).

The OTS is able to tell with an accuracy of 77% the final visual outcome of the patient ± within one visual category. It helps allay the patient anxiety and helps them deal with the economic and rehabilitation issues and guides the ophthalmologist in triage and patient counselling.

Calculation of OTS

The OTS is a simple tool and is calculated as below:

Step 1. *Identify the value of the raw points* which can be attributed to the patient based on your assessment. At the time of the initial evaluation, ascertain the visual acuity of the patient at presentation and arrive at a tissue diagnosis (Table 1.1).

Table 1.1 *Raw points attributed to various variables in the OTS*

Variable	*Raw points*
A. Initial vision	
• No light perception	60
• Light perception/hand movements	70
• 1/200–19/200	80
• 20/200–20/50	90
• ≥ 20/40	100
B. Rupture	–23
C. Endophthalmitis	–17
D. Perforating injury	–14
E. Retinal detachment	–11
F. Afferent pupillary defect	–10

Step 2. *Calculate the algebraic sum of the raw points* (Table 1.2). Assign a raw point value for the initial visual acuity from Row 'A' of Table 1.1; subtract the appropriate row point for each diagnosis from Rows 'B' – 'F'. (For example, a patient with an initial visual acuity of 1/200, scleral, rupture and retinal detachment would receive an OTS score of 80–23–11 = 46). Higher the OTS, the better is the prognosis.

Step 3. *Conversion of the sum into OTS and calculating the likelihood of final vision at 6 months.* To provide an estimate of the patient's probability of attaining a specific visual acuity range at a six-month follow-up, locate the row in Table 1.2 which corresponds to the patient's OTS (As in the example above, the patient having an OTS of 46 would have a category score of 2). Table 1.2 shows the estimated probability of all potential visual outcomes after six months.

Clinical implications

It is imperative to arrive at a proper diagnosis when dealing with a patient of ocular trauma.

- *BETT terminology* helps us to define and determine the nature of injury.
- *Ocular trauma classification* guides us to label its type, grade, zone of involvement and the presence or absence of RAPD.
- *Ocular trauma score* gives an approximate idea regarding the retrieval of final visual acuity at six months follow-up of the patient thereby helping the ophthalmologist in proper patient guidance and counselling.

NON-MECHANICAL INJURIES

This group includes all ocular injuries other than caused by mechanical trauma. That include:

1. ***Chemical injuries*:** Chemical injuries are by no means uncommon and can be caused by chemical solution, powder or gases. These vary in severity from a trivial and transient irritation of little significance to complete and sudden loss of vision. Chemical injuries have been covered in detail in Chapter 13.
2. ***Radiational injuries*** can be caused by ultraviolet, infrared or ionizing radiations. These have been described in Chapter 14.
3. ***Thermal injuries*** are usually caused by fire, or hot fluids. The main brunt of such injuries lies on the lids. Conjunctiva and cornea may be affected in severe cases. Thermal injuries are covered in Chapter 15.
4. ***Electrical injuries*** are caused due to passage of electric current from the area of eye and can involve each part of the eyeball. These are covered in Chapter 15.
5. ***Barometric injuries*** are caused due to atmospheric pressure changes and are described in Chapter 15.

BIBLIOGRAPHY

1. Kuhn F, Morris R, Witherspoon CD, Heimann K, Jeffers JB, Treister G. A standardized classification of ocular trauma. Ophthalmology. 1996; 103(2):240–243.
2. Kuhn F, Maisiak R, Mann L, Mester V, Morris R, Witherspoon CD. The Ocular Trauma Score (OTS). Ophthalmol Clin North Am 2002; 15:163–165.

Table 1.2 *Likelihood of final visual outcome at six months*

Sum of raw points	*OTS*	*NLP*	*LP/HM*	*1/200–19/200*	*20/200–20/50*	*≥ 20/40*
0–44	1	74 %	15 %	7 %	3 %	1 %
45–65	2	27 %	26 %	18 %	15 %	15 %
66–80	3	2 %	11 %	15 %	31 %	41 %
81–91	4	1 %	2 %	3 %	22 %	73 %
92–100	5	0 %	1 %	1 %	5 %	94 %

2 TRAUMATIC EYE: EVALUATION AND ASSESSMENT

INTRODUCTION

A proper evaluation of the traumatized eye is absolutely essential for appropriate and effective management of the injury. Classification of the injury and calculation of the ocular trauma score are essential aspects which should be brought into practice. It should be remembered that in case of ocular trauma, the ophthalmologist is treating the patient and not only the eye, pay attention to any systemic features, social bearing of the ocular injury and ultimately to the visual rehabilitation of the patient. Scheme of approach to a patient with ocular trauma described below is summarized in Fig. 2.1.

Initial approach. Patients usually present to the ocular emergency in a state of panic or frenzy. The sudden threat to vision can be emotionally damning. This places upon the treating ophthalmologist an added responsibility of counselling not only the patient but also their family members. It is always advisable to maintain a confident and humane approach.

Systemic evaluation. Prior to taking history and performing a thorough examination of the eye, it is important for the attending ophthalmologist to evaluate the systemic condition of the patient. Ocular trauma can be compounded by life-threatening injuries as in cases of polytrauma commonly observed in road traffic accidents. If a systemic injury is found, its treatment will obviously take precedence over the ocular management. In these cases, the emergency team stabilizes the patient before calling in for an expert ophthalmic opinion. Even in cases presenting directly to the ophthalmologist, it is always better to be suspicious of occult injury to other organ systems.

Initial triage should consist of systemic evaluation of vitals, gross mental status and obvious fractures or soft tissue injuries. The patient should be referred to a trauma facility, if at any point of the examination, the following are found:
- Unstable vital parameters
- Altered mental status or an unresponsive patient
- Serious bony or soft tissue injury

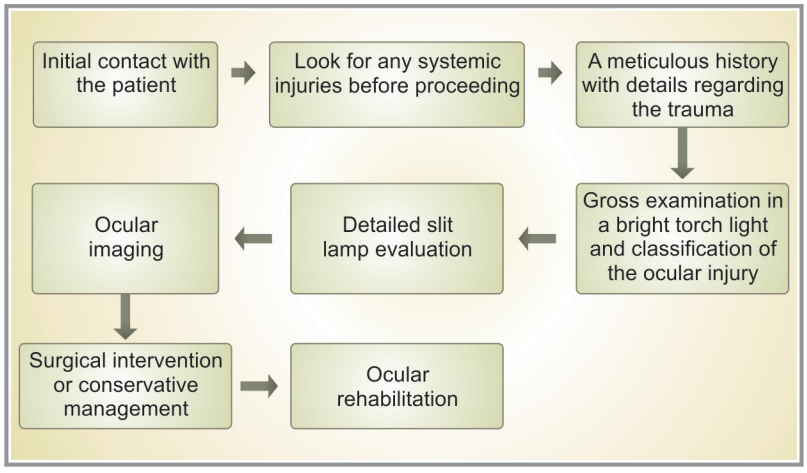


Fig. 2.1 *Scheme of approach to a patient with ocular trauma*

Once it is established that the systemic status is stable, the surgeon can turn attention to the ocular evaluation.

CLINICAL WORKUP

HISTORY

The importance of a well-taken history, at the time of initial presentation, cannot be over-emphasized. Not only does this give the ophthalmologist a chance to build a rapport and earn the trust of the patient but a well-documented history is also necessary for legal proceedings. The history will guide the ophthalmologist towards the examination.

It is best to allow the patient to tell his or her version of the incident without much of an interruption. Leading questions can be asked in between to bring the patients back on track, if they ever get diverted off course. The history should highlight the following important points:

Events leading up to the injury. It is of utmost importance to elucidate the minutest detail of activity which the patient was performing at the time of sustaining the injury, e.g. whether the activity was related to sports, bow and arrow and bursting of crackers during Diwali/Dusshera festivals, a laborer crushing stones while using a chisel and hammer, industrial or agricultural pursuits, involved in roadside accidents and finally an assault with the use of some kind of armament.

***Detailed description of the mechanism of trauma to note whether*:**

- A high-velocity or a low-velocity trauma, and
- Injury with a blunt or a sharp object

Time of the injury and time elapsed between the insult and initial presentation should be documented:

- As it decides management. A fresh open corneal wound would be dealt with urgently and more aggressively than a self-sealed corneal laceration in a quiet eye which is a week old.
- Important for medicolegal purposes.

Rural or an urban setting should be noted. The incidence of infection in cases of trauma in rural settings is higher and so is the risk of endophthalmitis.

Chemical nature of the insulting object should be noted

- If an intraocular foreign body is suspected its nature and chemical composition must be known (iron, copper or steel)
- Any chemical agent, such as an alkali or acid, may further complicate the mechanical injury.

Prior ocular history should specifically include:

- Any history of previous ocular surgery or trauma
- Use of any ocular medications, and
- Prior vision of the injured eye and the un-injured eye.

Generalized medical history of any chronic systemic illness or use of any drugs or

medications should be documented. It is important to note any drug allergies and status of tetanus immunization. If an open globe injury is suspected, general anaesthesia would be required and the patient should be asked about the time he last consumed solids and liquids.

OCULAR EXAMINATION

External inspection in diffuse illumination

Prior to examining the patient on the slit-lamp, a gross evaluation of the ocular condition can be made out with the help of a diffuse illumination of a pen torch.

- *Forehead and the periorbital tissues* should be inspected under bright illumination. Evaluate for the presence of any laceration, abrasion, periorbital edema and ecchymosis.
- *Look for exophthalmos*, enophthalmos or any foreign body, such as a stone present in the margins of the laceration.
- *Orbital walls* should be palpated to look for evidence of any bony discontinuity.
- *Crepitus and infraorbital hypoesthesia* may indicate an orbital fracture.

Inspection of globe

Attention should now be given to the ocular structures per se. The eyelids may be parted with the help of an eye speculum or a lid retractor in individuals wherein the periorbital edema makes examination difficult. Inspect the globes for:

- Prolapse of intraocular contents
- Protruding foreign bodies, and
- Any sign of occult open globe injury (hemorrhagic chemosis, pupillary peaking).

Note. It should be kept in mind that no pressure is given on the globe lest the intraocular contents prolapse out. In cases of highly swollen lids or an uncooperative patient, the examination of the globe can be deferred till imaging is done or can be carried out under sedation.

Visual function assessment

Visual acuity. The presenting visual acuity is a crucial prognostic indicator in determining the outcome of injury. The visual acuity is measured separately for each eye. It should be preferably recorded on a standardized chart (ETDRS or Snellen). If the patients are immobilized or on a stretcher, due to systemic comorbidities, visual acuity can be assessed by asking the patient to count fingers at a specific distance. Poor vision can be recorded as either hand motions or light perception with a documentation of projection of rays. The test of light perception and projection of rays should be carried out with the brightest possible light (indirect ophthalmoscope).

Relative afferent pupillary defect. The presence or absence of RAPD is an indicator of gross visual dys function. The test is performed as a swinging flash-light test with a bright light source. Apparent dilation of the pupil of the eye in which light is shown points towards the presence of RAPD. It indicates an optic nerve or a severe retinal damage with a poor prognosis.

Afferent pupillary defect can also be elucidated in cases where-in the iris is injured and the pupil is not reacting. In this case rather than visualizing the direct pupillary response in each eye, only the response in the normal reacting pupil is observed. RAPD is said to be present when the pupil of the fellow eye dilates when light is moved to the injured eye.

Visual field assessment. Rapid assessment of the peripheral visual field can be carried out in the emergency setting using the confrontation test. It can give additional information about retinal or optic nerve damage.

Ocular motility assessment

- If *injury to the cranial nerves* or bony orbital margin is suspected, ocular motility must be evaluated.
- *A case of blow-out fracture* with an entrapped inferior rectus muscle can be made out at this stage and treatment modified accordingly.
- However, it is not always possible to examine for motility as the patient's periorbital oedema or lack of cooperation may mask the findings.

Examination of conjunctiva

Foreign bodies or precipitates of chemicals may be lodged within the conjunctival fornices. The lids should be everted and fornices examined.

Double eversion of the upper lid with a Desmarres retractor is needed to look for hidden foreign bodies in the superior fornix.

Presence of hemorrhagic chemosis should make one suspect of an underlying breach in the eyewall.

Subconjunctival hemorrhage, the posterior extent of which cannot be reached, raises the possibility of a fracture of the base of the skull.

Lacerations of the conjunctiva may be difficult to make out initially. Manipulation with a cotton swab following anaesthetic instillation can clearly delineate the edge of the laceration. A thorough search for an underlying scleral wound should be made in these cases.

Examination of cornea

Epithelial defects. Patients usually present with pain and photophobia. A drop of a topical anesthetic helps to allay their discomfort and allows for a thorough examination at the slit-lamp. Fluorescein staining and documentation of the size of the epithelial defect is of prime importance. Look for abrasion, opacification and ulcerations.

Superficial corneal foreign body. The depth of penetration of the foreign body should be evaluated on the slit-lamp. If the entire thickness of the cornea is breached, the injury gets classified as an open globe injury. The foreign body in this case is best removed in the operation theatre. For smaller foreign bodies which are more superficial, removal on a slit-lamp with a hypodermic needle is sufficient.

Corneal wounds should be analysed whether they are full thickness or partial thickness. This can be carried out with the help of a Seidel's test. Leakage of aqueous from a full thickness breach would dilute the fluorescein dye forming a green stream (positive Seidel's test).

Examination of sclera

- A detailed examination of the sclera should be carried out to look for any breach in the eyewall. This is not always easy as the associated subconjunctival hemorrhage may prevent adequate visualization.
- If a defect in the continuity of the scleral wall is suspected and adequate visualization is not possible, a surgical exploration should be planned.

Examination of anterior chamber

Contents of anterior chamber should be analysed for the presence of any aqueous cells or flare. Traumatic iritis following the insult can lead to inflammation in the anterior chamber. RBCs may also be found in the anterior chamber with damage to the iris. Look for any retained foreign body, hyphema or hypopyon.

Depth of the anterior chamber must be noted:

Deep anterior chamber may be a sign of:

- Posterior dislocation of the lens, or
- Posterior scleral rupture, or
- Iridodialysis.

Shallow anterior chamber may be a sign of:

- Anterior dislocation of the lens, or
- Corneoscleral perforation, or
- Suprachoroidal haemorrhage, or
- Serous choroidal detachment.

Examination of iris

- *Iris is one of the most common sites of damage* in both open and closed globe injuries. A slit-lamp evaluation should be carried out to look for sphincter tears, iridodialysis, iridodonesis and full thickness iris defects.
- *In case of corneoscleral wounds*, the iris may be prolapsed to block the site of perforation. In old injuries, the iris tissue may get incarcerated in the wound leading to an adherent leucoma.

Examination of crystalline lens

- A note should be made of phacodonesis, dislocation, subluxation or zonular dehiscence.
- Blunt trauma can lead to a break in the posterior capsule forming a rosette-shaped concussion cataract at the posterior subcapsular region.
- Look for the integrity of the anterior capsule. A tear in the capsule would result in anterior subcapsular opacification or in leak of cortical material into the anterior chamber and further inflammation.
- Intralenticular foreign bodies must be looked for.

Intraocular pressure measurement

- Measurement of intraocular pressure should be carried out in all cases of trauma; provided an open globe injury has been ruled out.
- Following a contusion, the intraocular pressure may rise acutely, especially if inflammation and blood is present.
- An abnormally low IOP would point towards an occult open globe injury but can also be seen with ciliary body detachment.

Examination of posterior segment

- *An indepth analysis of the posterior segment* of the eye should be carried out after ruling out globe rupture before the media clarity is compromised.
- *90D slit-lamp examination* should be attempted in case the media permits or else *20D indirect ophthalmoscopy* be carried out (without indentation at this stage) in order to rule out retained intraocular foreign body, vitreous hemorrhage, retinal break (infero-temporally—direct injury) or retinal dialysis (supero-nasally—counter-coup injury), choroidal ruptures, macular edema and optic nerve avulsion, etc.
- *In most cases, mydriatics* should be used to facilitate view of the retina and vitreous. It is to be borne in mind that the use of mydriatics should be properly documented so as to avoid misinterpretation of subsequent pupillary examinations. (Pupillary reflexes are also evaluated to look for evidence of neurological damage).
- *In case of open globe injuries with prolapse of uveal tissue*, it is advisable to defer the evaluation of the posterior segment to a later date after the surgical repair is completed.

ORBITAL IMAGING

It becomes necessary to bank upon imaging modalities to provide additional information whenever significant trauma is suspected to the periorbita or in cases where in view of the posterior segment is compromised (corneal decompensation, traumatic hyphema). In cases of open globe injury, some form of an imaging investigation should be ordered to look for a retained intraocular foreign body.

PLAIN RADIOGRAPHY

- With the advent of CT scan, the dependency on plain X-ray radiography has diminished. However, if a CT scan is not available, an X-ray of the orbit can also serve as a useful tool in evaluating bony trauma (Fig. 2.2) or an intraocular foreign body (Fig. 2.3).
- In addition to the advantage of diminished exposure to radiation as compared to CT, plain X-ray orbit will save the practicing ophthalmologist from the risk of Consumer Protection Act (CPA) and must be ordered even with the slightest suspicion of retained intraocular foreign body (RIOFB).

COMPUTED TOMOGRAPHY

- *CT scan has replaced X-ray radiography* as the most commonly used and most useful investigation in patients with severe periorbital or ocular trauma.
- *Coronal and axial scans* provide a detailed view of the bony structure of the orbit (Fig. 2.4) as well as the ocular anatomy. The size, shape and location of a foreign body can be easily demarcated with a CT scan (Fig. 2.5).

Fig. 2.2 *Plain X-ray orbit (AP view) showing herniated orbital contents (arrow) with blow-out fracture*

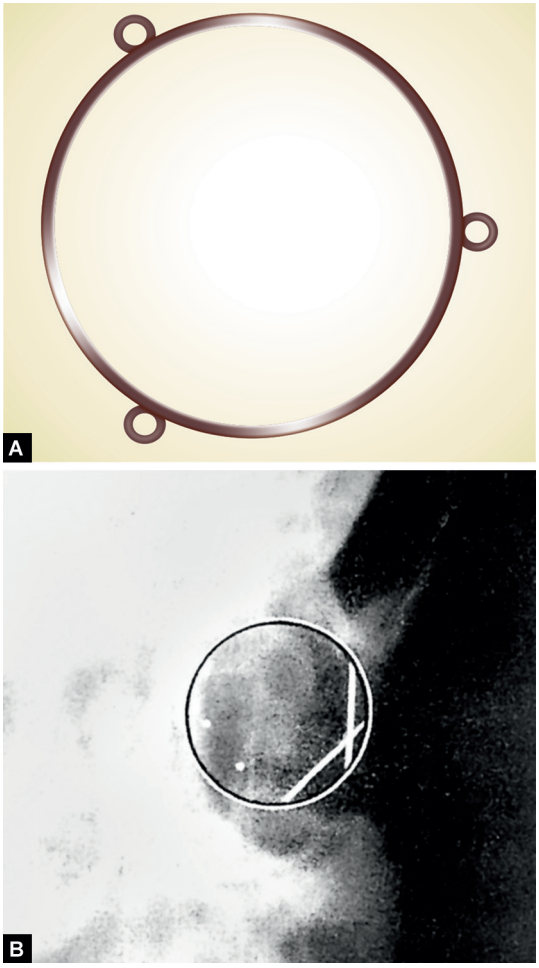


Fig. 2.3 *Limbal ring method of localizing RIOFB: (A) Limbal ring, (B) X-ray orbit lateral view with limbal ring*

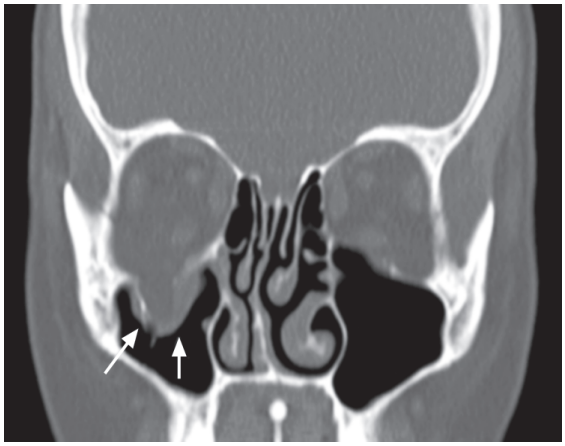


Fig. 2.4 *CT scan of orbit: Axial view depicting fracture floor of the orbit with herniation of the orbital contents*

Fig. 2.5 *CT scan of the orbit depicting intraocular foreign body*

- Being readily available in the emergency setting, CT scan unlike ultrasonography *can be carried out even in patients with open globe injuries.*
- *Radiologist should be advised to use thinner cuts* (1–2 mm) so as to better delineate the ocular anatomy.
- *Common CT scan findings* that are suggestive of open globe injury are:
  - Deformity of the globe
  - Intraocular foreign body
  - Intraocular air
  - Intraocular haemorrhage
- *Sensitivity and specificity of CT scan* in determining open globe injury are 56–68% and 79–100%, respectively.

ULTRASONOGRAPHY

- *Utilizes high frequency sound waves* to delineate ocular structures in real-time.
- *Ultrasonography requires a direct contact* with the lids and in cases of open globe injuries is contraindicated till the injury is repaired. In these cases, USG can be carried out in the operating room after repair with the patient under general anaesthesia.
- *B-scan ultrasonography helps to realize posterior segment pathology*, if the view of the fundus is compromised. It is useful in detecting (Fig. 2.6):
  - Retinal detachment (Fig. 2.6A),

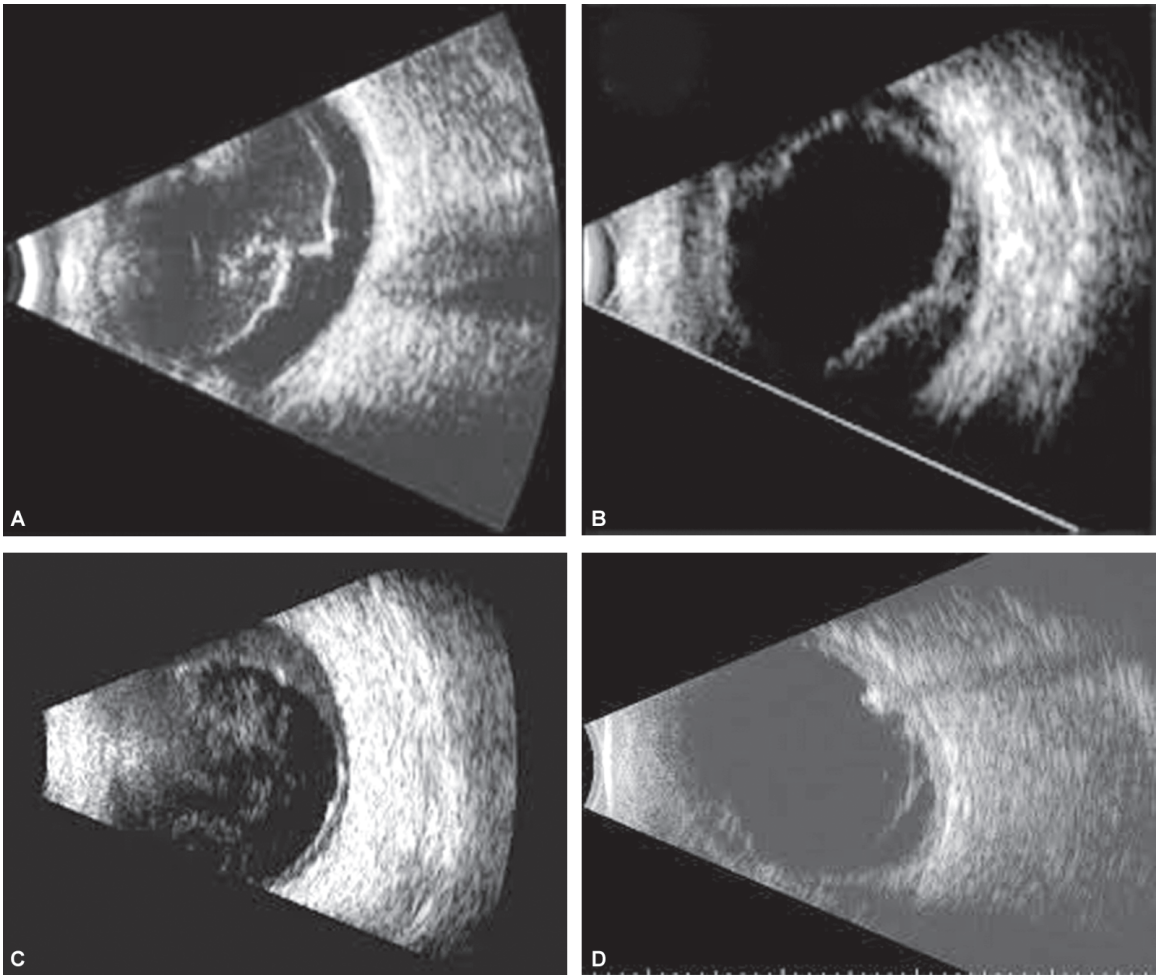


Fig. 2.6 *B scan of traumatic eyeball depicting: A. Traumatic retinal detachment; B. Choroidal detachment; C. Vitreous haemorrhage; D. Intraocular foreign body*

– Choroidal detachment (serous or haemorrhagic) (Fig. 2.6B),
– Vitreous haemorrhage (Fig. 2.6C),
– Posterior vitreous detachment
– Intraocular foreign bodies (radiolucent and radio-opaque) (Fig. 2.6D), and
– Posterior breaks in the continuity of the eyewall (perforation *vs* penetrating injury).

MAGNETIC RESONANCE IMAGING

Role of an MRI in the setting of ocular trauma is limited by its availability and longer image acquisition times. Furthermore, it cannot be used if a metallic intraocular foreign body (iron) is suspected or in patients on pacemakers.

SURGICAL EXPLORATION AND EXAMINATION UNDER ANAESTHESIA

Indications. In cases wherein significant doubt remains about the nature of injury despite imaging modalities and examination or those cases who resist examination, a surgical exploration may be necessary for accurate diagnosis.

- *General anaesthesia* should be preferred.
- *An adequate conjunctival peritomy* should be done and the scleral shell should be evaluated under high magnification for any breach. Always remember to look at weak points on the eyewall especially at the limbus, at areas of old scars and at the insertion of extraocular muscles.

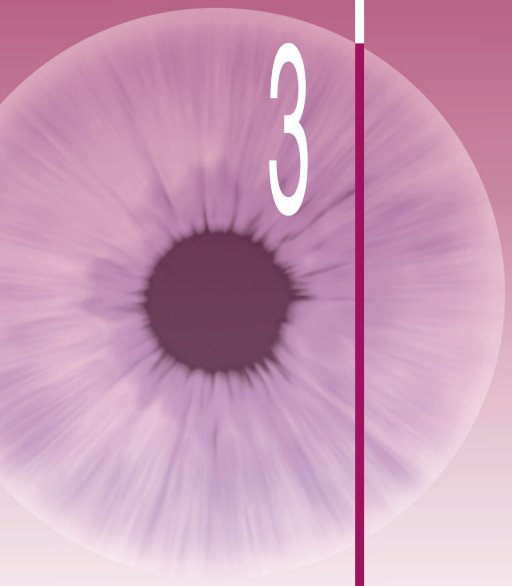
- *Cornea and anterior chamber should be examined* under high magnification. The angle can be evaluated with the help of a direct gonioscope lens.
- *Ultrasonography and indirect ophthalmoscopy* can be performed to look for posterior segment pathology.

PATIENT COUNSELLING

Last but not the least patient counselling is most important sensitive part of clinical work of eye trauma. Counselling of the patient and relatives begins at the point of initial contact in the emergency environment. This begins with initial comforting of the patient and aims to allay anxiety. The counselling must be informative, truthful, accurate and should be an ongoing process till the conclusion of treatment. This is especially important in patients who would require surgical intervention. It is true that the final visual acuity remains in doubt following ocular trauma in the initial few weeks, however, a realistic opinion about the visual prognosis can be gathered from the ocular trauma score. The patient must be encouraged not to give up hope. It is important to counsel the patient for any life adjustments that may be required.

BIBLIOGRAPHY

1. Arey ML, Mootha VV, Whittemore AR, Chason DP, Blomquist PH. Computed tomography in the diagnosis of occult open-globe injuries. Ophthalmology 2007;114:1448–1452.
2. Boldt HC, Pulido JS, Blodi CF et al. Rural endophthalmitis. Ophthalmology 1989;96:1722–1726.
3. Kuhn F, Maisiak R, Mann L, Mester V, Morris R, Witherspoon CD. "The Ocular Trauma Score (OTS)". Ophthalmol Clin North Am 2002; 15:163–165.



3 EMERGENCY MANAGEMENT OF OCULAR INJURIES

PRELIMINARY CONSIDERATIONS
- Introduction
- Initial history and evaluation
- Formulation of a management strategy

ANAESTHESIA AND SPECIFIC CONSIDERATIONS FOR EMERGENCY EYE SURGERY
- Indications for emergency eye surgery
- Timing of surgery
- Pre-anaesthetic evaluation
- Local versus general anaesthesia
- Sedation in ocular injuries
- Choice of drugs for general anaesthesia
- Airway management and mode of ventilation
- Analgesic and anti-emetic drugs in ocular injuries
- A practical approach to emergency eye anaesthesia
- Regional anaesthesia for traumatic eye injuries

EMERGENCY MANAGEMENT STRATEGIES FOR OCULAR INJURIES
- Adnexal trauma
- Extraocular foreign body
- Corneal injuries
- Closed globe trauma
- Open globe injury
- Retained intraocular foreign body
- Traumatic endophthalmitis
- Traumatic optic neuropathy
- Retrobulbar haemorrhage
- Orbital fractures
- Intraorbital foreign body

PRELIMINARY CONSIDERATIONS

INTRODUCTION

The approach of an ophthalmologist working in the emergency and the outpatient setting is different; in the emergency setting, the patients as well as the relatives are in a state of dismay and shock, therefore, the cordial and comforting interaction is desirable. Allaying of the patient anxiety with prompt treatment is of paramount importance and goes a long way in forming the patient–doctor bond which is quite essential in these cases as they would require motivation for undergoing repeated surgeries or long-term follow-ups. Patients in the emergency may have varied clinical presentations; this chapter aims to provide to the reader, the basic knowledge that would be required in dealing with these situations, however, for a detailed description they are referred to the relevant chapters of the book.

As mentioned previously, it is imperative to understand that management of ocular injuries in the setting of polytrauma usually takes a backseat to allow for initial evaluation of grave systemic injuries. It must, however, be noted that a prompt ophthalmological consultation of the patient should be carried out as early as the situation allows so as to formulate a treatment strategy for the same. Although it is understandable that life-threatening injuries should take priorty over ocular trauma but one should bear in mind that vision loss following ocular injuries severely dampens the quality of life of the patient.

INITIAL HISTORY AND EVALUATION

A detailed history about the nature of trauma is essential in a case of ocular injury as it guides the ophthalmologist towards the examination. A proper documentation of the records is also necessary for medicolegal purposes.

Ocular injury in many cases accompanies systemic injuries and in these patients the ophthalmologist may have limited exposure to the patient in view of life-saving interventions. A pen torch diffuse light evaluation is essential in these cases so as to have a gross idea of the nature of the ocular injury and to rule out an open globe injury. In stable and conscious patients who are co-operative for evaluation, a detailed slit-lamp examination should be performed.

In patients suffering from intracranial injuries, it must be enforced that pharmacological dilation of the pupil should not be attempted as assessment of pupillary reflexes is necessary for monitoring their systemic status. In addition, the information obtained after a fundus evaluation in this manner usually provides little or no alteration in the management strategy.

FORMULATION OF A MANAGEMENT STRATEGY

Following a thorough examination, the ophthalmologist must be in a state to formulate a plan to obtain the maximum benefit for the patient. The traditional approach focuses on a more passive role of the surgeon, taking into account a step by step approach instead of anticipating and planning ahead. This results in repeated surgeries which may have a bearing on the psychology of the patient. While forming the management strategy, the ophthalmologist must take into account the nature of the injury and anticipate complications which may occur either secondary to the trauma or during surgery. This makes the role of the ophthalmologist a more active one with fewer surgeries for the patient and an improved chance of faster visual restoration. It must be emphasized that the management strategy does not end with surgery but proper counselling of the patient should be done so that he / she is rehabilitated in the society.

ANAESTHESIA AND SPECIFIC CONSIDERATIONS FOR EMERGENCY EYE SURGERY

INDICATIONS FOR EMERGENCY EYE SURGERY

An emergency is defined as an event that has to be dealt with immediately, usually within the first hour after presentation. The commonest eye emergencies that fall into this category are chemical burns of the eye and retinal artery occlusion. Neither of these requires surgery as part of the initial management. The majority of cases presenting as emergencies can, therefore, be defined as urgent cases. Trauma is by far the commonest indication for urgent surgery. Traumatic injuries can be blunt or penetrating (open eye). The incidence is highest in young adult males and children. Trauma is often associated with industrial or motor vehicle accidents. Eye protection in the work place and car safety belts have lowered the incidence of eye trauma in many countries. Eye trauma is usually confined to one eye. Some patients may present with trauma to both eyes or with multiple injuries. There is usually enough time, however, to allow for fasting prior to surgery.

TIMING OF SURGERY

Ideally all patients should be kept fasting before undergoing general anaesthesia to minimise the risk of aspiration and subsequent lung injury. This obviously has to be weighed against the risk to the eye that delaying surgery may cause. It is essential to liase closely with the surgeon to establish the degree of urgency. Most cases involving blunt trauma can usually be delayed to allow for patient fasting. Penetrating injuries may need to be dealt with more urgently due to the risk of infection and endophthalmitis. If the patient has an open globe injury, there is also the risk of vitreous loss and retinal detachment. Even with open globe injuries, many ophthalmic surgeons are willing to delay surgery until a patient is adequately fasted prior to anaesthesia. This is especially the case where there is severe damage to the eye and surgery is not going to improve sight. This group of patients are usually admitted for bed rest and have an eyeshield covering the injured eye until they are ready for primary closure of their eye wounds. Open globe injuries in which the eye is still largely intact and the visual prognosis is good need to be dealt with more urgently. Decision need to be made on a case by case basis. The degree of urgency will depend on the size of the laceration and commensurate risk of loss of ocular

contents, how dirty the wound is and the risk of infection. A fast of six hours is normally suggested in the uncomplicated patient. It is now common practice to allow patients to drink clear fluids (water, non-fizzy fruit drinks) up to two to four hours prior to the time of surgery. In patients who have had trauma or received opioids, it can take up to 24 hours for gastric emptying to take place. The most important time interval is that between the last meal and the time of the injury. If trauma occurs soon after a large meal, the patient may still have a full stomach after the standard six-hour fast. Alcohol also delays gastric emptying. If surgery is necessary in a patient with a full stomach, then a rapid sequence induction technique should be used.

How long patients should be fasted for prior to surgery with a local anaesthetic block is controversial. We feel that in the patient undergoing emergency eye anaesthesia the above principles regarding fasting should be used irrespective of the anaesthetic technique chosen.

PRE-ANAESTHETIC EVALUATION

Eye trauma requiring surgery may be associated with other injuries that may or may not require surgery. In the scenario of polytrauma, normal trauma principles must always be applied. Life-threatening problems should be dealt with before sight-threatening problems. Patients with other disease processes, such as diabetes or ischaemic heart disease, should have these optimised prior to surgery, if time allows.

LOCAL VERSUS GENERAL ANAESTHESIA

The choice of technique will depend on patient factors as well as local facilities and surgeon preferences. In many countries, extraocular, anterior segment and vitreoretinal eye surgery is routinely performed using local anaesthetic techniques. However, there are many practical reasons why a general anaesthetic is often preferable for emergency cases. Firstly, the patient must be able to lie flat, still and protect his or her own airway safely for the duration of the procedure. Thus, children, uncooperative or intoxicated patients are usually better candidates for a general anaesthetic. An uncooperative patient with an open eye is extremely difficult to manage. Spread of local anaesthetic agents is poor in patients with eye and orbital infections.

Some procedures, such as scleral buckling for retinal detachment, can be extremely uncomfortable even with a good local anaesthetic block. In our experience, younger adults tend to tolerate surgery with a local anaesthetic technique poorly compared with elderly patients.

In open globe injuries, local anaesthetic techniques are usually avoided. Injection of local anaesthetic using peribulbar and retrobulbar techniques is associated with an increase in intraocular pressure which may lead to vitreous loss. Oculocompression after the block is also not an option, if the patient has an open globe injury. In some patients, it may be possible to operate on small open globe injuries using topical anaesthesia, sub-tenon blocks or a careful peribulbar or retrobulbar block.

SEDATION IN OCULAR INJURIES

Sedation should be used cautiously. Over sedation can convert a cooperative patient into a difficult to manage patient due to airway problems and confusion. Sedation should not be used as an alternative to a general anaesthesia in a patient with a full stomach. If a patient develops pain during surgery using a local anaesthetic technique, the patient requires analgesia and not sedation. The surgeon should supplement the block using local anaesthesia or small doses of intravenous analgesia should be given.

If sedation is to be used, then small doses of a short-acting agent, such as midazolam, should be given. Diazepam in small doses may also be an option. Propofol in small 10 mg increment doses can also be used especially prior to performing a local anaesthetic eye block. Some anaesthetists use small doses of alfentanil or fentanyl. The key to good sedation is to maintain verbal contact with the patient. Careful surgical draping is also important. Patients become claustrophobic, if their faces are draped. Use of a bar to hold up the drapes can allow a tent to be made to allow better ventilation. Oxygen should be given to the patient, especially if sedation is to be used. Patients may find a face

mask or nasal oxygen cannula uncomfortable. Oxygen can be insufflated under the drapes using a breathing circuit. This also improves air circulation under the drapes.

Many of the problems associated with local techniques can be avoided with a clear explanation of the procedure to the patient prior to commencing surgery, having a comfortable operating table, and somebody to hold the patient's hand throughout. Allowing patients to empty their bladder prior to surgery also helps.

CHOICE OF DRUGS FOR GENERAL ANAESTHESIA

The choice of intravenous induction agent will depend on local availability and user familiarity. Most intravenous induction agents reduce intraocular pressure, therefore, preventing further damage to the injured eye. Ketamine possibly raises intraocular pressure although the literature is conflicting. Most textbooks state that it should be avoided in open globe injuries. If it is to be used, it is best to use it in combination with small doses of a benzodiazepine (midazolam, diazepam) to blunt its excitatory effects. The majority of problems with ketamine and intraocular pressure seem to occur when it used as a sole agent in a patient with an unprotected airway breathing spontaneously. Ideally ketamine should be used with a muscle relaxant and controlled ventilation, if intraocular pressure control is important.

All the non-depolarising muscle relaxants can be used without adverse effects on the eye so choice will depend on the availability. Suxamethonium (scoline) increases intraocular pressure, the exact mechanism of which is unclear but it is not thought to be solely due to contraction of the extraocular muscles. Suxamethonium also causes an increase in the intraocular blood volume and this may contribute to the rise in intraocular pressure.

The rise in intraocular pressure occurs after one to two minutes and wanes after six to ten minutes. The extent of the rise in intraocular pressure will depend on the other drugs used and the response to laryngoscopy and intubation. Its use in penetrating eye injury anaesthesia is controversial. The majority of eye surgeons prefer if it is not used. Adequate fasting prior to surgery will allow suxamethonium to be avoided for the majority of urgent cases. This obviously presents a dilemma in the patient with a full stomach as suxamethonium is used as part of a 'rapid sequence induction' to enable an airway to be secured quickly. In this situation, the relative risks need to be weighed, i.e. prevention of aspiration (potentially life-threatening) verses ocular damage (potentially sight-threatening). Suxamethonium-avoiding techniques include the use of large doses of vecuronium or pancuronium to speed up its onset of action as part of a modified rapid sequence induction technique. The non-depolarising neuromuscular blocker rocuronium has a rapid onset of action with a duration of 30 to 40 minutes. It can be used for a rapid sequence induction technique but can only be recommended to those who have gained experience in its use and for patients in whom airway problems are unlikely to occur. On balance, there are no case reports of ocular damage with suxamethonium use, and no good evidence that suxamethonium-avoiding techniques are any better or safer.

AIRWAY MANAGEMENT AND MODE OF VENTILATION

It is considered good practice to intubate and ventilate the patient to ensure a secure airway (the surgical field is inclose proximity) and to facilitate mild hypocarbia (this reduces intraocular pressure). The laryngeal mask airway is a popular choice for airway management for elective eye surgery in the UK. Laryngeal mask insertion avoids the presser response to laryngoscopy and intubation causing raised intraocular pressure.

ANALGESIC AND ANTI-EMETIC DRUGS IN OCULAR INJURIES

Analgesic drugs

- *Paracetamol. Children*: 90 mg/kg total per 24 hours. Avoid, if liver dysfunction peptic ulcer disease. *Acetaminophen,* orally or rectally in 4–6 divided doses dose to total of 60 mg/kg per 24 hours, if treatment for more than 48 hours. *Adults*: 1 g orally or rectally. 4 g total per 24 hours.

- *Ibuprofen. Children*: 10 mg / kg orally, 4 doses in 24 hours. Ibuprofen has the lowest side effect of the non-steroidal anti-inflammatory drugs. Avoid in renal and use with care in asthma. Not in children <7 kg.
  Adults: 400 mg orally, 4 doses maximum in 24 hours.
- *Diclofenac. Children*: 1 mg / kg orally or rectally, 3 doses in 24 hours. Cautions as for Ibuprofen.
  Adults: 150 mg total by any route in 24 hours.
- *Codeine phosphate* 0.5 mg / kg orally 6 hourly. Use with care when co-administered with other opioids.

Anti-emetic drugs

- *Droperidol.* 0.5 to 1 mg in adults, up to 3 times a day, cheap and effective but causes drowsiness, sedation, anxiety and restlessness. Risk of extrapyramidal effects.
- *Cyclizine. Children*: 1 mg / kg IV up to 3 times a day.
  Adults: 50 mg IV antihistamine and anticholinergic effect.
- *Ondansetron. Children*: 0.1 mg / kg IV 3–4 doses per 24 hours.
  Adults: 4 mg IV expensive but effective with low side effect profile. Does not protect against aspiration of gastric contents. Its use in emergency anaesthesia is, therefore, limited.

Analgesia and control of nausea and vomiting

It is possible to manage pain in the majority of patients after eye surgery with oral analgesia. Avoiding opioids, if possible, helps prevent nausea and vomiting. Regular doses of paracetamol (acetaminophen) and a non-steroidal anti-inflammatory drug (ibuprofen, diclofenac, ketoprofen) should be prescribed. Codeine phosphate can also be added. These drugs are best accepted by children, if given as an elixir (syrup).

In patients having surgery with general anaesthesia, it is a good idea to ask the surgeon to perform a local anaesthetic block before waking up the patient. If stronger analgesia is required this is best given as small intravenous doses of morphine or pethidine.

Nausea and vomiting after emergency eye anaesthesia can be a major problem in some patients. Anti-emetic prophylaxis may help prevent this. Some patients may benefit from a regular anti-emetic in the postoperative period. There is a vast number of anti-emetic drugs available. Most have a limited efficacy. Using a combination of small doses of anti-emetic drugs from different pharmacological classes may enhance efficacy and reduce side effects.

A PRACTICAL APPROACH TO EMERGENCY EYE ANAESTHESIA

- *Assess the indication for emergency anaesthesia* in discussion with the surgeon. Can surgery be deferred until normal working hours and to allow adequate fasting?
- *Carry out a full preoperative assessment* including a history and examination.
- *Are there any medical/trauma issues that need addressing first?* Decide on choice of anaesthetic technique. Provide the patient with a full explanation. Tell the patient what to expect, if a local anaesthetic technique is to be used.
- *If a general anaesthesia is chosen,* decide if the patient has a full stomach and is at risk of aspiration.
- *If the patient has a full stomach,* a rapid sequence induction technique should be used. They should be preoxygenated with 100% oxygen. Pressure on the affected eye from the mask must be avoided. The patient should then be induced with an intravenous anaesthetic agent (e.g. thiopentone 47 mg / kg) and a rapid onset muscle relaxant (suxamethonium 1–1.5 mg / kg is currently the only realistic option). While the patient is being induced, cricoid pressure should be applied by an assistant (Sellick's manoeuvre) thus occluding the oesophagus behind. The patient's trachea should be intubated after which the cricoid pressure can be removed. Note that the endotracheal tube tie should not be tight around the neck as this impedes venous drainage and raises intraocular pressure.
- *Choice of maintenance depends* on local availability, e.g. 40% O_2, 60% NO and an inhalational agent note that all inhalational agents reduce intraocular pressure.

- *Control ventilation* during the procedure aiming for low to normal end-tidal carbon dioxide. This may require the use of a longer acting muscle relaxant (e.g. vecuronium 0.1 mg/kg). A slight head up tilt helps reduce intraocular pressure.
- *At the end of the procedure, the patient should* be extubated on their side and once airway protective reflexes have returned. In patients not deemed at risk of aspiration extubation with the patient having deep and spontaneous breathing may prevent coughing. Severe coughing and straining needs to be avoided as this increases the risk of ocular haemorrhage.
- *If the patient does not have a full stomach* and is not deemed at risk of aspiration, general anaesthesia should proceed as for an elective patient. Pre-oxygenate the patient for safety and induce with an intravenous agent, give a long-acting muscle relaxant once ability to hand ventilate is established. Laryngoscopy should be performed gently. Consider spraying the vocal cords with lignocaine.

REGIONAL ANAESTHESIA FOR TRAUMATIC EYE INJURIES

Regional anaesthesia may be a reasonable alternative in those scenarios where general anaesthesia presents an unacceptable or elevated risk to either the patient systemically, or the eye in specific.

Regional anaesthesia as retrobulbar (intraconal) and peribulbar (extraconal) blocks may be performed using single-injection combinations of 2 or 4% lidocaine and .75% bupivacaine admixed with small aliquots of hyaluronidase. A prior lid block to attenuate eyelid squeezing during the orbital injection may be particularly useful in open globe trauma. In the operating room, subconjunctival irrigation of local anaesthetic via a blunt cannula may be useful in open globe trauma used as needed to supplement the initial injection. Intravenous sedation may be provided at the discretion of the anaesthetist.

Regional anaesthesia with sedation

Regional anaesthesia with sedation is a good alternative to general anaesthesia, when required.

Topical anaesthesia for traumatic eye injuries

Topical anaesthesia has gained acceptance over the past few years for cataract surgery and may be a prudent alternative in those select open globe scenarios where general or regional anaesthesia present exceptional risk.

Topical anaesthesia may consist of .4% oxybuprocaine-soaked cellulose sponges placed in the upper and lower fornices for 20 min prior to wound closure.

Topical anaesthesia and intravenous sedation may also be a reasonable alternative for less severe traumatic eye injuries.

***Risks and techniques*:** Regional and topical anaesthesias for ophthalmic surgery are certainly not without inherent risks. A review of all monitored anaesthesia care closed malpractice claims in the American Society of anaesthesiologists Closed Claims Database revealed that one in five such legal cases derived from eye surgery.

Rethinking anaesthesia strategies for patients with traumatic eye injuries.

Unlike general anaesthesia, these techniques mandate patient cooperation. Patient movement due to cough, fluctuating levels of consciousness, rebreathing of carbon dioxide, or restlessness with prolonged duration of surgery can precipitate dire visual consequences.

EMERGENCY MANAGEMENT STRATEGIES FOR OCULAR INJURIES

Common ocular injuries encountered as emergency in day-to-day practice are open globe injuries with and without intraocular foreign bodies, closed globe injuries, chemical injuries, extraocular foreign bodies, traumatic optic neuropathy, blow-out fractures of the orbit and traumatic endophthalmitis. These are truly classified as ocular emergencies and require prompt and urgent management to safeguard vision.

ADNEXAL TRAUMA

Most patients present with injuries to the periocular structures following road traffic accidents or with a history of fall. It may range from a minor abrasion to a muscle-deep or bone-deep laceration with extensive bleeding.

- *All periocular injuries should be cleaned thoroughly* with povidone iodine or any other antiseptic agent.
- *Careful evaluation* of the lesion should be done to look for any retained foreign bodies in the wound.
- *A note should also be made of injury to the lid margin or the canaliculi* as these would require specialized treatment at the time of primary repair itself.
- *History of tetanus immunization* should be taken and wherever found to be lacking appropriate measures should be undertaken.
- *Abrasions and some superficial lacerations* require application of only an antibacterial ointment and the maintenance of proper wound hygiene.
- *Deeper laceration* would require suturing. The muscle and subcutaneous tissue should be snugly sutured with an absorbable suture (6–0 vicryl) while the overlying skin is sutured with a non-absorbable suture (5–0 silk or prolene). The skin sutures can be removed in 7–10 days as the wound healing permits.
- *Patients are instructed to maintain proper wound hygiene* and can be started on oral antibiotics and anti-inflammatory agents.

Periocular ecchymosis

- *Blunt trauma to the forehead* may result in the seepage of blood into the eyelids rendering them a purplish hue.
- *Periocular ecchymosis requires closer evaluation* as it may be the only indication of a fracture involving the base of the skull, particularly if bilateral.
- *If the site of blunt trauma is the eye* as in case of injury with a fist or a ball, a complete ocular evaluation should be carried out with full mydriasis to look at ocular injury secondary to the contusion.
- *'Raccoon eyes' or 'black eye'* requires cold compresses for resolution along with oral anti-inflammatory agents to mask the pain. Provided there is no underlying bony injury the blood usually clears away in 10–14 days.

Conjunctival injuries

Subconjunctival hemorrhage. There is usually no treatment required for subconjunctival hemorrhage following ocular trauma. An attempt should be made to trace the posterior limit of the hemorrhage, which if not reached usually points towards a fracture of the base of skull. Tear substitutes may help in providing some degree of comfort to the patient. NSAIDs should be discontinued in favour of acetaminophen which does not alter the clotting profile of the patient.

Conjunctival laceration. Lacerations of the conjunctiva can be picked up on slit-lamp examination with or without the use of fluorescein stain. The margins of the laceration tend to be rolled up due to the elastic nature of the conjunctiva. Not all lacerations require suturing and small ones can be left unsutured with pressure patching and the application of an antibacterial ointment. Most of the small lacerations tend to heal well when treated in this manner. For lacerations usually greater than 1–1.5 cm, suturing of the torn ends with 8–0 vicryl with buried knots is advocated with excellent results.

EXTRAOCULAR FOREIGN BODY

Corneal and conjunctival foreign bodies usually present with mild to moderate amount of pain with ocular discomfort.

- *Corneal abrasions and track marks* are tell tale signs of a foreign body and in all cases the conjunctival fornices should be carefully examined.
- *In cases of impacted foreign bodies,* always evaluate the depth of penetration of the object before removal.
- *Topical anaesthetic agent* in the form of 4% lignocaine or 0.5% proparacaine is administered in the cul-de-sac.
- *After appropriate anaesthesia,* the foreign body is removed with the help of a 26 G needle. While removing the foreign body gently

scrape the edge of the foreign body and approach it tangentially to avoid iatrogenic injury.

- *Iron foreign bodies may leave a small rust ring* around the site of impaction of the foreign body.
- *Following removal of the particle,* the patient must be kept under frequent follow-up till the epithelial defect heals.
- *Topical antibiotic and NSAID* should be prescribed, in cases of corneal foreign bodies, cycloplegia may help in alleviating the pain. (For details *see* Chapter 5.1)

CORNEAL INJURIES

Corneal abrasions

Presentation. Patients with corneal abrasion usually present with severe degree of pain and photophobia because of denudation of corneal nerves.

Examination. After examining and ruling out the presence of an open globe injury, application of topical proparacaine helps alleviate the symptoms and makes the patient co-operative for evaluation. Corneal abrasions can be picked up on a slit-lamp with fluorescein staining. The shape and size of the abrasion should always be clearly defined as it helps in the follow-up evaluation.

Treatment. Small corneal abrasion can be treated with the help of a bandage contact lens with frequent application of a topical antibiotic. For moderate to large abrasions, patching the eye with an antibiotic ointment is recommended. All patients with corneal abrasions should be kept under close follow-up till the epithelial defect heals. A cycloplegic agent helps to relieve the pain while a tear substitute will look after the foreign body sensation and vitamin C may help in expediting the healing process.

Corneal lacerations

Evaluation. In evaluating patients with corneal lacerations, the depth of the laceration helps to determine the treatment protocol. A Seidel's test should always be performed in cases of corneal laceration to look for occult leaks.

Treatment. Lacerations extending to the deeper stroma or lacerations with a positive Seidel's test should always be sutured with a non-absorbable 10–0 monofilament nylon sutures with micro-point spatulated needles. Superficial lacerations can be treated in the form of a corneal abrasion.

Photokeratitis

Photokeratitis, also termed as photo-ophthalmitis, is a particularly painful ocular condition arising from inadequate protection to the eyes during exposure to ultraviolet rays from natural or artificial sources.

Presentation. Typically the patient presents few hours following welding arc exposure with complaints of tearing, photophobia and ocular pain.

Evaluation. The history is very suggestive and fluorescein staining shows the presence of diffuse punctate staining under cobalt blue filter suggestive of epithelial erosions.

Treatment involves the use of a topical anti-inflammatory and copious use of artificial tears. Patients must be instructed about the occurrence of the condition and should be counselled to prevent future episodes.

Chemical injuries

Chemical burns with either acids or alkalis can prove to be devastating for the cornea, though alkali injuries are usually more severe than acid injuries.

Initial approach towards managing chemical injuries is copious irrigation; the attending ophthalmologist must consider all previous attempts at irrigation as being insufficient.

- *Irrigation helps to prevent further exposure* of the inciting agents and shortens the healing time.
- *During the process of irrigation,* the fornices should be cleared using a Desmarre's retractor.
- *Sterile saline* is the preferred agent for irrigation but no differences have been shown between saline, ringer lactate and other irrigating solutions. If none is available even tap water can be used. Irrigation should be continued to around 30 minutes.

Grading. Chemical burns can be graded using the Roperhall classification system.

- *Mild chemical burns* can be managed in the outpatient setting with the use of a topical antibiotic, copious tear substitutes, cycloplegics, topical steroids and a pressure lowering topical β-blocker. Oral anti-inflammatory agents help to reduce the pain, while vitamin C tablets accelerate the healing of the corneal epithelium. Patients must be reviewed every day till the epithelial defect heals.
- *Moderate to severe chemical burns* may require treating the patient on an in-patient basis. In severe cases, debridement of the necrotic corneal epithelium may be necessary to allow for proper re-epithelialization.

CLOSED GLOBE TRAUMA

Anterior segment trauma

Hyphema, iritis, iridodialysis

Hyphema. Layering of the RBCs in the inferior anterior chamber can occur following blunt trauma to the eyeball and may also be associated with penetrating ocular injuries. In cases of penetrating injuries, the hyphema may be drained at the time of globe repair. A slit-lamp evaluation of the hyphema is necessary for appropriate documentation. It is graded as under:

Hyphema	*Suspended RBC without formation of a layered clot*
1+	< 1/3 chamber hyphema
2+	1/3 – 1/2 chamber hyphema
3+	1/2 to near total hyphema
4+	Total hyphema (8-ball hyphema)

- An increase in intraocular pressure is one of the most common and dreaded complication of hyphema. The RBCs are trapped in the trabecular meshwork wherein they increase outflow resistance.
- *Outpatient management* should be considered only for adults who are compliant with a hyphema grade 2+ or less.
- *Hand-off approach.* The proper management of the condition is disputed with Romano and Phillips demonstrating a hands-off approach with excellent results. The approach consisted of using only oral steroids and hospitalization of all patients, with no ocular manipulation in the form of tonometry or use of any eye-drops. The practice usually followed is to advise strict bed rest with head end elevation and discontinuation of any oral anticoagulants. Oral steroids are started with anti-inflammatory agent (acetaminophen should be preferred). The eye should be patched using an eyeshield. The use of cycloplegics in hyphema management is again controversial. Anti-glaucoma medications should be initiated to tide over the initial rise of IOP which is usually transient and seen in around 30% of the cases lasting for 5–7 days.

Traumatic iritis occurs secondary to blunt trauma to the anterior segment as in cases of motor vehicle accidents, firecracker injuries, battery blasts, projectile injuries. Young males tend to be affected more commonly with traumatic iritis responsible for about 20% of the cases of iritis.

- *Topical cycloplegics with a topical steroid* are beneficial in correcting this pathological entity.
- *A topical β-blocker* may be added, if increased pressures are noted.

Iridodialysis. A localized tearing away of the iris from the ciliary body can result from injuries with blunt projectiles, such as air bags, cricket-ball injuries, water-balloons, fireworks, etc. Patients with small amounts of iridodialysis need no surgical intervention and should be followed up for increased IOP. If the patient has symptoms in the form of mono-ocular diplopia or glare the iridodialysis can be repaired at a later date.

Lenticular subluxation and dislocation

Presentation. Lenticular subluxation refers to partial displacement of the lens from the patellar fossa; complete displacement is termed as dislocation. Patients can be discomforted with the sudden diminished vision that accompanies this setting due to acquired myopia, astigmatism and diplopia.

Treatment. The amount of subluxation should be noted down and the patient can be rehabilitated with refractive correction in mild cases.

- *Severe cases of subluxation* should be treated in a manner similar to dislocation with extracapsular cataract extraction and if possible an IOL fixated in the primary sitting or at a later date.
- *In cases of dislocation of the lens into the anterior chamber,* prompt surgery should be undertaken to prevent endothelial decompensation and rise of IOP.
- *Posterior dislocation* is treated by a pars plana vitrectomy, phacofragmentation and transscleral fixation of an IOL at a later stage.

Posterior segment trauma

Vitreous haemorrhage

Presentation of the patient suffering from vitreous hemorrhage following trauma is dramatic with a sudden profound deterioration in the visual acuity.

Diagnosis of vitreous haemorrhage is usually straight-forward on a slit-lamp examination with a 90 D lens. The red glow of the fundus is either very dull or absent depending upon the severity of the haemorrhage. The posterior segment evaluation should be attempted with indirect ophthalmoscopy; if not visible a B-scan ultrasonography should be carried out to look for retinal detachment, choroidal detachment, posterior vitreous detachment or globe rupture.

Treatment. Bed rest with head end elevation should be encouraged to allow for the blood to settle and provide a view of the fundus. The patient is kept under observation for a period of two months, however, early surgical intervention is advocated in cases of accompanying retinal detachment.

Preretinal haemorrhage

Presentation. Preretinal bleeds are confined to the space between the nerve-fibre layer and the internal limiting membrane of the retina. Patients present in a similar state of frenzy following marked diminished vision, particularly if the preretinal bleed rests in front of the macula.

Management. The initial management consists of only reassurance along with a complete evaluation of the fundus with indirect ophthalmoscopy. A documentation of the extent of the haemorrhage either by a diagram or better still with a fundus camera should be done so as to record the diminishing size of the haemorrhage on sequential follow-up visits.

Commotio retinae

Presentation. It is a countercoup injury to the retina following a blunt trauma to the anterior segment of the eye. The patient complains of diminished vision but the retina appears normal on initial examination. The affected area turns white and opaque some hours after the initial insult due to disorganization of the outer retinal layers.

Treatment. Usually no treatment is required and the prognosis is good. A detailed evaluation should be carried out to look for subfoveal choroidal rupture or subfoveal haemorrhages which if present carry a poorer prognosis.

OPEN GLOBE INJURY

- *When the patient is first received in the emergency setting* an effort should be made to look for an open globe injury since the management of open globe trauma differs completely from contusion injuries.
- *While evaluating cases of open globe injury* be sure not to put pressure on the globe lest the intraocular contents should prolapse out. In an uncooperative patient, if an open globe injury is confirmed or suspected never perform a forceful examination in the emergency room, in such a case, a controlled environment under sedation or general anaesthesia is preferred. In cases of open globe injury, the detail regarding the inciting insult should be explored; one should always be suspicious of a retained intraocular foreign body particularly in cases of hammer and chisel injuries.
- *Eyeball should be patched immediately* with the help of a shield to prevent chances of further injury and the patient should be instructed not to cough violently or undertake any undue stress.
- *Co-ordination with the attending anaesthesiologist* will help in early exploration and primary repair.

- *Preoperative CT scan* can be carried out not only for documentation of the injury but also to exclude any intraocular foreign body and assessment of surrounding orbital trauma. Topical medications should be avoided in any open globe injury patients.
- *Systemic antibiotic* prophylaxis should be started (iv levofloxacin 500 mg).
- *Every attempt should be carried out to salvage the eye*, however, if the trauma is too extensive and the eyeball is mutilated beyond repair despite best efforts then it can be enucleated with prior patient counselling in order to decrease the chances of development of sympathetic ophthalmia.

RETAINED INTRAOCULAR FOREIGN BODY

- *An intraocular foreign body should be suspected* in all cases of open globe injury. Small corneal wounds, iris holes or break in the anterior capsule of the lens can be clues to a retained foreign body on examination.
- *Preoperative ultrasound* can be done in patients with self-sealed lacerations, however, it should be avoided in frank open globe injuries due to the external pressure it puts on the eyeball.
- *USG B-scan and CT scan* are essential in delineating the extent and location of the foreign body.
- *MRI should be avoided* unless the non-metallic nature of the foreign body is confirmed.
- *Appropriate management strategy* should be carved out trying for primary repair and removal of the foreign body at the initial sitting.
- *Intravitreal antibiotics* should be injected in all cases. Selection of the antibiotics should include a coverage of anaerobes especially in cases of wooden foreign bodies.

TRAUMATIC ENDOPHTHALMITIS

Endophthalmitis is a known complication in open globe injury particularly in cases with retained foreign bodies, hence an emphasis is placed on prophylaxis and both intravenous and topical antibiotics should be initiated at the earliest. Post-traumatic endophthalmitis progresses rapidly and affects the prognosis of vision. The risk of endophthalmitis after penetrating injury can be reduced by prompt wound closure and early removal of intraocular foreign bodies.

TRAUMATIC OPTIC NEUROPATHY

Presentation and evaluation. A patient with traumatic optic neuropathy can be easily picked up on pen torch examination in the presence of a relative afferent pupillary defect. These individuals usually have evidences of high velocity injuries to the head and neck region and require a careful evaluation. A CT scan of the orbit should be done to look for evidence of direct injury to the optic nerve.

Management of traumatic optic neuropathy remains controversial in the absence of any randomized control trials. In indirect optic nerve injury, the favoured approach is of administration of intravenous steroids of the order of methylprednisolone 1 gram every day for 3 days followed by oral steroids, if the patient presents within 8 hours of trauma. For patients presenting later than 8 hours, a wait and watch policy can be instituted.

RETROBULBAR HAEMORRHAGE

Presentation

Retrobulbar haemorrhage following ocular trauma is a grave emergency. The patients present with severe ocular pain, diminished vision or loss of vision and diplopia which may be accompanied by nausea and vomiting.

Evaluation

The attending ophthalmologist should maintain a high index of suspicion in these cases particularly in patients on anticoagulants. Leakage of blood into the orbital space, a closed environment, gradually compresses on the ocular structures leading to an acute orbital compartment syndrome, if not treated at the earnest.

- *These patients* exhibit signs of a non-pulsating exophthalmos with resistance to retropulsion, ophthalmoplegia, increased intraocular pressure and optic disc or retinal pallor.
- *Pupillary reflex* may be absent or may show the presence of relative afferent pupillary defect (RAPD) in optic neuropathy owing to the compression on the optic nerve.

- *CT scan* can be done in the emergency setting to confirm the diagnosis and to look for any associated orbital trauma. However, it is emphasized that a radiological evaluation should not delay the prompt management of this condition.

Treatment

Treatment includes medical and surgical measures:

Medical treatment with intravenous mannitol and acetazolamide aims at reducing the intraocular pressure. Intravenous steroids can be administered taking into account the compressive optic neuropathy. Controversies exist in the medical management of retrobulbar haemorrhage since none of the treatment options cater to the increased intraorbital pressure. Medical treatment can only be tried in mild cases wherein no pupillary abnormalities or visual compromise is observed. These cases need to be followed up closely and, if at any time features of optic neuropathy appear, surgery should be undertaken.

Surgical treatment aims to relieve the orbital compression which is achieved by a lateral canthotomy and cantholysis. To perform a canthotomy, an infiltration of lignocaine and epinephrine is given in the lateral canthal region followed by incising the lateral canthal tendon with a sharp forceps. An inferior cantholysis is performed by grasping the lower lid away from the globe. A Westcott scissors is then introduced inferolaterally between the skin and the conjunctiva. Strum the tissue near the orbital rim to locate the fibrous bands of the inferior crus of the lateral canthal tendon. These fibres are then completely cut with the scissors to free the lower eyelid adequately. Mild pressure on the globe can allow for a passive egress of blood from the orbit. If sufficient decompression is not achieved by an inferior cantholysis, a superior cantholysis can be performed in a similar manner.

ORBITAL FRACTURES

Evaluation. Fractures are a relatively common result of blunt injury. While evaluating the patient of blunt trauma:

- *Bony walls* of the orbit should be palpated to look for any break in continuity.
- *Lids and periorbital skin should be palpated* to look for surgical emphysema which is indicative of an air leak from a sinus and thereby a fracture of the orbital bony cage.
- *Integrity of the globe should be evaluated* and look for extraocular movements to rule out muscle entrapment.
- *CT scan of the orbit* is necessary whenever a fracture is suspected to document the site of the break and to look for herniation of orbital contents.
- *X-ray paranasal sinuses* anterior group (maxillary sinus) may also suffice, if CT scan is not available.

Fracture of the orbital roof should be viewed with caution; it is a potentially life-threatening injury as it establishes a continuation between the cranial and the orbital cavities. A neurosurgical consult is warranted at the earnest.

Blowout fracture of floor. An important consideration for the attending ophthalmologist is a blowout fracture of the orbital floor following concussive trauma. The diagnosis of this can be easily picked up with the clinical features of enophthalmos, pseudoptosis and reduced superior ocular movements. However, in the emergency setting with surrounding soft tissue inflammation, it may be difficult as the patient is not always co-operative for evaluation. A tear drop sign with herniation of the orbital contents should be looked for in the X-ray anterior group of paranasal sinuses. Immediate action is not usually necessary in these cases which can be managed conservatively for about 7–10 days after which a re-assessment is done to look into the magnitude of diplopia and loss of cosmesis caused by the fracture. If significant, repair of the orbital floor with release of the entrapped inferior rectus is undertaken.

Other cases of orbital fractures if the displacement is not significant the patients can be managed conservatively. A broad-spectrum oral antibiotic should be initiated to prevent the chances of orbital cellulitis along with an NSAID. The patients are instructed not to blow their nose and to use a cold compress

for the initial 48–72 hours. A surgical intervention is usually reserved at a later date, if at all indicated.

INTRAORBITAL FOREIGN BODY

An intraorbital foreign body can be considered in high velocity periocular injuries.

- *CT scan* can be helpful in determining the site of lodging of the foreign body.
- *Foreign bodies can be either organic or inorganic*. Inorganic foreign bodies are usually inert and the injury that they cause is only limited to the initial act of the trauma.
- *Anteriorly located foreign bodies* are usually easy to remove.
- *Posteriorly located inorganic foreign bodies*, if causing no inflammation or pain, can be left in situ lest it should cause mechanical damage to the orbital contents during its surgical extraction. The same, however, cannot be said for organic foreign bodies which need to be removed as they are more likely to lead to infective complications, like orbital cellulitis, orbital abscess, meningitis and a chronically draining fistula.
- Anti-tetanus prophylaxis should be instituted for all patients.

BIBLIOGRAPHY

1. Canavan YM, O'Flaherty MJ, Archer DB, Elwood JH. A 10 year survey of injuries in northern Ireland 1967-76. Br J Ophthalmol 1980; 64:618–625.
2. Chang Y, Oh S, Chi NC. A clinical observation of ocular injuries of inpatients. J Korean OphthalmolSoc 1993; 34:257–263.
3. Dannenberg AL, Parver LM, Brechner RJ, Khoo L. Penetrating injuries in the workplace. Arch Ophthalmol 1992; 110:843–849.
4. Desai P, MacEwen CJ, Baines P, Minassian DC. Incidence of cases of ocular trauma admitted to hospital and incidence of blinding outcome. Br J Ophthalmol 1996; 80:592–596.
5. Karlson TA, Klein BEK. The incidence of acute hospital-treated eye injuries. Arch Ophthalmol 1986; 104:1473–1476.
6. Kim SS, Yoo JM. A clinical study of industrial ocular injuries. J Korean Ophthalmol Soc 1988; 29:393–403.
7. Klopfer J, Tielsch JM. Ocular trauma in the United States Eye injuries resulting in hospitalization, 1984 through 1987. Arch Ophthalmol 1992; 110:838–842.
8. Kuhn F, Morris R. A standardized classification of ocular trauma. Graefe's Arch Clin Exp Ophthalmol 1996; 614:399–403.
9. Lee KJ, Oh JH. A statistical observation of the ocular injuries. J Korean OphthalmolSoc 1990; 31:229–239.
10. Maltzman BA, Pruzon H, Mund ML. A survey of ocular trauma. Surv Ophthalmol 1976; 2:285–290.
11. Morris RE, Witherspoon CD, Helms HA Jr, Feist RM, Byrne JB Jr. Eye injury registry of Alabama (preliminary report): Demographics and prognosis of severe eye injury. South Med J 1987; 80:810–816.
12. Nash EA, Margo CE. Patterns of emergency department visits for disorders of the eye and ocular adnexa. Arch Ophthalmol 1998; 116:1222–1226.
13. Patel BC, Morgan H. Work-related penetrating eye injuries. ActaOphthalmol 1991; 69:377–381.
14. Thoradson U, Ragnarsson AT, Gudbrandsson B. Ocular trauma: Observation in 105 patients. Acta Ophthalmol 1978; 57:922–928.
15. Tielsch JM, Parver L, Shankar B. Time trends in the incidence of hospitalized ocular trauma. Arch Ophtalmol 1989; 107:519–523.
16. Tsai CC, Kau HC, Kao SC, Liu JH. A review of ocular emergencies in a Taiwanese medical center. Chung Hua I HsuehTsaChih 1998; 61:414–420.
17. Voon LW, See J, Wong TY. The epidemiology of ocular trauma in Singapore: perspective from the emergency service of a large tertiary hospital. Eye 2001; 15:75–81.