Chapter

# 27 Anaesthesia for Ophthalmic Surgery in Children

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## Introduction

Ophthalmic surgery is undertaken across the entire paediatric age range, from the newborn with a congenital cataract to the teenager with a lens dislocation. The most common procedures are listed in Table 27.1. In contrast to adults, children undergoing eye surgery will nearly always require general anaesthesia. Many of these children are ASA class 1 and will be managed as routine day cases. In others, the eye problem may be associated with a congenital or metabolic abnormality, and anaesthesia may not be so straightforward.

**Table 27.1** Procedures that may require general anaesthesia

| | |
|---|---|
| **Examination of the eye** | - General examination<br>- Measurement of intraocular pressure<br>- Retinoblastoma follow-up |
| **Extraocular procedures** | - Steroid injection of haemangioma |
| *On the lids and orbit* | - Excision of meibomian cysts<br>- Excision of orbital dermoids/tumours<br>- Ptosis surgery<br>- Tarsorrhaphy |
| *On the nasolacrimal system* | - Syringing and probing of ducts<br>- Insertion of Crawford tubes<br>- Dacryocystorhinostomy (DCR) |
| *On the eye* | - Squint surgery<br>- Episcleral dermoid excision<br>- Enucleation/evisceration<br>- Laser surgery/cryotherapy |
| **Intraocular procedures** | - To reduce intraocular pressure<br>  - Goniotomy<br>  - Trabeculectomy<br>- Lensectomy ± artificial lens insertion<br>- Vitreoretinal surgery<br>- Corneal grafting<br>- Intravitreal injection<br>- Eye trauma |

## Preoperative Assessment

It is important to establish potential anaesthetic difficulties in those patients whose eye problem is part of a syndrome. This may be limited to developmental delay but may on occasion pose significant airway difficulty.

Most congenital cataracts are idiopathic; some are hereditary. Occasionally they occur after intrauterine infection with rubella, cytomegalovirus or toxoplasma with attendant associated anomalies. Congenital cataracts can also be associated with a chromosomal abnormality (e.g. Down syndrome), the Pierre Robin sequence and Stickler syndrome (an inherited connective tissue disorder of collagen associated with airway problems similar to Pierre Robin, with micrognathia and cleft palate). Neonatal cataracts are also a feature of Hallerman–Strieff syndrome, which, although very rare, is associated with a particularly difficult airway. Squints and glaucoma may be seen in other syndromes in which there may be major airway and intubation difficulties, such as the craniosynostoses or the mucopolysaccharidoses (see Table 27.2).

Other disorders that are associated with eye lesions requiring surgery include homocystinuria, Marfan syndrome and the phakomatoses.

Homocystinuria is a metabolic disorder in which hypoglycaemia and thromboembolic episodes occur readily. Patients may have dislocated lenses that require extraction. It is recommended that an intravenous glucose infusion is started preoperatively to ensure adequate hydration and prevent catabolism in these children. Patients may be on low-dose aspirin or other anti-thrombotic medication, which should be continued in the perioperative period to minimise the risk of thromboembolic episodes.

**Table 27.2** Syndromes with eye disorders and airway difficulties

| Syndromes associated with airway difficulty | Associated eye disorders |
|---|---|
| Mucopolysaccharidoses | Corneal clouding, glaucoma |
| Craniosynostoses<br>- Crouzon, Apert, Pfeiffer | Squints, cataracts, glaucoma, proptosis |
| Craniofacial syndromes<br>- Goldenhar, Treacher Collins, Smith Lemli Opitz, Pierre Robin | Nasolacrimal duct obstruction, lid colobomas, squints, cataract, glaucoma |
| Hallerman–Strieff | Neonatal cataracts |
| Stickler | Cataracts, glaucoma, retinal detachment |

Dislocated lenses also occur in patients with Marfan syndrome, a disorder caused by a deficiency of the structural protein fibrillin. Cardiac abnormalities such as mitral regurgitation, mitral valve prolapse and aortic root dilatation are common in these children, although most have no cardiovascular symptoms; many will be on β-blockers. Hypertension should be avoided. There is a small risk of spontaneous pneumothorax in these patients, and particular care must be taken with patient positioning due to their hypermobile joints.

The congenital phakomatoses are neuro-oculocutaneous disorders and may have ocular lesions that require surgery. This group includes Sturge–Weber syndrome, neurofibromatosis and tuberous sclerosis, disorders that are associated with seizures and cardiac lesions, and in von Hippel–Lindau disease with phaeochromocytoma. These patients will require careful preoperative assessment and management.

## General Principles of Anaesthesia

Most children undergoing eye surgery are otherwise healthy day-case patients. Some will have very poor vision, and particular care is necessary in approaching and handling children who may not be able to see or be fully aware of what is happening. Many children, particularly those with glaucoma, cataracts or retinoblastoma, may need to undergo multiple procedures over several years. They too will need sympathetic handling as they can develop periprocedural anxiety.

Premedication and induction are a matter of personal and patient preference. Spontaneous ventilation via a face mask will suffice for simple eye examinations, although it is more convenient to use a supraglottic airway device (SAD) to allow the ophthalmologist unrestricted access to the eyes. Spontaneous ventilation with a SAD is also satisfactory for most extraocular cases and non-surgical procedures such as laser treatment. Although most orbital dermoids are superficial and simple to excise, some can be very deep and may require extensive surgery behind the globe. It is important to discuss the exact nature of these with the surgeon, as the anticipated length of surgery and the potential for bleeding may influence airway management.

The surgeon will usually require a 'quiet' eye for intraocular procedures, which is best achieved using paralysis and controlled ventilation. Because of the inaccessibility of the airway when the face is covered with sterile drapes, a secure airway is essential. The lower incidence of coughing at the end of a procedure associated with a SAD offers some advantage over a tracheal tube. It should be borne in mind, however, that the surgeon's and their assistants' hands are perilously close to the airway, particularly in small infants, and can dislodge a poorly secured SAD. If there is any doubt about the security or position of a SAD, a tracheal tube should be used. A pre-formed oral RAE tracheal tube is generally used, but the fixed length of the endotracheal portion of these tubes is often too long in infants and can result in endobronchial intubation. It is possible to insert some form of padding under the curve of the tube at the lips to prevent this. This can be bulky, and it is our practice to use a reinforced, flexible tracheal tube in infants under six months to ensure proper tube position.

A dilated pupil is necessary for many ophthalmic procedures. The mydriatic agents most used perioperatively are the parasympatholytic drug cyclopentolate 0.5% or 1%, or the sympathomimetic drug phenylephrine 2.5%. These are

normally administered preoperatively, but occasionally adequate pupillary dilatation is not achieved. Further drops can be applied once the child is asleep. Rarely, the surgeon will inject subconjunctival mydricaine, a mixture of adrenaline, atropine and procaine, to improve pupillary dilatation. It is prudent to avoid a high concentration of volatile agent in this scenario and to avoid hypercapnia to minimise the risk of dysrhythmias should there be systemic absorption of the mydricaine. On occasion, the surgeon may apply phenylephrine to the eye during surgery; systemic absorption via the lacrimal duct can lead to alarming hypertension and tachycardia, although this usually settles very rapidly.

Most surgical procedural pain involving the eye and orbit is well managed with intravenous paracetamol, topical anaesthetic agents and postoperative analgesia with oral paracetamol and a non-steroidal analgesic such as ibuprofen. Strabismus surgery, evisceration of the eye, cryotherapy and vitreoretinal surgery are associated with more severe perioperative pain, and an opiate such as fentanyl 1–2 mcg $kg^{-1}$ should be administered intraoperatively.

A regional block, often used in adult practice, may reduce opioid requirement as well as lower the incidence both of postoperative nausea and vomiting (PONV) and the oculocardiac reflex (OCR). A sub-Tenon block is regarded as the safest option in paediatrics because of the low risk of the severe complications of globe perforation and retrobulbar haemorrhage associated with intraconal (retrobulbar) and extraconal (peribulbar) blocks. An injection of less than 5 ml of local anaesthetic should be sufficient and avoids significant increases in intraocular pressure (IOP). Lidocaine 1% or 2% or bupivacaine 0.25% or 0.5% are suitable options. As the injection of local anaesthetic can increase IOP, blocks are generally avoided in conditions where increased IOP is already a concern. A scleral buckle (for retinal detachment) can make insertion of the block difficult and spread unreliable as a consequence of scar tissue. In children with retinoblastoma, a block is not recommended due to the risk of extraocular tumour seeding.

The successful and safe use in children of intraconal and extraconal blocks have been described for vitreoretinal surgery and laser treatment for retinopathy of prematurity (ROP) but are not widely used.

Many ophthalmic procedures in young children are quite short and there can be problems with emergence delirium, particularly if sevoflurane has been used. The intraoperative administration of a small dose of fentanyl, dexmedetomidine or clonidine may help to ameliorate this.

## The Oculocardiac Reflex

The OCR is a well-recognised occurrence during squint surgery, featuring in approximately 60% of cases. It is also encountered during enucleation, vitreoretinal surgery and orbital surgery. The OCR is evoked by pressure on the globe or by traction on the extrinsic eye muscles. It is generally believed that the OCR occurs most commonly when the medial rectus muscle is manipulated, but traction on any of the extraocular muscles can evoke it. The reflex is mediated through trigeminal afferent and vagal efferent pathways leading to bradycardia, which may be profound. The bradycardia reverts almost immediately once the stimulus is removed, and it is unusual to see a more serious rhythm disturbance, but rarely sinus arrest or major dysrhythmias may occur. Children with a positive OCR appear to be more likely to develop PONV than those with no obvious reflex, leading to suggestions that preventing the OCR may reduce the incidence of PONV (see Table 27.3). Blocking the afferent limb of the reflex using a sub-Tenon block at the start of surgery may be one way of achieving this. Administering atropine 10 mcg $kg^{-1}$ at induction and accepting the resultant modest tachycardia is another effective strategy. The administration of atropine is especially helpful if propofol, which has a bradycardic effect, is used for induction or maintenance of anaesthesia.

**Table 27.3** Oculocardiac reflex

| |
|---|
| - Common during squint surgery, particularly with traction on medial rectus muscle |
| - Also occurs in enucleation, vitreoretinal surgery, pressure on globe and surgery on maxilla |
| - Results in bradycardia, rarely sinus arrest |
| - Reverts when muscle traction released |
| - Associated with increased PONV |
| - Best prevented with IV atropine at induction |

# Specific Procedures

## Eye Examination under Anaesthesia (EUA)

General anaesthesia for EUA is necessary in very young children and some older children who are too uncooperative to allow an adequate examination when awake. This can be carried out satisfactorily using a face mask, although a SAD is preferable when the examination is likely to be lengthy, or where it is necessary to use the operating microscope. As many of these children require regular examinations and repeated anaesthetics, it is essential that induction is managed in as sympathetic a manner as possible.

### Measurement of Intraocular Pressure

Special consideration is required if IOP is to be measured, as most anaesthetic agents reduce IOP. It is a concern that IOP will be lowered to such an extent by injudicious anaesthesia that a high IOP may be masked, potentially compromising treatment and vision. Some anaesthetists therefore use ketamine, which does not reduce IOP. When it is not possible to obtain venous access, a dose of 5–10 mg $kg^{-1}$ ketamine intramuscularly will result in a child who is still enough to permit a thorough eye examination within a few minutes. It is essential to ensure that the airway is well maintained. Ketamine may lead to a slight increase in IOP, although there are conflicting reports about this, but it is probably safer to have a falsely high IOP than a falsely low one that might result in IOP treatment being delayed (see Table 27.4).

Most paediatric anaesthetists are reluctant to use intramuscular ketamine, and an alternative technique is to undertake an inhalation induction using sevoflurane. The ophthalmologist should be close by during induction and ready to measure the IOP as soon as the child stops moving and whilst the eyes are still central (i.e. before the 'excitation' phase of general anaesthesia). It is important to try to limit the sevoflurane concentration to minimise the fall in IOP. Care must be taken to ensure that the face mask does not encroach upon the eye as this may elevate IOP.

**Table 27.4** Intraocular pressure (IOP)

| |
|---|
| - Normal IOP is between 10 and 22 mm Hg. |
| - IOP depends on the balance between the production of aqueous humour (mainly from the ciliary body in the posterior chamber) and its drainage via a trabecular meshwork to the canal of Schlemm in the anterior chamber. |
| - Venous drainage from the eye is valveless. Any increase in venous pressure (for example, from coughing or straining) leads to an immediate rise in IOP by altering the volume of the choroid and by impeding aqueous drainage via the canal of Schlemm. |
| - Arterial pressure has little effect on IOP |

Both techniques are acceptable. As these children are likely to have repeated measurements over many months or years to assess efficacy of treatment, the more important issue is to ensure that the same technique is used when comparing IOP measurements over time. IOP measurements should be taken before laryngoscopy or SAD insertion, even though the latter does not appear to raise IOP significantly.

### Nasolacrimal Duct Obstruction

Children with blocked nasolacrimal ducts, usually caused by membranous obstruction, often present within the first year of life. Initial treatment involves probing of the punctum of the duct in the eyelid with a small blunt needle and irrigation with 1–2 ml of saline, sometimes with a dye such as fluoroscein in it. This is a short procedure and can be safely managed with a SAD. It is helpful to place a fine suction catheter in the nasal cavity to aspirate the irrigation fluid. Where a simple probing has failed, a Crawford tube or other fine silicone catheter may be passed through the duct into the nose and secured in place for a few weeks. This may be preceded by a dacryocystogram (DCG) in which about 1 ml of radio-opaque dye is injected into the duct and the course of the duct confirmed radiographically. Rarely, the surgeon will manipulate or 'fracture' the inferior turbinate to relieve any obstruction at the lower end of the duct. A very small amount of saline or blood may appear in the nose or nasopharynx, which should be suctioned before removal of the SAD.

When the duct is completely blocked, usually by bony obstruction, a dacryocystorhinostomy (DCR) may be undertaken. This involves surgical exposure of the lacrimal sac below the medial canthus and the creation of a new opening from it through the bony upper lateral aspect of the nose into the nasal cavity. This can result in modest amounts of blood trickling into the nasopharynx, so airway protection with a tracheal tube is recommended. A mild head-up tilt and a modest degree of hypotension are

helpful in minimising bleeding. Application of a topical vasoconstrictor to the nasal mucosa, such as xylometazoline or lidocaine with phenylephrine, may be beneficial. DCR can be painful, and opioid analgesia (e.g. fentanyl) is indicated.

Minimally invasive DCR utilising an endoscopic laser is now performed in some centres; a similar anaesthetic technique will be necessary.

Throat packs have previously been recommended in DCR to reduce respiratory complications from aspirated blood and to prevent PONV due to blood entering the stomach. A recent evidence-based consensus statement recommends against the routine insertion of throat packs in adults by anaesthetists because of the well-recognised complications and the lack of evidence of benefit. Studies in paediatrics have also demonstrated no difference in complications when throat packs are not used in ENT and maxillofacial surgery. The rationale for routine throat pack insertion should be questioned, and they should only be inserted for carefully selected cases.

The pharynx should be suctioned under direct vision to remove any clot or debris prior to extubation.

## Squint Surgery

Squint correction is the most common ophthalmic surgical procedure in children. It is usually performed on a day-case basis, but there is a high associated incidence of PONV which occasionally results in unplanned overnight admission. Squint surgery is also associated with the OCR (see the section 'The Oculocardiac Reflex'). There is reportedly an increased incidence of malignant hyperpyrexia in patients with a squint. Although this is rare, a high index of suspicion should be maintained for this; succinylcholine should be avoided, and temperature monitoring should be used.

A spontaneous ventilation technique with a SAD is commonly employed during squint surgery. Hypercarbia has been shown to double the incidence of significant bradycardia, and some surgeons prefer a completely immobile eye, so controlled ventilation may be more suitable. Atracurium is associated with a greater incidence of OCR than pancuronium, but the shorter duration of action of atracurium makes this a more appropriate choice. Rocuronium appears to attenuate the OCR and is a suitable alternative.

Squint surgery is one of the most painful ophthalmic procedures, but the use of intraoperative opioids risks an increased incidence of PONV. The use of morphine in preference to the shorter-acting opioids fentanyl and alfentanil has been demonstrated to reduce moderate to severe postoperative pain in squint surgery. This does not result in increased PONV if appropriate antiemetic prophylaxis is administered.

Use of a sub-Tenon block also reduces postoperative pain. Tenon's capsule is the fascial layer that extends from the limbus, fusing posteriorly to the optic nerve, separating the globe from orbital fat. Sensation of the eye is provided by ciliary nerves that cross the episcleral space after emerging from the globe. Strabismus surgery on the extraocular muscles is carried out within this space, so instilling local anaesthetic here can be very effective. This can be done at the start or end of the procedure, but the advantage of administering it at the start is less stimulation of the OCR and PONV, by blocking the afferent limb of the reflex.

Diclofenac 0.1% or oxybuprocaine 0.4% eye drops also provide useful analgesia following squint surgery. If these are administered selectively to the operative site by the surgeon prior to suturing the conjunctiva, the problems associated with an insensate cornea can be minimised.

Adequate postoperative analgesia can usually be achieved satisfactorily using topical anaesthesia, paracetamol and a non-steroidal analgesic such as diclofenac or ibuprofen. Where analgesia is inadequate, as it may be for the more painful myopexy repair or repeat surgery, ketorolac has been shown to be effective. On occasion, it may be necessary to administer stronger analgesia such as an opioid.

In some older, cooperative children, the surgeon may place an adjustable suture as part of the technique. Fine adjustments to the repair can be made, using topical anaesthesia, when the patient is awake. In some patients with strabismus, a minute quantity of botulinum toxin, a neuromuscular blocking agent, is injected directly into one or more extraocular muscles. This is often done using electromyography (EMG) control, so use of intravenous neuromuscular blocking drugs should be avoided.

## Vomiting Following Strabismus Surgery

Nausea alone is difficult to quantify in children, who generally have a higher incidence of postoperative vomiting than adults. PONV is a well-recognised complication following strabismus surgery, particularly in children over the age of two years, with studies showing that more than half of

**Table 27.5** Squint surgery

| |
|---|
| - Commonest paediatric ophthalmological surgical procedure |
| - Watch out for oculocardiac reflex |
| - High incidence of PONV – give antiemetics |
| - More painful than generally recognised |
| - Sub-Tenon block is very helpful, especially if performed at start of surgery |
| - Malignant hyperthermia (MH) risk – but very rare |

children undergoing strabismus surgery will be sick if no preventative measures are taken. Vomiting may not start until several hours after surgery, and parents should be warned about this at the preoperative assessment (see Table 27.5).

The precise mechanism for the increased incidence of vomiting following squint surgery remains unknown but may well be part of an oculo-emetic reflex, involving the ophthalmic division of the trigeminal nerve and the vomiting centre in the medulla. Local anatomic factors probably play a part, as different surgical techniques affect the incidence of vomiting. In particular, the Faden myopexy technique of squint repair has a significantly higher incidence of PONV than the simpler muscle recession/resection technique.

Many different strategies have been suggested to reduce the incidence of vomiting following squint surgery, with varying success. These include the use of anticholinergic agents (e.g. dimenhydrinate), dexamethasone, clonidine, antiemetics (e.g. metoclopromide, droperidol or ondansetron) and utilising the putative antiemetic properties of propofol either for induction or as part of a total intravenous anaesthesia (TIVA) technique. These publications have been comprehensively reviewed (see 'Further Reading').

Unfortunately, it is not possible to compare the studies relating to strabismus surgery and PONV satisfactorily because they involve very different underlying anaesthetic techniques and have often not taken into account different surgical techniques. It is clear, however, that 5-$HT_3$ (serotonin) antagonists have led to a significant reduction in the incidence of PONV and should be administered intraoperatively. Ondansetron alone is very effective, although combination therapy is better, for example using ondansetron 0.1 mg $kg^{-1}$ with dexamethasone 0.15 mg $kg^{-1}$. Dexamethasone is particularly useful in preventing late PONV (>6 hours). It is possible to reduce the incidence of vomiting to less than 10% using a multimodal approach. The 2016 updated APAGBI guidance recommends dual antiemetic prophylaxis intraoperatively with a different agent utilised in recovery if required. Droperidol 25 mcg $kg^{-1}$ and dimenhydrinate 0.5 mg $kg^{-1}$ are the only other two agents, aside from ondansetron and dexamethasone, shown to be effective and licensed in children. Cyclizine and metoclopramide are no longer recommended. A recent systematic review and meta-analysis found oral clonidine premedication at a dose of 4 mcg $kg^{-1}$ to be effective in reducing PONV after strabismus surgery. A secondary outcome was reduced postoperative pain.

### Enucleation/Evisceration

Removal of the whole eye, enucleation, may be necessary because of retinoblastoma or when there is an unsightly blind eye. The surgical technique involves dissection of each of the extraocular muscles off the globe, so the oculocardiac reflex may readily be evoked. Anaesthetic management should be as for strabismus surgery.

In evisceration, the contents of the globe are removed rather than the whole eye, leaving the sclera behind. There are no specific anaesthetic problems, but the procedure can be very painful and appropriate analgesia, including an intraoperative opioid, should be administered.

### Intraocular Surgery

Intraocular surgery in children may be for the management of glaucoma or for cataract extraction with or without an intraocular lens implant. Lens implants are being inserted now even in infants. Congenital cataracts will frequently need surgical removal in the first weeks of life to prevent permanent loss of vision. Neonates are at risk of postoperative apnoea, and arrangements should be made for appropriate postoperative monitoring. Paediatric glaucoma is usually a result of an intrinsic disorder of aqueous outflow. Medical therapy is of limited value, and surgery is usually required to improve aqueous humour drainage to lower IOP.

The principal surgical drainage procedures to treat glaucoma include goniotomy, trabeculotomy and trabeculectomy. An alternative technique is cyclodestruction of the ciliary body using laser cyclophotocoagulation or cryotherapy to reduce

aqueous humour production. These procedures can be painful and require good analgesia. Protective eye goggles need to be worn by all theatre staff during laser surgery. It is important to be aware that there are several different types of lasers, each requiring different goggles.

It is essential that the eye is motionless during intraocular procedures. Sudden rises in IOP should be avoided to prevent the extrusion of intraocular contents through the incision. Neuromuscular paralysis and controlled ventilation provide optimal operating conditions. Most intraocular surgery is not particularly painful, although a small dose of fentanyl is usually administered. Alternatively, a remifentanil infusion can be used which may obviate the need for paralysis. The combination of paracetamol and diclofenac is usually satisfactory for postoperative pain relief.

It is good practice to try to prevent an increase in IOP at the end of the procedure, caused for example by coughing on the tracheal tube at extubation. This is less critical than it used to be with the advent of very fine suture material allowing complete closure of the ocular wounds. A SAD can be used for intraocular surgery, even in small children, and has the advantage of smoother emergence with less coughing and reduced likelihood of acute IOP elevation than with a conventional tracheal tube. If a SAD is used, it is imperative to ensure that it is perfectly positioned and well secured before proceeding with surgery. If there is any doubt, a tracheal tube should be used.

Anaesthesia can be maintained until neuromuscular blockade has been reversed, the patient is breathing spontaneously and extubation has been performed. A small dose of propofol (0.5 mg $kg^{-1}$) given immediately prior to extubation may be useful in obtaining a smooth extubation. Topical anaesthesia to the airway can be helpful in older children, though this should be avoided in infants, as the simplest way to avoid the elevated IOP associated with crying in the immediate postoperative period is to offer them an early feed.

### Corneal Grafting (Keratoplasty)

Corneal opacities may be congenital or because of scarring from infection, burns or trauma in older children. Penetrating keratoplasty involves replacing all five layers of the cornea with donor cornea (full thickness graft). A more recent technique is a selective anterior lamellar keratoplasty which leaves healthy layers in situ. This may be preferable as it retains the host endothelium and reduces the risk of rejection. Anaesthesia for corneal grafting is like that outlined in the section 'Intraocular Surgery', but it is a longer procedure. It is particularly important to maintain a motionless eye and prevent sudden rises in IOP as a large defect is created over the cornea. There is a high risk of extrusion of intraocular contents. The surgeon may suture a ring around the cornea to support the eye during the procedure. Neuromuscular blockade and controlled ventilation should be used.

Acetazolamide, which reduces aqueous production, or mannitol may be administered intravenously during these procedures to lower the IOP, and it may be beneficial to induce modest hypotension. Acetazolamide can increase the incidence of PONV. The airway is often inaccessible to the anaesthetist and can be secured with either a SAD or tracheal tube (TT). Advantages of a SAD are a smoother emergence with less postoperative coughing causing increased IOP. A TT provides a definitive airway and is more suitable for the longer procedures or if there is any doubt about the SAD position. It is a painful procedure, and intraoperative opioids are warranted. Regional anaesthesia in the form of a sub-Tenon block offers good analgesia and akinesis and reduces PONV and the consequent increase in IOP. Isoflurane appears, in our experience, to produce a quieter eye than sevoflurane.

### Vitreoretinal Surgery

Retinal detachment is a tear in the retina, allowing the leak of aqueous humour which lifts the retina away from the underlying epithelium. It occurs most often secondary to trauma and is sight threatening. Certain predisposing ocular and systemic diseases increase the risk of detachment in children, for example retinoblastoma, ROP or Coats disease. Repair of retinal detachment generally takes place in specialised centres. Cryotherapy or laser therapy can be used to repair smaller retinal tears and to ablate the abnormal vessels in Coats disease. Vitrectomy may be needed in larger tears with the placement of a scleral buckle towards the back of the eye to obtain apposition of the retinal pigment epithelium and the neuroretina. An intraocular gas bubble containing sulphur hexafluoride ($SF_6$) or perfluoropropane ($C_3F_8$) may be injected into the eye to tamponade the detached surfaces together whilst adhesions develop. Nitrous oxide must not be administered when these gases are used, as it will rapidly diffuse into the gas bubble and increase its size. The intraocular gases may remain in

the eye for several weeks, and diffusion of nitrous oxide from a subsequent anaesthetic during this period into an existing intraocular gas bubble can result in rapid expansion of the bubble and an acute rise in pressure within the globe. This can cause irreversible ischaemic damage to the retina and optic nerve, so patients and their carers must be given very clear instructions about passing this information on to other anaesthetists should they require further surgery during this time.

Opioid analgesia should be administered perioperatively, as vitreoretinal surgery is painful. A sub-Tenon block has been shown to be effective in providing analgesia for children having vitreoretinal surgery and reduces the incidence of OCR.

## Emergency Eye Surgery

Injuries to the eye are common in paediatrics. They often occur in isolation, but in the context of polytrauma, management of life-threatening injuries takes priority. Orbital floor fractures can trap the extraocular muscles, restricting eye movement and triggering the OCR. This often necessitates timely surgical repair. Trauma that breaches the full thickness of the sclera, cornea or both is known as an 'open' globe injury. Urgent surgery is required to close the wound to reduce the risk of infection and extrusion of ocular contents and to prevent visual loss. This is a true ophthalmic emergency and should be performed within 12–24 hours of injury. Time to ensure fasting status may not be possible. This has been a contentious issue for anaesthesia. The possibility of a full stomach would conventionally dictate a rapid induction-intubation sequence using succinylcholine, but it has been traditionally taught that any acute rise in IOP, such as that caused by succinylcholine, may cause extrusion of ocular contents through even very small wounds, leading to total loss of vision in that eye.

There are in fact no well-documented reports describing vitreous extrusion following the use of succinylcholine, and in those difficult situations where the eye is at risk and regurgitation is a concern, there is no good reason to avoid succinylcholine as part of a conventional rapid sequence induction (RSI). However, rocuronium 1–1.2 mg $kg^{-1}$ is a good alternative and has largely superseded succinylcholine for RSI in the trauma population. The effects can be readily reversed with sugammadex 8–16 mg $kg^{-1}$ if necessary. This avoids the concern, albeit probably theoretical, of increased IOP with succinylcholine use. In small children who are at risk of aspiration, most experts advocate a modified RSI in which atracurium or rocuronium are used, and gentle ventilation is continued to avoid hypoxaemia until laryngoscopy. Premature attempts at intubation should be avoided, as this may provoke coughing, which significantly raises IOP. A nerve stimulator may be helpful in indicating when full neuromuscular blockade has occurred.

Occasionally children will allow removal of a foreign body when awake under local anaesthesia. Proxymetacaine is frequently used, as it causes less stinging and therefore improves compliance.

## Retinopathy of Prematurity (ROP)

Severe ROP still occurs despite meticulous neonatal care and can lead to total blindness. The improved survival of extremely and very preterm babies has resulted in a significant increase in the incidence of ROP. Infants at risk are those less than 31 weeks gestational age and/or less than 1,500 g (see Table 27.6). ROP is characterised by abnormal blood vessel growth in the retina and is classified in five stages, ranging from mild (stage 1) to severe (stage 5). Infants who develop severe ROP (stage 3 or more) are at significant risk of retinal detachment and blindness. The outcome of the disease process can be improved by cryotherapy or, more commonly now, argon laser photocoagulation, which ablates the peripheral retinal vessel proliferation. Treatment needs to be undertaken early in the disease, and so early identification is essential. Eye examinations in at-risk infants should take place between six- and seven-weeks postnatal age and continued every two weeks until the risk has passed.

These premature infants are transferred to theatre for their treatment, and the usual precautions for managing preterm infants should be adopted (see Chapter 19), particularly in relation to temperature and glycaemic control. Many of these infants will have other systemic disorders due to their extreme prematurity, such as bronchopulmonary dysplasia, which may influence both the conduct of anaesthesia and the need

**Table 27.6** Babies at risk for severe ROP

| |
|---|
| - Birth weight $\leq$1,500 g |
| and/or |
| - Gestational age $\leq$31 weeks |

for postoperative support, and they will need careful assessment. Laser therapy is better tolerated than cryotherapy, although both often warrant opioid analgesia. This has implications for the postoperative care of these babies, who will be at increased risk of apnoeic episodes following anaesthesia. Appropriate facilities for postoperative monitoring and ventilation must be arranged, and many return to NICU intubated.

Avoiding the risk of transfer to theatre and general anaesthesia is clearly beneficial. In some centres, carefully selected cases can undergo examination and laser treatment on the NICU using sedation combined with a regional technique. Chloral hydrate has been used successfully with a sub-Tenon block for this purpose. Both laser and cryotherapy can be painful and can cause cardiorespiratory instability.

A novel therapy for ROP is intravitreal injection of anti-vascular endothelial growth factor (VEGF) antibodies that work to block the angiogenic factors that stimulate pathological vessel proliferation. Early studies indicate it is well tolerated, and treatment could take place at the bedside on intensive care. Longer-term studies are required to look at safety outcomes.

Retinal detachment is a complication of severe ROP. Endoscopic vitrectomy is a new surgical method that can save some sight. Outcomes are better if performed early. There is a short window of opportunity to undertake this surgery, and cases may present as an emergency. As this is a painful procedure and often long, the majority of cases will return to NICU ventilated.

### Retinoblastoma

This is the most common intraocular malignancy in childhood with an average age of onset under two years old. It can occur sporadically or be inherited. Treatment and screening occur in specialist centres. Children who have a parent with the disease will undergo screening in the form of a regular EUA. In children with the disease, EUA can be as frequent as every one to two months until the child is three years old. Anxiety is common, and premedication may be necessary. There are different treatment modalities depending on the stage of the disease, which is determined by the size and location of the tumour and the chance that treatment will preserve some sight. Local therapies available for small tumours are cryotherapy, laser photocoagulation and plaque irradiation (local radiotherapy). Larger or bilateral tumours require chemotherapy. This can be delivered systemically or using more targeted methods of intravitreal or selective intra-arterial chemotherapy. Enucleation is performed for advanced unilateral disease where it is not possible to save the eye.

Intra-arterial chemotherapy, in which melphalan is injected directly into the ophthalmic artery, has specific anaesthetic considerations. This procedure takes place in an interventional radiology suite in only a few specialist centres in the United Kingdom and is described in detail in Chapter 36.

**Key Points**

- Bradycardia is readily produced by traction on extraocular muscles or pressure on the globe – the oculocardiac reflex.
- Squint surgery is associated with a high incidence of postoperative vomiting.
- A SAD can be used in most ophthalmic procedures but must be safely secured.
- A sub-Tenon block, most easily administered by the surgeon, is useful in many procedures.
- Nitrous oxide should be avoided in vitreoretinal surgery.

## Further Reading


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