Chapter 15: Anesthesia for Ophthalmic Procedures

Kristen Labovsky

INTRODUCTION

FOCUS POINTS

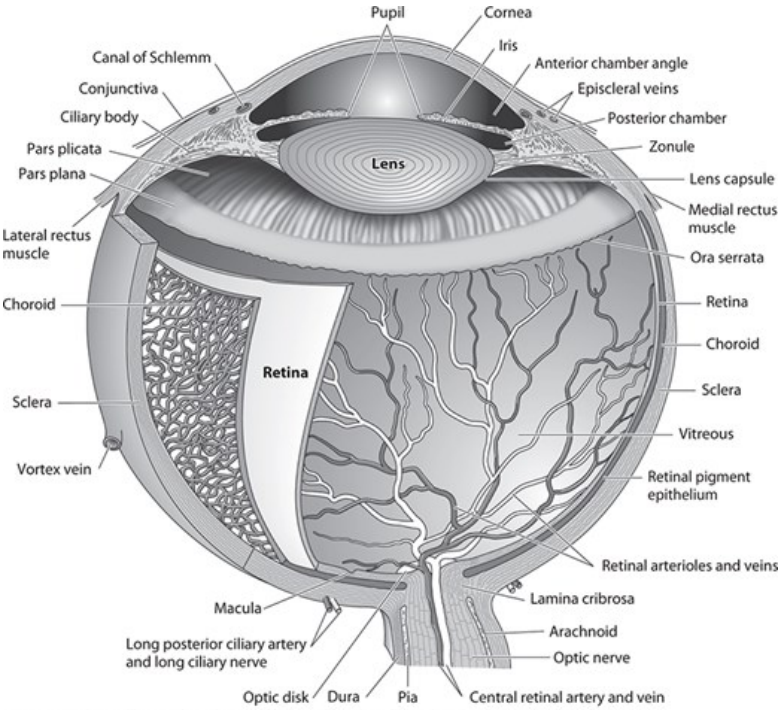
1. Ophthalmic procedures in children are mostly accomplished under general anesthesia with potent volatile anesthetics.
2. The airway is managed with a supraglottic device or endotracheal intubation with or without muscle relaxation dependent on duration and extent of the procedure.
3. Succinylcholine and post-administration fasciculations should be used with caution in these procedures; precurarization with a nondepolarizing muscle relaxant should be considered.
4. Releasing muscle tension and avoiding eye pressure can abolish the oculocardiac reflex (OCR) but anticholinergic medication administration may be required.
5. Serotonin 5-HT3 receptor antagonists (antagonists) and dexamethasone are effective in preventing postoperative nausea and vomiting (PONV).
6. Intravenous lidocaine and deep extubation are two useful modalities to avoid coughing during extubation in these procedures.
7. Retinopathy of prematurity is common in premature infants and treatment needs to be performed within 72 hours.

ANATOMY OF THE EYE

The maximum growth of a child's eyeball occurs during the first two years of life with an infant's eyeball volume increasing by 40%.[1] The outer transparent mucous membrane that covers the inner surface of the lids and the sclera is the **conjunctiva** (Figure 15-1). The conjunctiva is continuous with the skin at the margin of the lid. The **sclera** is a collagen containing outer fibrous layer of the eye. The **cornea** is an avascular, transparent layer that acts as the glass of a watch. The ophthalmic division of the trigeminal nerve supplies the sensory nerves to the cornea. The **iris** divides the anterior chamber from the posterior chamber and the round aperture in the center is the pupil. The iris, using a balance between parasympathetic mediated constriction and sympathetic mediated dilation, controls the amount of light entering the eye. The **ciliary body** contains the ciliary process that produces aqueous humor and the ciliary muscle, which allows a variable focus of the lens by altering the tension on the lens capsule. The lens is an avascular, transparent structure that separates the aqueous anteriorly from the vitreous posteriorly. It is suspended behind the iris by zonules that connect to the ciliary muscle. The **retina** is a thin multilayer neural membrane that lines the inner posterior two-thirds of the globe. Images are focused on the retina with signals sent to the brain. The **optic nerve** contains approximately 1 million axons that arise from the ganglion cells of the retina and exits the posterior portion of the globe. The blood supply for the optic nerve consists of branches of the central retinal artery, ophthalmic artery, and other internal carotid branches. The extraocular muscles consist of two oblique muscles which primarily control torsion movements and four rectus muscles that depress, elevate, adduct, and abduct the globe. Cranial nerve VI (abducens) innervates the lateral rectus muscle, cranial nerve IV (trochlear) innervates the superior oblique, and cranial nerve III (oculomotor) innervates the inferior oblique and superior, medial, and inferior rectus.[2]

Figure 15-1

Anatomy of the eye. (Reproduced with permission, from Riordan-Eva P, Augsburger JJ. Vaughan & Asbury's General Ophthalmology. 19th ed. 2018. https://accessmedicine.mhmedical.com. Copyright © McGraw Hill LLC. All rights reserved.)



Source: Herodotos Ellinas, Kai Matthes, Walid Alrayashi, Aykut Bilge: *Clinical Pediatric Anesthesiology*

PHYSIOLOGY OF THE EYE

Careful consideration and understanding of intraocular pressure (IOP) is important in managing anesthesia for eye surgeries. Normal IOP is reached by age 5 and is 10 to 20 mm Hg.[3] It is determined by changes in intraocular volume, external pressure, and venous congestion. Aqueous humor, produced by the ciliary bodies, is regulated to maintain normal IOP. Aqueous humor drainage is decreased with mydriasis and can lead to increased IOP.[4] Elevated IOP can lead to decreased arterial perfusion and optic nerve ischemia.[8] Physiologic factors that affect IOP are listed in Table 15-1. Anesthetic agents can also have an effect on IOP and this is important to consider when caring for patients with increased IOP (Table 15-2).

Table 15-1

Effect of Physiologic Factors on IOP

Factors	Effect on IOP
Elevated venous pressure	Increase
Cough, valsalva, vomiting	Increase (up to 40 mm Hg)
Hypoxia	Increase
Hyperoxia	Decrease
Metabolic alkalosis, respiratory acidosis	Increase
Metabolic acidosis, respiratory alkalosis	Decrease
Elevated systemic arterial pressure	Minimal effect, autoregulated

Table 15-2

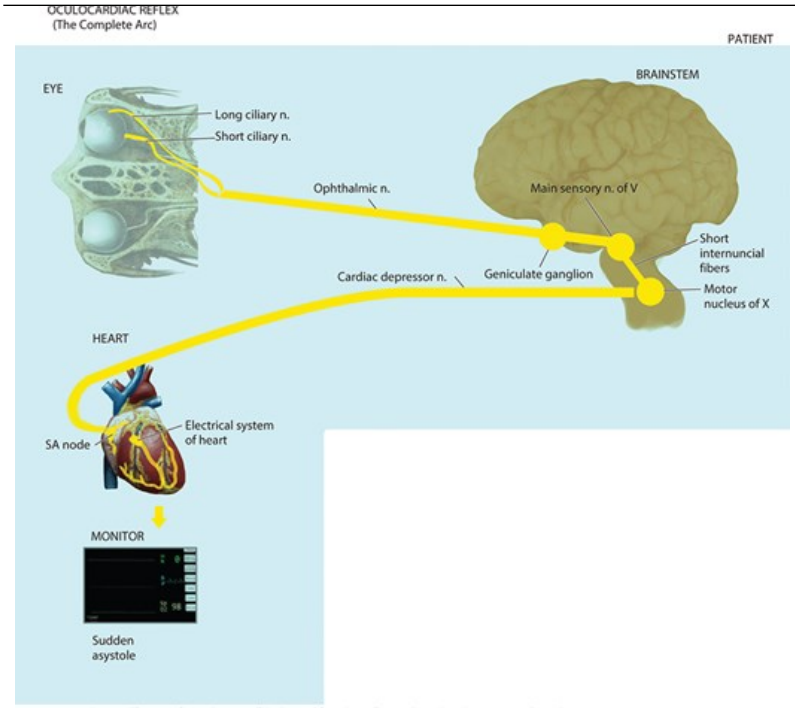
Effect of anesthetic agents on IOP[4]

Agent	Effect
CNS depressants (barbiturates, benzodiazepines, opioids)	Decrease
Thiopental, propofol, etomidate	Decrease
Ketamine	No consensus, associated with blepharospasm and nystagmus
Volatile anesthetics	Decrease
Succinylcholine	Increase (may be able to attenuate change with opioids, propofol, and precurarization with rocuronium)

The oculocardiac reflex (OCR) (Figure 15-2) is also important to consider in the anesthetic management of ophthalmologic procedures. The occurrence is as high as 65% to 79% during pediatric cases where no prophylaxis was given.[5–7] The afferent pathway is via the ophthalmic division of the trigeminal nerve and the efferent pathway involves the vagal nerve. The reflex is triggered by pressure on the eye or traction on the extraocular muscles and usually results in sinus bradycardia. More significant rhythm disturbances can include ventricular bigeminy, ventricular tachycardia, atrioventricular block, and asystole. Effects of the OCR usually end once the stimulus is removed.[4]

Figure 15-2

Oculocardiac reflex (Reproduced with permission, from Hadzic A. Hadzic's Textbook of Regional Anesthesia and Acute Pain Management. 2nd ed. 2017. https://accessanesthesiology.mhmedical.com. Copyright © McGraw Hill LLC. All rights reserved.)



Source: Herodotos Ellinas, Kai Matthes, Walid Alrayashi, Aykut Bilge: *Clinical Pediatric Anesthesiology*

COMMONLY USED OPHTHALMIC MEDICATIONS

Ophthalmologists will often use topical medications to alter IOP or to achieve optimal conditions for exam and surgery. Table 15-3 lists the common topical medications employed and side effects seen.[8]

Table 15-3

Common Topical Medications

Drug Class	Drug Names	Uses	Side Effects
Beta-blockers	Timolol	Decrease IOP by decreased aqueous humor production	Caution in children with asthma
	Betaxolol		
	Levobunolol		
Carbonic anhydrase inhibitors	Dorzolamide brinzolamide	Decrease IOP by decreased aqueous humor production	No systemic side effects, metallic taste
Alpha agonists	Brimonidine, apraclonidine	Decrease IOP by decreased aqueous humor production and increased outflow from eye	Brimonidine (crosses blood-brain barrier)–bradycardia, respiratory depression, hypothermia, lethargy in infants
Beta agonists	Dipivefrin	Decrease IOP	No side effects–least potent
Parasympathomimetics	Pilocarpine	Decrease IOP by increased outflow from eye	Pain with use, headaches, blurry vision
Alpha 1 agonist	Phenylephrine 2.5%	Mydriasis	Increased blood pressure
Anticholinergic	Atropine 0.5%	Cycloplegia, mydriasis	Tachycardia, fever, flushing, delirium
Anticholinergic	Cyclopentolate 0.5%	Cycloplegia, mydriasis	Inhibits cholinesterase in vitro, caution with succinylcholine
Anticholinergic	Tropicamide 0.5%	Cycloplegia, mydriasis	No side effects

OCULAR DISEASES AND PROCEDURES

Strabismus

Strabismus is defined as misalignment of the eyes, either by turning out (exotropia), being crossed (esotropia), or vertical misalignment (hypertropia, hypotropia). Repair of strabismus involves manipulation of the eye muscles to realign the eyes. The surgical repair involves moving, strengthening, or weakening the eye muscles.

Table 15-4 shows common strabismus procedures to achieve alignment.

Table 15-4

Strabismus Surgical Procedures

Resection	Strengthening muscle by tightening
Recession	Weakening muscle by transection or moving insertion posteriorly
Transposition	Changing action of muscle by moving insertion site

Nasolacrimal Duct Surgeries

The nasolacrimal duct is not open distally in 60% of newborns.[9] It is most spontaneously opened or opened with conservative treatment (massaging) during the first year of life, with studies showing a resolution rate of 96%.[10] Surgery involves nasolacrimal duct probing where a metal probe is passed into the canaliculi to the lacrimal sac and down into the nose.[9] In recurrent cases, a silicone tube may be placed to function as a stent. If the nasolacrimal duct does not function, a drainage path from the eye through the lacrimal sac to the nose can be created during a dacryocystorhinostomy.

Glaucoma

Increased intraocular pressure that results in an optic neuropathy is referred to as glaucoma. Treatment can be surgical or medical. Common medications used to decrease intraocular pressure in children include beta-blockers, alpha agonists, and carbonic anhydrase inhibitors. If intraocular pressure remains elevated after topical medications, oral and intravenous agents, such as acetazolamide, may be used. Surgery is indicated if medical management does not decrease intraocular pressure. Laser or cyrotherapy is used to destroy ciliary processes and decrease aqueous humor production.

Retinoblastoma

Retinoblastoma is the most common form of intraocular cancer in children and is generally diagnosed by age 3. The prevalence is 1:20,000 and half of the cases are due to a mutation in the retinoblastoma gene. Treatment for retinoblastoma has included enucleation, external beam radiation, and chemotherapy.[11] There is a risk of secondary cancers in the field of external beam radiation, so currently patients with bilateral disease that require enucleation or diffuse vitreous and subretinal seeding are considered candidates for this radiation treatment. Patients with less advanced disease may be managed with chemoreduction and focal ablation.[4] There has been a shift in treatment toward chemotherapy, delivered either intravenously, intra-arterially, intravitreally, or periocularly.[12]

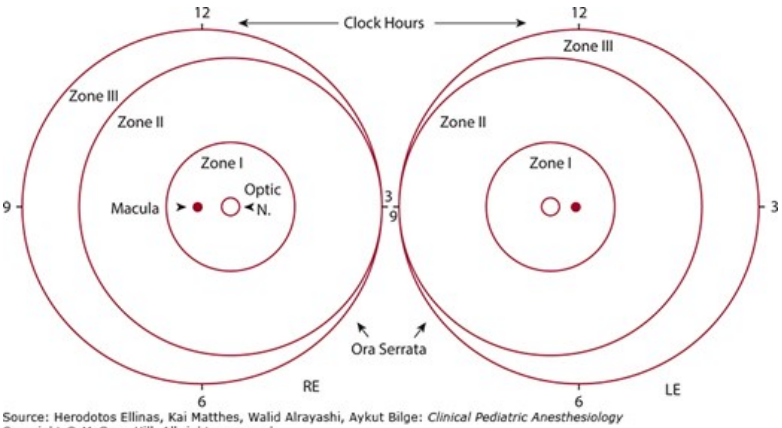
Retinopathy of Prematurity

The incidence of retinopathy of prematurity reported from a multicenter U.S. study was 68% in infants less than 1251 g.[13] Retinopathy of prematurity (ROP) is classified by the zone of the retina involved (Figure 15-3), the severity of disease, and the degree of venous congestion.14 Zone 1 is central (and more likely to progress to severe) and zone 3 is most peripheral, while severity is divided into five stages. “Plus disease” indicates a significant amount of venous congestion or arteriolar tortuosity. Treatment should be performed within 72 hours of diagnosis in patients with high-risk pre-threshold disease:

- Any stage ROP with plus disease in zone I
- Stage 3 ROP without plus disease in zone I
- Stage 2 or 3 ROP with plus disease in zone II[15,16]

Figure 15-3

Zones of the retina. (Reproduced with permission, from Kline MW, ed. Rudolph's Pediatrics, 23rd ed. 2018. https://accesspediatrics.mhmedical.com. Copyright © McGraw Hill LLC. All rights reserved.)



Source: Herodotos Ellinas, Kai Matthes, Walid Alrayashi, Aykut Bilge: *Clinical Pediatric Anesthesiology*

Earlier treatment of high-risk threshold ROP has been shown to reduce unfavorable structural outcomes, such as retinal folds involving the macula or retinal detachment involving the macula later in life.[17] Treatment involves laser therapy or anti-VEGF (vascular endothelial growth factor) therapy.

Trauma

A child with a ruptured globe is an emergency and must undergo surgical repair within several hours of the injury. An important consideration is avoiding increases in IOP that may occur with anxiety provoking for IV placement and induction. Premedication with oral midazolam and use of topical anesthetics may be useful for IV placement and a modified rapid sequence induction using a nondepolarizing neuromuscular blocker can be used for induction in the emergent case that is not NPO.[4] Succinylcholine may also be used with precurarization to prevent fasciculations and subsequent increase in IOP.

ANESTHESIA FOR EYE PROCEDURES

Premedication of children prior to eye surgery can include oral midazolam (usually 0.25–0.5 mg/kg, max 10–15 mg) with effect reached between 10 to 20 minutes.[18] Other options include oral valium, intranasal midazolam (0.2 mg kg, max 10 mg), or intranasal dexmedetomidine (1–2 mcg/kg). Preoperative assessment should include a thorough airway assessment as ocular problems can be associated with diseases that may involve difficult airways, such as Pierre Robin syndrome, Treacher Collins syndrome, Apert syndrome, Crouzon disease, mucopolysaccharidosis, and glycogen storage disease.[8]

Pediatric patients mostly require general anesthesia for ophthalmologic procedures and commonly will have a mask induction with nitrous oxide and sevoflurane. Depending on the patient, duration of procedure, and comorbidities, a supraglottic device or intubation with an endotracheal tube may be used. Frequently, the pediatric ophthalmologist will measure the IOP prior to any further procedure. This can be accomplished immediately after general anesthesia has been induced and when adequate deep state has been established. General anesthesia is then maintained with volatile anesthetics, opioids, and neuromuscular blockade, if needed. As described earlier, the OCR frequently occurs in pediatric patients undergoing eye surgery and protection against this can be accomplished with pretreatment with atropine 0.02 mg/kg up to 0.6 mg or glycopyrrolate 0.01mg/kg.[8] If a patient does have bradycardia from the OCR, the inciting stimulus should be stopped and then atropine 0.01 to 0.02 mg/kg can be administered. If inert gas (sulfur hexafluoride, SF_6) is inserted into the eye after a retinal procedure, nitrous oxide should be avoided.

Premature infants needing therapy for ROP are a distinct population with unique considerations. Numerous anesthetic techniques have been employed including topical anesthesia, sedation, and general anesthesia. A study of 97 treatments comparing topical anesthesia, general anesthesia (GA), and fentanyl infusion showed greater cardiorespiratory instability in patients treated with topical anesthesia.[19] Intubation allows for less movement, more stability, and improved ability to complete the treatment with good pain relief.[20] However, this may result in prolonged intubation, especially in the setting of chronic lung disease, and has led some to utilize sedation with nasopharyngeal long prongs.[21] Patient history and

comorbidities, individual center personnel availability (neonatologist, pediatric anesthesiologist), procedure location (neonatal intensive care unit, operating room), and coordination with ophthalmologist all must be taken into consideration when planning for these patients.

Caution should be used at the end of the operation to avoid coughing. To prevent this challenge, deep extubation with spontaneous breathing and stage 3 anesthesia has been utilized by many pediatric anesthesiologists. Others have used lidocaine at 1.5 mg/kg intravenously prior to extubation.

A significant postoperative consideration for ophthalmic procedures includes prophylaxis for postoperative nausea and vomiting (PONV). Pediatric patients undergoing strabismus surgery have a high rate of PONV, ranging from 40% to 90%.[22,23] Ondansetron has been shown to decrease rates of PONV.[24–27] Combination therapies such as ondansetron and dexamethasone are also effective.[28] Other agents such as scopolamine patch, diphenhydramine, and droperidol also decrease PONV but can have side effects such as sedation.[8,24,28] Combination prophylaxis therapy of dexamethasone and ondansetron has also been shown to decrease the risk of PONV compared to either agent alone.[29]

REFERENCES

1. Moeller H. Milestones and normative data. In: Lambert S, Lyons C eds. *Pediatr Ophthalmol.* London: Blackwell Scientific; 2017:40–49.

2. Riordan-Eva P. Anatomy and embryology of the eye. In: Riordan-Eva P, Augsburger JJ eds. *Vaughan & Asbury's General Ophthalmology*. 19th ed. New York: McGraw-Hill.

3. Pensiero, Da Pozzo S, Perissutti P. Normal intraocular pressure in child. *J Pediatr Ophthalmol Strabismus*. 1992;29:79. [PubMed: 1588480]

4. Ricketts K, Valley RD, Bailey AG, Justice LT. Smith's Anesthesia for Infants and Children, 2017; 34: 892–912

5. Ruta U, Möllhoff T, Markodimitrakis H, Brodner G. Attenuation of the oculocardiac reflex after topically applied lignocaine during surgery for strabismus in children. *Eur J Anaesthesiol.* 1996;11.

6. Allen LE, Sudesh S, Sandramouli S, Cooper G. The association between the oculocardiac reflex and post-operative vomiting in children undergoing strabismus surgery. *Eye*. 1998;12:193. [PubMed: 9683936]

7. Ducloyer J, Couret C, Magne C et al. Prospective evaluation of anesthetic protocols during pediatric ophthalmic surgery. *Eur J Ophthalmol.* 2019;29(6):606–614. [PubMed: 30280604]

8. Bissonette, Anderson BJ. *Pediatric Anesthesia: Basic Principles–State of Art-Future*. Shelton, CT: People's Medical Publishing House; 2011.

9. Hurwitz J. *The Lacrimal System*. Philadelphia, PA: Lippincott-Raven; 1996.

10. MacEwen CJ, Young JD. Epiphora during the first year of life. *Eye (Lond)*. 1991;5(pt 5):596–600. [PubMed: 1794426]

11. Abramson DH. Retinoblastoma: saving life with vision. *Annu Rev Med.* 2014;65:171–184. [PubMed: 24422571]

12. Kaliki S, Shields CL. Retinoblastoma: achieving new standards with methods of chemotherapy. *Indian J Ophthalmol.* 2015;63(2):103–109. [PubMed: 25827539]

13. Good WV, Hardy RJ, Dobson V et al. The incidence and course of retinopathy of prematurity: findings from the early treatment for retinopathy of prematurity study. *Pediatrics*. 2005;116(1):15. [PubMed: 15995025]

14. Screening examination of premature infants for retinopathy of prematurity. A joint statement of the American Academy of Pediatrics, the American Association for Pediatric Ophthalmology and Strabismus, and the American Academy of Ophthalmology. *Ophthalmology*. 1997;104:888. [PubMed: 9160039]

15. The Committee for the Classification of Retinopathy of Prematurity. An international classification of retinopathy of prematurity. *Arch Ophthalmol.*

1984;102:1130–1134. [PubMed: 6547831]

16. International Committee for the Classification of Retinopathy of Prematurity. The international classification of retinopathy of prematurity revisited. *Arch Ophthalmol.* 2005;123:991–999. [PubMed: 16009843]

17. Good WV. The early treatment for retinopathy of prematurity study; structural findings at age 2 years. *Br J Ophthalmol.* 2006;90:1378–1382. [PubMed: 16914473]

18. Cote CJ, Cohen IT, Suresh S et al. A comparison of three doses of a commercially prepared oral midazolam syrup in children. *Anesth Analg.* 2002;94(1):37–43, table of contents. [PubMed: 11772797]

19. Jiang JB, Strauss R, Luo XQ et al. Anaesthesia modalities during laser photocoagulation for retinopathy of prematurity: a retrospective, longitudinal study. *BMJ Open*. 2017;7(1):7e013344.

20. Sato et al. Multicenter observational study comparing sedation/analgesia protocols for laser photocoagulation treatment of retinopathy of prematurity. *J Perinatol.* 2015;35:965–969. [PubMed: 26355942]

21. Woodhead DD, Lambert DK, Molloy DA et al. Avoiding endotracheal intubation of neonates undergoing laser therapy for retinopathy of prematurity. *J Perinatol.* 2007;27(4):209–213. [PubMed: 17304206]

22. Baines D. Postoperative nausea and vomiting in children. *Paediatr Anaesth.* 1996;6:7–14. [PubMed: 8839082]

23. Kuhn I, Sheiffler G, Wissing H. Incidence of nausea and vomiting in children after strabismus surgery and postoperative vomiting in children after strabismus surgery following desflurane anesthesia. *Paediatr Anaesth.* 1999;9:521–526. [PubMed: 10597556]

24. Tramér M, Moore A, McQuay H. Prevention of vomiting after paediatric strabismus surgery: a systemic review using the numbers to treat method. *Br J Anaesth.* 1995;75:556–561. [PubMed: 7577280]

25. Patel RI et al. Single-dose ondansetron prevents postoperative emesis in children. *Anesthesiology*. 1996;85:270–276. [PubMed: 8712441]

26. Lawhorn CD, Stewart FC, Stoner JM, Shirey R, Volpe P et al. Ondansetron dose response curve in high-risk pediatric patients. *J Clin Anesth.* 1997;9:637–642. [PubMed: 9438891]

27. Patel RI, Davis PJ, Orr RJ et al. Single-dose ondansetron prevents postoperative vomiting in pediatric outpatients. *Anesth Analg.* 1997;85:538–545. [PubMed: 9296406]

28. Horimoto Y, Tomie H, Hanzawa K, Nishida Y. Scopolamine patch reduces postoperative emesis in paediatric patients following strabismus surgery. *Can J Anaesth.* 1991;38:441–444. [PubMed: 2065410]

29. Shen YD, Chen CY, Wu CH, Cherng YG, Tam KW. Dexamethasone, ondansetron and their combination and postoperative nausea and vomiting in children undergoing strabismus surgery: a meta-analysis of randomized controlled trials. *Pediatric Anesthesia*. 2014;24:490–498. [PubMed: 24612183]