Chapter 16
Ophthalmology

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A 2-year-old, 8.5 kg girl is scheduled for bilateral rectus recession with adjustable sutures. She was born at 32 weeks, required some supplemental oxygen for a few days but not intubation or mechanical ventilation, and went home with an apnea monitor for a month that “never alarmed” according to the parents. Her vital signs are blood pressure of 92/55, pulse 120, respiration 32, and temperature 37 °C. Hematocrit is 32. She has never had any previous surgery.

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Preoperative Evaluation

Questions

1. Of what significance is the early history of prematurity? Why? Do you still anticipate problems? Should this patient have a retinal exam preoperatively for retinopathy of prematurity (ROP)? Why/why not? Is the concentration of inspired oxygen a concern in your anesthetic plan? Should this patient receive narcotics?

2. Is this patient at greater risk for the development of malignant hyperthermia? Why/why not? How can you further determine this? Should the patient have a muscle biopsy? Would you use a clean technique? Why/why not?

Intraoperative Course

Questions

1. What are your considerations for anesthetic induction? Why? Your colleague stops by and suggests pretreating with an anticholinergic? What do you think? Should this patient have been premedicated with an anticholinergic an hour earlier? Is intravenous administration during induction more or less effective for prevention of the oculocardiac reflex? Why/why not?

Preoperative Evaluation

Answers

1. She is quite small for her age, so the first thing to be concerned about is failure to thrive; an average 2-year-old should weigh about 12 kg. If she is simply small for her age and has been consistently at the lower end of the growth curve, then reassurance from the pediatrician along with an adequate nutritional history would probably suffice, but it is very possible that with poor intake, she may be anemic and immunodeficient and have other issues that require further medical consultation. She may have retinopathy of prematurity, which has been associated with a history of supplemental oxygen therapy in prematures and many other neonatal factors as well; however, the index of suspicion for severe retinopathy is probably low, because the treatment was of short duration. Nevertheless, it would be reasonable for the ophthalmologist to do a quick exam just to answer the question about the appearance of the fundus so that it can be documented, and it is likely that with this history, an exam would have been done anyway. It would not dissuade me from delivering a routine anesthetic consisting of an F_iO_2 of 0.3–0.4 following 100 % oxygen prior to intubation. Likewise, I would not be concerned about a significant risk of respiratory depression with judicious amounts of opioids, with this history of 2 years of age in an otherwise asymptomatic ex-34 weeker.

2. Malignant hyperthermia has been associated in the past with strabismus, principally through case reports in the ophthalmology literature, although a higher than background rate (fourfold higher) association with masseter muscle spasm has been described in strabismus patients who underwent anesthetic induction with halothane and succinylcholine. The association between masseter muscle spasm and the subsequent development of malignant hyperthermia remains unclear. I would proceed, therefore, with a routine inhalation induction but nevertheless try to avoid succinylcholine for the more typical reason of its higher incidence of masseter muscle spasm and other possible adverse effects such as rhabdomyolysis or hyperkalemia in children. In addition, many ophthalmologists prefer not to have the sustained extraocular muscle contracture, produced as a side effect of succinylcholine, influence their measurements for the procedure.

Intraoperative Course

Answers

1. My principal consideration for this child, who is certainly small for her age but in reasonable health according to her vital signs and hematocrit, is her separation/preoperative anxiety. This can be dealt with by anxiolytic premedication with or without a parent-present induction. The premedication is more likely to be anxiolytic than the presence of the parent, although there is much variation. Moreover,

2. Is a muscle relaxant necessary for this case? Why? What is your choice of muscle relaxant? Why? Will you use nitrous oxide? Why/why not? Should this patient routinely receive antiemetics? What's your choice? Why? What are the disadvantages of metoclopramide in a child compared with an adult? Is total intravenous anesthesia with propofol an advantage? Would ondansetron be of any greater benefit? Is dexmedetomidine part of your anesthetic plan? Advantages? Disadvantages?

many parents wish to be present for a variety of reasons beyond “reassurance,” such as curiosity and education, and these may be very reasonable because ultimately satisfying these needs will inform future decisions and may be helpful for siblings as well. However, parents should not feel compelled to go into the operating room or participate in the parent-present induction if they do not wish to do so. Many in the past have felt that an anticholinergic premedication in the setting of strabismus surgery is required to decrease the incidence of the oculocardiac reflex. When working with experienced surgeons, the bradycardia of the oculocardiac reflex is most rapidly treated by asking the surgeon to stop the traction on the extraocular muscle. If an anticholinergic is needed to treat the bradycardia, it can be administered intravenously at that time. Most patients, however, do not experience the bradycardia of the oculocardiac reflex in the hands of a skilled surgeon, so their routine exposure to an anticholinergic is not necessary.

2. A muscle relaxant is not necessary for this case, as long as the patient is well anesthetized and motionless. Movement under the microscope will be magnified, and there is the possibility of significant compromise of the surgical procedure and injury to the patient. Surgeons often have a preference for operating with or without the administration of a neuromuscular blocking agent and will often make that part of their preoperative discussion with the anesthesiologist. The most important thing, however, is consistency of anesthetic technique with regard to the surgeons’ caliper measurements for muscle resection and recession. The choice of muscle relaxant will depend on the anticipated length of the surgery (i.e., the number of muscles). Pancuronium, with its associated tachycardia, may be a very reasonable choice for this particular procedure. Neuromuscular blockade should be monitored carefully because of the echothiophate treatment. I would use nitrous oxide as part of the anesthetic technique, with only a minor concern about its possible contribution to perioperative nausea and vomiting (PONV), which is likely to occur in any event with this patient because of the association of PONV with strabismus surgery. Prophylactic antiemetic administration is very reasonable given the high association of strabismus surgery with PONV. For years, droperidol was routinely administered to strabismus surgery patients, but now there is concern about its effect on cardiac conduction and its possible contribution to Torsades, an extremely rare event which nevertheless resulted in a “Black Box” warning from the FDA which effectively stopped the use of droperidol as an antiemetic. Other antiemetics include ondansetron, a selective 5-HT3-receptor antagonist which blocks serotonin, both peripherally on vagus nerve terminals and centrally in the chemoreceptor trigger zone. Metoclopramide can also be used, but is associated with a higher incidence of tardive dyskinesia in children than in adults, although these are typically in larger dose ranges than those administered by anesthesiologists. Propofol-based TIVA may have some advantages in that it has an antiemetic effect and would also allow avoidance of the use of potent inhalation anesthetic agents. Its antiemetic effect, however, may be of questionable duration into the postoperative period, so a more sustainable strategy might involve the use of ondansetron, dexamethasone, and possibly metoclopramide.

3. During surgery, the patient suddenly develops a drop in heart rate from 110 to 54 beats per minute. What is your differential diagnosis? How can you go about treating? What would you do? Why? Why does this happen? What is the specific pathway of this reflex? Does greater anesthetic depth block this reflex? What is a traction test? What is a duction test?

Postoperative Course

Questions

1. The anesthesia resident would like to do a deep extubation. What are the advantages of a deep extubation? Would you choose this method? Why/why not? What are the risks of a Valsalva maneuver in this patient? What if she had just undergone an open globe procedure?

3. The most likely cause of this bradycardia is the oculocardiac reflex, mediated in its afferent limb by the long and short ciliary nerves, synapsing in the ciliary ganglion and traveling through the ophthalmic division of the trigeminal nerve. The efferent limb travels from the motor nucleus of the vagus nerve through the peripheral portion of the vagus nerve and terminates in the heart. Other causes include hypoxia, hypertension, elevated intracranial pressure, and other noxious stimuli mediated through the vagus. Direct myocardial depression from the inhalation anesthetic, specifically through its antichronotropic effects, or cardiac effects of other drugs, such as opioids, should also be included in the differential diagnosis. The first maneuver would be to make the surgeon aware of the heart rate and request that he or she discontinue their procedure; the patient may then be observed for a relatively rapid return to a normal heart rate. If this does not occur, then an anticholinergic should be promptly administered IV. An increase in anesthetic depth may block this bradycardia, but it may also contribute, because of the antichronotropic effect, to a worsening of the bradycardia. When traction is applied to the extraocular muscles, it will eventually produce a bradycardic response followed by a recovery tachycardia upon release of the traction. Fatigue of the oculocardiac reflex typically occurs with subsequent manipulation; this is generally referred to as a traction test. A forced duction test is a maneuver used to evaluate mechanical restriction to ocular movement. The sclera is grasped with a forceps and the eye is moved into each field of gaze. This allows the surgeon to differentiate between a paretic muscle and a muscle with restricted movement. Many surgeons prefer that neuromuscular blockade be used during a forced duction test to eliminate the variability in muscle tone with the changing depth of anesthesia. This test is most useful for those undergoing repeat strabismus surgery or in those with paralysis or prior trauma causing a mechanical restriction.

Postoperative Course

Answers

1. A deep extubation, when well conducted, will allow for a motionless emergence without bearing down or "bucking" on the endotracheal tube with resultant strain and an increase in mean arterial and central venous pressure as well as head and neck venous pressure. There is, in addition, some evidence that suggests higher oxygen saturations through emergence following deep extubation in children [1]. The Valsalva maneuver would increase venous pressure in the head and neck and influence the accumulation of edema in the surgically resected tissue; however, this is less of a problem in extraocular surgery than with intraocular surgery, such as an open globe. Most pediatric patients, however, will cry after these procedures, testing the closure of the globe anyway.

2. You are called urgently to the PACU 15 min post-op because the patient has been screaming, banging her head against the side rails, and not making any sense and is inconsolable. She is scratching at her eyes. What is your differential diagnosis? Should you sedate her? Get a blood gas? Give her physostigmine?

3. As part of the plan, the surgeon would like to adjust the correction in the PACU via the adjustable sutures:
   (a) What will the surgeon need from you in order to obtain the best result?
   (b) What medication will you use?
   (c) Are there any premedication administration criteria that you use to determine the patient's fitness for this portion of the procedure?
   (d) What monitoring will you choose?

Additional Topics

Questions

1. A 5-year-old just fell from the Jungle Gym at MacDonald's with a Big Mac in his mouth and landed on a rock causing an open eye injury. The ophthalmologist wants to go to the operating room right away because the eye is salvageable and the surgery should be accomplished as quickly as possible. The child is crying in the emergency room when you see him. He is otherwise healthy, hematocrit 36 %. What anesthetic plan and counseling will you give to the parents?

2. Emergence delirium can occur for a variety of reasons; the most common in this situation would be the delirium associated with emerging from a sevoflurane anesthetic (the etiology of which remains unclear) and the central nervous system effects of anticholinergic syndrome, resulting from the administration of anticholinergics during surgery or as part of the reversal of neuromuscular blockade, particularly if atropine was used (tertiary ammonium molecule which can cross the blood-brain barrier). There is a lower chance of this syndrome with the use of glycopyrrolate, a quaternary ammonium molecule which is much less likely to cause CNS effects because it is a polar molecule. Hypoxia, respiratory distress, and pain should be considered in the differential diagnosis as well. Sedation may work if the patient is having a difficult time adjusting to the emergence and is at risk for self-injury, although ideally she should simply be protected from hurting herself until the delirium (if that is what it is to be determined) passes. A blood gas is unlikely to help in further delineating hypoxia beyond the reading of a pulse oximeter probe. The administration of antilirium (physostigmine), a centrally acting anticholinesterase, may be useful diagnostically, but its synergy with echothiophate should prompt concern.

3. Adjustable suture strabismus surgery is used to “fine-tune” the position of the extraocular muscles in the postoperative period. An adjustable suture is placed on the extraocular muscle(s) that was repaired via standard strabismus surgery, and then the eye alignment is checked in the immediate postoperative period [2]. The adjustment suture can be adjusted by sliding the knot and then securing it into a permanent position. While adults and some adolescents can undergo this adjustment with topical anesthesia, most children will require an anesthetic in order for the surgeon to work in a motionless field and maximize patient safety and comfort. Continuous infusion propofol in the PACU is typically sufficient to provide these conditions without requiring a trip back to the operating room. Standard noninvasive monitoring is utilized, including end-tidal CO_2 via nasal cannula, plastic face mask, or a Jackson-Rees breathing circuit.

Additional Topics

Answers

1. This is one of the “classical” controversies in pediatric anesthesia, balancing the risk of the full stomach and aspiration of gastric contents with the risk of extrusion of a portion of the vitreous. It is also important not to forget that, in dealing with the whole patient, there may be other associated injuries, in this case, the possibility of loss of consciousness or orbital fracture. Assuming these other possibilities are ruled out and it is decided to proceed to the operating room as quickly as possible in order to obtain the best possible result, my priority would be a calm, anxiolytic induction of anesthesia. If an IV is in place, this would probably entail

2. What happens to intraocular pressure with a vigorous Valsalva maneuver? (Describe the pathway, specifically, and how it affects the aqueous humor.) Is it rational to use a muscle relaxant if a patient performs a Valsalva maneuver? Are there any relaxants to be avoided? Why? What about propofol or any other hypnotic?

3. What are the systemic effects of the following antiglaucoma drugs that are of significance to the anesthesiologist?

   Timolol
   Brinzolamide
   Pilocarpine

sedation with an intravenous anxiolytic such as midazolam. If an IV is not in place, then I would choose an oral premed with midazolam. It is tempting to consider a rapid sequence induction of anesthesia with cricoid pressure and succinylcholine; however, succinylcholine has been associated with an elevation of intraocular pressure, even with the administration of intravenous barbiturates and/or "precurarization." A good alternative would be to use the priming method with a nondepolarizing neuromuscular blocking agent, with the administration of one-tenth of the intubating dose, waiting for 2–3 min for a partial depletion of acetylcholine quanta at the neuromuscular junction, and then intravenous induction (with thiopental or propofol) followed by an intubating dose of the nondepolarizing neuromuscular blocking agent. The onset of adequate relaxation for tracheal intubation usually follows within 90 s, during which time gentle ventilation with positive pressure up to 10–12 cm. H_2O and cricoid pressure may be delivered. Although part of the counseling for the parents should include the seriousness of the situation with regard to balancing the aspiration considerations against eye salvage, practically speaking, if the patient has already been crying, he may suffer no more risk with anesthetic induction than he already has prior to surgery [3].

2. The effect of the Valsalva maneuver is as follows: it raises the central venous pressure, it impedes drainage of the aqueous humor through the canal of Schlemm into the episcleral venous system, it increases intraocular blood volume, and therefore it increases intraocular pressure. The administration of a nondepolarizing muscle relaxant may be necessary to immobilize a patient if a Valsalva maneuver occurs during an alteration of the depth of anesthesia. If succinylcholine is chosen, it may actually elevate intraocular pressure as a result of its tonic effect on extraocular muscles. It may be more efficacious to administer thiopental or propofol intravenously in order to acutely lower the intraocular pressure.

3. Antiglaucoma medications include cholinergic agonists (miotics), sympathomimetics, beta-adrenergic antagonists, carbonic anhydrase inhibitors, alpha-2-selective agonists, and prostaglandin analogs.

   Beta-blockers block beta-adrenergic receptor sites decreasing aqueous production in the ciliary body. Beta-blockers have a wide range of side effects including bradycardia, hypotension, depression, arrhythmias, bronchospasm, apnea, and dizziness. One drop of 0.5 % timolol can reach cardiac beta-blockade levels in infants under 2 years of age, and timolol is commercially available as a 0.25 or 0.5 % solution or in a gel form. Timolol is more effective in children over 10 years of age, in cases where glaucoma is mild and where it is the sole agent. Betaxolol is cardioselective with less effect on the pulmonary system. Neonates have developed Cheyne- Stokes breathing and apneic spells lasting up to 30 s that resolved after timolol 0.25 % was discontinued, and there has been a report of multiple severe asthma exacerbations in a toddler. It is thus contraindicated in children with cardiac arrhythmias and bronchospasm and should be used in the lowest possible dose for healthy children. Timoptic, a gel-forming, sustained-release

preparation of timolol administered once daily, was shown in adult patients to be as efficacious in reducing intraocular pressure as timolol ophthalmic solution (0.25 and 0.5 %) twice daily, with measurably less systemic absorption. The 0.25 % dosage of either sustained-release preparation is often sufficient and is the preferred agent in pediatric glaucoma, due to the lower concentration, decreased systemic absorption, and once-daily dosing.

Carbonic anhydrase inhibitors are sulfonamide derivatives used topically or systemically to inhibit production and secretion of aqueous humor. The systemic forms are used as adjunctives to topical glaucoma treatment. The topical preparations are used for short-term treatment before laser surgeries to prevent postoperative pressure elevations. Dorzolamide 2 % and brinzolamide 1 % are eye drops, and acetazolamide is administered orally as a liquid suspension at a pediatric dose of 8–30 (generally 10–15) mg/kg/day. Cosopt® is a fixed combination of timolol 0.5 % and dorzolamide 2 %. Side effects of acetazolamide include gastrointestinal upset. Anorexia is frequently seen when used in infants and hyperpnea is also common. Urinary frequency may develop, but usually normalizes after several weeks. Less frequently, renal calculi are seen. This class is contraindicated in patients with severe kidney or liver disease, as well as reduced sodium or potassium serum levels, or adrenal failure. It is also contraindicated in those with true sulfa allergies. Metabolic acidosis severe enough to require administration of bicarbonate, blood dyscrasias, and Stevens-Johnson syndrome have also been reported.

Alpha-adrenergic agonists decrease aqueous production and may increase uveoscleral outflow. Brimonidine 0.15 and 0.2 % crosses the blood-brain barrier. They are relatively contraindicated in children, due to side effects of somnolence and fatigue, presumably due to central nervous system depression. It was recently reported that two infants, both younger than 2 months, experienced apnea, lethargy, hypotension, hypothermia, and hypotonia, after the administration of one drop in each eye of topical brimonidine. Both infants recovered without sequelae after brimonidine was discontinued. There have also been reports of syncopal episodes in two children, both 10 years of age [44]. A case of intermittent coma in a neonate treated with brimonidine was remarkable for findings of plasma brimonidine concentrations 12–24 times higher than the mean plasma concentration observed in adults. Symptoms were reversed temporarily with naloxone and ceased after brimonidine was discontinued. The other agent in this class, apraclonidine 0.5/1.0 %, is much less selective for alpha-2 adrenoreceptors than is brimonidine, and it is also more useful for short-term rather than long-term therapy.

Prostaglandin analogs are a newer class of medications with impressive potency in adults, once- daily dosing, flat diurnal curve effects, and few side effects. This class includes latanoprost 0.005 %, bimatoprost 0.03 %, travoprost 0.004 %, and unoprostone 0.15 %. These agents are analogs of endogenous F2-alpha prostamides, and they activate matrix metalloproteinases to remodel the extracellular matrix of the uveoscleral pathway, facilitating flow of aqueous humor. This effect is enhanced by

4. An ex-premie is scheduled for an examination under anesthesia and cryotherapy for retinal detachment. What exactly is cryotherapy? What is the difference between that and a scleral buckle procedure? How will you anesthetize him? Where will you measure his oxygen saturation? Should you anticipate any other problems specific to his ex-premature state?

their ability to relax nocturnal ciliary muscle tone. Dosing more often than once daily may mediate inflammatory effects, causing an increase in intraocular pressure.

Miotics and sympathomimetics are historically first-line agents that are rarely used today. *Pilocarpine* is a cholinomimetic-miotic used for glaucoma. It causes miosis and therefore increases the size of the canals of Schlemm, promoting outflow of the aqueous humor. Miotics may be used pre- or postoperatively in glaucoma surgery to constrict the pupil and pull the iris away from the anterior chamber angle. Because the muscle-tendon attachments are not well formed in infants, miotics have only a minor influence on aqueous outflow in this age group. Sympathomimetics work by decreasing aqueous production via vasoconstriction of blood vessels in the ciliary body. With prolonged use, they improve aqueous outflow, likely in part by desensitization of beta-adrenergic responses. To a lesser extent, they improve uveoscleral output as well.

For the most part, timolol gel once daily and brinzolamide are recommended first-line glaucoma agents often used together, with timolol gel providing the advantage of low cost and once-daily dosing and brinzolamide preferred by patients for comfort. Brinzolamide is contraindicated in the presence of sulfa allergies. Additional medications are added as required for optimal control. Miotics, such as pilocarpine, while well tolerated, are infrequently used because of the required frequency of dosing. Brimonidine is contraindicated in young children and the sympathomimetics usually add little to treatment.

4. Cryotherapy is used when retinopathy of prematurity has led to cicatrix formation in the retina and impending retinal detachment and loss of vision. Cryotherapy is used to produce a chorioretinal scar, sealing a retinal break as a result of the accumulation of subretinal fluid with subsequent detachment. Cryotherapy may be used as part of a sequence including a scleral buckling procedure for reattachment of the retina to the pigment epithelium. In scleral buckling, the sclera is physically indented in order to bring the retinal tear closer to the pigment epithelium. External drainage of the subretinal fluid may be necessary as well. The anesthetic required is a general endotracheal anesthetic. Special consideration has to be given to the use of nitrous oxide; if chosen as part of the anesthetic technique, the air in the posterior chamber may actually increase in volume if nitrous oxide is continued once the eye is closed; therefore, nitrous oxide should be discontinued approximately 20 min prior to sealing the chamber. Alternatively, nitrous oxide can be avoided as part of the anesthetic technique. Oxygen saturation can be measured in any extremity or the earlobe and should provide an accurate reflection of retinal saturation. While there may be theoretical concerns about oxygen treatment in the setting of established retinopathy of prematurity, the patient already has very significant injury from multifactorial causes, and the entire patient has to be considered. Patients with coexisting conditions such as cardiac lesions may require additional considerations for oxygen monitoring.

References

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