Chapter 14
Otolaryngology

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A 10 kg, 2.5-year-old boy is scheduled for adenotonsillectomy for sleep-disordered breathing. He had a sleep study with an apnea-hypopnea index of 12. His parents say they can hear him snoring two doors away at home. They proudly brought in his report card from preschool where his teacher indicated that he is the best behaved boy in the class because he always takes his nap at naptime and never has a problem falling asleep. Occasionally he has to go to the school nurse because of headaches. Admission vital signs: BP 128/85, HR 130, RR 45/min.

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Preoperative Evaluation

Questions

1. Why is this patient underweight for his age? What else would you like to know specific to his growth that would influence your anesthetic plan? Why does this happen? Is it more or less common for children with OSA to be underweight?

2. How do the other symptoms and signs influence your plan? What is the significance of his good behavior at naptime? Are headaches common in children with OSA? Why? Why is he hypertensive and tachycardiac? What is the significance of his respiratory rate? Do you think he has "white coat hypertension" or could this be something else? Does this patient need a preoperative echocardiogram? What specifically on the echo would be worrisome or reassuring to you as an anesthesiologist? Would a preoperative ECG suffice?

3. Would you premedicate this patient? What are your concerns? What are the advantages? What agent(s) would you consider? Would you modify your anesthetic technique as a result?

Preoperative Evaluation

Answers

1. In contrast to the popular association of hypoventilation and airway obstruction with the Pickwickian syndrome, most pediatric sleep-disordered breathing is associated with either a normal body habitus or weight below normal, even to the point of failure to thrive. The reason for this is that often children with chronic airway obstruction are slow eaters because they are forced to chew and swallow between episodes of mouth breathing. For that reason, many will choose to avoid foods that require a lot of chewing, such as meats, and therefore they will limit their own diet. They may also have impaired taste and smell if they have substantial nasal obstruction.
   Interestingly, following adenotonsillectomy, approximately 75 % exhibit an increase in growth hormone, insulin-like growth factor 1, and significant weight gain. Comorbidities that may be associated with prolonged upper airway obstruction involve effects on the cardiovascular system such as pulmonary hypertension, systemic hypertension, morphometric facial changes ("adenoid facies"), and sleep fragmentation.

2. Behavioral abnormalities typically reside on a spectrum of irritability to somnolence and are difficult to separate out from normal toddler development. The constellation of symptoms is more important, and chronic airway obstruction is often associated with parental nighttime complaints of fears that their child will stop breathing, loud snoring, gasping, choking, coughing, periods of apnea, restless sleep, and the child's head extension in an effort to unconsciously resolve the airway obstruction. Morning or daytime headaches are a frequent complaint and may be a result of systemic hypertension, nighttime fragmented sleep, head and neck muscular pain, or various combinations. Hypertension in children may be associated with a visit to the doctor's office, so-called white coat hypertension, but in this patient population, elevations in blood pressure, especially systolic pressure, are also associated with sleep-disordered breathing in direct relationship to the apnea-hypopnea index. Moreover, these patients may have biventricular dysfunction on echo – features of left ventricular hypertrophy, pulmonary hypertension, and impaired right ventricular performance. It would not be unreasonable to seek this kind of evaluation in patients with long-standing sleep-disordered breathing because of these possibilities.

3. Premedication would depend on assessment in the preoperative period; the strategy has to take into account the concerns of the parent about the child's behavior, the judgement of the anesthesiologist with regard to the effects of immediate preoperative stress on the cardiopulmonary system, and the concerns about any abnormalities of ventilatory control being aggravated by the premedication. Benzodiazepines alone would not be likely to shift the CO_2 response curve much if at all, but residual effects may very well emerge in the immediate postoperative period following inhalation anesthetics and/or opioids, so this must be kept in mind.

Intraoperative Management

Questions

1. Does this patient need any monitors beyond standard noninvasive monitoring? What monitors do you have available among your standard monitors that help you evaluate the pulmonary circulation and the right heart?

2. Mask vs. intravenous induction – are both acceptable? Mom insists on being present for induction – is this a good idea? As the patient enters stage II, he develops "seesaw" breathing with phonation and profuse salivation, is moving all extremities in a flexion pattern, and seems to be struggling. What's happening and why? His SpO_2 is 94 %, but in 5 s it goes to 88 %. What is your next move? Choices of drugs? How and where would you deliver them? The child was given an adequate dose of intramuscular succinylcholine and atropine (40 and 0.4 mg), but his heart rate has slowed to 62 although you are now moving the chest with adequate ventilation. What is your next move? Should you begin CPR?

Intraoperative Management

Answers

1. No further monitoring is needed beyond standard noninvasive monitors. That said, the available standard monitors should be regarded with an additional level of interpretation to reflect possible aggravation of pulmonary hypertension and biventricular performance. Oxygen saturation will depend to some extent on pulmonary artery pressures as well as right heart performance; blood pressure will be a reflection of this as well. Left ventricular dysfunction may also be reflected in abnormal blood pressure responses, but it will depend on the balance of chronically elevated catecholamines along with any myocardial contractility impairment, especially with propofol or higher doses of inhalation anesthetics. Because of the solubility of carbon dioxide, it is not likely that patients will exhibit significant alterations of $ETCO_2$ as a reflection of elevated pulmonary artery pressures. ECG findings in severe circumstances might include bradycardias, right heart strain patterns, or ectopy.

2. While both are acceptable, there is no doubt that a mask induction would be easier, unless there was a preexisting IV. That is not very likely, as this child is probably coming in from home. That said, an IV induction should not be completely ruled out, because it affords a more rapid induction, bypassing the likelihood of passing through an excitement stage during an inhalation induction and allowing the rapid administration of neuromuscular blocking agents to minimize the chance of laryngospasm, which is higher in this patient population, particularly with the diagnosis of airway obstruction. Mom can certainly be present for the induction, with careful discussion beforehand that the primary job of the anesthesiologist remains the care of the patient and not the parent and the use of the euphemism "falling asleep" is just that – it is, after all, not really "sleep."

   The excitement stage during an inhalation induction is associated with the increased elaboration of endogenous catecholamines, which may be associated with all of these signs of reactivity, and in addition will produce an increase in oxygen consumption and therefore carbon dioxide production as well. Some positive pressure in the circuit by closing the APL valve is a reasonable strategy as is the insertion of an oral airway to improve upper airway patency. Occasionally, laryngospasm can only be treated with neuromuscular blockade; a depolarizing agent such as succinylcholine can be co-administered with an anticholinergic intravenously or intramuscularly (if prior to IV insertion), or a nondepolarizing drug such as rocuronium can be used. If the heart rate continued to decrease for a few seconds following administration of neuromuscular blockade, and the chest was rising and adequate gas exchange was the result, I think I would wait a few more seconds to see if the saturation began to improve. There is a little bit of a delay in the display of the SpO_2 in relation to improvement in ventilation. If the heart rate continued to decrease and there was evidence of impaired gas exchange, worsening hypoxia, and bradycardia, then CPR should be quickly initiated to augment the circulation of further resuscitation drugs and augment cardiac output and cerebral blood flow.

3. He now has an IV. How will you plan your anesthetic at this point? Do these events influence your plan? The surgeon suggests a deep extubation because he thinks the wake-ups are less problematic. Do you agree? Would you choose that strategy? Why?

4. Does this patient need to go to the ICU?

Perioperative Care

Questions

1. The patient is brought to the ICU, extubated. His SpO_2 on arrival, with blow-by oxygen, is 94 % and he is sleepy. What are the possibilities? On auscultation, he has diffuse, moist, and coarse breath sounds without wheezing. You think you can hear rales at the lung bases. Is this kind of patient at risk for post-tonsillectomy pulmonary edema? How does this happen? What is the appropriate course of action at this point? At what point will it be safe to transfer him from the ICU?

2. What will you counsel the parents about with regard to his recovery course for the next few days? Over what period of time will he actually "normalize" his cardiopulmonary system alterations to chronic upper airway obstruction?

3. Once an IV is in place, then the anesthetic planned for this patient can be continued. This may or may not include a "deep" extubation, which has the advantage of a well-anesthetized airway at the end of the case so coughing and "bucking" are avoided but also has the disadvantage of an anesthetized unprotected airway at the end of the case. Those experienced in the technique typically have very few difficulties with either strategy; those less experienced should perfect their technique in healthy tonsillectomy patients first before using this technique in patients with significant comorbidities.

4. The ICU is the appropriate perioperative destination for this patient, in accordance with typical concerns about their perioperative risk of airway obstruction and ongoing disordered breathing, especially following a general anesthetic. It is now part of the guidelines of the American Academy of Otolaryngology-Head and Neck Surgery for tonsillectomy in children as well as the American Academy of Pediatrics. Children less than 3 years of age should be kept overnight in the intensive care unit.

Perioperative Care

Answers

1. Impaired oxygenation in the immediate post-op period can be for a variety of reasons – aspiration, somnolence, atelectasis, or a phenomenon well recognized with tonsillar hypertrophy, post-extubation pulmonary edema. While an abnormal chest x-ray aids the diagnosis, rales will often reveal themselves prior to radiological confirmation, as will impairment in oxygenation. Likewise, improvement in oxygenation and auscultation will be more rapid than radiological resolution of abnormalities. Appropriate intervention may simply include elevating the inspired fraction of oxygen using a nonrebreathing mask, but diuretics, CPAP, or reintubation and positive pressure ventilation may be required in severe cases. Discharge directly from the ICU after an overnight stay is possible with complete normalization in room air; otherwise, continued inpatient observation may be warranted if resolution is slower.

2. There will be no "immediate" effect on snoring or respiratory control in the first few postoperative days, although there will be noticeable improvement in snoring over the first few weeks. If there is a central control component, that will improve in the first few weeks to months after surgery. Pulmonary hypertension and right heart dysfunction will improve in most patients over weeks to months following surgery.

Additional Questions

Questions

1. What is the CHARGE syndrome? Of what importance is choanal atresia in the first week of life? What special considerations are there for the surgical correction? Are there specific anesthetic implications?

2. A 12-year-old boy presents with a growth in the nasopharynx and is scheduled for biopsy. What concerns do you have? Of what significance is the diagnosis of juvenile nasal angiofibroma? What implications does it have for anesthetic management? Is it important to know about the extent of this tumor prior to anesthesia? Why? What implications does it have for management? The patient will first be scheduled for coil embolization under anesthesia in the interventional radiology suite. How will your anesthetic management be influenced for this procedure? How should the CO_2 be controlled? Is there an optimal choice of anesthetic agents? Should the patient be managed with controlled hypotension? Why/why not?

Additional Questions

Answers

1. The CHARGE syndrome is an acronym that stands for colobomas of the eye, heart disease, atresia of the choanae, retarded growth, genital anomalies, and ear anomalies. It is a more extreme form of choanal atresia, which may occur unilaterally or bilaterally. In addition to the acronym findings, CHARGE patients often have CNS abnormalities such as olfactory bulbs that are abnormal, cranial nerve abnormalities, and pharyngeal dyscoordination leading to aspiration. Because these anomalies occur early in embryological development, there can be varying stages of severity for each, along with impairments of development of other contiguous structures such as the branchial arches and occipital somites. It is therefore not uncommon to have a short neck, short mandible, small mouth, clefting of the lip or palate, a range of cardiac anomalies of varying severity, and failure to thrive. In the newborn period, severe respiratory distress may occur which cannot be relieved by a nasal airway. Likewise, nasogastric intubation for decompression or feeding may not be possible.

   Surgical correction at this point has progressed to transnasal endoscopically guided membranous and bony resection in the majority of case, although transpalatal approaches are still utilized. The surgical goal is to create choanal patency, preserve mucosal integrity, and minimize the chance of restenosis. If stenting is utilized, then when the patient returns for stent removal after about 3 weeks, dilation or dilation plus injection of mitomycin C is often used to promote epithelial growth.

   Anesthetic considerations include the possibility of midfacial dysmorphism, congenital heart disease, developmental delay, and pharyngeal dysfunction with aspiration. Midfacial dysmorphism with a foreshortened nasomaxillary complex may make the mask fit as well as direct laryngoscopy difficult and the medical consequences of prolonged upper airway obstruction and its cardiopulmonary consequences challenging.

2. Most childhood tumors in the nasopharynx are benign, but can have significant consequences nevertheless. Encephaloceles, dermoids, and benign teratomas can occur as congenital remnants, in which case they present at an early age with airway obstruction or more insidiously in older patients. The juvenile nasal angiofibroma is the most aggressive of these benign tumors presenting in early adolescence, usually in boys. They extend locally into the surrounding nasopharyngeal tissue and cranially through the skull base. They are typically evaluated radiologically by CT scan, MRA, and/or angiogram and at the same time embolized in order to reduce the vascularity for subsequent surgical resection. Because transit time in vascular areas is related to volume, pressure, and pH, all three can be positively influenced by the anesthetic technique. For placement of embolization devices, increased volume, normal to slightly higher than normal blood pressure, and moderate controlled hypercarbia may facilitate coil placement. For the surgical procedure, this physiology should be reversed, so that bleeding may be decreased through the use of carefully controlled hypotension, volume reduction, and positive pressure-controlled hyperventilation.

3. A 15-year-old is scheduled for incision and drainage of a peritonsillar abscess; she has trismus and is frightened. What are your considerations for anesthetic induction? Should this patient undergo an awake intubation? Rapid sequence induction? Should she receive a muscle relaxant? What about an awake transnasal fiber-optic intubation? How is this situation different than a Ludwig's angina patient?

4. A 5-year-old Haitian girl who speaks only Creole is scheduled for partial reduction glossectomy for cystic hygroma. How will you evaluate her? Her tongue protrudes 7 in. beyond her mouth, and the distal 3 in. are desiccated and macerated. How will you begin your induction sequence? Is it likely that you will be successful at orally intubating her? Nasally intubating her? How would you preoxygenate? What are your postoperative considerations?

3. This is a very typical presentation in an older pediatric patient with a sore throat, difficulty swallowing, often sick for a few days, and occasionally, voice changes with difficulty talking. She may even have some mild respiratory distress. Although the majority will have been treated successfully with antibiotics, those coming to surgery have usually failed such therapy. Most patients will have had CT scans of their upper airway preoperatively, and therefore the extent of the peritonsillar abscess is easy to evaluate. Trismus is difficult to evaluate with regard to predicting the ease of direct laryngoscopy and endotracheal intubation. It is typically relieved following induction with a hypnotic agent and the use of a muscle relaxant unless the inflammation and edema have been progressive over several days. Assuming that the clinical exam and radiological evaluation do not suggest anatomic difficulties with a rapid sequence induction of anesthesia, direct laryngoscopy, and intubation of the trachea, this would be the optimal choice. Secondary choices include topical anesthesia, sedation, and an awake "look" or placement of an endotracheal tube; however, the risks of patient discomfort, coughing, and potential disruption of the abscess may outweigh the benefit. An alternative would be the maintenance of spontaneous ventilation either following intravenous induction with a hypnotic agent or mask induction with a volatile agent. A transnasal fiber-optic intubation would be very hazardous because the peritonsillar abscess often extends into the upper pole of the tonsillar bed, right at the junction of the soft palate, and instrumentation of the soft tissue in the area could be a significant risk for abscess disruption.

4. There are several important features here; first of all, the inability to provide positive pressure ventilation or even supplemental oxygenation by mask is most influential on the anesthetic plan. Secondly, the patient does not speak English and therefore will have a more difficult time cooperating with an anesthetic plan that involves sedation, topicalization, and an "awake" intubation.

   Her ability to cooperate must be carefully assessed with the aid of a translator in the presence of the parents who can help to explain what the anesthesiologist will be doing. An IV should be established first in order to provide sedation to the point of arousable somnolence. A variety of medications can be used for this purpose, but a combination of midazolam and fentanyl would probably be my choice. Topical anesthesia can be provided by lidocaine (a 2 % concentration in this age group should be enough) to the level of the laryngeal inlet. Depending on the choice made, standard or video direct laryngoscopy or fiber-optic laryngoscopy (transnasal or transoral) can be accomplished. Supplemental oxygen can be delivered by an assistant while asking the patient to take deep breaths. Postoperatively, depending on the duration and extent of the surgery, she may have swelling that would make nasal reintubation more comfortable for the patient and more secure for her ICU stay.

5. Differentiate epiglottitis, croup, and bacterial tracheitis. What difference does it make to your anesthetic management to consider these as different entities?

6. How does a laryngeal cleft occur embryologically? What are the implications for airway management? Should these patients receive a tracheostomy in the newborn period? Why/why not?

7. What are your considerations for using jet ventilation as part of your management of the airway during laser surgery for juvenile laryngeal papillomatosis?

5. Epiglottitis refers to the acute bacterial infection of the supraglottic larynx that had historically been caused by *Haemophilus influenzae* type B. The typical clinical appearance is the sudden onset of fever and airway distress in the absence of a URI in a toxic-appearing young child. They are often sitting, rather than laying down, because they can breathe more easily. Radiographically, they typically have a thumb sign of the epiglottis. Croup, or laryngotracheobronchitis, is usually more gradual in its onset, preceded by several days of URI-like symptoms and caused by URI-related organisms such as parainfluenza. Many patients have a typical "barking" cough with or without stridor, while others can have significant upper airway obstruction. Biphasic stridor supports the diagnosis of laryngotracheobronchitis. The age group is somewhat younger, usually 6 months–3 years of age. Radiographically, a "steeple" sign is present in the subglottis. Bacterial tracheitis may present with fever, stridor, voice change with a brassy quality, and a toxic appearance. The trachea usually has purulent debris, crusting, ulceration, and membranes that may require removal. A range of gram-positive and gram-negative organisms are often the culprits. These patients often need to be supported with endotracheal intubation and perioperative intensive care. It is important to differentiate the disorders because airway support is often necessary for epiglottitis and bacterial tracheitis, while airway instrumentation and endotracheal intubation should usually be avoided for croup.

6. Failure of complete separation of the primitive foregut into the trachea and esophagus can result in varying degrees of residual communication between the two. It can be as subtle as a small communication between the arytenoid cartilages indicating incomplete formation of the interarytenoid muscle or complete communication at the cranial portion of the larynx and upper third of the trachea, making them functionally one tube. These infants have an abundance of pharyngeal secretions, recurrent aspiration pneumonias, choking episodes, and respiratory distress, typically associated with attempts at feeding. A significant portion also have tracheoesophageal fistulas. A tracheostomy may be ineffective in establishing an airway because of the tendency for the tracheostomy tube to pass through the posterior wall of the trachea into the esophagus. It is usually better to attempt a primary closure of the mucosa separating the trachea and esophagus through suspension laryngoscopy while maintaining endotracheal intubation. The alternative, open repair and separation of the trachea and esophagus, is often fraught with hazards of perioperative tissue breakdown and formation of fistulous communications.

7. Jet ventilation accomplishes several things that intubation with a metal tube or foil-wrapped tube cannot. First of all, it provides unimpaired access to the airway and complete visualization for the surgeon. Secondly, it decreases the risk of fire by not having any combustible material within the airway at all. The hazards are several: there is a risk of barotrauma and dissection of tracheal, pretracheal, or pharyngeal tissue if the driving pressure of the jet is too high, and for that reason, a pressure/compliance curve is an optimal strategy, where the amount of driving pressure is just enough to ventilate the patient, assessed by using chest wall movement and/or breath sounds as an endpoint for adequate ventilation. The airway is unsecured, and therefore, debris and smoke can be "jetted" into the unprotected airway, so efforts at ventilation should be made in concert with the surgeon's laser resection.

8. You are called into a colleague's room because the laser aperture was accidentally left open and the laser fired on a polyvinylchloride endotracheal tube that remained in place just prior to extubation and after the suspension laryngoscope was placed; the patient has flames and smoke in the tube and singed lips. Your colleague's sleeve has caught fire, and he is preoccupied with that. What do you do next?

8. The colleague will probably be adequately cared for by the OR personnel, who likely know how to handle this straightforward situation. The patient's airway situation is more complicated. Working in conjunction with the surgeon, ventilation of the lungs has to be discontinued, and all anesthetic gases including oxygen have to be discontinued as well. The flames should be extinguished with saline and the endotracheal tube removed. All of these steps should take place virtually simultaneously. At that point, the patient's lungs should be ventilated by mask, and the surgeon should prepare to evaluate the trachea endoscopically for damage and burns. Depending on the degree of burn and damage, endotracheal intubation and perioperative mechanical ventilation may be required.

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