Update in Anaesthesia

Anaesthesia in patients with asthma, bronchiolitis and other respiratory diseases

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Summary

Respiratory illnesses are common in the paediatric population. As a result, children often present for surgery and anaesthesia with respiratory symptoms. The child with well controlled asthma or minimal symptoms of respiratory infection may proceed with anaesthesia. The dilemma lies in the decision to cancel or proceed when symptoms are more than minimal. This article describes respiratory conditions in children as they relate to anaesthetic perioperative management. Our goal is to inform anaesthesia providers of safe practices, and the risks and benefits of administering anaesthetics to these patients.

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ASTHMA

Introduction

Asthma is a leading cause of morbidity in children throughout the world.[1] In urban hospitals, it is the most common reason for hospital admission. The prevalence among children in Western countries is between 2 and 10%.[1] Asthma is a lung disease characterized by three distinct features: airway obstruction, airway inflammation and airway hyper-responsiveness. Symptoms manifest as episodes of recurrent wheezing, chest 'tightness', dyspnoea and dry cough. Typically episodes result in variable obstruction of airflow that resolves either spontaneously or with treatment. Asthma has no radiologic, histologic or confirmatory blood test. It is characterized by reversible symptoms, findings on examination and pulmonary function tests. While the characteristic symptom of asthma is wheezing (usually expiratory), it is important to realize that wheezing is produced simply by airflow passing through a sufficiently narrowed airway. Wheezing can occur during different phases of the respiratory cycle depending on the site of the airway obstruction and its cause. The differential diagnosis of wheezing in children is extensive and includes: asthma, foreign body, bronchiolitis, inhalational injury, pneumothorax, endobronchial intubation, herniated endotracheal tube cuff, cardiac failure, cystic fibrosis, sickle cell disease, recurrent aspiration, mediastinal mass, tracheomalacia, vascular ring, tracheal web/stenosis, bronchial stenosis and roundworm infestation.[2]

An acute exacerbation of asthma can quickly progress to severe respiratory distress and may ultimately lead to respiratory failure defined by hypoxaemia/hypercarbia. It is important to note that as an acute asthma attack worsens and the child fatigues, wheezing may become diminished or be completely absent. Many children with chronic asthma also have chronic inflammatory changes that may be associated with permanent alterations in their airway structure. These patients may not be responsive to commonly used treatments.

Epidemiology

The median age of onset for asthma is 4 years old with more than 20% of children developing symptoms within the first year of life.[1] However, the diagnosis of asthma in an infant is unusual and other causes for wheezing should be investigated. Asthma most likely results from an interaction between both an inherited modifier of inflammation and environmental influences. A number of risk factors have been identified but the best researched include gender, atopy, allergens, infections, obesity, tobacco smoke, and perinatal factors.

Childhood asthma tends to occur predominantly in males until puberty. After age 20 the prevalence is equal between the sexes. The association between asthma and other atopic diseases has been well researched. An "atopic march" has been identified which starts as atopic dermatitis in the infant, followed by allergic rhinitis and asthma in the older child or adolescent. Indoor allergens have been shown to play a significant role in the development of asthma. The dust mite, *Alternaria* mould, cockroach allergens, as well as cat and dog allergens have all been implicated.

Smoke exposure from cooking on open wood fires is an important risk factor in many developing countries. Viral and bacterial infections are well known triggers of asthma exacerbations but their causal relationship remains unproven. Several large studies have suggested that patients with an elevated body mass index (BMI) or that are actively smoking are at increased risk of developing asthma. Lastly, perinatal risk factors have been studied extensively but have so far found few strong correlations. This is most likely due to the inherent difficulty in controlling for confounders between study groups.[1]

Pathophysiology

The chronic airway obstruction seen in asthmatic patients is caused by inflammation and hypertrophied bronchial smooth muscle leading to hyperinflation and air trapping. This results in decreased lung compliance and increased work of breathing. Chronic airway obstruction leads to a ventilation/perfusion mismatch and dead space ventilation which are clinically evident as hypoxaemia and further increased work of breathing.

Preoperative assessment

Assessment of acute asthma

Important questions when evaluating a child with asthma include the following:

- frequency of symptoms,
- amount and purulence of sputum,
- use and effectiveness of medications,
- asthma triggers,
- activity level, previous history of surgery and anaesthesia, recent upper respiratory infections,
- hospitalizations and emergency department attendance.[2]

Investigate hospitalizations to determine if ICU admission or intubation were required. Use the physical examination to assess for wheezing, a prolonged expiratory phase, use of accessory muscles of breathing (e.g. intercostal and subcostal retractions), respiratory rate, cyanosis, and drowsiness. Oxygen saturation (SpO_2) is useful to have preoperatively.

Preparation for surgery

Instruct parents to administer all asthma medications, including on the morning of surgery to ensure optimal treatment. Children with well controlled asthma who are scheduled for elective surgery should not have wheezing on the morning of surgery. Preoperative wheezing is predictive of perioperative complications. Stabilize patients in conjunction with the paediatric medical team and anaesthetise only when determined to be stable by a senior anaesthetist.

Treatment

Understanding the patient's asthma severity is critical to administering the appropriate preoperative treatment. Table 1 defines each severity classification based on frequency of daytime symptoms, frequency of night time symptoms, ratio of Peak Expiratory Flow Rate (PEFR) to Forced Expiratory Volume over 1 second (FEV_1) and the PEFR variability. In medical settings where these pulmonary function tests are unavailable, spirometry is a useful alternative for preoperative assessment. Spirometry offers an easy method of determining the presence and severity of airway obstruction. The patient is asked to place on a nose clip and then take a deep breath, exhaling into the spirometer as hard and for as long as possible. This is immediately followed by a rapid inhalation and results in a diagnostic flow-volume loop.

Preoperative treatment for mild intermittent or mild persistent asthma involves administering a nebulized β_2-adrenergic agonist, such as salbutamol, 1 to 2 hours prior to surgery.

Preoperative treatment for moderate persistent asthma involves additional optimization with any inhaled anti-inflammatory agent (i.e. cromolyn, theophylline, montelukast - all act by suppressing the inflammatory mediators that cause airway hyperreactivity) and by consistent use of nebulized β_2 agonists in the week prior to surgery. Preoperative treatment for severe persistent asthma involves a visit to their primary care physician or pulmonologist prior to surgery in order to optimize treatment. Some children benefit from short-term oral corticosteroid therapy, such as prednisone ($2mg.kg^{-1}$ PO once daily for 3-5 days, max of $60\ mg.dose^{-1}$) or oral dexamethasone ($0.6mg.kg^{-1}$ PO once daily for 2 days, max of $16mg.dose^{-1}$) prior to surgery.

These preoperative treatments have all been shown to be both effective and safe with a low incidence of side effects.[1] However, determining the severity of the patient's asthma is not sufficient. It is also important to determine the patient's control of their disease. A patient with severe asthma may nevertheless be well controlled, whereas a patient with mild asthma may be very poorly controlled. It is also important to note the difference between poorly controlled asthma and severe persistent asthma. Poorly controlled asthma (i.e. non-compliant with preventative or therapeutic medications) can occur within all severity classifications of chronic asthma. However, to be categorized as having severe persistent asthma the patient must meet the specific qualifications of symptom frequency and measured PEFR and FEV_1 values. The potential for perioperative complications (e.g., bronchoconstriction, bronchospasm, laryngospasm and reduced FEV_1) is present with either of these scenarios. Most patients with asthma should be seen by the physician who manages their disease one week prior to surgery for appropriate and timely preoperative management.

For the child with asthma, base your decision whether to proceed with surgery on the stability of asthma symptoms and whether symptoms are optimally managed. The possible intraoperative complications include bronchospasm and laryngospasm. Warner and colleagues[3] identified three factors that correlate with perioperative bronchospasm:

1. Use of bronchodilators
2. Recent asthma exacerbation

Table 1. *Severity classification of chronic asthma*

	Days with symptoms	Nights with symptoms	PEFR/FEV_1 % predicted	PEFR variability
Mild intermittent	≤ 2 / week	≤ 2 / month	≥ 80%	≤ 20%
Mild persistent	3-6 / week	3-4 / month	≥ 80%	20-30%
Moderate persistent	Daily	≥ 5 / month	60-80 %	> 30%
Severe persistent	Continuous	Frequent	≤ 60%	>30%

3. Recent visit to a medical facility to treat asthma.

This makes an accurate asthma history crucial. The intraoperative goal is to depress airway reflexes with appropriate anaesthetic drugs. This will prevent bronchoconstriction of the patient's hyperreactive airway that can occur with airway manipulation. Stimuli that would not usually cause an airway response in a patient without asthma may initiate a serious episode of bronchoconstriction in a patient with asthma.

Intraoperative management

Anaesthetic technique

Consider regional anaesthesia as the sole technique since this may prevent the need for airway instrumentation. This is particularly important in patients undergoing emergency surgery when there is insufficient time to optimize their pulmonary status. When choosing to do a general anaesthetic, a thorough understanding of the physiological effects of each anaesthetic drug and its interaction with an asthmatic patient is crucial. These are described below.

Intravenous drugs

Midazolam does not alter bronchial tone and is therefore a safe choice for preoperative anxiolysis.

Propofol inhibits bronchoconstriction and increases airway dilation by directly relaxing the airway smooth muscle. These actions decrease the risk of bronchospasm during induction and propofol is considered safe for patients with asthma. This agent may not be suitable for haemodynamically unstable patients.

Ketamine has sympathomimetic bronchodilatory properties, with a direct relaxing action on bronchial smooth muscle. These actions decrease the possibility of bronchospasm with induction so that ketamine has been proposed as a good choice for patients with severe persistent asthma. Ketamine also increases bronchial secretions and should be given simultaneously with an anticholinergic drug such as glycopyrolate or atropine. If possible, ketamine sedation may also be considered as an alternative to general anaesthesia.

Thiopental use has been associated with bronchospasm, making it a poor first choice for induction of anaesthesia.

Lidocaine, when given intravenously, significantly increases the histamine threshold and blocks the cough reflex. It may be given to decrease the airway responses associated with endotracheal intubation.

Morphine causes histamine release which may result in bronchospasm. Fentanyl, if rapidly administered in large doses, can result in chest rigidity which could be mistaken for bronchospasm. However, fentanyl administered more judiciously is preferable to morphine.

Inhalational anaesthetics

Halothane, enflurane and isoflurane are potent bronchodilators that act via β-adrenergic receptor stimulation. They have been shown to decrease airway responsiveness and help ease histamine-induced bronchospasm. Many studies have shown their effectiveness in the treatment of status asthmaticus. Sevoflurane has controversial effects in asthmatics: some studies show an increase in airway resistance and others show no change. Desflurane is a very pungent agent that is irritant to the airway and has been shown to increase secretions, coughing, and laryngospasm. Halothane and sevoflurane remain good choices for inhalational induction.

Muscle relaxants

Gallamine, pipecuronium and rapacuronium are all neuromuscular blockers that bind and stimulate M2 muscarinic receptors more than M3 muscarinic receptors, causing bronchoconstriction. The neuromuscular blockers that stimulate the M2 and M3 muscarinic receptors evenly, such as vecuronium, rocuronium, cisatracurium and pancuronium, do not cause bronchoconstriction. Atracurium, mivacurium and suxamethonium dose-dependently release histamine and thus trigger bronchoconstriction. The rapid onset and short duration of action of suxamethonium continue to make it a useful agent for a rapid sequence induction.

Intubation technique

Airway manipulation, particularly in a light plane of anaesthesia, is a potent stimulus of bronchospasm, laryngospasm, coughing and breath-holding. Use of an inhaled β_2-agonist before intubation may reduce bronchospasm. In general, avoidance of airway stimulation seems sensible. For short cases a face mask may be sufficient. Whenever possible, avoidance of tracheal intubation is preferred and a laryngeal mask airway (LMA) should be used since it may be less stimulating than an endotracheal tube.[2] However, in cases that require airway protection (for instance patients with severe gastro-oesophageal reflux disease), and endotracheal intubation is necessary, ensuring a deep level of anaesthesia prior to airway instrumentation reduces the risk of bronchoconstriction.[2] An endotracheal tube that is too long and touches the carina is a potent cause of bronchospasm; the length of the endotracheal tube should therefore be assessed carefully after intubation. The Morgan formula, (endotracheal tube length measured at the front upper teeth [cm] = 0.10 x height [cm] +5), is a useful gauge of appropriate endotracheal tube depth in children. Another alternative which is simple to calculate for oral endotracheal tube depth (in cm) is endotracheal tube (internal diameter) size x 3. Neither formula uses age in its calculations, since this can be misleading in poorly-nourished populations.

Maintenance

Maintenance of anaesthesia with inhalational agents such as halothane helps to dilate bronchioles and prevent bronchospasm. It is important to have a method to deliver a bronchodilator (e.g. salbutamol) intraoperatively after the airway is secured. A simple technique is to remove the plunger from a 60ml syringe and place a bronchodilator metered dose inhaler (MDI) into the barrel. The plunger is then replaced and when depressed will trigger the MDI to spray through the Luer Lock connector of the syringe. This can easily be incorporated into the anaesthesia circuit at the elbow connecting the endotracheal tube. Synchronize the MDI with inspiration to increase its administration. Commercially available adaptors also exist which optimize timing of drug administration with inspiration and further improve efficiency.[4]

You must be vigilant for the signs of intraoperative bronchospasm in order to be able to treat it. Intraoperative bronchospasm presents as a prolonged expiratory phase/wheeze with increased airway pressure,

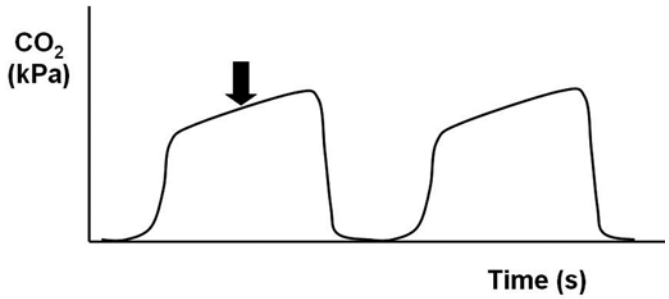

Figure 1. *Typical up-sloping capnograph trace seen with bronchospasm*

upsloping in the end-tidal CO_2 waveform and hypoxia, and may result in difficulty with ventilation. You must rule out other causes of airway obstruction (e.g. equipment malfunction) and wheeze (e.g. pulmonary aspiration) before starting treatment:

Treatment of bronchospasm under general anesthesia

1. Remove causative stimulus, while increasing the FiO_2
2. Deepen the volatile anaesthetic
3. Inhaled salbutamol
4. SC or IV adrenaline (10mcg.kg^{-1} SC or 1mcg.kg^{-1} IV, caution with IV adrenaline)
5. IV steroids
6. Paralysis (if not already)
7. IV ketamine (consider).

The end-tidal CO_2 waveform is an early indicator of the effectiveness of these interventions. Do not be overly concerned with treating a high CO_2 which may lead to excessive ventilation, elevated peak inspiratory pressures and possible pneumothorax.

Extubation

For patients undergoing elective surgery and where no other contraindications exist, deep extubation is the best option. The depth of anaesthesia should be sufficient to prevent laryngo-/bronchospasm when the endotracheal tube is removed. For patients undergoing emergency surgery, with a potentially full stomach, awake extubation is a more sensible option. An awake extubation occurs after upper airway reflexes have returned and the patient can therefore protect their airway. Sufficient amounts of opioid and re-dosing of inhaled β_2-agonists may also be useful prior to extubation to decrease the reflex bronchoconstriction that may occur. It is important to remember when reversing muscle relaxants that both neostigmine and physostigmine cause increased secretions and bronchial hyperreactivity.

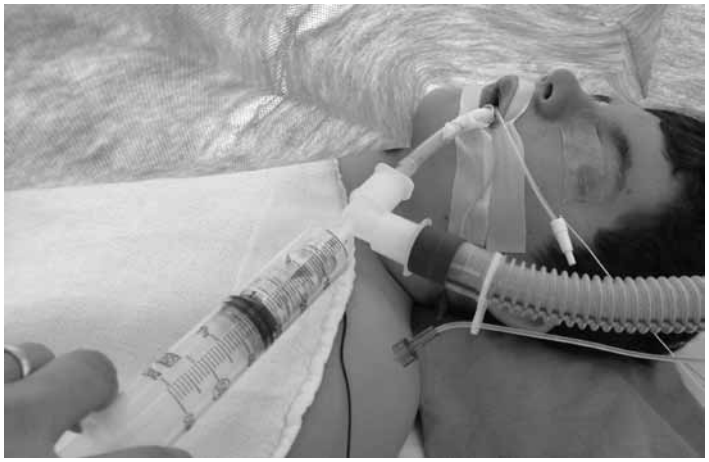

Figure 1: *MDI incorporated into anaesthesia circuit using a 60ml syringe*

Postoperative management

Analgesia

When possible and where indicated, postoperative regional analgesia is preferable. A functioning epidural will block afferent pathways mediating pain from the abdominal viscera/incision and therefore help to maintain the patient's respiratory muscle function. This leads to more adequate tidal volume and vital capacity and helps to preserve diaphragm function. A regional-only anaesthetic technique also eliminates the need for airway manipulation, thus preventing potential airway irritation. Avoidance of both meperidine (pethidine) and morphine is preferable, given their ability to release histamines which can result in bronchospasm. As mentioned above, fentanyl is the best opioid alternative. An infusion of ketamine has also been used in the postoperative period since it is capable of providing analgesia with the direct advantage of preventing bronchospam.[4] Use nonsteroidal anti-inflammatory drugs (e.g. ibuprofen and ketorolac) with caution in patients with asthma given that a small proportion of children (1 in 50) may have a bronchospastic response.

Monitoring

Standard postoperative monitors are indicated while waiting for the patient to regain normal airway/breathing function. The head up position is preferred to help clear secretions and prevent atelectasis. The early control of sputum and respiratory symptoms helps to prevent postoperative complications.

BRONCHIOLITIS

Introduction

Bronchiolitis is a lower respiratory tract infection with a spectrum of clinical presentations ranging from minimal symptoms to fulminant respiratory failure requiring mechanical ventilation. It is usually a clinical diagnosis; routine laboratory or radiologic studies are not recommended. A child usually presents with symptoms of a respiratory infection (e.g. cough, nasal congestion). This may be followed by fever, poor appetite and lethargy. Clinical symptoms peak around day 3 to 4 of illness and bronchiolitis is usually a self-limiting disease.[6] Those at higher risk of clinical deterioration include infants with chronic lung disease, congenital heart disease, and/or prior prematurity.

Epidemiology

Viral bronchiolitis is the most common cause of respiratory disease in children under two years of age requiring hospitalization. The most common cause (80%) is respiratory syncytial virus (RSV). Less common causes include rhinovirus, parainfluenza, influenza, human metapneumovirus and adenovirus. Annual epidemics of RSV

bronchiolitis occur during the winter and spring months. Risk factors include prematurity (gestation < 37 weeks), low birth weight, age < 6–12 weeks, chronic lung disease, haemodynamically significant congenital heart disease, immune deficiency, neurologic disease and anatomical airway abnormalities.[7] Outcome is generally favourable, although a significant number will develop reactive airway disease.

Pathophysiology

The virus penetrates the terminal bronchiole's lining of epithelial cells, causing necrosis, ciliary disruption and peri-bronchiolar lymphocyte infiltration. Pathological changes are detectable 18 to 24 hours after infection. Subsequently oedema, excess mucus and sloughed epithelial cells lead to obstruction of small airways and atelectasis. Ventilation-perfusion mismatch leads to hypoxaemia. Infants are more susceptible than adults due to proportionally smaller diameter airways.

Preoperative management

Assessment

When you assess a child with bronchiolitis prior to surgery, it is important to assess the severity of illness to determine the course of action. Postponing surgery may well be safest. Usually the child with mild bronchiolitis presents with nasal congestion. With increasing severity, hallmark findings include rhonchi and crepitations, with occasional expiratory wheezes.[8] More severe disease is associated with respiratory distress (increased work of breathing and tachypnea), cyanosis, hypoxaemia (SpO_2 < 95% on room air), dehydration and restlessness or lethargy. Severe cases often involve infants younger than 3 months old, who appear ill or toxic, and likely will have atelectasis on chest X-ray.[9] The most significant clinical parameters in determining severity of illness are respiratory rate, work of breathing, and hypoxia. Possible indications for medical management in the intensive care unit include recurrent apnoea, slow irregular breathing, reduced level of consciousness, shock, exhaustion, hypoxia despite high levels of inspired oxygen, and respiratory acidosis (pH < 7.20).[4] Continuous positive airway pressure can be effective; however, the majority of deteriorating infants require mechanical ventilation.

In the setting where the child with bronchiolitis presents for surgery, you must evaluate the urgency of the surgical procedure. If it is an elective case, postpone it and reschedule after 4 to 6 weeks. If the procedure is an emergency or urgent, the risks associated with anaesthesia may be outweighed by the benefits of surgery. These risks include:

- Airway hyperreactivity - this may result in bronchospasm, laryngospasm and wheezing
- Supplemental oxygen
- Excessive secretions - may cause airway obstruction, necessitating frequent suctioning
- Apnoea and respiratory failure - RSV causes significant apnoea in infants by an unknown mechanism. In one retrospective review, 21% of infants who were hospitalized with RSV presented with apnoea. This may be worsened by the use of inhalation anaesthetics, sedatives and opioids.

As a result, children with bronchiolitis undergoing general anaesthesia have a higher risk of requiring mechanical ventilation in the postoperative period.

Preoperative treatment

Preoperative treatment goals for the child with active symptoms of bronchiolitis, who requires urgent surgery include optimizing the respiratory status and rehydration. The key therapeutic intervention is oxygen administration to maintain SpO_2 > 92%. Oxygen can be administered via nasal cannula, head box or facemask. Nasopharyngeal suctioning is often effective and can relieve upper airway obstruction, increase comfort and decrease work of breathing. Intravenous fluids are often administered starting with a crystalloid bolus of $10ml.kg^{-1}$ until deficits are replaced. Fluid requirements are increased due to fever, tachypnoea and decreased oral intake. Consider nasogastric feeding for nutritional support until feeding improves prior to surgery, provided that it meets fasting time requirements prior to surgery.

Therapeutic interventions that have been used include bronchodilators, corticosteroids, antiviral agents, antibacterial agents, chest physiotherapy and decongestant drops. None of these have demonstrated significant impact on illness duration, severity or clinical outcomes.

The use of bronchodilators in the routine treatment of bronchiolitis is not recommended by the American Academy of Pediatrics. Their efficacy is uncertain and published results have been variable.[10] Given the excellent safety profile of this medication, you may consider a trial of bronchodilators, but continue only if a response is documented. Adrenaline and salbutamol are used most commonly (refer to Table 2), although adrenaline should be reserved for hospitalized patients only.

Table 2. *Recommended doses of medications*

Salbutamol:
0.15 $mg.kg^{-1}$ (minimum 2.5mg, maximum 5mg) diluted in 2.5 to 3ml saline and administered over 5 to 15 minutes via nebuliser (requires oxygen/driving gas); or 4 to 6 puffs via MDI with spacer and facemask dependent upon size/age of child.
Adrenaline:
0.05$ml.kg^{-1}$ of 2.25% adrenaline diluted in 3ml normal saline and administered via nebuliser.

Corticosteroids should not be used as they have not been shown to reduce the length of stay or disease severity. In addition, they have a well-established undesirable side effect profile. Chest physiotherapy should also be avoided as it will not improve the diffuse regions of inflammation involved in bronchiolitis. Likewise, ribavirin and antibacterial agents are not recommended for routine use.

Intraoperative management

Choice of anaesthetic technique

Preoxygenation is essential prior to induction of anaesthesia. Where IV access is available it might be the preferable route for induction. It may be better to use agents that are associated with less bronchoconstriction and suppress airway reflexes (e.g. propofol), as

for the asthmatic child. Wherever possible, avoidance of opioids will decrease the risk of postoperative apnoeic episodes. When IV access is unavailable, proceed with cautious inhalation induction (using halothane or sevoflurane) recognizing that there is an increased risk of bronchospasm and laryngospasm. Avoid nitrous oxide as it may worsen hypoxaemia.

Intubation technique

It is essential to ensure a deep plane of anaesthesia before attempting intubation. IV lidocaine can reduce airway reflex responses. Endotracheal tube placement provides advantages of a definitive airway and allows for frequent suctioning. Once the airway is secured, the goals of ventilation are to minimize air-trapping and lung distention, and prevent barotrauma. If available, employ a pressure-controlled mode of mechanical ventilation (or manual ventilation) to minimize the risk of dangerously high inspiratory pressure. A preset long respiratory phase will allow full expiration.

Intraoperative management

Maintenance of anaesthesia using volatile agents which bronchodilate may be preferable (e.g. halothane). Drying of secretions with atropine or glycopyrrolate may be useful intra-operatively but can exacerbate mucus plugging postoperatively. Avoid histamine-releasing agents which may contribute to bronchospasm. Consider regional and neuraxial anaesthesia for analgesia. These techniques should reduce opioid use and decrease the risk of postoperative apnoea and hypoventilation.

Intraoperatively, monitor airway pressure closely for subtle changes in lung compliance. A sudden elevation of airway pressure may be due to mechanical problems such as kinking or mucus plugging of the endotracheal tube, pneumothorax, or endobronchial intubation. If obstruction of the endotracheal tube from mucus plugging is thought to be the cause, suctioning using soft catheters may reduce obstruction, or replacement may be required. The use of humidifiers may reduce the risks of inspissated mucus plugs. If the cause is thought to be bronchospasm, inhaled salbutamol (4-8 puffs every 20 minutes x 3 doses) can be introduced into the anaesthesia circuit. Further interventions may include subcutaneous adrenaline ($10mcg.kg^{-1}$ SC every 20 minutes x 3 doses, up to $500mcg.dose^{-1}$) or intravenous adrenaline ($1mcg.kg^{-1}$ IV every 20 minutes). Given its cardiovascular side effects, use intravenous adrenaline cautiously and reserve it for cases when other treatments fail to alleviate symptoms. Capnography is a useful monitor as the changing shape of the capnograph trace (slower upstroke) is an early indicator of bronchospasm and the effectiveness of treatment.

Extubation

For some elective surgery patients, the trachea may be extubated under deep inhalational anaesthesia to avoid triggering bronchospasm. Close monitoring into the postoperative recovery phase is mandatory. For emergency surgery with a potentially full stomach, extubate the trachea once the child is awake and the upper airway reflexes have returned. The use of anticholinesterases for neuromuscular blockade reversal is recommended if muscle relaxants were used to optimize respiratory function postoperatively. In some circumstances, you may prefer to leave the child electively intubated at the conclusion of surgery. This is particularly true in patients with a history of apnoea, hypoxaemia, hypercapnia ($PaCO_2$ > 55mmHg/7kPa) prior to surgery, haemodynamically significant heart disease and chronic lung disease.

Postoperative management

Analgesia

Avoid opioids or titrate them carefully. Multi-modal analgesia, using acetaminophen (paracetamol), non-steroidal anti-inflammatory drugs and regional anaesthesia techniques are useful to supplement postoperative analgesia.

Monitoring

Postoperative monitoring with continuous pulse oximetry and apnoea monitoring for 24 hours minimum is recommended. If frequent monitoring with pulse oximetry is impractical, the child should be located such that there is direct visual monitoring of the patient (e.g., close to the nursing station).

OTHER RESPIRATORY DISEASES

Overview

The spectrum of respiratory tract infections ranges from the uncomplicated upper respiratory infection (URI) to pneumonia and pneumonitis. The most frequently encountered by the anaesthesia provider is the child with an uncomplicated URI, who presents with nasal secretions and cough. Provided that there is no fever, no lethargy or decreased appetite, and no findings of respiratory disease on physical examination (e.g. lack of wheeze or crepitus on auscultation), consider the child as having an uncomplicated URI. If the child presents with the above symptoms, a complicated URI (e.g. pneumonia) must be considered. The more common etiologies include viral (influenza, parainfluenza, adenovirus, human metapneumovirus, rhinovirus) and bacterial (*Streptococcus pneumoniae, Mycoplasma pneumoniae, Chlamydophilia pneumoniae*) causes. In immunocompromised children, additional etiologies include tuberculosis, fungal and less common bacterial and viral causes.

Management of respiratory diseases will depend on the severity of infection and the etiology. In uncomplicated viral URIs, no additional measures are usually required. However, in the case of more severe disease, antibiotics targeting the organisms involved, oxygen, nasal pharyngeal suction, rehydration, and respiratory support may be necessary.

Upper respiratory infections

A longstanding controversial issue is whether to proceed with anaesthesia in a child who presents with an uncomplicated URI. As a general rule, elective surgery should be postponed 4 to 6 weeks from the end of symptoms to allow acute airway reactivity to resolve. The risks of anaesthesia in the setting of increased airway reactivity include severe coughing, breath holding, bronchospasm, laryngospasm, apnoea with more rapid oxygen desaturation and post operative oxygen desaturation.[11] In a study by Cohen and Cameron, patients with URI symptoms preoperatively were 2 to 7 times more likely to experience respiratory related intraoperative complications and 11 times more likely if intubated.[12]

However, a child may experience 6 to 8 URIs per year and to postpone surgery for 4 weeks after symptom resolution may make scheduling of a procedure logistically impractical. Furthermore, in otherwise healthy children, the problems encountered intraoperatively can generally be easily handled without serious complications.[13] Ungern-Sternberg and colleagues reported that increased perioperative risk of adverse respiratory events only occurred when URI symptoms were present on the day of surgery or had occurred within the preceding two weeks.[14] Thus, the decision whether or not to proceed with an elective procedure should be made on a case by case basis, keeping in mind the anaesthesiologist's experience, level of comfort, and potential for management of possible complications.

SUMMARY

Asthma

- 3 distinct features: airway obstruction, airway inflammation, airway hyperresponsiveness
- Clinical diagnosis
- Optimize medical treatment before surgery, per the severity classification of chronic asthma
- Induction agents of choice: propofol, ketamine, halothane, sevoflurane
- Avoid intubation if possible, and consider deep extubation.

Bronchiolitis

- Wide spectrum of severity
- Most common cause is RSV
- Usually self limiting course
- Treatment is generally supportive with oxygen, nasopharyngeal suctioning and rehydration
- Recommend postoperative monitoring with pulse oximeter and apnoea monitor.

Upper respiratory tract infections

- Common presentation in children
- General management depends on severity of infection and etiology
- Postpone elective surgery 4 to 6 weeks to allow acute airway hyperreactivity to resolve
- In otherwise healthy children with uncomplicated URI, intraoperative complications can generally be managed without serious complications
- Proceeding with anaesthesia in a child with an uncomplicated URI is a case by case decision.

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