Review Article

Anaesthesia for children with bronchial asthma and respiratory infections

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ABSTRACT

Asthma represents one of the most common chronic diseases in children with an increasing incidence reported worldwide. The key to successful anaesthetic outcome involves thorough pre-operative assessment and optimisation of the child's pulmonary status. Judicious application of proper anti-inflammatory and bronchodilatory regimes should be instituted as part of pre-operative preparation. Bronchospasm triggering agents should be carefully probed and meticulously avoided. A calm and properly sedated child at the time of induction is ideal, so also is extubation in a deep plane with an unobstructed airway. Wherever possible, regional anaesthesia should be employed. This will avoid airway manipulations, with additional benefit of excellent peri-operative analgesia. Agents with a potential for histamine release and techniques that can increase airway resistance should be diligently avoided. Emphasis must be given to proper post-operative care including respiratory monitoring, analgesia and breathing exercises.

Key words: Anaesthesia, paediatric asthma, peri-operative management

INTRODUCTION

Bronchial asthma is the most common chronic disease in children[1] and respiratory infections occur with a frequency of 3–8 per year for children younger than 5 years. The frequency may be as high as once a month if the child happens to be of school-going age. Children with bronchial asthma and respiratory infections have significant peri-operative implications for the anaesthesiologists. With improvements in medical knowledge and anaesthesia techniques, morbidity and mortality associated with an asthmatic child undergoing surgery have come down. But still bronchospasm represents a life-threatening complication in the peri-operative period[2] for these children. The key in successfully navigating patients with irritable airway in the peri-operative period is to prevent intraoperative bronchospasm[3] with suitable anaesthetic techniques. Bronchospasm is most likely to occur at induction and emergence.[2]

PATHOPHYSIOLOGY

Key features in asthma are airway inflammation, airway hyper-responsiveness and narrowing leading to airway obstruction.[4] Even though the association between airway inflammation and hyper-responsiveness is consistent, the exact mechanism involved is not completely elucidated.[4] Hyper-responsiveness of airway in turn leads to airway narrowing and obstruction. The airway narrowing is believed to be due to structural changes that occur in both large and small airways and by neurohumoral influences.[4-6] Airway structural changes described as airway remodelling include subepithelial fibrosis, increased smooth muscle mass, gland enlargement, neovascularisation and epithelial alterations.[6] These structural changes can lead to impaired response to bronchodilator therapy.[6] Asthma symptoms can be triggered by several events like infections, cold air, air pollution, allergens, exercise, crying or even any stressful events.[7] Airway oedema and mucous

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plugging can also worsen luminal obstruction.[2] Endotracheal tube insertion can itself act as a potent stimulus that can trigger bronchoconstriction in asthmatic patients.[2] By several mechanisms, general anaesthesia can precipitate an asthma exacerbation. These include decreased mucociliary function, inability to cough and altered diaphragmatic function.[8] These changes in lung function can result in mucous plugging, basal atelectasis, bronchospasm, hypoxaemia and pneumonia.[9]

PRE-OPERATIVE EVALUATION AND OPTIMISATION

Key to successful management of asthmatic patients involves thorough pre-operative assessment and intervention before taking up the case. While in a well-prepared child, asthma possess no additional risk,[10,11] one with uncontrolled baseline bronchial hyperactivity poses extra risk for peri-operative adverse respiratory events.[11,12] In the setting of emergency surgery, there is always an additional risk with poorly controlled asthmatic child as there is limited time frame for any effective pre-operative intervention. But in an elective procedure, surgery may be deferred and rescheduled till asthma is well under control. In the pre-operative visit, it is important to note the level of asthma control and present medications. A history of recent exacerbations of symptoms, dose of inhaled corticosteroids, β2 agonists, hospital admissions, previous anaesthetic history, cough and sputum production are important in formulating an anaesthetic plan. A family history of asthma, atopy or personal history of eczema increases the likelihood of peri-operative respiratory adverse events.[12-14]

Even though an otherwise healthy child with upper respiratory infections (URIs) may be managed safely during that period, risk of bronchospasm is high in asthmatic child.[12,13] Surgery needs to be postponed for 4–6 weeks,[13,14] after an episode of respiratory infections till they are asymptomatic, since the airway hyper reactivity will persist for several weeks after resolution of infectious symptoms.[12,13] Children with both active and recent respiratory infections are more likely to have higher overall peri-operative adverse respiratory events than normal children.[12-14] So evidence of active infections like fever, cough, green runny nose, copious secretions should be sought in the peri-operative visit. But a decision to postpone the procedure depends on other variables like nature of procedure viz., emergency versus elective. Even in emergency procedures, a history of respiratory infections should alert the anaesthesiologist to probe medication history. If already on systemic corticosteroids, child must be planned for peri-operative supplementation in order to avoid adrenal crisis.[14,15] Present recommendation is to go for replacement therapy if the child has received steroids for more than 2 weeks within the prior 6 months.[14,15] An obese child not only poses a variety of anaesthetic challenges, but also there is increased likelihood of intraoperative bronchospasm even without a definite history of asthma.[15,16] Environmental tobacco exposure is considered as a risk factor for peri-operative adverse respiratory events and a sign of poor asthma control.[16,17] They carry risk of laryngospasm at emergence from anaesthesia also.[17] History of latex allergy especially in children who have undergone multiple surgical procedures from very young age should be sought. A positive history means a high risk of peri-operative anaphylactic reactions.[18] Symptoms of gastro-oesophageal reflux disease should be probed especially in older children. As in adults, this can often be a trigger for asthma symptoms.[19]

In elective procedures, definite pre-operative therapy needs to be instituted to reverse inflammation and bronchospasm. For a well-controlled asthmatic, use of inhaled β2 adrenergic agonists 1–2 h before surgery may be sufficient.[13,14] An asymptomatic or moderately controlled asthma requires additional optimisation with an inhaled anti-inflammatory agent along with regular use of nebulised adrenergic β2 agonists. Children presenting with poorly controlled asthma may require, in addition to inhaled β2 agonists and inhaled steroids, either oral prednisolone 1 mg/kg/day (60 mg maximum) 3–5 days before surgery or oral dexamethasone 0.6 mg/kg (16 mg maximum).[10,11,20] Use of oral methylprednisolone 1 mg/kg for 48 h before surgery is another option.[20] In case the child is already on chronic steroid regime, dose needs to be increased for 5 days before surgery.[9] A child with status asthmaticus is considered for anaesthesia only in dire life threatening situations. β2 receptor agonists administered via inhaled, intravenous (IV) or subcutaneous routes remain the mainstay of treatment. Continuous nebulisation appears to be superior to intermittent doses for children who need frequent doses of β2 agonists. Along with this, inhaled anticholinergic agents and parenteral corticosteroids are employed as first-line therapy in status asthmaticus.

Corticosteroids such as prednisolone have been shown to improve lung function by several mechanisams. Proposed theories involve a

suppression in multiple components of allergic airway inflammation like cell recruitment, cytokine production and adhesion molecular expression or release.[21] Children with URI do not necessarily have increased white cell count (WBC). Hence, routine measurement of WBC count to establish URI is of limited value.[22]

An X-ray chest is indicated in cases where the child has signs of lower respiratory tract infections. This will help to diagnose associated pneumonia or atelectasis. Pre-operative pulmonary function tests (PFTs) will be useful in a grown up child with long-standing history of asthma. PFTs will help us to know the extent of obstructive airway disease and the reversibility with bronchodilators. But PFTs could be normal between exacerbations so that a normal value does not guarantee a smooth peri-operative course.

INTRAOPERATIVE MANAGEMENT

There is evidence to show that a family centred pre-operative advance preparation programme is effective in reducing surgical stress levels of children.[23,24] Since it is well recognised that psychological stress can precipitate an acute panic attack, it is imperative to ensure a parental presence during induction phase of anaesthesia. Oral midazolam at 0.5 mg/kg given 20 min before procedure has been shown to relieve separation anxiety and to give a positive effect on the co-operation of child with anaesthesiologist.[23,24] A dose of 0.5 mg/kg is found to be safe in asthmatic children.[24,25] $\alpha 2$ agonists appear to be an attractive option because it has got actions like anxiolysis, sympatholysis and drying up of secretions without respiratory depression. But literature search does not yield any strong supportive evidence of its use in asthmatic children.[2]

A potential trigger for bronchospasm at the time of induction is airway instrumentation.[2] Variety of steps at induction like laryngoscopy, tracheal intubation or extubation, airway suctioning or even cold inspired gases can act as potential triggering agents. Intravenously administered lignocaine in doses of 1–1.5 mg/kg IV, 1–3 min before intubation has shown to attenuate intubation-induced bronchospasm,[25,26] even though there are studies that disprove the same.[9] But what is proved to be effective is adequate pre-operative preparation with bronchodilators that can attenuate bronchoconstriction caused by intubation.[26,27]

Induction agents

Among IV inducing agents, propofol is the drug of choice in haemodynamically stable asthmatic children.[13,14] The exact mechanism as to how it helps to protect from reflex bronchoconstiction to stimuli in reactive airway disease is yet to be elucidated. Multiple theories are proposed. But what is perceived most is the mechanism that involves attenuating tachykinins acting at neurokin-2 receptors on airway smooth muscle.[27,28] However, a cautious approach in using propofol has been suggested in children with history of allergy to eggs and peanut oil.[28,29] In haemodynamically unstable patients, ketamine remains the induction agent of choice. Ketamine has a bronchodilatory effect related to its action at some point of the inositol 1,4,5-triphosphate signalling in the endothelin pathway.[29,30] But given its mucous secreting effect and chance of dysphorea, adjuvants such as antisialogogues and benzodiazepines are useful.

Inhalational agents

Sevoflurane remains the most used inhalational agent in paediatric population. It is well tolerated and has got good bronchodilatory effect. Sevoflurane is the agent of choice for mask induction in paediatric population.[30,31] Use of sevoflurane even in high concentration for intubation in children is not advisable as it can cause increase in respiratory system resistance.[31,32] The increase in resistance observed is proportionately more in asthmatic than in non-asthmatic. Desflurane on the other hand is found to increase airway resistance at minimum alveolar concentration-equivalent doses.[13,14] Halothane was once used extensively in asthmatic patients. But its popularity declined with the advent of sevoflurane. One drawback with halothane is its tendency to sensitise myocardium to circulating catecholamines.

Airway control

Whenever possible, regional anaesthesia should be considered as airway manipulation is avoided. But this may not be possible sometimes in a un co-operative paediatric patient or the site of surgery requires general anaesthesia. Even in these situations regional anaesthesia can be combined with general anaesthesia as it will give excellent post-operative analgesia. The choice between endotracheal tube, laryngeal mask airway (LMA) or providing anaesthesia with mask ventilation depends on clinical situation. It was shown that with endotracheal tube placement there is significant increase in airway resistance compared to LMA.[32,33] Children with evidence of URIs

will definitely benefit by the use of LMA.[34] Groeben *et al*. observed a 50% reduction in forced expiratory volume in 1 s (FEV1) after endotracheal intubation.[34] This is somewhat blunted with pre-treatment with β2 adrenergic agonists (reduction in FEV1 as low as 20%).[34] The choice between cuffed and non-cuffed endotracheal tube is still a dilemma. Uncuffed tubes are the first choice options in paediatric population especially in smaller ones. Once proper size is selected the anatomical peculiarities of child's airway will ensure proper sealing. However, there are authors who support the use of cuffed tubes in asthmatic child.[35] Perceived advantages of cuffed tube are that it avoids need for multiple attempts due to air leak, and that it gives a more reliable $ETCO_2$ tracings and the use of lower fresh gas flows.[36]

Muscle relaxants

Use of non-histamine releasing muscle relaxants like vecuronium, rocuronium, cisatracurium and pancuronium are considered safe in asthmatic child.[14] Mivacurium and atracurium should be used with caution because of its known histamine-releasing properties.[37-39] Theoretically use of acetylcholinesterase inhibitors carries the risk of initiating bronchospasm due to muscarinic side effects. In practice, this is not an issue, when given along with atropine or glycopyrrolate. There is paucity in data to suggest safe use of sugammadex especially in children below 2 years.[39,40] However, it has got a role in case of allergic manifestations to muscle relaxants.

Ventilation

Intraoperatively, mechanical ventilator mode should be adjusted to suit the pulmonary physiology of an asthmatic child. That is done to keep a longer expiratory time. This will avoid air trapping and build up intrinsic or auto positive end-expiratory pressure.[2] Humidification of inspired gases is advocated to reduce airway irritation and to maintain adequate ciliary clearance mechanism especially when low flow technique is not employed.[13,14] Tracheal suctioning if required should be done only under deep planes of anaesthesia.

Extubation

At the end of procedure, deep extubation technique is preferred to blunt the risk of bucking induced bronchospasm.[13,14] Before attempting deep extubation, it is important to ensure unobstructed spontaneous breathing and avoiding excessive stimulation during suctioning of the secretions.

Analgesia

Non-steroidal analgesics can result in relative excess of leukotriene production and can result in sudden deterioration of asthma symptoms. Even though diclofenac is used safely in asthmatic children; a recent Cochrane review suggested more detailed evaluation to assess its safety before recommending routine use.[40,41] Paracetamol is a good alternative to non-steroid anti-inflammatory drugs with proven safety record.[41,42] It is widely available as tablet, syrup, dispensible or suppository formulations for use in paediatric practice. Use of morphine in asthmatic children is discouraged because of its known histamine-releasing properties.[42,43] Newer synthetic opioids like fentanyl or remifentanil don't pose much histamine release and is used safely in asthmatic children.[43] A word of caution is occasional coughing reported with both these agents. This has a potential to trigger bronchospasm in asthmatic children. Post-operatively, child should be observed in a post-operative care unit and bronchodilator therapy should be continued. Whenever possible, especially in co-operative children, early ambulation, breathing exercises such as incentive spirometry should be instituted. In the event of persistent bronchospasm after extubation, non-invasive ventilation should be considered.

SUMMARY

Children with bronchial asthma and respiratory infections pose unique challenges for the anaesthesiologist. Proper pre-operative evaluation and optimisation is integral to successful outcome. Procedures in a child with active URI should be postponed and taken up after optimisation. The goal should be to minimise the risk of inciting bronchospasm and to avoid any triggering stimulus. Regional anaesthesia is a desirable option as it avoids airway instrumentation. Sevoflurane is the most commonly used anaesthetic for induction and maintanence. Mechanical ventilation must be tuned to avoid a positive end expiratory airflow obstruction. Key to successful outcome involves continued post-operative care also.

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Conflicts of interest

There are no conflicts of interest.

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