Chapter 10

Asthma

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A five-year-old male with a history of asthma and eczema presents for laparoscopic orchiopexy. His home regimen includes fluticasone, two puffs twice daily, and albuterol as needed. His mother reports he had an upper respiratory tract infection (URI) a few weeks ago, and since then has been using his albuterol inhaler more frequently. Ten days ago, the wheezing worsened and she took him to the emergency department where he was treated with nebulized albuterol and discharged home with a three-day course of oral corticosteroids. Since then he has returned to his usual state of activity, URI symptoms have resolved, and he has not used albuterol in the past three days. According to mom, she was told to hold all medications in preparation for surgery; therefore, he did not take fluticasone this morning.

His current vital signs are: heart rate 127, respiratory rate 28, blood pressure 101/70, SpO_2 95% on room air, with an axillary temperature of 37.0°C.

On physical exam, the child is alert and interactive. Respirations are unlabored, without nasal flaring or intercostal retractions. Chest auscultation reveals mild expiratory wheezes bilaterally.

What Is the Definition of Asthma?

Asthma is a common chronic disorder of the airways that is characterized by variable and recurring bronchial hyperresponsiveness, airflow obstruction, mucus secretion, and inflammation.

What Are the Important Differential Diagnoses to Consider?

Not all wheezing is asthma. Other diagnoses to consider include: tracheomalacia, bronchomalacia, bronchiolitis, bronchial foreign body, bronchopulmonary dysplasia, cystic fibrosis, tracheal web/stenosis, and bronchial stenosis.

What Is the Prevalence of Asthma?

Asthma is the most common chronic disease of childhood in industrialized countries, affecting more than 6 million children in the United States. The prevalence of asthma in US children is approximately 10%, and its incidence has increased by an average of 4.3% each year.

The Pathophysiology of Asthma

Although much remains unknown about the exact pathophysiologic mechanisms, the development of asthma appears to be a complex process involving the interaction of host factors and environmental exposures, leading to chronic airway inflammation and excessive airway reactivity.

One of the key drivers in the pathophysiology of asthma is inflammation, by the interaction of mast cells and eosinophils, which, when activated by interaction with antigen, release cytokines and lipid mediators that result in bronchial inflammation and airflow limitation. Airflow obstruction is caused by a combination of several factors including bronchoconstriction, airway edema, hypersecretion, and mucus plugging. This leads to increased work of breathing, ventilation-perfusion mismatch, air trapping, hyperinflation, hypoxemia, diaphragmatic fatigue, hypercapnia and, if left untreated, respiratory failure.

What Are Some Precipitating Factors of Acute Asthma?

Environmental factors, including airborne allergens and viral respiratory infections, play a crucial role in asthma exacerbation (Table 10.1). Emotional stimuli – including stress, fear, anxiety, and excitement – are also known triggers of asthma. Airway manipulation, such as occurs during induction of general anesthesia, may trigger or exacerbate asthma symptoms.

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Table 10.1 Common precipitating factors for asthma

Precipitating factors of asthma
Respiratory infection (RSV)
Airway irritants (tobacco smoke, inhaled anesthetics)
Allergens
Exercise
Emotional stress
Dry/cold air
Chronic gastroesophageal reflux disease
Drugs (aspirin, beta-blockers)
Airway manipulation/stimulation

What Are the Clinical Symptoms of Asthma?

Acute exacerbations of asthma may include wheezing, dyspnea on exertion, chest tightness, or dry cough. When severe, it may be manifest as chest wall retractions, use of accessory muscles of respiration, and prolonged expiratory phase due to bronchospasm.

Are There Any Chronic Consequences of Asthma?

Airway remodeling describes permanent airway changes that develop from chronic inflammation. Structural changes include smooth muscle hypertrophy, hyperplasia, blood vessel proliferation, epithelial thickening, and fibrosis. This results in progressive loss of lung function that is not prevented or fully reversible by current available treatments.

What Are the Different Pharmacologic Agents Available for Asthma?

Medications available to treat acute exacerbations and long-term control consist of bronchodilators and anti-inflammatory drugs in six different classes:

- ***Beta$_2$-adrenergic agonists***: induce bronchial smooth muscle relaxation and bronchodilation. Short-acting beta$_2$-adrenergic agonists are the first line treatment in acute asthma exacerbation. Long-acting beta$_2$-agonists are used in combination with inhaled corticosteroids in moderate or severe persistent asthma.
- ***Corticosteroids:*** the most potent and effective anti-inflammatory agents used in the long-term control of asthma. They block late-phase reactions, reduce airway hyperreactivity, and inhibit inflammatory cell activation. Most often used inhaled, with oral use reserved for severe or persistent asthma.
- ***Leukotriene inhibitors***: antagonize the leukotriene receptor leading to inhibition of leukotriene-induced bronchial smooth muscle constriction. They are mainly used as an alternative, not preferred, treatment of asthma, and often used as an adjunctive therapy to corticosteroids.
- ***Methylxanthines***: mild to moderate bronchodilator used as an alternative, not preferred, and as adjunctive therapy with corticosteroids. Monitoring of serum level is essential due to narrow therapeutic index.
- ***Cromolyn sodium***: pulmonary mast cell stabilizer that diminishes the IgE antibody-induced release of inflammatory mediators. Used as an alternative, but not preferred, medication in mild persistent asthma, or as a preventive treatment in exercise-induced asthma.
- ***Anticholinergics***: inhibit muscarinic cholinergic receptors, reducing the intrinsic vagal tone of bronchial smooth muscle. Can be used in combination with, or as an alternative to beta$_2$-adrenergic agonists.

The Preanesthetic Assessment of the Asthmatic Patient

The anesthesiologist should assess the severity and current status of disease by taking a detailed history and physical exam. Important details of the medical history include:

- Triggering factors
- Frequency and type of asthma medication used for maintenance and rescue
- Most recent use of oral corticosteroids
- History of hospitalizations, intubations, and/or emergency room visits due to asthma
- Recent upper respiratory infection, sinus infection, fever
- History of pneumothorax or respiratory arrest

The physical examination should focus on respiratory rate, signs of lung infection, air movement, detecting expiratory wheeze, and a prolonged expiratory time.

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The baseline room air oxygen saturation should be determined.

What Preoperative Testing Is Indicated?

Children with well-controlled asthma who are not steroid-dependent generally do not require additional testing.

- ***Pulmonary function testing:*** Spirometry and measurement of peak flow rate can be used in older children to detect severity of airway obstruction and hyper-reactivity in an office setting. It is of limited use in assessing asthma preoperatively.
- ***Chest radiograph***: a chest radiograph may show signs of hyperinflation but is rarely useful unless looking for a condition other than asthma, such as pulmonary infection or barotrauma.
- ***Laboratory testing:*** Preoperative blood tests are not routinely indicated and should only be performed as they would be for patients without asthma.

The above emphasizes the importance of a detailed history and physical examination in the preoperative evaluation of a patient with asthma.

What Premedication Should Be Considered in Asthmatics?

Midazolam is safe to use as premedication in asthmatics to reduce anxiety; however, it does not reduce the incidence of bronchospasm. Inhaled beta$_2$-adrenergic agonists treatment should be given 20–30 minutes prior to induction of anesthesia. If the patient is on systemic corticosteroids and/or high-dose inhaled corticosteroids, the benefit of a stress dose with intravenous hydrocortisone is recommended to avoid adrenal crisis.

When Should Elective Surgery Be Delayed?

Elective surgery should be delayed if the patient's asthma symptoms do not appear to resolve with therapy, or the oxyhemoglobin saturation is below 95% on room air. Signs of a lower respiratory tract infection, such as focal wheeze or diminished air entry are also cause for concern and may warrant a chest radiograph.

URI in asthmatic children is often associated with the exacerbation of bronchospasm and increases the risk of perioperative complications. Ideally, a child with asthma should be free of URI symptoms for 4–6 weeks before an elective procedure.

Is There a Difference Between Intravenous and Inhalational Induction in Asthmatics?

The goal of induction in the asthmatic patient is to attain an adequate depth of anesthesia to prevent a response (e.g., coughing, laryngospasm or bronchospasm) to airway manipulation. Therefore, an IV induction is preferred if tolerated by the child, using either propofol or ketamine. Ketamine may also be useful in asthmatics because of its sympathomimetic bronchodilator properties and inhibition of vagal pathways. But ketamine is also associated with increased secretions, postoperative nausea and vomiting, and psychomimetic activity, and thus, is not the first line choice.

Inhaled anesthetic agents are known bronchodilators, decrease airway responsiveness, and attenuate bronchospasm. However, these agents are unable to completely abolish the bronchoconstrictive response to intubation during induction of anesthesia. Therefore, if an inhalational induction is chosen, it should be smooth and rapid, and supplemented with an IV anesthetic agent when IV access is obtained. Sevoflurane is the most effective bronchodilator and is the agent of choice in asthmatics and for pediatric inductions. Desflurane should not be used in asthmatics because of its potent airway irritating properties.

Since tracheal stimulation may trigger bronchospasm, tracheal intubation is avoided when possible, in lieu of a laryngeal mask airway (LMA) or mask ventilation.

Will the Presence of Asthma Change Your Ventilator Settings?

For children with well-controlled asthma and no signs of bronchospasm, ventilator settings should be the same as for non-asthmatics. If there are signs of bronchospasm, ventilator settings should be designed to avoid hyperinflation, air trapping, and barotrauma by:

- Reducing respiratory rate
- Reducing tidal volume
- Reducing inspiratory time and prolonging expiratory time by reducing I:E ratio (1:4)

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- Using positive end-expiratory pressure 3–5 cm H_2O
- Allowing permissive hypercapnia
- Utilizing pressure regulated settings rather than volume or assist control

How Will You Manage Intraoperative Bronchospasm?

First, determine the cause of wheezing. The differential diagnosis includes a kinked endotracheal tube, mainstem bronchial intubation, airway secretions, pulmonary edema, pulmonary embolus, pulmonary aspiration, and anaphylaxis. If wheezing is thought to be due to bronchospasm, the most common causes are light anesthesia and stimulation from the endotracheal tube at the carina within the right main bronchus. Deepen the anesthetic by increasing the concentration of inhaled agent or administering IV propofol or ketamine. Lidocaine (1 mg/kg) given IV may reduce airway reactivity. If bronchospasm continues, administer a short-acting beta$_2$-adrenergic agonist, such as albuterol, via an endotracheal tube using a metered-dose inhaler. A small percentage of the administered dose will reach the end of the endotracheal tube and the lungs; therefore, multiple puffs of the beta$_2$-adrenergic agonist should be delivered and may need to be repeated.

Severe bronchospasm that impairs oxygenation requires further intervention, including:

- Maximal use of the bronchodilating properties of volatile anesthetic agents (sevoflurane or isoflurane)
- IV magnesium sulfate
- Anticholinergics, including IV atropine or glycopyrrolate, or nebulized ipratropium
- Epinephrine should be administered for refractory bronchospasm, especially if anaphylaxis is suspected
- IV terbutaline
- IV glucocorticoids (but will not be effective for 4–6 hours)
- Neuromuscular blocking agents may improve mechanics of ventilation but will not alleviate smooth muscle bronchoconstriction

How Should Emergence and Extubation Be Managed in the Asthmatic Child?

The goal is to achieve a nonairway stimulating emergence that might trigger or exacerbate bronchoconstriction. A "deep" extubation can be accomplished safely with the patient spontaneously ventilating, and the use of oropharyngeal or nasopharyngeal airway devices to manage partial airway obstruction after removal of the endotracheal tube. A successful awake extubation can be achieved by suctioning tracheal secretions, repeating a dose of inhaled beta$_2$-agonist, and IV lidocaine (1 mg/kg) to minimize tracheal stimulation.

The Surgeon Asks You to Administer IV Ketorolac to Aid with Postoperative Pain Control. Are There Any Risks Using Nonsteroidal Anti-inflammatory Drugs (NSAIDs) in Children with Asthma?

NSAIDs inhibit cyclooxygenase and result in increased leukotriene production, which can lead to bronchospasm, laryngospasm, and periorbital edema. NSAID hypersensitivity appears to be more common in asthmatic adults than children. NSAIDs are relatively contraindicated in older children with atopy and severe asthma.

Suggested Reading

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