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Management of severe asthma in children

Background

Asthma is the most common chronic disease of childhood and the leading cause of childhood morbidity from chronic disease. When uncontrolled, asthma can place significant limits on daily life, and is sometimes fatal.

Objective

This article describes the initial assessment and management of status asthmaticus in children.

Discussion

Status asthmaticus is a medical emergency in which asthma symptoms are refractory to initial bronchodilator therapy. Patients may report chest tightness, rapidly progressive shortness of breath, dry cough and wheezing. Typically, patients present a few days after the onset of a viral respiratory illness, following exposure to potent allergens or irritants, or after exercise in a cold environment, however, they can also present with sudden onset of symptoms with an unknown trigger. Early recognition and initiation of therapy is vital in preventing severe complications such as respiratory failure. Aggressive treatment with beta-agonists, anticholinergics and corticosteroids remains the gold standard for this condition.

Keywords: child health; emergencies; asthma; respiratory tract diseases



Asthma is the most common chronic disease of childhood and the leading cause of childhood morbidity from chronic disease as measured by school absences, emergency department visits, and hospitalisations.¹ The most recent National Heart Lung and Blood Institute (NHLBI) expert panel guidelines on the diagnosis and management of asthma define asthma as a common chronic disorder of the airways that is complex and characterised by variable and recurring symptoms, airflow obstruction, bronchial hyper-responsiveness and underlying inflammation. The interaction of these features of asthma determines the clinical manifestations, disease severity

and response to treatment.² Exacerbations of asthma are episodes of progressive increase in shortness of breath, cough, wheezing or chest tightness. Status asthmaticus is a condition of progressively worsening bronchospasm and respiratory dysfunction due to asthma, which is unresponsive to conventional therapy and may progress to respiratory failure (with the need for mechanical ventilation) or death.³ Children presenting with severe acute exacerbations of asthma should be referred to a hospital for further assessment and monitoring. However, initial emergency management will need to be instituted in the community setting before transfer.

Epidemiology

Asthma is the third leading cause of hospitalisation among people under 18 years of age in the United States of America.⁴ Over 2.2 million Australians have currently diagnosed asthma, 14–16% of these are children. Asthma is more common among Indigenous Australians and deaths are more common among those living in less affluent localities in Australia.⁵ Asthma typically begins in early childhood, with an earlier onset in males than females.^{6,7} Asthma is an infrequent cause of death during childhood. Delayed presentation in someone known to have severe asthma attacks is considered to be a major risk factor. In some cases, severity may have been underestimated, or escalation of treatment delayed.

Pathophysiology

Asthma is a chronic inflammatory condition of the airways. Asthma is characterised by reversible, diffuse lower airway obstruction, caused by airway inflammation and oedema, bronchial

smooth muscle spasm, and mucus plugging. Young children are particularly susceptible to status asthmaticus. The hyper-reactive airway of the asthmatic child can be primed for acute obstruction by triggers such as viral infection, allergy, weather changes, cigarette smoke or other inhaled irritants, gastro-oesophageal reflux, exercise and cold air.^{8–10} Drug sensitivity, particularly to aspirin products, may induce hyper-reactive airways.¹¹ However, exposure to ibuprofen, in patients who are not allergic to aspirin or nonsteroidal anti-inflammatory drugs, does not appear to worsen asthma morbidity and may actually reduce outpatient visits.^{12,13}

Risk factors

Identifying children at risk for fatal asthma attacks has proven to be difficult. Several contributors to the mortality risk have been described (Table 1). However, up to one-third of children who die from asthma have previously had only mild disease. In an Australian study describing 51 paediatric deaths due to asthma, Robertson et al¹⁴ found that only 39% of the patients had potentially preventable factors: of these patients 68% had inadequate assessment of, or therapy for, prior asthma; 53% had poor therapy compliance; and 47% had delay in seeking help. In addition, 36% were judged to have had severe asthma, 43% were taking regular inhaled beclomethasone or sodium cromoglycate, and 10% were taking regular oral steroids. Twenty-two percent had a previous admission to an intensive care unit.¹⁴ Patients at high risk of asthma related death need closer observation and should be encouraged to seek medical attention early in acute exacerbations.

Clinical presentation and assessment

Most children with acute exacerbation of asthma present with cough, wheeze, dyspnoea and increased work of breathing (eg. tachypnoea, intercostal recession, subcostal retraction). Table 2 outlines normal ranges of respiratory rate per age group. The degree of wheeze does not correlate well with the severity of the disease.¹⁵ Absent breath sounds – ‘silent chest’ – in the face of increased work of breathing may indicate respiratory failure. Other findings of severe asthma include disturbance in the level

of consciousness, inability to speak, markedly diminished or absent breath sounds and central cyanosis.

The initial assessment of a child with acute asthma should include a brief history of previous episodes and other risk factors, and an assessment of severity according to the National Asthma Council Australia (Table 3).¹⁶ During a severe acute exacerbation, the following brief history should be taken while treatment is initiated.

- History of previous medications (especially oral/inhaled steroids in the past 6 months)
- History of previous episodes including emergency department visits, hospital admissions, and admissions to an intensive care unit
- The duration of the current episode and onset
- Parents’ subjective assessment of severity
- Associated symptoms and triggers
- Current medications (dose, route, timing of the last dose)
- History of missed doses from noncompliance or vomiting.

Alternative diagnoses such as inhaled foreign body or structural abnormalities should be considered in children with asthma symptoms that appear to be resistant to standard therapies.

As previously mentioned, the assessment of a child with a severe attack relies mostly on clinical observations. However, additional diagnostic tests may provide additional information in certain situations. These are not routine and should not delay treatment.

- Chest radiography – not routinely indicated except for patients with suspected pneumothorax or pneumonia, those who are intubated, or when other causes of wheezing are suspected¹⁷
- Arterial blood gas – measurement may be helpful in assessing pulmonary gas exchange in critically ill children¹⁸

- Pulmonary function tests – may give an objective measure of severity in some cases. They can only be performed in children over 6 years of age.¹⁹

Treatment

The aims of treatment in status asthmaticus are to reverse bronchoconstriction, treat the airway inflammation, correct hypoxemia and monitor for complications.

Oxygen

All patients with asthma have ventilation/perfusion mismatch and the presence of hypoxemia should be treated urgently. Supplemental oxygen should be administered to achieve and maintain oxygen saturation above 94%.

Bronchodilator therapy

Beta-agonists are the most important part of the initial treatment in patients with status asthmaticus because they produce smooth muscle relaxation. The initial dose of beta-agonist may be given by oxygen driven nebuliser if hypoxemia is present, or by a pressurised metered dose inhaler (MDI) with a spacer with mask or mouthpiece.²⁰ For most children, there is evidence that MDI plus spacer is more efficient than a nebuliser.^{21,22} Salbutamol is the most commonly used short acting beta-agonist used, but others include terbutaline (which is not suitable for younger patients).

Table 2. Normal respiratory rate for age

Age	Respiratory rate (breaths per minute)
Infant	30–60
Toddler	24–40
Preschooler	22–34
School aged child	18–30
Adolescent	12–16

Table 1. Risk factors for near fatal asthma

- History of near fatal asthma requiring intubation and mechanical ventilation³⁸
- Insufficient or poor adherence to controller therapy
- Patients with severe asthma not currently using inhaled glucocorticoids³⁹
- Patients who are overdependent on rapid acting inhaled B2 agonists, especially those who use more than one canister of salbutamol (or equivalent) monthly⁴⁰
- Patients with a history of noncompliance with an asthma medication plan
- Dysfunctional family unit

Table 3. Initial assessment of acute asthma in children¹⁶

Symptoms	Mild	Moderate	Severe and life threatening*
Altered consciousness	No	No	Agitated/confused/drowsy
Oximetry on presentation (SO ₂)	94%	94–90%	<90%
Speaks in:	Sentences	Phrases	Single words or unable to speak
Pulse rate (beats/minute)	<100	100–200	>200
Central cyanosis	Absent	Absent	Likely to be present
Wheeze intensity	Variable	Moderate to loud	Often quiet

Note: Children under 7 years of age are unlikely to perform peak expiratory flow or spirometry reliably during an acute episode. These tests are usually not used in the assessment of acute asthma in children¹⁶

*Any of these indicates that the episode is severe. The absence of any feature does not exclude a severe attack

Intravenous beta-agonists should be considered in patients unresponsive to treatment with continuous nebulisation as well as those in whom nebulisation is not possible (eg. intubated patients or those with poor air entry).

Adverse effects of these medications include tachycardia, arrhythmia, hypertension or hypotension, and hypokalaemia.²³ However, there is no significant risk of cardiac toxicity.²⁴ Appropriate doses are:^{16,25}

- 6 puffs MDI via spacer (children younger than 6 years) = 2.5 mg salbutamol
- 12 puffs MDI via spacer (children 6 years or older) = 5 mg salbutamol

These doses should be given every 20 minutes for three doses in the first hour. If the patient improves, but salbutamol is required again within 3–4 hours, further doses should be given. If the child needs salbutamol more frequently, they should be referred to hospital.

If the child has severe asthma, use continuous nebulised salbutamol with high flow oxygen and arrange urgent transfer to hospital.²⁶

Anticholinergics

Anticholinergic agents are usually administered via the inhaled route and the most common is ipratropium bromide. Studies suggest that the addition of inhaled ipratropium bromide (eg. Atrovent) to a beta-agonist for moderate to severe asthma improves the outcome and decreases hospitalisation rates.^{27,28}

Doses of ipratropium bromide are:¹⁶

- 2–4 puffs (children younger than 6 years)
- 4–8 puffs (children 6 years or older).

These doses are given every 20 minutes for three doses in the first hour and then every 4–6 hours if required.

Steroids

Steroids are part of the first line treatment for acute asthma exacerbations. They help control airway inflammation by modifying the inflammatory response, restoring disrupted epithelium, decreasing mucus secretions, and downregulating the production of pro-inflammatory cytokines.²⁹

Oral or parenteral steroids are equally efficacious, although parenteral steroids are preferred for critically ill children and those with vomiting. The administration of steroids is most effective when given early in the exacerbation.^{30,31} Appropriate doses of steroids are:

- prednisolone 1–2 mg/kg per day for 3–5 days is often sufficient
- methylprednisolone 1 mg/kg intravenously every 6 hours initially.¹⁶

If these medications are not available, use another systemic steroid of an equivalent dose, eg. hydrocortisone 2–4 mg/kg.

Magnesium sulphate

The mechanism of action of magnesium sulphate (MgSO₄) is believed to be smooth muscle

relaxation by inhibition of calcium uptake. Magnesium sulphate may prevent hospitalisation in children with severe asthma when added to bronchodilators and steroids. Intravenous MgSO₄ is preferred.^{32,33}

Methylxanthines

Theophylline has two distinct actions in the airway of patients with asthma: smooth muscle relaxation and suppression of the response of the airways to stimuli.³⁴ Theophylline has a narrow therapeutic range. Aminophylline (the intravenous form of theophylline) is only indicated for children with severe asthma in hospital.³⁵

The role of newer medications, such as leukotriene inhibitors, in severe asthma episodes is yet to be determined.

Indications for hospitalisation

Any of the following are indications for admission to hospital.²⁵

- No response to three doses of an inhaled short acting beta-agonist within 1–2 hours
- Tachypnoea despite three doses of an inhaled short acting beta-agonist (Table 2)
- Cyanosis
- Child is unable to speak or drink or is breathless
- Subcostal retractions
- Oxygen saturation when breathing room air, less than 92%
- Social environment that impairs delivery of acute treatment.

Intubation and mechanical ventilation

Intubation of patients with severe asthma is not routinely recommended, and it can increase the risk of barotrauma and aggravate the bronchoconstriction. Absolute indications for intubation include:

- cardiopulmonary arrest
- severe hypoxia
- rapid deterioration in the child's mental state.

If the decision of intubation is made, ketamine should be the induction agent because of its bronchodilatory action.^{36,37}

Conclusion

In summary, asthma continues to be a highly prevalent disease in both developing and

developed countries with significant morbidity in children. Identifying a child at risk of a severe attack remains challenging. Early recognition and initiation of therapy is vital in preventing severe complications, such as respiratory failure. Aggressive treatment with beta-agonists, anticholinergics and corticosteroids remains the gold standard for this condition.

Key points

- Patients at high risk of asthma related death need close observation and should be encouraged to seek medical attention early in an acute exacerbation.
- Absent breath sounds ('silent chest') in the face of increased work of breathing may indicate respiratory failure.
- Initial management includes a beta-agonist via MDI plus spacer or nebuliser.
- The addition of inhaled ipratropium bromide improves the outcome and decreases hospitalisation rates.
- Steroids are also useful, particularly when given early in an exacerbation.

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Conflict of interest: none declared.

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