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## Guideline for the management of acute asthma in children: 2013 update

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## GUIDELINES FOR THE MANAGEMENT OF ACUTE ASTHMA IN CHILDREN: 2013 UPDATE






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# Guideline for the management of acute asthma in children: 2013 update

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**Background.** Acute asthma exacerbations remain a common cause of hospitalisation and healthcare utilisation in South African children.
**Aim.** To update the South African paediatric acute asthma guidelines according to current evidence, and produce separate recommendations for children above and below 2 years of age.
**Methods.** A working group of the South African Childhood Asthma Group was established to review the published literature on acute asthma in children from 2000 to 2012, and to revise the South African guidelines accordingly.
**Recommendations.** Short-acting inhaled bronchodilators remain the first-line treatment of acute asthma. A metered dose inhaler with spacer is preferable to nebulisation for bronchodilator therapy to treat mild to moderate asthma. Two to four puffs of a short-acting bronchodilator given every 20 - 30 minutes, depending on clinical response, should be given for mild attacks; up to 10 puffs may be needed for more severe asthma. Children with severe asthma or oxygen saturation ($SpO_2$) <92% should receive oxygen and frequent doses of nebulised $\beta_2$-agonists, and be referred to hospital. Nebulised ipratropium bromide (via nebulisation or multidosing via pMDI-spacer combination) should be added if there is a poor response to three doses of $\beta_2$-agonist or if the symptoms are severe. Early use of corticosteroids reduces the need for hospital admission and prevents relapse; oral therapy is preferable. Assessment of acute asthma in children below the age of 2 years can be difficult, and other causes of wheezing must be excluded. Treatment of acute asthma in this age group is similar to that of older children.
**Conclusion.** Effective therapy for treatment of acute asthma – primarily inhaled short-acting $\beta_2$-agonists, oral corticosteroids and oxygen with appropriate delivery systems – should be available in all healthcare facilities and rapidly instituted for treatment of acute asthma in children.
**Endorsement.** The guideline document is endorsed by the Allergy Society of South Africa (ALLSA), the South African Thoracic Society (SATS), the National Asthma Education Programme (NAEP), the South African Paediatric Association (SAPA) and the South African Academy of Family Practice.

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Asthma is the most common chronic disease of childhood. Acute asthma exacerbations cause considerable morbidity and health cost utilisation, as well as substantial mortality. Asthma exacerbations are an indication of loss of asthma control and should prompt re-evaluation of the child's illness and the use of controller therapy. The last South African paediatric acute asthma guidelines were published in 1993.[1] The current revision was prompted by the following:

- subsequent publication of several studies of different management strategies for acute asthma
- changes in international guidelines
- updated recommendations for the recognition and assessment of acute severe asthma

- increasing recognition of the importance of preschool wheezing, and the need for different treatment strategies in very young compared with older children
- the development of new formulations and asthma drugs.

## Abbreviations

| | |
|---|---|
| ABG | Arterial blood gas |
| CS | Corticosteroids |
| CXR | Chest X-ray |
| ED | Emergency department |
| IB | Ipratropium bromide |
| $PaCO_2$ | Partial pressure of carbon dioxide in arterial blood |
| $PaO_2$ | Partial pressure of oxygen in arterial blood |
| PEF | Peak expiratory flow |
| PEFR | Peak expiratory flow rate |
| PICU | Paediatric intensive care unit |
| pMDI | Pressurised metered dose inhaler |
| SACAWG | South African Childhood Asthma Working Group |
| $SpO_2$ | Oxygen saturation (measured peripherally by pulse oximetry) |

## 1. Methodology

The acute asthma working group guideline was developed as part of the South African Childhood Asthma Working Group (SACAWG) guideline, with the chronic management guideline published in 2009.[2] A Pubmed literature search was performed for English language publications on treatment of acute asthma in children, from 2000 to 2012 inclusive. The search strategy used the following terms: 'asthma' and 'child' and 'treatment', and 'acute asthma attack' and 'status asthmaticus'.

Although many of the drugs used in the treatment of acute asthma in children are used off-label, the recommendations are based on the best available evidence and the drugs are in common use.

### 1.1 Levels of evidence

The strategies recommended in this guideline are classified according to the evidence categories in Table 1 and denoted as **evidence A, B, C** or **D**.

### 1.2 Definitions

**Acute asthma** is characterised by a progressive increase in shortness of breath, cough, wheeze or tight chest that does not respond to the patient's usual bronchodilator therapy.

**Table 1. Categories of evidence for management strategies in asthma (reproduced from Global Initiative for Asthma - 2009[3])**

| Evidence category | Sources of evidence |
|---|---|
| A | Randomised controlled trials: Rich body of data |
| B | Randomised controlled trials: Limited body of data |
| C | Non-randomised trials: Observational studies |
| D | Panel consensus judgement |

**Mild asthma exacerbations** are just outside the normal range of variation for an individual patient and are difficult to distinguish from transient loss of asthma control.[4]

**Moderate asthma exacerbations** are defined as at least one of the following occurring for at least 2 days without the need for systemic corticosteroids (CS): increasing asthma symptoms, worsening lung function, and/or increased rescue bronchodilator use.[4] Emergency department (ED) visits not requiring CS are classified as moderate disease exacerbations.

**Severe asthma exacerbations** necessitate urgent action by the patient/parent and doctor to prevent a serious outcome, such as hospitalisation or death. The definition requires either an asthma-related hospitalisation or a visit to the ED or an urgent care facility, together with treatment with systemic CS for at least 3 days.[4] The features of a severe asthma exacerbation are: inability to complete sentences in one breath and/or too breathless to talk or feed; use of accessory muscles of respiration; tachycardia; tachypnoea; agitation; oxygen saturations ($SpO_2$) <92%; peak expiratory flow rate (PEFR) 33 - 50% best or predicted.[3]

**Acute severe asthma**, formerly known as status asthmaticus, is defined as severe asthma unresponsive to repeated courses of $ß_2$ agonist therapy. It is a medical emergency that requires immediate recognition and treatment.

**Near-fatal asthma** is acute severe asthma associated with a respiratory arrest or hypercarbia.[5]

## 2. Assessment

The management of acute asthma depends on the assessment of severity. The initial quick assessment should determine whether the child shows any risk factors for (Table 2) or symptoms or signs of life-threatening asthma (Table 3).[3,6] The PEFR can usually only be measured in children older than 6 years, and who are accustomed to having their PEF measured.

Before children can receive appropriate treatment for acute asthma, the severity of their symptoms must be assessed accurately. The following clinical signs should be recorded:

- pulse rate
- respiratory rate and degree of breathlessness (ability to complete sentences in one breath or to feed)
- use of accessory muscles of respiration
- amount of wheezing (how audible it is)
- degree of agitation and level of consciousness.

Increasing tachycardia generally denotes worsening asthma, whereas a fall in heart rate in life-threatening asthma is a pre-terminal

**Table 2. Risk factors for potentially fatal asthma in children (adapted from Global Initiative for Asthma,[3] British Thoracic Society/Scottish Intercollegiate Guidelines Network[6])**

| |
|---|
| Previous near-fatal asthma |
| Previous admission to a PICU for asthma |
| Admission for asthma in the last year |
| Excessive use of or overdependence on $ß_2$ agonists |
| Current use or recent use of oral corticosteroids |
| Repeated attendances at emergency unit for asthma treatment, especially if in the last year |
| 'Brittle' asthma (sudden onset of acute severe asthma attacks) |
| Poor adherence to medication |
| Psychosocial and/or family problems |

**Table 3. Assessment of severity of acute asthma (adapted from Global Initiative for Asthma,[3] British Thoracic Society/Scottish Intercollegiate Guidelines Network[6])**

| | Clinical signs | Measurements |
|---|---|---|
| Life-threatening asthma | Silent chest | $SpO_2$ <92% |
| | Cyanosis | PEFR <33% best or predicted or unable to perform PEFR measurements due to fatigue |
| | Poor respiratory effort | |
| | Hypotension | |
| | Exhaustion | |
| | Confusion or drowsiness | |
| | Bradycardia – a pre-terminal event | |
| Severe asthma exacerbation | Unable to complete sentences in one breath; too breathless to talk or feed | $SpO_2$ <92% |
| | Agitation | PEFR 33 - 50% best or predicted or unable to perform PEFR measurements due to fatigue |
| | Accessory muscle use during expiration | |
| | Tachycardia* | |
| | Tachypnoea† | |
| Moderate asthma exacerbation | Able to talk in sentences<br>Pulse rate within normal limits<br>Respiratory rate within normal limits | $SpO_2$ ≥92%<br>PEFR ≥50% best or predicted |

*Tachycardia – heart rate >160 beats/min in children aged <1 year; >140 beats/min in children 1 - 5 years; >130 beats/min in children >5 years.

†Tachypnoea – respiratory rate >50 breaths/min in children aged <1 year; >40 breaths/min in children 1 - 5 years; >30 breaths/min in children >5 years.

event. Although wheezing initially becomes more apparent as airway obstruction increases, severe airway obstruction decreases air flow, with wheezing becoming softer and then diminishing completely (silent chest).

It is important to realise that clinical signs correlate poorly with the severity of airways obstruction.[6-10] Some children may have very severe airways obstruction without appearing to be obviously distressed.

## 3. Investigations

### 3.1 Pulse oximetry

Oxygen saturation monitors should be available at all facilities that treat children with acute asthma. Low arterial oxygen saturation in room air ($SpO_2$ <92%) after the initial bronchodilator therapy suggests a more severe group of patients and is an indication for admission.[6-8,10] All children with $SpO_2$ <92% in room air after initial bronchodilator therapy must be admitted for inpatient treatment and monitoring.

### 3.2 Chest X-ray (CXR)

Routine CXRs are unnecessary. Indications for a CXR in acute asthma are:

- failure to respond to standard therapy
- subcutaneous emphysema or chest pain, suggesting an air leak or pneumothorax
- clinical signs suggesting lung collapse, consolidation or pneumothorax
- life-threatening asthma not responding to maximal therapy.

A CXR may also be indicated to rule out alternative or concomitant diagnoses, especially in children not responding to treatment.

### 3.3 Arterial blood gas (ABG)

Indications for doing an ABG include severe or life-threatening asthma not responding to treatment. The $PaCO_2$ is low in the early stages of acute asthma as a compensatory mechanism. A normal or raised $PaCO_2$ indicates worsening asthma and respiratory failure.

## 4. Initial and first-line management of acute asthma

The initial treatment of an acute asthma attack consists of repeated doses of rapidly acting inhaled $\beta_2$-agonists, systemic CS, and oxygen if hypoxic; all these therapies are supported by existing evidence as indicated in the text.

### 4.1 Oxygen

Children with life-threatening asthma, severe asthma or oxygen saturations less than 92% should receive oxygen via a high-flow face mask or nasal cannulas to maintain normal saturations (**evidence A**) and be admitted (**evidence B**). There is currently no consensus as to whether the oxygen should be humidified.[11,12] In hospitals, nebulisers should preferably be oxygen-driven.

### 4.2 Short-acting beta-2 ($\beta_2$)-agonist bronchodilators

Short-acting inhaled $\beta_2$-agonists are the mainstay of therapy for acute asthma, and the first-line treatment (**evidence A**). They stimulate $\beta_2$ receptors on airway smooth muscle, resulting in smooth muscle relaxation.[13] However, receptors are also found in the heart, blood vessels, skeletal muscle, liver, pancreas and uterus, accounting for some of the side effects of $\beta_2$-agonists including tachycardia, tremor, hypokalaemia and hyperglycaemia. The most commonly used agents in South Africa are salbutamol and fenoterol; salbutamol is the $\beta_2$ agonist of choice in the majority of international acute asthma guidelines.[3,6]

Inhaled $\beta_2$-agonists are preferably delivered by pressurised metered dose inhaler (pMDI) with a spacer (2 - 10 puffs, each inhaled separately with five tidal breaths at 15 - 30-second intervals) or by oxygen-driven nebuliser (**evidence A**).[14] A pMDI plus spacer

is the preferred drug-delivery device for the treatment of mild to moderate acute asthma, while oxygen-driven nebulisers are preferred for severe or life-threatening acute asthma (**evidence A**). In young children (<3 years old), a spacer with a mask should be used; in older children, a pMDI and spacer with mouthpiece is preferable. Home-made spacers are as effective as commercial spacers in the treatment of acute asthma.[15,16] If using a pMDI and spacer with a mask, ensure that the mask fits closely onto the child's face.

Frequent doses of $\beta_2$-agonists are safe for the treatment of acute asthma (**evidence A**). Two to four puffs repeated every 20 - 30 minutes depending on clinical response should be given for mild attacks; up to 10 puffs may be needed for more severe asthma. Bronchodilator therapy should be individualised depending on the severity of the acute asthma and the response to treatment. If hourly bronchodilators are required for more than 4 - 6 hours, the pMDI-spacer combination should be changed to a nebuliser.[6] Children who have not improved after receiving up to 10 puffs of $\beta_2$-agonist should be referred to hospital. Children with severe or life-threatening asthma should receive nebulised $\beta_2$-agonists (2.5 - 5 mg salbutamol or 0.5 - 1 mg fenoterol) and oxygen and should be transferred urgently to hospital. Nebulisation with $\beta_2$-agonists can be repeated every 20 - 30 minutes or given continuously. The results of studies comparing intermittent and continuous nebulised short-acting $\beta_2$-agonists are conflicting. A recent Cochrane review reported that continuous nebulised $\beta_2$ agonists offered a small advantage over intermittent nebulisation in terms of hospital admission and lung function, with no increase in side-effects (**evidence A**).[17]

## Administration of $\beta_2$-agonists

- pMDI/spacer: start with 2 puffs of $\beta_2$-agonist. Give single puffs one at a time; each must be inhaled separately with five tidal breaths at 15 - 30-second intervals. Increase $\beta_2$-agonist dose by 2 puffs every 2 minutes according to response up to 10 puffs
- A SPACER **MUST** be used in conjunction with a MDI in children of ALL ages to enable adequate delivery of bronchodilator
- doses can be repeated every 20 - 30 minutes.
- Nebuliser: 2.5 - 5 mg salbutamol *or* 0.5 - 1 mg fenoterol + saline to make nebuliser volume up to 4 ml.* Repeat at 20 - 30 -minute intervals
- Continuous nebulised $\beta_2$-agonists: 2.5 - 5 mg salbutamol **or** 0.5 - 1mg fenoterol + saline to make nebuliser volume up to 4 ml.* Repeat every 15 minutes until response occurs.

*The fill volume may differ depending on the nebuliser.

### 4.3 Steroid therapy

CS are standard first-line treatment for acute asthma, as they treat the underlying cause of asthma: inflammation (**evidence A**). They increase $\beta_2$ receptor sensitivity by upregulating $\beta_2$ expression on airway smooth muscle.[11,18] CS have been shown to decrease mortality, relapses, hospital admission and bronchodilator use. As systemic steroids require 6 - 24 hours to promote the anti-inflammatory response, early administration after presentation is necessary to reduce hospital admission.[12] The earlier they are administered in the acute attack, the better the outcome (**evidence A**).[19,20] Oral steroids are as effective as intravenous therapy, and preferable because of their ease of administration, cost-effectiveness and fewer side-effects.[21-23] The recommended dose of oral prednisone or prednisolone is 1 mg/kg/d, i.e. 20 mg in children aged 2 - 5 years and 30 - 40 mg in children aged >5 years.[24] Children on **maintenance oral CS** should receive 2 mg/kg/d up to a maximum dose of 60 mg.[6] A 3-day course is usually sufficient for children who are not hospitalised; however, if the asthma attack has not completely resolved then a longer course (7 - 14 days) may be needed.[6,25] It is unnecessary to taper the steroid dose unless it is used for longer than 14 days.[26,27] Intravenous steroids (which include hydrocortisone, methylprednisolone and dexamethasone), should be reserved for children with life-threatening asthma or those who cannot tolerate oral CS.

## Administration of steroid therapy

- Prednisone or prednisolone 1 - 2 mg/kg orally (recommended dose 20 mg for children aged 2 - 5 years and 30 - 40 mg for children >5 years)
- Methylprednisolone 2 mg/kg 8-hourly IV
- Dexamethasone 0.6 mg/kg IV daily

### 4.4 Ipratropium bromide

Ipratropium bromide (IB) is an anticholinergic agent that produces bronchodilatation within 20 - 30 minutes. Nebulised IB (250 µg/dose mixed with the nebulised $\beta_2$-agonist solution) should be added if the child does not respond to three doses (nebulisation or multidosing via pMDI-spacer combination) of $\beta_2$-agonists, or if the symptoms are severe (**evidence A**). Frequent doses of IB can be used every 20 - 30 minutes, together with $\beta_2$-agonists, for the first 2 hours of a severe asthma attack[6] The dose frequency should be reduced to 4 - 6-hourly as clinical improvement occurs. Inhaled IB may be especially useful in patients who have been using high doses of $\beta_2$-agonists before seeking medical care. IB alone is a less effective bronchodilator than a $\beta_2$-agonist alone, but the combination of nebulised IB with a nebulised $\beta_2$-agonist results in greater bronchodilatation than a $\beta_2$-agonist on its own.[28,29]

Pre-mixed combination $\beta_2$-agonist and anticholinergic inhalant solutions should be used with caution in children, as the concentrations of the individual drugs are higher than recommended for the paediatric population (Table 4).

## 5. Additional therapy for acute asthma

The following therapies may be considered in the management of acute severe asthma not responding to standard treatment.

## Administration of IB

- Add 250 µg IB/dose to 2.5 - 5.0 mg of salbutamol **or** 0.5 - 1 mg fenoterol solution with saline to make a total volume of 4 ml* in the same nebuliser and administer every 20 - 30 minutes initially then 4 - 6-hourly as improvement occurs.

* The fill volume may differ depending on the nebuliser.

**Table 4. Concentrations of $\beta_2$-agonists and IB in commercially available products in SA**

| Product name | Constituents |
|---|---|
| Adco-Combineb | IB 500 µg, salbutamol 2.5 mg/2.5 ml |
| Adco-Nebrafen | IB 500 µg, fenoterol 1.25 mg/4 ml |
| Combivent | IB 500 µg, salbutamol 2.5 mg/2.5 ml |
| Duolin | IB 500 µg, salbutamol 2.5 mg/2.5 ml |

IB = ipratropium bromide.

### 5.1 Intravenous low-dose bolus salbutamol

The use of IV low-dose salbutamol (15 µg/kg as a once-off bolus dose), added to standard therapy in the early management of acute severe asthma in children presenting to the emergency department (ED), may reduce the duration of the exacerbation and hasten the children's discharge from hospital (**evidence B**).[30,31] IV salbutamol alone is not better than inhaled $\beta_2$-agonists.[32]

### 5.2 Intravenous salbutamol by continuous infusion

In the paediatric intensive care unit (PICU) a high IV loading dose of salbutamol (5 - 10 µg/kg/min of 1 mg/ml solution infused at 0.3 - 0.6 ml/kg/h for 1 hour ) followed by continuous infusion (1 - 5 µg/kg/min at 0.06 - 0.3 ml/kg/h) may be effective, and is probably safer than aminophylline. Continuous intravenous infusion should be considered when there is uncertainty about reliable inhalation of $\beta_2$-agonists or for severe refractory asthma. Electrolytes should be monitored regularly (**evidence C**).[6] Nebulised bronchodilator therapy should be continued while the patient is receiving IV salbutamol.[6]

#### How to administer IV salbutamol

- Bolus dose only: 15 µg/kg in 10 ml saline over 10 minutes
- Continuous infusion: load 5 - 10 µg/kg/min of 1 mg/ml solution at 0.3 - 0.6 ml/kg/h for 1 hour, then salbutamol infusion 1 - 5 µg/kg/min of a 1mg/ml solution at 0.06 - 0.3 ml/kg/h

### 5.3 Intravenous aminophylline

Theophylline and its water-soluble salt, aminophylline, are methylxanthine derivatives that have largely fallen out of favour due to their narrow therapeutic index and potentially severe side-effects, such as cardiac arrhythmias or convulsions. Neither theophylline nor aminophylline is indicated in patients with mild to moderate acute asthma (**evidence A**), but may be used in cases of near-fatal or life-threatening asthma in the PICU (**evidence C**).[33-36] A 5 mg/kg loading dose should be given over 20 minutes under continuous ECG monitoring, followed by a continuous infusion at 0.5 - 1 mg/kg/h; the loading dose should be omitted in children receiving maintenance oral theophylline (**evidence B**).

### 5.4 Magnesium sulphate

Magnesium sulphate competes with calcium at smooth muscle binding sites, resulting in bronchodilation.[37] A single dose of **intravenous** magnesium sulphate 25 - 75 mg/kg (recommended dose 50 mg/kg, maximum dose 2 g) given over 20 minutes has been shown to be safe and effective in adults and children with acute severe asthma, who have had a poor response to initial therapy.[37,38] The response to magnesium appears to be best in patients who present with very severe illness (**evidence C**).[39-41]

The benefits associated with the use of **nebulised** magnesium sulphate remain controversial. Nebulised magnesium sulphate (0.4 ml 50% $MgSO_4$ added to total volume of 4 ml nebuliser volume to achieve an isotonic solution) added to inhaled $\beta_2$-agonists in the treatment of an acute asthma exacerbation has been shown to improve lung function in patients with severe asthma, with a trend towards fewer hospital admissions.[42]

### 5.5 Adrenaline

Intramuscular adrenaline is given for acute anaphylaxis (which may be confused with acute asthma) and angio-oedema, but it is not routinely indicated for acute asthma. Subcutaneously administered adrenaline may be used in patients who are moribund on presentation to the ED, or in an emergency situation where inhaled therapy is not available (**evidence D**).[43]

### 5.6 Inhaled steroids (ICS)

Insufficient evidence exists to recommend the use of ICS as alternative or additional therapy in acute asthma. Maintenance doses of ICS should be continued or started as soon as possible to form the basis of the chronic asthma management plan, and to allow the educational process regarding controller therapy to start even while the patient is hospitalised.[6,44-48]

### 5.7 Rapid-onset long-acting $\beta_2$-agonists (formoterol)

Formoterol is a long-acting $\beta_2$-agonist with a rapid onset of bronchodilation. Formoterol should never be used as monotherapy, as the use of long-acting $\beta_2$-agonists is associated with increased risk of asthma mortality. Combination products containing formoterol and budesonide have been used as reliever medication for mild acute asthma symptoms in children older than 4 years (**evidence B**).[49] However, there are currently insufficient data to make a recommendation regarding the use of formoterol as a reliever instead of short-acting $\beta_2$-agonists in acute asthma.[50,51]

### 5.8 Leukotriene receptor antagonists

There is no evidence to support the use of leukotriene receptor antagonists for the treatment of acute asthma in children. In three trials comprising 194 children with acute asthma, there was no difference between **oral** leukotriene receptor antagonists (LTRA) and controls (**evidence A**).[52] One trial in 276 children compared **intravenous** LTRA to placebo and resulted in decreased hospital admission, but this was not statistically significant (**evidence B**).[52,53] Further research is required regarding the role of IV LTRA in acute asthma, but there is currently no IV LTRA that is registered in South Africa.

### 5.9 Antibiotics

Antibiotics are not routinely indicated in acute asthma, which is usually precipitated by a viral infection (**evidence D**).[54]

### 5.10 Heliox

Current evidence does not support the use of heliox in the initial treatment of acute asthma, but it may have a small role in acute asthma in children with severe obstruction, provided hypoxaemia is not severe. (**evidence B**).[55,56]

### 5.11 Intravenous fluids

Patients with prolonged severe asthma may become dehydrated as a result of poor intake or vomiting. It is, however, inadvisable to overhydrate patients with acute asthma as they are prone to transcapillary fluid migration and alveolar flooding.[57,58]

## 6. Indications for hospitalisation

The indications for hospitalisation are listed in Table 5.

## 7. Indications for PICU admission

The indications for PICU admission are listed in Table 6. Any child with acute severe asthma who is not responding to maximal inhaled therapy and systemic steroids, or who has features of life-threatening asthma not responding to initial therapy, should be admitted to the PICU.

### 7.1 Treatment of acute severe asthma in ICU

The detailed management of acute severe asthma in the ICU is beyond the scope of this guideline, but it includes continuous nebulised $\beta_2$-agonists with oxygen, inhaled IB added to the salbutamol, systemic (IV) steroids and possibly either or both IV aminophylline and IV salbutamol.[59,60] Non-invasive ventilation is increasingly used for the management of respiratory failure in acute asthma, but requires the patient to be co-operative.[61-63] If intubation and mechanical ventilation are required, the currently preferred mode of ventilation is pressure control or pressure support ventilation, with slower rates allowing a sufficiently long expiratory time to permit emptying of the lungs.[63,64] Ketamine is recommended for sedation in intubated patients, and inhaled anaesthetic gases may be required in very severe cases not responding to maximal other therapy.[63]

## 8. Acute asthma in very young children

The assessment of acute asthma in children younger than 2 years can be very difficult, as objective measures of severity are not always reliable and other conditions, such as foreign body inhalation, gastro-oesophageal reflux with aspiration, lower respiratory tract infection, compression of the airways due to a congenital abnormality or tuberculous lymph nodes, and cystic fibrosis, may mimic asthma. Signs of severe acute asthma are: low oxygen saturation ($SpO_2$ <92%), marked respiratory signs (using accessory muscles of respiration, marked retraction, tachypnoea) and inability to feed because of shortness of breath. Any one of these signs should place the child into the severe category. Apnoea, bradycardia or poor respiratory effort are features of life-threatening acute asthma.[6]

**Table 5. Indications for hospitalisation**

| |
|---|
| 1. Any sign of life-threatening asthma |
| Silent chest |
| Cyanosis |
| Poor respiratory effort |
| Hypotension, bradycardia |
| Exhaustion |
| Confusion or drowsiness |
| 2. Any sign of severe asthma |
| Unable to complete sentences in one breath; too breathless to talk or feed |
| Agitation |
| Accessory muscle use |
| Heart rate >160 beats/min in children aged <1 year; >140 beats/min in children 1 - 5 years; >130 beats/min in children >5 years |
| Respiratory rate >50 breaths/min in children aged <1 year; >40 breaths/min in children 1 - 5 years; >30 breaths/min in children >5 years |
| Room air $SpO_2$ <92% despite bronchodilator therapy |
| PEFR <50% predicted |
| 3. Moderately severe asthma not responding to $\beta_2$-agonist therapy |
| 4. Home circumstances which do not allow safe or reliable treatment |

**Table 6. Indications for admission to PICU**

| |
|---|
| Cyanosis or hypoxaemia ($PaO_2$ <8 kPa (60 mmHg); $SpO_2$ <90%) unrelieved by $O_2$ |
| $PaCO_2$ >4.5 kPa (34 mmHg) |
| Minimal chest movement, 'silent' chest |
| Severe chest retractions |
| Deteriorating mental status, lethargy or agitation |
| Cardiorespiratory arrest |

### 8.1 Treatment of acute asthma in children aged <2 years

**Oxygen** via close-fitting mask or nasal prongs must be administered to attain $SpO_2$ >92%.

A trial of **inhaled $\beta_2$-agonist bronchodilator** therapy should be instituted, in the same doses as for the older child. If there is a poor response to this treatment, the diagnosis of asthma should be reviewed. The optimal delivery system is a pMDI with spacer and mask for mild to moderate acute asthma, and oxygen-driven nebuliser for severe acute asthma (**evidence A**).[65-67] Oral $\beta_2$-agonists are not recommended for the treatment of acute asthma in infants (**evidence B**).

**Oral steroids, tablets or liquid** (prednisone or prednisolone) should be given early in the management of severe acute asthma, and should be continued for up to three days (**evidence B**).[24,68-70]

If there is a poor response to inhaled $\beta_2$-agonist therapy (after 3 treatments) or if the symptoms are more severe, add **IB** in the same dose as for older children (**evidence B**).[6,71]

## 9. Hospital discharge and follow-up[6]

A child can be discharged when:

- he/she is stable on 3 - 4-hourly inhaled bronchodilators that can be continued at home
- he/she is feeding well, is not tachypnoeic and no chest wall indrawing is present
- $SpO_2$ >94% in room air
- PEFR and/or $FEV_1$ should be >75% of best or predicted
- appropriate care can be provided at home.

Caregivers and children should receive asthma education with the emphasis placed on treatment and inhaler technique. Children should be discharged on appropriate maintenance therapy with a spacer, educated and with a written action plan to manage exacerbations. They should have a follow-up appointment with their primary care provider within a week of discharge. Patients with severe exacerbations or life-threatening asthma should preferably be referred to a clinic with a special interest in severe asthma and should be discharged on ICS controller therapy. Caregivers should be counselled regarding environmental triggers, especially for the child to avoid exposure to passive smoke or indoor air pollution.

**Conflict of interest.** S Kling: member of executive committee of the Allergy Society of South Africa; MSD speakers' bureau; instructor on Certificate of Asthma Care of National Asthma Education Programme. H Zar: president, South African Thoracic Society; president, Pan African Thoracic Society; Forum International Respiratory Societies; Global Advisory Committee Allergic Rhinitis and its Impact on Asthma (ARIA); World Allergy Organisation Special Committee on Paediatric Asthma. M Levin: member of executive committee of the Allergy Society of South Africa; instructor on Certificate of Asthma Care of National Asthma Education Programme; speaker at events sponsored by ThermoFisher,

Pharma Dynamics, Nestlé, Cipla, Sanofi Aventis and Schering Plough; advisory board: Cipla; research support from ThermoFisher, ALLSA, GSK and Nestlé; advisor, Pharma Dynamics. R Green: chair, Allergy Society South Africa; executive member, South African Thoracic Society, National Asthma Education Programme; advisory board, Aspen, Cipla, MSD, Pfizer; speakers bureau: Abbott, Aspen, Cipla, MSD, Nycomed, Pfizer, Sanofi Aventis. P Jeena: chair of Paediatric Essential Drug Committee of South Africa; no conflict of interest. S Risenga: member of executive committee of the Allergy Society of South Africa; speaker for Nestlé and SAMA. S Thula, P Goussard, R Gie declare no conflicts of interest.

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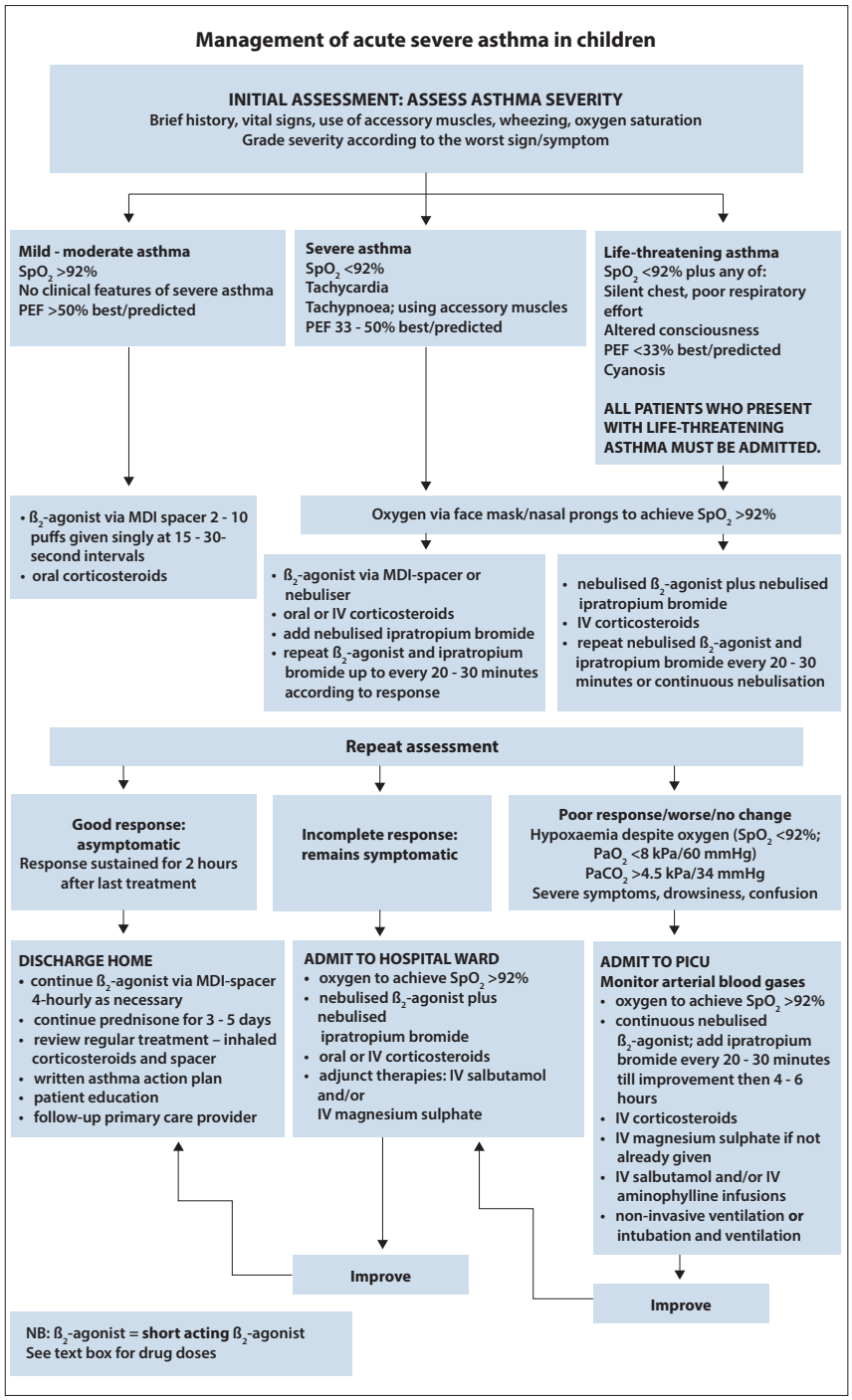


## Drug doses for acute asthma

### $\beta_2$-agonist

- pMDI with spacer: $\beta_2$-agonist 2 - 10 puffs
  - Give single puffs, one at a time; each to be inhaled separately with five tidal breaths at 15 - 30-second intervals
  - Increase $\beta_2$-agonist dose by 2 puffs every 2 minutes, up to 10 puffs according to response
  - Repeat $\beta_2$-agonist every 20 - 30 minutes according to response
- Nebuliser: salbutamol 2.5 - 5 mg or fenoterol 0.5 - 1 mg + saline. Repeat at 20 - 30-minute intervals

### Corticosteroids

- Oral prednisone or prednisolone 1 - 2 mg/kg (20 mg for children aged 2 - 5 years; 30 - 40 mg for children aged >5 years) (maximum dose 40 mg)
- IV methylprednisolone 2 mg/kg 8-hourly
- IV dexamethasone 0.6 mg/kg daily

### Ipratropium bromide (IB)

- IB 0.25 mg added to $\beta_2$-agonist + saline; nebulise every 20 - 30 minutes x 3 doses, then 4 - 6-hourly

### Adjunct therapies

- Single dose IV salbutamol 15 µg/kg in 10 ml saline over 10 minutes
- Single dose IV magnesium sulphate 50% solution (2 mmol/ml) 0.1 ml/kg (50 mg/kg) (maximum 2g) in 20 ml saline over 20 minutes

### Adjunct therapies in ICU

- IV salbutamol: load 5-10 µg/kg/min (1mg/ml solution) at 0.3-0.6ml/kg/h for 1 hour, then salbutamol infusion 1-5 µg/kg/min 1mg/ml solution at 0.06-0.3ml/kg/h
- IV aminophylline load 5 mg/kg over 20 minutes, then infuse at 0.5 -1 mg/kg/h