



Managing the paediatric patient with an acute asthma exacerbation

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Français en page 257

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Children with acute asthma exacerbations frequently present to an emergency department with signs of respiratory distress. The most severe episodes are potentially life-threatening. Effective treatment depends on the accurate and rapid assessment of disease severity at presentation. This statement addresses the assessment, management and disposition of paediatric patients with a known diagnosis of asthma who present with an acute asthma exacerbation, especially preschoolers at high risk for persistent asthma. Guidance includes the assessment of asthma severity, treatment considerations, proper discharge planning, follow-up, and prescription for inhaled corticosteroids to prevent exacerbation and decrease chronic morbidity.

Key Words: *Asthma; Disposition; Emergency management; Paediatrics; Preschoolers*

La prise en charge du patient pédiatrique présentant une exacerbation aiguë de l'asthme

Les enfants ayant des exacerbations aiguës de l'asthme consultent souvent à l'urgence parce qu'ils présentent des signes de détresse respiratoire. Les crises les plus graves peuvent mettre en jeu le pronostic vital. L'efficacité du traitement dépend de l'évaluation exacte et rapide de la gravité de la maladie à la présentation. Le présent document de principes porte sur l'évaluation, la prise en charge et la conduite à tenir auprès des patients pédiatriques ayant un diagnostic connu d'asthme qui consultent en raison d'une exacerbation aiguë de l'asthme, notamment les enfants d'âge préscolaire très vulnérables à un asthme persistant. Les conseils incluent l'évaluation de la gravité de l'asthme, les considérations thérapeutiques, la planification convenable du congé, le suivi et une prescription de corticoïde par aérosol pour prévenir les exacerbations et réduire la morbidité chronique.

EPIDEMIOLOGY AND BACKGROUND

Asthma is a common, chronic inflammatory disorder of the airways associated with airway hyper-responsiveness. Asthma exacerbations are the leading cause of hospitalization in children (1), and the lifetime prevalence of asthma in Canadian children has been estimated at 11% to 16% (2).

For this statement, asthma exacerbation is defined as an acute or subacute deterioration of symptom control that causes distress or risks health to the extent that a visit to a health care provider or treatment with systemic corticosteroids becomes necessary (3). The most common triggers for asthma exacerbations in both younger and older children are viral respiratory tract infections; other typical factors are exposure to allergens and a suboptimal control of asthma as a baseline (4). Acute exacerbations are a frequent cause of emergency department (ED) visits (5,6). Guttmann and colleagues (5) reported that in Ontario, over 9% of children with asthma had made at least one ED visit in the past two years, and asthma exacerbations accounted for 3% to 7% of all paediatric ED visits. More than 50% of children who present to the ED with an asthma exacerbation are preschool age (<5 years) (5). Rosychuk et al (6) recently reported that in Alberta, nearly 10% of the paediatric ED visits resulted in an admission to hospital, with one death for every 25,000 ED visits.

Many health care centres across Canada and a wide range of national and international health organizations have developed their own practice guidelines for the assessment and management of acute asthma exacerbations (3,7-9). The use of evidence-based

asthma guidelines can improve outcomes for children with asthma (10). This statement specifically addresses the ED management of acute asthma exacerbations in paediatric patients with a known diagnosis of asthma, particularly preschoolers with early transient wheezing whose pattern of symptoms and history of atopy suggest a high risk for persistent asthma (11).

ED management objectives for acute asthma exacerbations are:

1. An immediate and objective assessment of their severity.
2. Prompt and effective medical intervention to decrease respiratory distress and improve oxygenation.
3. Appropriate disposition of the patient after emergency management.
4. Arranging proper follow-up.

1. Assessing the child in respiratory distress from an acute asthma attack

Effective treatment depends on an accurate and rapid assessment of disease severity upon presentation (3,7-10,12). For definition of mild, moderate and severe, see Table 1.

Assessment should include:

- Signs and symptoms of respiratory distress and airway obstruction, including clinical documentation of vital signs. Pulse oximetry should be used in all patients. Pulsed oxygen saturation (SpO₂) of 92% or less on presentation (before oxygen or bronchodilator treatment) is associated with higher morbidity and greater risk for hospitalization (13).

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TABLE 1
Classification of asthma severity

Clinical features	Mild	Moderate	Severe	Impending respiratory failure
Mental status	Normal	Might look agitated	Usually agitated	Drowsy or confused
Activity	Normal activity and exertional dyspnea	Decreased activity or feeding (infant)	Decreased activity, infant stops feeding	Unable to eat
Speech	Normal	Speaks in phrases	Speaks in words	Unable to speak
Work of breathing	Minimal intercostal retractions	Intercostal and substernal retractions	Significant respiratory distress. Usually all accessory muscles involved, and may display nasal flaring and paradoxical thoraco-abdominal movement	Marked respiratory distress at rest. All accessory muscles involved, including nasal flaring and paradoxical thoraco-abdominal movement
Chest auscultation	Moderate wheeze	Loud pan-expiratory and inspiratory wheeze	Wheezes might be audible without stethoscope	The chest is silent (absence of wheeze)
SpO ₂ on room air	>94%	91–94%	<90%	<90%
Peak flow versus personal best	>80%	60–80%	best <60%	Unable to perform the task

Definitions are not absolute and can overlap. The presence of several parameters indicates the classification of the exacerbation.

- A focused medical history recording previous medications and risk factors for ICU admission and death (14):
 - previous life-threatening events,
 - admissions to ICU,
 - intubation,
 - deterioration while already on systemic steroids.
- A focused physical examination to estimate the functional severity of airway obstruction, documenting the use of accessory muscles, air entry in both lungs and wheezing, level of alertness, ability to speak in full sentences; and activity level (Table 1). A silent chest is an ominous sign that there is not enough gas exchange and a warning that respiratory failure is imminent. Mental agitation, drowsiness and confusion are clinical features of cerebral hypoxemia and should be considered signs of extreme severity.
- When children are able to perform the task, spirometry is an objective measure of airway obstruction. Spirometry is difficult to perform in children younger than six years of age and/or during an exacerbation. Peak flow meters may be more readily available but are a less sensitive measure of airway obstruction and may be unreliable, especially in children younger than 10 years of age (15). Peak flows should be compared to readily available normal values or, if known, the child's 'personal best'.
- Ancillary tests are not routinely recommended.
 - Chest x-rays are very rarely indicated unless the clinician suspects complications (ie, pneumothorax), bacterial pneumonia, the presence of a foreign body, or in cases that fail to improve with maximized conventional treatment. In the absence of suggestive clinical features, there is a documented risk of overdiagnosis of pneumonia (16).
 - Blood gases are not routinely required to treat a child with asthma exacerbation unless the patient has no clinical improvement with maximal aggressive therapy. A normal capillary carbon dioxide level despite persistent respiratory distress is a sign of impending respiratory failure.

After conducting the initial assessment, a treating physician should categorize disease severity. There are different clinical tools for assessing disease severity in patients with acute asthma exacerbation (17–19). Birken et al (20) compared the performance of various assessment tools and concluded that the Clinical Assessment Score (17) and the Pediatric Respiratory Assessment Measure (PRAM) (18) both reliably assess the severity of an acute

asthma exacerbation and are sensitive to changes in clinical status. Typically, clinical tools take into consideration many of the following parameters: level of alertness, ability to speak in full sentences, use of accessory muscles, air entry in both lungs, presence of wheezing and O₂ saturation (Table 1).

Independent of the method of assessment, the same parameters used to estimate disease severity at baseline should be used after each treatment, on a regular basis, and at discharge.

2. Medical management steps

- Treat hypoxemia,
- Give short-acting β_2 -agonists,
- Prescribe corticosteroids,
- Assess treatment response, and
- Consider other modalities of treatment.

Patients who are acutely distressed, have signs of severe respiratory impairment or show signs of impending respiratory failure (eg, altered level of consciousness, silent chest, central cyanosis) should be treated immediately with oxygen and short-acting bronchodilators (3,7,12). Anaphylaxis can present with severe respiratory distress that mimics a severe asthma attack (21). If anaphylaxis is suspected, treat immediately with epinephrine.

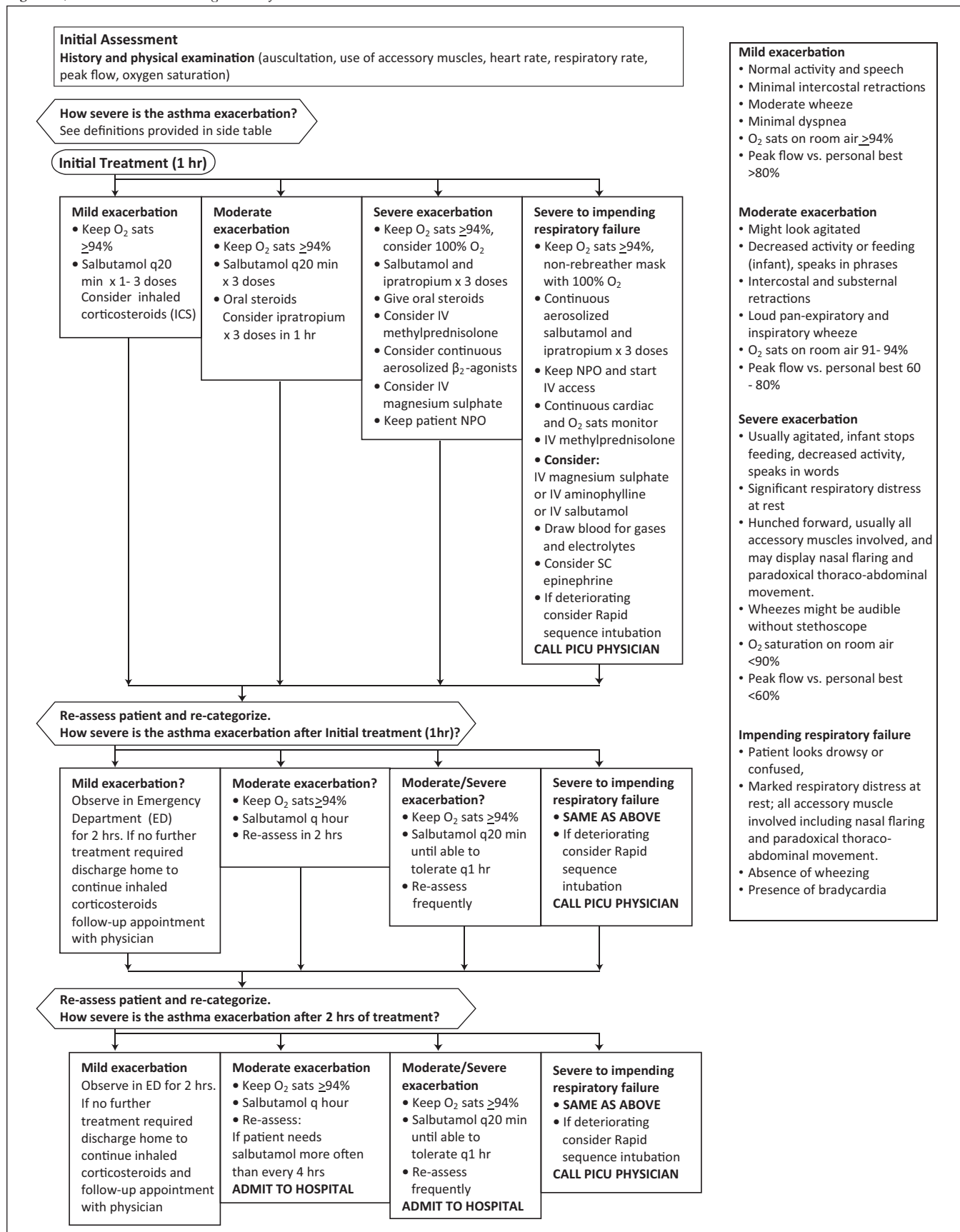
Otherwise, treatment should be instituted as soon as the assessment is completed. Patients should then be monitored closely to assess their response to initial management and to ensure proper care and disposition after the acute episode.

The flow diagram (Figure 1) shows a pathway to assess and treat children with asthma exacerbation.

Oxygen: Hypoxemia (SpO₂ <92%) must be treated urgently with oxygen delivered by face mask or nasal canulae. There is no strong evidence in support of a specific goal for SpO₂. In the context of acute respiratory distress, a SpO₂ \geq 94% appears reasonable (8,12,13).

Short-acting β_2 -agonists: Salbutamol (albuterol) is the bronchodilator of choice (3,8,12). A metered-dose inhaler (MDI) with a spacer is the preferred device for salbutamol administration because it is more efficient than a nebulizer for bronchodilator delivery (22). An MDI can be used in almost all situations except for very severe episodes with impending respiratory failure. Even in the presence of hypoxemia, oxygen can be given by nasal canulae at the same time that salbutamol is given by MDI and spacer. In children without initial oxygen requirements, β_2 -agonists administered by MDI and spacer are less likely to provoke hypoxemia and tachycardia than a nebulizer (22).

Figure 1) Assessment and management of an asthma exacerbation in children



O₂ sats Oxygen saturation; IV Intravenous; NPO Nothing by mouth; SC Subcutaneous; PICU Paediatric intensive care unit

TABLE 2
Medications and dosages for acute asthma treatment as per disease severity

Asthma severity	Drug and route	Dose (maximum)	Risks	Comment
Mild	Inhaled corticosteroids	See discharge plan and Table 3		
Moderate*	Salbutamol, MDI with spacer	<20 kg = 5 puffs (0.1 mg/puff), >20 kg =10 puffs every 20 min during the first hour		Preferable route
	Salbutamol, intermittent nebulization	5 mg in 2 ml of normal saline to be given every 20 min during the first hour		Monitor potassium serum levels in patients requiring frequent doses
	Oral corticosteroids	Prednisone or prednisolone 1 to 2 mg/kg/day (maximum 60 mg) OR dexamethasone 0.15–0.3 mg/kg/day (maximum 10 mg)	Prolonged course or frequently repeated doses can be associated with adrenal suppression	Start treatment early. Recommended as one single dose in the morning to decrease risk of adrenal suppression
	Ipratropium bromide, MDI/spacer	Puffs (100 µg) every 20 min x 3 doses <20 kg = 3 puffs, >20 kg = 6 puffs		Use with caution in children with soy allergy
Severe†	Salbutamol, continuous nebulization	0.3 mg/kg/hr 5 mg in 4 ml of normal saline	Tachycardia, hypokalemia, hyperglycemia	Monitor heart rhythm and rate, glucose and electrolytes
	Ipratropium bromide, nebulized	<20 kg = 0.25 mg, >20 kg = 0.5 mg every 20 min maximum 3 doses		Can be mixed with salbutamol aerosols
	IV corticosteroids	Methylprednisolone: 1–2 mg/kg/dose (maximum 60 mg q.6 h) hydrocortisone: 5–7 mg/kg (maximum 400 mg q.6 h)		
	IV magnesium sulfate	25–50 mg/kg IV bolus over 20 min (maximum 2 g)	Hypotension	Consider if patient is not improving
Severe to impending respiratory failure	IV salbutamol	Load: 7.5 mcg/kg over 2–5 min, followed by 1 mcg/kg/min. Titrate upwards with increments of 1 mcg/kg/min (maximum 5 mcg/kg/min)	Tachycardia, hypokalemia, hyperglycemia	Monitor heart rhythm and rate, glucose and electrolytes

*Conventional treatment: Oral corticosteroids, nebulized salbutamol ± ipratropium; †Maximized treatment: intravenous (IV) steroids, continuous nebulized salbutamol + ipratropium. MDI metered-dose inhaler

TABLE 3
Inhaled corticosteroid (ICS) dosing categories in paediatrics

Corticosteroid	Trade name	Daily inhaled corticosteroid dose, µg					
		(6 to 11 years of age)			(12 years of age and over)		
		Low	Medium	High	Low	Medium	High
Beclomethasone dipropionate HFA	QVAR†	≤200	201–400	>400	≤250	251–500	>500
Budesonide*	Pulmicort Turbuhaler‡	≤400	401–800	>800	≤400	401–800	>800
Ciclesonide*	Alvesco§	≤200	201–400	>400	≤200	201–400	>400
Fluticasone	Flovent MDI and spacer; Flovent Diskus¶	≤200	201–500	>500	≤250	251–500	>500

Dose equivalencies are approximate and are based on efficacy data. Categories are somewhat arbitrary but are based on manufacturers' recommendations. *Licensed for once daily dosing in Canada; †Graceway Pharmaceuticals, Canada; ‡AstraZeneca Inc, Canada; §Nycomed Canada Inc, Canada; ¶GlaxoSmithKline Inc, Canada. HFA Hydrofluoroalkane; µg micrograms; MDI Metered-dose inhaler. ICS are currently approved for the following ages: Flovent 12 months and over, QVAR 5 years and over, Alvesco 6 years and over, Pulmicort (nebulizer) 3 months and over (products insert). This information was originally published in *Can Respir J* 2010 17(1): 15–24

TABLE 4
Starting doses for inhaled corticosteroids for asthma therapy in children in Canada*

Medication and inhaler device	Minimum age licensed for use in Canada		
	Low to moderate dose	High dose†	
Beclomethasone–hydrofluoroalkane by metered-dose inhaler and spacer	5 years	100–150 µg twice daily	200 µg twice daily
Budesonide by dry powder inhaler	6 years‡	200 µg twice daily	400 µg twice daily
Budesonide by wet nebulizer†	3 months	250–500 µg twice daily	1000 µg twice daily
Fluticasone by metered-dose inhaler and spacer or dry powder inhaler	12 months‡	100–125 µg twice daily	250 µg twice daily
Ciclesonide by metered-dose inhaler and spacer	6 years	100–200 µg once daily	400 µg once or twice daily§

*Adapted from the Canadian asthma consensus report (1999); †It is preferable to administer high-dose inhaled corticosteroids (or budesonide by nebulizer) in consultation with an asthma expert; ‡The youngest children able to use a dry powder inhaler are generally 4 to 5 years of age (11); §Ciclesonide is usually used once daily except in cases of more severe disease. Reference 11 was used as a source, with permission, for this table

The recommended doses for MDI and nebulizer β_2 -agonist delivery are listed in Table 2. The dose and frequency of intermittent salbutamol therapy depend on the severity of an acute attack and the patient's response to treatment. The first dose of

salbutamol should be given as soon as possible after rapid triage and evaluation in the ED. In patients having a severe asthma attack, the continuous administration of nebulized β_2 -agonists may have a better and more prolonged bronchodilator effect compared

with intermittent therapy (23). Side effects of salbutamol include tachycardia, hyperglycemia and hypokalemia, which are generally well tolerated. There is no evidence in the paediatric age group of reversible arrhythmias following treatment with β_2 -agonists, but this side effect has been reported in adults. Paediatric patients treated with continuous nebulized β_2 -agonists should be monitored for cardiac arrhythmias.

Inhaled anticholinergics: Inhaled ipratropium bromide can be used as an add-on therapy to β_2 -agonists. Some randomized control trials demonstrated reduced hospital admission rates and better lung function when β_2 -agonists were used in combination with inhaled ipratropium during the first hour, compared with β_2 -agonists used alone (24,25). The dose may be repeated every 20 min for the first hour, mixed with β_2 -agonists. There are no clinical trials supporting ipratropium use beyond the first hour in children.

Oral/intravenous (IV) corticosteroids: Children who have a moderate to severe asthma exacerbation should receive systemic steroids as part of their initial treatment. This medication should be administered as early in the ED visit as feasible. Steroids may reduce the need for hospitalization and the risk of relapse after initial treatment and may also facilitate an earlier discharge from the hospital (26). The recommended doses of corticosteroids are listed in Table 2. Children with severe asthma or impending respiratory failure should receive IV steroids. The drugs of choice are methylprednisolone and hydrocortisone.

Magnesium sulphate: A recent meta-analysis suggested that IV magnesium sulphate may be effective in children with severe acute asthma, improving respiratory function and decreasing hospital admissions (27). IV magnesium sulphate may be considered in cases of moderate and severe asthma with incomplete response to conventional therapy during the first 1 h to 2 h (27). Patients treated with magnesium sulphate can have hypotension and bradycardia as side effects, and their vital signs should be monitored during treatment. Consultation with an intensive care unit (ICU) physician or respirologist is recommended.

IV salbutamol infusion: This delivery method should be used in patients with severe asthma who do not respond to other treatments (28). In patients with severe attacks, IV β_2 -agonists have been shown to improve pulmonary function and gas exchange (28). In general, inhaled drugs may have a limited effect in patients with nearly complete airway obstruction and have practical limitations in ventilated patients. Cardiac responses, such as arrhythmia and tachycardia, are significant side effects of this medication. Patients receiving IV salbutamol should be in a setting where continuous cardiac monitoring is available.

IV aminophylline: This bronchodilator is reserved for children in the ICU setting with a severe asthma exacerbation who have failed to improve despite maximized therapy (continuous inhaled β_2 -agonists, IV corticosteroids) (28,29).

Heliox: Using a helium-oxygen gas mixture is reserved for children in the ICU setting with severe asthma exacerbation who have failed to improve despite maximized therapy (30).

Endotracheal intubation and ventilation for impending respiratory failure:

Intubation and mechanical ventilation can be life-saving interventions but their use in paediatric patients with asthma have been associated with significant adverse effects. Up to 26% of children intubated due to asthma have complications, such as pneumothorax or impaired venous return, and cardiovascular collapse because of increased intrathoracic pressure (31). Mechanical ventilation during an asthma exacerbation is associated with increased risk of death and should be considered as a

last resort and only in conjunction with the support of a paediatric ICU specialist.

3. Disposition

Admission should be considered if any one of the following apply:

- An ongoing need for supplemental oxygen
- Persistently increased work of breathing
- β_2 -agonists are needed more often than q4 h after 4 h to 8 h of conventional treatment
- The patient deteriorates while on systemic steroids.

Other criteria may also be taken into consideration (eg, distance from home, comorbid conditions such as anaphylaxis).

ICU admission or referral to a tertiary care centre should be considered if:

- The patient requires continuous nebulized salbutamol and fails to improve on this therapy. Call a tertiary care centre PICU specialist to discuss patient management and transport.

Discharge criteria from the ED include:

- Needing β_2 -agonists less often than q4 h after 4 h to 8 h of conventional treatment
- A reading of $\text{SpO}_2 \geq 94\%$ on room air
- Minimal or no signs of respiratory distress
- Improved air entry.

4. Discharge home plan (follow-up)

Children with persistent asthma and/or who have a moderate or severe episode should be given inhaled corticosteroids (ICS) on a regular basis. If the patient is already taking ICS, the dose should be reviewed and adjusted (9,13). ICS are the cornerstone of regular preventive anti-inflammatory treatment to protect against exacerbations and chronic morbidity. The literature does not support a role for short-term intermittent therapy. ICS in appropriate doses are safe and efficacious. Long-term studies have demonstrated that ICS use does not impair growth or affect final adult height. Although there is a potential risk for adrenal suppression when high doses of ICS are used over prolonged periods, this risk can be diminished with proper monitoring and the use of newer ICS. Common ICS and doses are listed in Tables 3 and 4 (9,11).

- Complete a 3- to 5-day course of oral steroids, depending on the severity of the illness at presentation.
- Continue to use a short-acting β_2 -agonist such as salbutamol (200 μg [0.3 puffs/kg to a maximum of 10 puffs] every 4 h) until exacerbations resolve and then as needed, with directions to see a health care professional if therapy is needed more often than every 4 h.
- Prepare a written asthma action plan.
- Review techniques for using inhaled asthma medications as well as for cleaning/maintaining the inhaler device.
- Encourage follow-up with the patient's primary care physician or a local asthma clinic to review asthma control, environmental history and symptom recognition. Every effort should be made to ensure proper follow-up and to implement a long-term plan with the patient's primary care physician within two to four weeks of discharge from the ED. If severe or frequent exacerbations lead to further treatment in the ICU, referral to an asthma specialist, such as a paediatric allergist or respirologist, is strongly recommended.

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