

# Managing Asthma Exacerbations in the Emergency Department

## Summary of the National Asthma Education and Prevention Program Expert Panel Report 3 Guidelines for the Management of Asthma Exacerbations

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This article summarizes the recommendations regarding the management of asthma exacerbations presented in the Expert Panel Report 3 (EPR3) (1). The evidence supporting these recommendations can be found in the report itself. All of the recommendations in this article are strong recommendations, unless indicated by the term “conditional.”

Asthma exacerbations consist of acute or subacute episodes of progressively worsening shortness of breath, coughing, wheezing, and chest tightness or any combination thereof. These episodes differ from poor asthma control in that diurnal variability in airflow, a key marker of poor asthma control, might not change during an exacerbation (2). An important advance in the new National Asthma Education and Prevention Program (NAEPP) EPR3 guidelines (1) is the creation of a chapter devoted to the management of asthma exacerbations. Moreover, the new EPR3 guidelines present different spirometry cut points for assessing the severity of acute asthma (exacerbations) versus chronic asthma. These and other changes underscore the distinction between acute and chronic asthma management.

Two patient populations at particular risk during an asthma exacerbation include patients with one or more risk factors for asthma-related death (Table 1) and infants, who are at greater risk for respiratory failure because of differences in lung anatomy and physiology. The assessment and treatment of young children pose unique challenges, but management of asthma exacerbations in older children is generally similar to that in adults.

Abbreviations used: ED, Emergency department; EMS, emergency medical services; EPR3, Expert Panel Report 3; MDI, metered-dose inhaler; PEF, peak expiratory flow; Sa<sub>O</sub><sub>2</sub>, arterial oxygen saturation.

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Early treatment of asthma exacerbations is the best strategy for management. Important elements of early treatment at the patient's home include a written asthma action plan; recognition of early signs and symptoms of worsening; appropriate intensification of therapy by increasing short-acting  $\beta$ -agonists and, in some cases, adding a short course of oral corticosteroids; removal, or withdrawal from an environmental factor contributing to the exacerbation; and prompt communication between the patient and clinician, seeking emergency care for severe manifestations, or both. Despite adherence to optimal chronic asthma care, it is increasingly recognized that some patients will require an urgent office visit or even an emergency department (ED) visit for further asthma care.

### CLASSIFYING THE SEVERITY OF ASTHMA EXACERBATIONS

Symptoms of asthma exacerbations include breathlessness, coughing, wheezing, and chest tightness. The signs of asthma exacerbation include agitation, increased respiratory rate, increased pulse rate, and decreased lung function as measured by FEV<sub>1</sub>, peak expiratory flow (PEF), PaO<sub>2</sub>, PaCO<sub>2</sub>, and arterial oxygen saturation (Sa<sub>O</sub><sub>2</sub>). The use of accessory muscles and the inability to talk in sentences or even in phrases might or might not be present, depending on the severity of the exacerbation.

The severity of these symptoms and signs, along with the findings on functional lung assessment, are used to categorize asthma exacerbations as mild, moderate, severe, or life-threatening (Table 2). The primary determinant of severity is percent predicted FEV<sub>1</sub> or PEF. The exacerbation severity determines treatment. Mild exacerbations can usually be managed at home, but more severe exacerbations might require treatment and monitoring in the ED or, in more serious cases, hospital admission.

### INITIAL ASSESSMENT OF ASTHMA EXACERBATIONS IN THE ED

Severe exacerbations of asthma are potentially life-threatening and therefore require prompt care, close observation for deterioration, and frequent treatments. Serial measurement of lung function provides an objective measure of improvement. The NAEPP Expert Panel recommends that all clinicians treating asthmatic patients be prepared to treat an asthma exacerbation, recognize the signs and symptoms of severe and life-threatening exacerbations (Table 2), and be familiar with the risk factors for asthma-related death (Table 1). All patients presenting with a reported asthma exacerbation should be evaluated and triaged immediately, with treatment instituted

**TABLE 1. RISK FACTORS FOR DEATH FROM ASTHMA (ORIGINALLY PUBLISHED AS FIGURE 5-2A IN THE EPR3 [1])**

Asthma history
Previous severe exacerbation (e.g., intubation or ICU admission for asthma)
Two or more hospitalizations for asthma in the past year
Three or more ED visits for asthma in the past year
Hospitalization or ED visit for asthma in the past month
Using > 2 canisters of SABA per month
Difficulty perceiving asthma symptoms or severity of exacerbations
Other risk factors: lack of a written asthma action plan, sensitivity to <i>Alternaria</i>
Social history
Low socioeconomic status or inner-city residence
Illicit drug use
Major psychosocial problems
Comorbidities
Cardiovascular disease
Other chronic lung disease
Chronic psychiatric disease

*Definition of abbreviations:* ED = emergency department; ICU = intensive care unit; SABA, short-acting beta<sub>2</sub>-agonist.

Sources: Abramson *et al.*, 2001; Greenberger *et al.*, 1993; Hardie *et al.*, 2002; Kallenbach *et al.*, 1993; Kikuchi *et al.*, 1994; O'Hollaren *et al.*, 1991; Rodrigo and Rodrigo, 1993; Strunk and Mrazek, 1986; Suissa *et al.*, 1994.

promptly on determination of a moderate, severe, or life-threatening exacerbation (Figure 1).

While initial treatment is given, the clinician should obtain a brief history and perform a brief physical examination. The clinician should assess lung function (unless patient is in respiratory extremis) and obtain laboratory studies only as needed.

## HISTORY

The brief history should include the time of onset; any potential causes of the exacerbation; the severity of symptoms, especially compared with previous exacerbations; and the response to any treatment given before admission to the ED. In addition, the clinician should list all current medications and the time of the last dose (especially for asthma medications), along with the estimated number of previous unscheduled office visits, ED visits, and hospitalizations for asthma, particularly within the preceding year. It is also important to note any previous episodes of serious respiratory insufficiency (e.g., involving loss of consciousness or intubation) and any other potentially complicating illness, particularly pulmonary or cardiac disease or any disease that might be aggravated by systemic corticosteroid therapy, such as diabetes or hypertension.

## PHYSICAL EXAMINATION

The objective of the brief physical examination is to assess both the severity of the exacerbation (Table 2) and overall patient status, including level of alertness, fluid status, presence of cyanosis, respiratory distress, and wheezing, although wheezing can be an unreliable indicator of airway obstruction. Any possible complications, such as pneumonia, pneumothorax, or pneumomediastinum, should be identified. Upper airway obstruction, such as that caused by foreign bodies, epiglottitis, organic diseases of the larynx, vocal cord dysfunction, and extrinsic and intrinsic tracheal narrowing, should be ruled out. Clues to the presence of upper airway obstruction as a cause of dyspnea include dysphonia, inspiratory stridor, monophonic wheezing that is loudest over the central airway, normal PaO<sub>2</sub>, and complete resolution of airflow obstruction with intubation. If upper airway obstruction is suspected, the patient should be evaluated by using flow–volume curves and laryngoscopy, either during or after the ED visit, depending on the severity of the obstruction.

## ASSESSMENT OF LUNG FUNCTION

In adults and most children older than 5 years, serial measurement of lung function by using either FEV<sub>1</sub> or PEF performed at presentation and again 30 to 60 minutes after initial treatment is very useful in categorizing the severity of the exacerbation and indicating the need for hospitalization. However, in patients experiencing a severe or life-threatening exacerbation with obvious airway compromise and cyanosis, these objective measurements are not recommended at the time of presentation because they provide little additional information and can be very uncomfortable for the patient. In such cases the physical presentation should suffice for initial clinical assessment, and treatment should be initiated promptly. Thus 100% FEV<sub>1</sub> or PEF testing at triage is not a realistic or desirable goal. The optimal percentage of early spirometric testing (e.g., > 80%) will depend on the frequency of very severe exacerbations in a given ED. For the patients who present in respiratory extremis, for whom initial FEV<sub>1</sub> or PEF assessment was not performed, it is important to note that they are likely to benefit from such testing later in the ED visit (e.g., after a few inhaled short-acting β<sub>2</sub>-agonist treatments or before hospital admission).

Assessment of lung function is more difficult in children than in adults. No single assessment tool appears to be the best for determining the severity of exacerbation in children (3–11), and in some children neither FEV<sub>1</sub> nor PEF results are obtainable during an exacerbation. In one study only 65% of children aged 5 to 18 years could complete either of these measurements during an exacerbation; among children younger than 5 years, these maneuvers were almost impossible (4).

For this reason, pulse oximetry performed at the time of arrival to the ED and repeated 1 hour after initial treatment is recommended for assessment of lung function in infants and young children. After 1 hour, those children who continue to meet the criteria for a severe exacerbation have a greater than 86% chance of requiring hospitalization, those who meet the criteria for a moderate exacerbation have an 84% chance of requiring hospitalization, and those in whom the second assessment indicates mild exacerbation have only an 18% chance of requiring hospitalization (7).

In infants, assessment of lung function depends more on physical examination than on objective measurement. Use of accessory muscles, inspiratory and expiratory wheezing, paradoxical breathing, cyanosis, and a respiratory rate of greater than 60 breaths/minute all signal serious distress, as does SaO<sub>2</sub> of less than 90%. Because infants are at greater risk of respiratory failure, a lack of response to short-acting β<sub>2</sub>-agonist therapy, as evidenced by either physical examination or objective measurements, indicates the need for hospitalization (9). In infants it is particularly important to monitor SaO<sub>2</sub> by means of pulse oximetry because infants' ventilation–perfusion characteristics cause them to become hypoxemic more readily than adults. SaO<sub>2</sub> should be normal for altitude, and a repeat SaO<sub>2</sub> of less than 92% on room air 1 hour after initial treatment is a reliable predictor of the need for hospitalization (10, 12, 13). Use of oral corticosteroids early in the episode is essential but should not substitute for careful assessment by a physician. Most acute wheezing episodes result from viral infections and might be accompanied by fever; antibiotic treatment generally is not required.

## LABORATORY STUDIES

Most patients with an asthma exacerbation do not require laboratory studies. If ordered, laboratory studies must not result

**TABLE 2. CRITERIA FOR CATEGORIZING THE SEVERITY OF ASTHMA EXACERBATIONS (ORIGINALLY PUBLISHED AS FIGURE 5-3 IN THE EPR3 [1])**

	Mild	Moderate	Severe	Subset: Respiratory Arrest Imminent
<b>Symptoms</b>				
Breathlessness	While walking	While at rest (infant—softer, shorter cry, difficulty feeding)	While at rest (infant—stops feeding)	
Talks in Alertness	Can lie down Sentences May be agitated	Prefers sitting Phrases Usually agitated	Sits upright Words Usually agitated	Drowsy or confused
<b>Signs</b>				
Respiratory rate	Increased	Increased Guide to rates of breathing in awake children: Age < 2 mo 2–12 mo 1–5 yr 6–8 yr Commonly	Often > 30/minute Normal rate < 60/min < 50/min < 40/min < 30/min Usually	
Use of accessory muscles; suprasternal retractions	Usually not			Paradoxical thoracoabdominal movement
Wheeze	Moderate, often only end expiratory	Loud; throughout exhalation	Usually loud; throughout inhalation and exhalation	Absence of wheeze
Pulse/minute	< 100	100–120 Guide to normal pulse rates in children: Age 2–12 mo 1–2 yr 2–8 yr	> 120 Normal rate < 160/min < 120/min < 110/min	Bradycardia
Pulsus paradoxus	Absent < 10 mm Hg	May be present 10–25 mm Hg	Often present > 25 mm Hg (adult), 20–40 mm Hg (child)	Absence suggests respiratory muscle fatigue
<b>Functional assessment</b>				
PEF percent predicted or percent personal best	≥ 70 percent	~ 40–69 percent or response lasts < 2 hours	< 40 percent	< 25 percent (Note: PEF testing may not be needed in very severe attacks)
Pa <sub>O</sub> <sub>2</sub> (on air) and/or Pco <sub>2</sub>	Normal (test not usually necessary)	≥ 60 mm Hg (test not usually necessary)	< 60 mm Hg: possible cyanosis	
Sa <sub>O</sub> <sub>2</sub> percent (on air) at sea level	< 42 mm Hg (test not usually necessary) > 95 percent (test not usually necessary) Hypercapnia (hypoventilation) develops more readily in young children than in adults and adolescents.	< 42 mm Hg (test not usually necessary) 90–95 percent (test not usually necessary)	≥ 42 mm Hg: possible respiratory failure < 90 percent	

*Definition of abbreviations:* Pa<sub>O</sub><sub>2</sub> = arterial oxygen pressure; Pco<sub>2</sub> = partial pressure of carbon dioxide; PEF = peak expiratory flow; Sa<sub>O</sub><sub>2</sub> = oxygen saturation. The presence of several parameters, but not necessarily all, indicates the general classification of the exacerbation.

Many of these parameters have not been systematically studied, especially as they correlate with each other. Thus, they serve only as general guides (Cham *et al.*, 2002; Chey *et al.*, 1999; Gorelick *et al.*, 2004b; Karras *et al.*, 2000; Kelly *et al.*, 2002b and 2004; Keogh *et al.*, 2001; McCarren *et al.*, 2000; Rodrigo and Rodrigo 1998b; Rodrigo *et al.*, 2004; Smith *et al.*, 2002).

The emotional impact of asthma symptoms on the patient and family is variable but must be recognized and addressed and can affect approaches to treatment and follow up (Ritz *et al.*, 2000; Strunk and Mrzcek 1986; von Leupoldt and Dahme 2005).

in delay of treatment. Laboratory studies are used to detect actual or impending respiratory failure, theophylline toxicity, or conditions that complicate asthma treatment, such as cardiovascular disease, pneumonia, or diabetes. For example, arterial blood gas measurements are helpful for evaluating Pa<sub>CO</sub><sub>2</sub> in patients with suspected hypoventilation, those in severe distress, or those with FEV<sub>1</sub> or PEF results of 25% or less of predicted value after initial treatment. A complete blood cell count is rarely needed, but might be appropriate in patients with fever or purulent sputum, but clinicians should bear in mind that modest leukocytosis is common in patients with asthma. A chest radiograph is not recommended for routine assessment but should be obtained for patients suspected of having congestive heart failure, pneumothorax, pneumomediastinum, pneumonia,

or lobar atelectasis. A baseline electrocardiogram and monitoring of cardiac rhythm are appropriate in patients older than 50 years and in those who have known coexistent heart disease or chronic obstructive pulmonary disease.

## TREATMENT OF ASTHMA EXACERBATIONS

### Prehospital Management

The Expert Panel recommends that emergency medical services (EMS) providers administer supplemental oxygen and inhaled short-acting bronchodilators to all patients who have signs or symptoms of an asthma exacerbation. EMS providers should have a standing order allowing them to provide albuterol to patients with an asthma exacerbation, which is consistent with

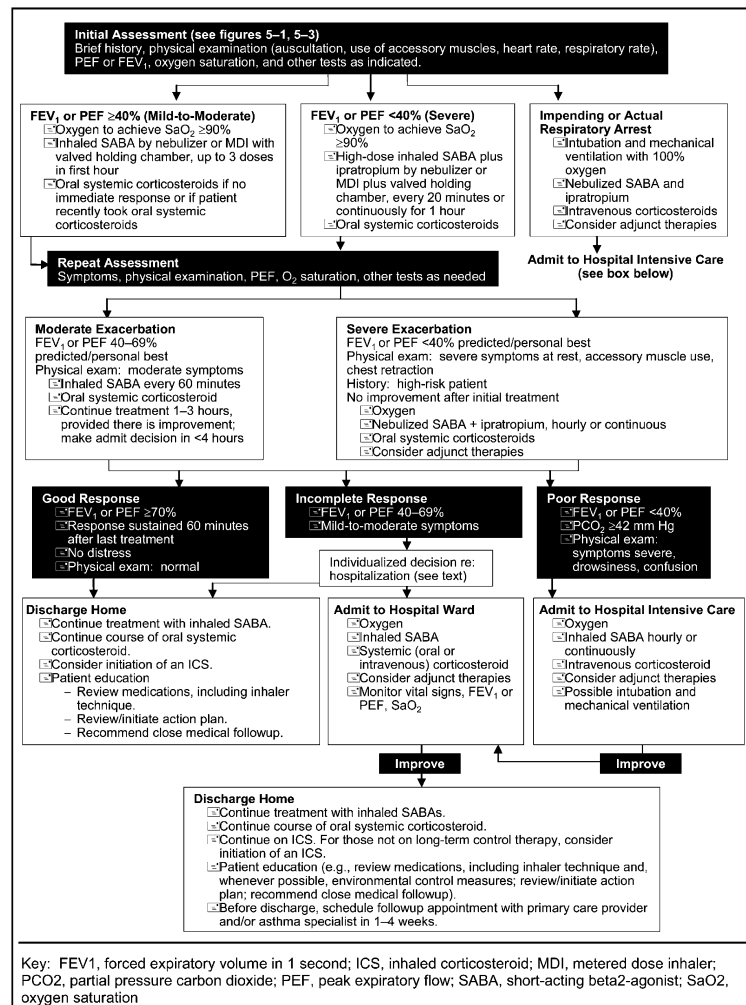


Figure 1. Management of asthma exacerbations: ED- and hospital-based care (originally published as Fig 5-6 in the EPR3 [1]).

their legally authorized scope of practice and with local medical directives. They should also have available a nebulizer, an inhaler plus a spacer/holding chamber, or both for  $\beta_2$ -agonist administration. If  $\beta_2$ -agonist treatment is not possible, subcutaneous epinephrine or terbutaline can also be administered for severe exacerbations (14, 15).

When administering bronchodilator treatment, EMS personnel should not delay patient transport to the hospital. Treatment can be repeated while transporting the patient to a maximum of three bronchodilator treatments during the first hour and then one per hour thereafter. All EMS personnel should receive training in how to respond to the signs and symptoms of severe airway obstruction and impending respiratory failure (16).

## ED Management

In the ED, the severity of the asthma exacerbation determines the intensity of treatment and the frequency of patient monitoring. In general, primary treatment (i.e., administration of oxygen, inhaled  $\beta_2$ -agonists, and systemic corticosteroids) is the same for all asthma exacerbations, but the dose and frequency of administration, along with the frequency of patient monitoring, differ depending on the severity of the exacerbation (Figure 1 and Table 3). In addition to these three primary treatments,

therapy with inhaled ipratropium bromide or other agents might also be necessary in severe exacerbations.

**Oxygen.** Administration of oxygen through nasal cannulae or a mask is recommended to maintain SaO<sub>2</sub> at greater than 90% (> 95% in pregnant women and patients with concomitant heart disease). Oxygen saturation should be monitored until a clear response to bronchodilator therapy has occurred.

**Inhaled short-acting  $\beta_2$ -agonists.** All patients should receive inhaled  $\beta_2$ -agonist treatment because repetitive or continuous administration of these agents is the most effective means of reversing airflow obstruction (Table 3) (17-20). In the ED, three treatments administered every 20 to 30 minutes is a safe strategy for initial therapy. Thereafter, frequency of treatment varies according to patient response (i.e., improvement in airflow obstruction and associated symptoms). About 60% to 70% of patients will respond sufficiently to the initial three doses to be discharged, and most of these will demonstrate a significant response after the first dose (18, 21, 22).

In patients with severe exacerbations (i.e., < 40% of predicted value for either FEV<sub>1</sub> or PEF), continuous administration of  $\beta_2$ -agonists might be more effective than intermittent administration (17). The duration of bronchodilation from short-acting  $\beta_2$ -agonists is not precisely known, but might be significantly shorter than in patients with stable asthma. Because of

TABLE 3. DOSAGES OF DRUGS FOR ASTHMA EXACERBATIONS (ORIGINALLY PUBLISHED AS FIGURE 5-5 IN THE EPR3 [1])

Medication	Dosages		Comments
	Child Dose*	Adult Dose	
<b>Inhaled short-acting beta<sub>2</sub>-agonists (SABA)</b>			
<b>Albuterol</b>			
Nebulizer solution (0.63 mg/3 ml, 1.25 mg/3 ml, 2.5 mg/3 ml, 5.0 mg/ml)	0.15 mg/kg (minimum dose 2.5 mg) every 20 min for 3 doses then 0.15–0.3 mg/kg up to 10 mg every 1–4 h as needed, or 0.5 mg/kg/h by continuous nebulization.	2.5–5 mg every 20 min for 3 doses, then 2.5–10 mg every 1–4 h as needed, or 10–15 mg/h continuously.	Only selective beta <sub>2</sub> -agonists are recommended. For optimal delivery, dilute aerosols to minimum of 3 ml at gas flow of 6–8 L/min. Use large volume nebulizers for continuous administration. May mix with ipratropium nebulizer solution.
MDI (90 µg/puff)	4–8 puffs every 20 min for 3 doses, then every 1–4 h inhalation maneuver as needed. Use VHC; add mask in children < 4 yr.	4–8 puffs every 20 min up to 4 h, then every 1–4 h as needed.	In mild-to-moderate exacerbations, MDI plus VHC is as effective as nebulized therapy with appropriate administration technique and coaching by trained personnel.
<b>Bitolterol</b>			
Nebulizer solution (2 mg/ml)	See albuterol dose; thought to be half as potent as albuterol on mg basis.	See albuterol dose.	Has not been studied in severe asthma exacerbations. Do not mix with other drugs.
MDI (370 µg/puff)	See albuterol MDI dose.	See albuterol MDI dose.	Has not been studied in severe asthma exacerbations.
<b>Levalbuterol (R-albuterol)</b>			
Nebulizer solution (0.63 mg/3 ml, 1.25 mg/0.5 ml, 1.25 mg/3 ml)	0.075 mg/kg (minimum dose 1.25 mg) every 20 min for 3 doses, then 0.075–0.15 mg/kg up to 5 mg every 1–4 h as needed.	1.25–2.5 mg every 20 min for 3 doses, then 1.25–5 mg every 1–4 h as needed.	Levalbuterol administered in one-half the mg dose of albuterol provides comparable efficacy and safety. Has not been evaluated by continuous nebulization.
MDI (45 µg/puff)	See albuterol MDI dose.	See albuterol MDI dose.	
<b>Pirbuterol</b>			
MDI (200 µg/puff)	See albuterol MDI dose; thought to be half as potent as albuterol on a mg basis.	See albuterol MDI dose.	Has not been studied in severe asthma exacerbations.
<b>Systemic (injected) beta<sub>2</sub>-agonists</b>			
Epinephrine 1:1,000 (1 mg/ml)	0.01 mg/kg up to 0.3–0.5 mg every 20 min for 3 doses sq.	0.3–0.5 mg every 20 min for 3 doses sq.	No proven advantage of systemic therapy over aerosol.
Terbutaline (1 mg/ml)	0.01 mg/kg every 20 min for 3 doses then every 2–6 h as needed sq.	0.25 mg every 20 min for 3 doses sq.	No proven advantage of systemic therapy over aerosol.
<b>Anticholinergics</b>			
<b>Ipratropium bromide</b>			
Nebulizer solution (0.25 mg/ml)	0.25–0.5 mg every 20 min for 3 doses, then as needed	0.5 mg every 20 min for 3 doses then as needed	May mix in same nebulizer with albuterol. Should not be used as first-line therapy; should be added to SABA therapy for severe exacerbations. The addition of ipratropium has not been shown to provide further benefit once the patient is hospitalized.
MDI (18 µg/puff)	4–8 puffs every 20 min as needed up to 3 h	8 puffs every 20 min as needed up to 3 h	Should use with VHC and face mask for children < 4 yr. Studies have examined ipratropium bromide MDI for up to 3 h.
<b>Ipratropium with albuterol</b>			
Nebulizer solution (each 3-ml vial contains 0.5 mg ipratropium bromide and 2.5 mg albuterol)	1.5 ml every 20 min for 3 doses, then as needed	3 ml every 20 min for 3 doses, then as needed	May be used for up to 3 h in the initial management of severe exacerbations. The addition of ipratropium to albuterol has not been shown to provide further benefit once the patient is hospitalized.
MDI (each puff contains 18 µg ipratropium bromide and 90 µg of albuterol)	4–8 puffs every 20 min as needed up to 3 h	8 puffs every 20 min as needed up to 3 h	Should use with VHC and face mask for children < 4 years.
<b>Systemic corticosteroids</b>			
(Applies to all three corticosteroids)			
Prednisone	1–2 mg/kg in 2 divided doses (maximum = 60 mg/d) until PEF is 70% of predicted or personal best	40–80 mg/d in 1 or 2 divided doses until PEF reaches 70% of predicted or personal best	For outpatient “burst,” use 40–60 mg in single or 2 divided doses for total of 5–10 days in adults (children: 1–2 mg/kg/d maximum 60 mg/d for 3–10 d).
<b>Methylprednisolone</b>			
Prednisolone			

*Definition of abbreviations:* ED = emergency department; MDI = metered-dose inhaler; PEF = peak expiratory flow; VHC = valved holding chamber.

There is no known advantage for higher doses of corticosteroids in severe asthma exacerbations, nor is there any advantage for intravenous administration over oral therapy provided gastrointestinal transit time or absorption is not impaired.

The total course of systemic corticosteroids for an asthma exacerbation requiring an ED visit of hospitalization may last from 3 to 10 days. For corticosteroid courses of less than 1 week, there is no need to taper the dose. For slightly longer courses (e.g., up to 10 d), there probably is no need to taper, especially if patients are concurrently taking ICSs.

ICSs can be started at any point in the treatment of an asthma exacerbation.

\* Children ≤ 12 years of age.

potential cardiotoxicity, only selective short-acting  $\beta$ -agonists (albuterol, levalbuterol, and pirbuterol) should be administered in high doses.

In patients with milder exacerbations, treatment should consist of high doses (4–12 puffs) of a  $\beta_2$ -agonist administered by trained personnel through a metered-dose inhaler (MDI) with a valved holding chamber or by means of nebulizer therapy. Nebulizer therapy might be preferred for those patients who are unable to cooperate effectively in using an MDI because of their age, agitation, or more severe exacerbations.

**Systemic corticosteroids.** Systemic corticosteroids are recommended for most patients (Table 3) because they speed the resolution of airflow obstruction and reduce the rate of post-ED relapse (23). In the ED, systemic corticosteroids should be administered to all patients with moderate-to-severe exacerbations and to those who do not respond to initial  $\beta_2$ -agonist therapy.

The Expert Panel recommends oral administration of prednisone, which has been shown to have effects equivalent to those of intravenous methylprednisolone (24, 25) but is less invasive. Supplemental doses should be given to patients who regularly take corticosteroids, even if the exacerbation is mild. In patients with moderate-to-severe exacerbations, early administration of corticosteroid therapy might reduce the likelihood of hospitalization (23).

The Expert Panel agrees that current evidence is insufficient to warrant recommending high-dose inhaled corticosteroids over oral corticosteroids in the ED; more study is needed regarding the use of inhaled corticosteroids for acute treatment (26).

**Inhaled ipratropium bromide.** The Expert Panel recommends use of inhaled ipratropium bromide for acute treatment in the ED. Multiple high doses (0.5 mg of nebulizer solution or 8 puffs by means of MDI in adults and 0.25–0.5 mg of nebulizer solution or 4–8 puffs by means of MDI in children) should be added to  $\beta_2$ -agonist therapy to increase bronchodilation. The combination of a  $\beta_2$ -agonist and inhaled ipratropium bromide has been shown to reduce hospitalizations, particularly in patients with severe airflow obstruction (27, 28).

**Other treatments.** Antibiotics are not generally recommended for the treatment of asthma exacerbations because viruses are a much more common cause of exacerbations than bacteria. Thus antibiotics should be reserved for relatively rare cases in which there is strong evidence of a coexistent bacterial infection (e.g., pneumonia or sinusitis). Data on possible benefits of macrolide antibiotics are discussed later in this issue, although their use is still not recommended in the absence of other clinical indications based on currently available data. Aggressive hydration is not recommended for older children and adults but might be appropriate for some infants and young children, who could become dehydrated as a result of increased respiratory rate and decreased oral intake. Fluid status should be assessed before administering hydration therapy. The Expert Panel does not recommend the use of methylxanthines, chest physiotherapy, mucolytics, or sedation.

### Repeat Assessment

The Expert Panel recommends that patients with severe exacerbations undergo repeat assessment after the initial dose of inhaled bronchodilator treatment and that all patients, regardless of exacerbation severity, are assessed after three doses of inhaled bronchodilator treatment (i.e., 60–90 min after initiation of therapy). Response to treatment in the ED is a better predictor of the need for hospitalization than the severity of an exacerbation at the time of presentation (3, 5, 7, 9, 29–35). All repeat assessments should include the patient's subjective response to

treatment, physical findings, and FEV<sub>1</sub> or PEF results (or arterial blood gas measurements or pulse oximetry in patients with suspected hypoventilation, those who are in severe distress, and those with FEV<sub>1</sub> or PEF results  $\leq$  25% of predicted value; see earlier discussion of laboratory studies in INITIAL ASSESSMENT OF ASTHMA EXACERBATIONS IN THE ED).

### Impending Respiratory Failure

Although most patients respond well to therapy, a small percentage will show signs of worsening ventilation. Because respiratory failure can progress rapidly and is difficult to reverse, early recognition and treatment are necessary. Signs of impending respiratory failure include an inability to speak, altered mental status, intercostal retraction (29), worsening fatigue, and a PaCO<sub>2</sub> of 42 mm Hg or greater. The Expert Panel recommends that intubation not be delayed once it is deemed necessary.

Because intubation of a severely ill asthmatic patient is difficult and can result in complications, other treatments, such as intravenous magnesium, heliox, and other treatments, are sometimes attempted.

- Intravenous magnesium sulfate has no apparent value in patients with exacerbations of lower severity, but it might be considered (conditional recommendation) in those with life-threatening exacerbations and those whose exacerbations remain severe after 1 hour of intensive conventional treatment (36, 37). The selective use of intravenous magnesium sulfate already has been adopted by many academic EDs (38). The dose is 2 g over 20 minutes in adults and 25 to 75 mg/kg in children (up to a maximum of 2 g).
- Heliox-driven albuterol nebulization can also be considered (conditional recommendation) in these patients (39, 40). Heliox also can be used to quickly decrease the work of breathing. Unfortunately, the heliox literature is complicated by the small number of subjects in most trials and by important methodological differences between trials. For example, some studies have neglected to account for the different effect of heliox versus oxygen on respirable mass (41). A large multicenter study is needed to resolve lingering questions about this promising therapy.
- Intravenous administration of  $\beta_2$ -agonists is a largely unproved treatment (20), and the Expert Panel does not recommend use of intravenous isoproterenol in the treatment of asthma because of the danger of myocardial toxicity. Similarly, there is insufficient evidence to date to recommend the use of leukotriene modifiers (42) or non-invasive ventilation (43) in the treatment of acute asthma.

### Intubation

The Expert Panel makes the following recommendations with regard to intubation:

- Patients presenting with apnea or coma should be intubated immediately. Persistent or increasing hypercapnia, exhaustion, and depressed mental status strongly suggest the need for ventilatory support.
- Consultation with or comanagement by a physician expert in ventilator management is essential because ventilation of patients with severe asthma is complicated and risky.
- Because intubation is difficult in asthmatic patients, it should be done semielectively and before respiratory

**EMERGENCY DEPARTMENT—ASTHMA DISCHARGE PLAN**

**Name:** \_\_\_\_\_ was seen by **Dr.** \_\_\_\_\_ on \_\_\_\_/\_\_\_\_/\_\_\_\_

- Take your prescribed medications as directed—do not delay!
- Asthma attacks like this one can be prevented with a long-term treatment plan.
- Even when you feel well, you may need daily medicine to keep your asthma in good control and prevent attacks.
- Visit your doctor or other health care provider as soon as you can to discuss how to control your asthma and to develop *your own* action plan.

**Your followup appointment** with \_\_\_\_\_ is on: \_\_\_\_/\_\_\_\_/\_\_\_\_. **Tel:** \_\_\_\_\_

**YOUR MEDICINE FOR THIS ASTHMA ATTACK IS:**

Medication	Amount	Doses per day, for # days
Prednisone/prednisolone (oral corticosteroid)		_____ a day for _____ days Take the entire prescription, even when you start to feel better.
Inhaled albuterol		_____ puffs every 4 to 6 hours if you have symptoms, for _____ days

**YOUR DAILY MEDICINE FOR LONG-TERM CONTROL AND PREVENTING ATTACKS IS:**

Medication	Amount	Doses per day
Inhaled corticosteroids		

**YOUR QUICK-RELIEF MEDICINE WHEN YOU HAVE SYMPTOMS IS:**

Medication	Amount	Number of doses/day
Inhaled albuterol		

**ASK YOURSELF 2 TO 3 TIMES PER DAY, EVERY DAY, FOR AT LEAST 1 WEEK:**  
 “How good is my asthma compared to when I left the hospital?”

If you feel much better:	If you feel better, but still need your quick-relief inhaler often:	If you feel about the same:	If you feel worse:
<ul style="list-style-type: none"> <li>• Take your daily long-term control medicine.</li> </ul>	<ul style="list-style-type: none"> <li>• Take your daily long-term-control medicine.</li> <li>• See your doctor as soon as possible.</li> </ul>	<ul style="list-style-type: none"> <li>• Use your quick-relief inhaler.</li> <li>• Take your daily long-term control medicine.</li> <li>• See your doctor as soon as possible—don't delay.</li> </ul>	<ul style="list-style-type: none"> <li>• Use your quick-relief inhaler.</li> <li>• Take your daily long-term control medicine.</li> <li>• Immediately go to the emergency department or call 9–1–1.</li> </ul>

**YOUR ASTHMA IS UNDER CONTROL WHEN YOU:**

① Can be active daily and sleep through the night.	② Need fewer than 4 doses of quick-relief medicine in a week.	③ Are free of shortness of breath, wheeze, and cough.	④ Achieve an acceptable “peak flow” (discuss with your health care provider).
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Figure 2. ED asthma discharge plan (originally published as Fig 5-7 in the EPR3 [1]).

arrest occurs. Once intubation is deemed necessary, it should not be delayed and therefore should be performed in the ED, with the patient transferred to an intensive care unit appropriate to the patient’s age.

- Two issues must be considered at the time of intubation. First, intravascular volume should be maintained or replaced because hypotension commonly accompanies the initiation of positive pressure ventilation. In addition, high ventilator pressures, with their associated risks of barotrauma, should be avoided.
- “Permissive hypercapnia” or “controlled hypoventilation” is the recommended ventilator strategy because it provides adequate oxygenation while minimizing airway pressures and the possibility of barotrauma (44–46). However, this strategy is not uniformly successful in critically ill asthmatic patients, and additional therapies are under evaluation.

**EDUCATION OF THE ASTHMATIC PATIENT IN THE ED**

The Expert Panel acknowledges that more research is needed in this area but, based on currently available information, advises offering a focused patient-education intervention to individuals who present to the ED with an asthma exacerbation. The general points of focus for this intervention are general asthma education, review of inhaler technique, a simple written asthma discharge plan, and referral for follow-up.

To help patients recognize and respond to symptoms of asthma, the provider should prepare a simple asthma discharge plan for asthma symptoms and explain it and be sure to include daily treatment plans, as well as plans for how to manage an exacerbation (Figure 2). Because many patients do not use an inhaler correctly, it is important to review inhaler technique with the patient and correct technique errors (Figure 3). Also, refer the patient for a follow-up asthma care appointment with a primary care physician or an asthma specialist within 1 week

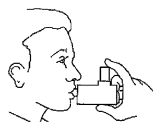
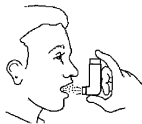
Using an inhaler seems simple, but most patients do not use it the right way. When you use your inhaler the wrong way, less medicine gets to your lungs.

For the next few days, read these steps aloud as you do them or ask someone to read them to you. Ask your doctor, nurse, other health care provider, or pharmacist to check how well you are using your inhaler.

Use your inhaler in one of the three ways pictured below. A or B are best, but C can be used if you have trouble with A and B. Your doctor may give you other types of inhalers.

### Steps for Using Your Inhaler

- |  |  |
|--|--|
| Getting ready  | 1. Take off the cap and shake the inhaler.<br>2. Breathe out all the way.<br>3. Hold your inhaler the way your doctor said (A, B, or C below).   |
| Breathe in slowly  | 4. As you start breathing in slowly through your mouth, press down on the inhaler one time. (If you use a holding chamber, first press down on the inhaler. Within 5 seconds, begin to breathe in slowly.)<br>5. Keep breathing in slowly, as deeply as you can. |
| Hold your breath   | 6. Hold your breath as you count to 10 slowly, if you can.<br>7. For inhaled quick-relief medicine (short-acting beta <sub>2</sub> -agonists), wait about 15–30 seconds between puffs. There is no need to wait between puffs for other medicines.               |
| A. Hold inhaler 1 to 2 inches in front of your mouth (about the width of two fingers). | B. Use a spacer/holding chamber. These come in many shapes and can be useful to any patient.   |
|  | C. Put the inhaler in your mouth. Do not use for steroids.   |



Clean your inhaler as needed, and know when to replace your inhaler. For instructions, read the package insert or talk to your doctor, other health care provider, or pharmacist.

**Figure 3.** ED asthma discharge education: how to use your MDI (originally published as Fig 5-7b in the EPR3 [1]).

and encourage the patient's participation in a more formal asthma education program.

### PATIENT DISCHARGE

The Expert Panel recommends that patients who demonstrate a rapid response to treatment be observed for 30 to 60 minutes after the most recent dose of bronchodilator therapy to ensure stability of response before discharge to home. In general, patients can be discharged if FEV<sub>1</sub> or PEF results are 70% or more of predicted value or personal best and symptoms are minimal or absent. Patients with an incomplete response to therapy (i.e., FEV<sub>1</sub> or PEF results of 50% to 69% of predicted value or personal best) and with mild symptoms should be assessed on an individual basis, taking into account any risk factors for asthma-related death. Extended treatment or observation in a holding or overnight unit might be appropriate for some patients.

Patients given systemic corticosteroids should be prescribed sufficient medication to continue therapy for 3 to 10 days after discharge. For those patients considered at high risk of non-adherence, intramuscular depot injections might be as effective as oral corticosteroids in preventing relapse (47–49). The need for additional corticosteroid treatment should be assessed at a follow-up visit. Patients who are currently receiving inhaled corticosteroid therapy should continue this treatment while taking systemic corticosteroids. The Expert Panel recommends

that clinicians consider (conditional recommendation) initiating inhaled corticosteroids at discharge in patients not already receiving them.

Because an ED visit is often the result of inadequate long-term management of asthma, clinicians should stress the need for regular care in an outpatient setting and ensure that all patients are referred for a follow-up medical appointment. When possible, the ED should schedule such an appointment before discharge to increase the likelihood that the patient will keep the appointment.

A discharge plan is useful to ensure that patients are provided with the necessary medications and taught how to use them, instructed in how to monitor symptoms, given a follow-up appointment, and instructed in a written plan for managing recurrence of airflow obstruction (Figures 2 and 3).

### SUMMARY

Most asthma exacerbations require immediate care, close observation for deterioration, frequent treatment, and repeated measurement of lung function. The NAEPP Expert Panel recommends that all clinicians treating asthmatic patients should be prepared to treat an asthma exacerbation, recognize the signs and symptoms of severe and life-threatening exacerbations, and be familiar with the risk factors for asthma-related death. Because infants are at greater risk for respiratory failure, clinicians should also be familiar with special considerations in the assessment and treatment of infants experiencing asthma exacerbations.



All patients presenting with an asthma exacerbation should be evaluated and triaged immediately, with treatment instituted promptly on determination of a moderate, severe, or life-threatening exacerbation. Primary treatment consists of administration of oxygen, inhaled  $\beta_2$ -agonists, and systemic corticosteroids, with the dose and frequency of administration, along with the frequency of patient monitoring, dependent on the severity of the exacerbation.

After treatment and repeat assessment, patients can generally be discharged if FEV<sub>1</sub> or PEF results are 70% or more of predicted value or personal best and symptoms are minimal or absent. Before discharge, patients should be prescribed 3 to 10 days of corticosteroid therapy to reduce the risk of recurrence and provided with a follow-up appointment to evaluate the need for additional corticosteroid treatment. Clinicians should consider (conditional recommendation) initiating inhaled corticosteroids. Patients should also be educated on correct use of the inhaler and should be given a written discharge plan for increasing medications or seeking care in the event of worsening asthma.

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