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Pamela Runge Wood and Vanessa L. Hill

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Practical Management of Asthma

Pamela Runge Wood, MD,* Vanessa L. Hill, MD†

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Objectives

After completing this article, readers should be able to:

1. Identify the major environmental factors and comorbid conditions that affect asthma.
2. Describe the role of a written asthma action plan in the management of asthma.
3. Know how to assess asthma control and adjust therapy appropriately.
4. Discuss the evaluation and management of the child who has an acute exacerbation of asthma.

Introduction

Despite advances in medical management, childhood asthma continues to be a leading cause of emergency department visits, hospitalizations, and school days missed in the United States. Children afflicted with uncontrolled asthma have difficulty exercising, sleeping, and participating in the normal activities of childhood. Their families may experience financial, social, and work-related difficulties as a result of the child's illness. By working in partnership with families, health-care professionals can help improve asthma outcomes and family functioning. This article reviews the management of asthma. Recommendations discussed in this article are based on the 2007 *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma* ("2007 Guidelines"). (1) The level of evidence for statements and recommendations is included, when possible. (1)

Initial Assessment

Once asthma has been diagnosed, the physician should determine the degree of severity in the individual patient. Severity is determined best at the time of diagnosis, before initiation of therapy. There are four categories of asthma severity: intermittent, mild persistent, moderate persistent, and severe persistent. The most important distinction is between intermittent and persistent asthma because all individuals who have persistent asthma should be started on long-term control medication. The 2007 Guidelines provide tables for determining asthma severity and initial treatment recommendations for three different age groups: children 0 to 4 years of age, children 5 to 11 years of age, and children 12 years of age and older and adults (Tables 1 to 3).

The category of asthma severity is based on the amount of "impairment" and "risk." Impairment includes the frequency and severity of daytime and nighttime asthma symptoms, frequency of short-acting beta$_2$ agonist (SABA) use other than for exercise-associated symptoms, degree of interference with activity, and results of pulmonary function testing. Risk is based on the frequency of asthma exacerbations requiring the use of oral corticosteroids. The level of severity always is determined by the most severe level of symptoms, medication use, and other factors. For example, a 6-year-old boy who experiences rare daytime symptoms, rarely uses SABAs, and has a normal activity level and no exacerbations in the past year would be categorized as having "moderate persistent asthma" if he has nighttime symptoms twice a week. Exercise-induced symptoms and the use of a SABA to prevent or treat such symptoms are not included in the determination of asthma severity. However, frequent or

Abbreviations

DPI: dry powder inhaler
EIB: exercise-induced bronchospasm
ICS: inhaled corticosteroid
Ig: immunoglobulin
LABA: long-acting beta$_2$ agonist
LTRA: leukotriene receptor antagonist
MDI: metered dose inhaler
SABA: short-acting beta$_2$ agonist
VHC: valved holding chamber

*Clinical Professor of Pediatrics.
†Assistant Professor of Pediatrics, University of Texas Health Science Center, San Antonio, Tex.

Table 1. Classifying Severity and Initiating Treatment: Children 0 to 4 Years

	Impairment		Risk	
Severity Category	Days and Nights With Symptoms	Interference With Normal Activity	Exacerbations	Preferred Treatment
Severe Persistent	Throughout (days) >1 night/wk (nights)	Extremely limited	(see below)	Step 3: Medium-dose ICS and consider short-course OCS
Moderate Persistent	Daily (days) 3 to 4 nights/month	Some limitation	(see below)	Step 3: Medium-dose ICS and consider short-course OCS
Mild Persistent	3 to 6 days/wk (days) 1 to 2 nights/month (nights)	Minor limitation	2 or more/6 months or ≥4 episodes of wheezing/yr with risk factors for asthma	Step 2: Low-dose ICS
Intermittent	≤2 days/wk (days) 0 nights/month (nights)	None	0 to 1/yr	Step 1: SABA PRN

Exacerbation: episode requiring OCS.
Risk factors for asthma: parent history of asthma, patient has eczema, patient sensitized to aeroallergens, or two of following: patient sensitized to foods, eosinophilia, wheezing apart from colds.
ICS=inhaled corticosteroids, LABA=long-acting beta$_2$ agonist, OCS=oral corticosteroids, SABA=short-acting beta$_2$ agonist
Adapted from the National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma, 2007.* NIH Publication No. 07-4051. Bethesda, Md: National Heart, Lung, and Blood Institute; 2007.

Table 2. Classifying Severity and Initiating Treatment: Children 5 to 11 Years

	Impairment			Risk	
Severity Category	Days and Nights With Symptoms	Interference With Normal Activity	Pulmonary Function	Exacerbations	Preferred Treatment
Severe Persistent	Throughout (days) Often (nights)	Extremely limited	FEV_1: <60% FEV_1/FVC: <75%	2 or more/yr	Step 4: Medium-dose ICS + LABA and consider short-course OCS Step 3: Medium-dose ICS and consider short-course OCS
Moderate Persistent	Daily (days) >1 night/wk (nights)	Some limitation	FEV_1: 60% to 80% FEV_1/FVC: 75% to 80%	2 or more/yr	Step 3: Medium-dose ICS and consider short-course OCS
Mild Persistent	3 to 6 days/wk (days) 3 to 4 nights/month (nights)	Minor limitation	FEV_1: >80% FEV_1/FVC: >80%	2 or more/yr	Step 2: Low-dose ICS
Intermittent	≤2 d/wk (days) ≤2 nights/month (nights)	None	FEV_1: >80% FEV_1/FVC: >85%	0 to 1/yr	Step 1: SABA PRN

FEV_1=forced expiratory volume in 1 second, FVC=forced vital capacity, ICS=inhaled corticosteroids, LABA=long-acting beta$_2$ agonist, OCS=oral corticosteroids, SABA=short-acting beta$_2$ agonist.
Adapted from the National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma, 2007.* NIH Publication No. 07-4051. Bethesda, Md: U.S. National Heart, Lung, and Blood Institute; 2007.

Table 3. Classifying Severity and Initiating Treatment: Youth 12 Years of Age and Older

Severity Category	Impairment: Days and Nights With Symptoms	Impairment: Interference With Normal Activity	Impairment: Pulmonary Function	Risk: Exacerbations	Preferred Treatment
Severe Persistent	Throughout (days) Often, 7×/wk (nights)	Extremely limited	FEV_1: <60% FEV_1/FVC: Reduced >5%	2 or more/yr	Step 5: High-dose ICS + LABA and consider short-course OCS Step 4: Medium-dose ICS + LABA and consider short-course OCS
Moderate Persistent	Daily (days) 2 to 6 night/wk (nights)	Some limitation	FEV_1: 60% to 80% FEV_1/FVC: Reduced 5%	2 or more/yr	Step 3: Low-dose ICS + LABA OR Medium-dose ICS and consider short-course OCS
Mild Persistent	3 to 6 days/wk (days) 3 to 4 nights/month (nights)	Minor limitation	FEV_1: >80% FEV_1/FVC: Normal	2 or more/yr	Step 2: Low-dose ICS
Intermittent	≤2 days/wk (days) ≤2 nights/month (nights)	None	FEV_1: >80% FEV_1/FVC: Normal	0 to 1/yr	Step 1: SABA PRN

FEV_1=forced expiratory volume in 1 second, FVC=forced vital capacity; ICS=inhaled corticosteroids, LABA=long-acting $beta_2$ agonist, OCS=oral corticosteroids, SABA=short-acting $beta_2$ agonist
Adapted from the National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma, 2007.* NIH Publication No. 07-4051. Bethesda, Md: National Heart, Lung, and Blood Institute; 2007.

severe exercise-associated symptoms often are a sign of poorly controlled asthma.

The determination of severity category based on the 2007 Guidelines is not reduced easily to a simple rule. The severity criteria vary with age. Children 0 to 4 years of age may have asthma that is categorized as persistent based on day-to-day impairment or frequent exacerbations (≥2 in 6 months or ≥4 in 1 year) *along with* risk factors for asthma (Table 1). Major risk factors (one required) are: 1) parental history of asthma, 2) atopic dermatitis, and 3) sensitization to aeroallergens. Minor risk factors (two required) are: 1) sensitization to foods, 2) more than 4% eosinophilia, and 3) wheezing apart from colds.

Another key component of initial assessment is to identify and address precipitating factors (asthma "triggers"). The most common categories of asthma triggers in children are: respiratory infections, allergens, airway irritants (eg, environmental tobacco smoke and air pollution), exercise, and medications (eg, nonsteroidal anti-inflammatory medications and beta blockers). The 2007 Guidelines contain sample questionnaires that should be used to help identify and reduce exposure to potential asthma triggers (see Additional Resources). Respiratory infections are a common asthma trigger and are difficult to avoid in young children. All individuals afflicted with asthma should receive an annual influenza vaccination, although data have not shown that the influenza vaccine improves health outcomes.

Many children who have asthma are exposed to environmental tobacco smoke, which is a potent airway irritant for all individuals who have asthma. Children experiencing high degrees of tobacco smoke exposure are more likely to have moderate or severe asthma and decreased lung function compared with those whose exposures are low. (2) Every child who has asthma deserves a smoke-free home, car, and school or child care environment. Household members and other close associates who smoke should be referred to smoking cessation resources. Each state maintains a free hotline for

smoking cessation (1-800-QUITNOW; 1-800-784-8669).

Most children who have asthma (60% to 80%) are sensitized to at least one aeroallergen. Common indoor allergens include house dust mite, cockroach allergen, animal dander, and molds. Prick skin testing or blood testing (allergen-specific immune globulin E [IgE] concentrations) to detect sensitization to common indoor allergens should be considered for any child experiencing persistent asthma, so treatment recommendations can be tailored to the individual child and family. Immunotherapy should be considered for children who have documented sensitivities and mild or moderate persistent asthma. (Evidence level B for house dust mite, animal dander, and pollen.)

The most effective programs to reduce indoor allergens are intensive, multifaceted interventions that address more than one allergen. (3) House dust mite is a common indoor allergen. Dust mite levels can be decreased by reducing indoor humidity, laundering bedding in hot water, placing mite-impenetrable covers on pillows and mattresses, and reducing "dust catchers" (stuffed animals, curtains, books, carpet) in the bedroom. Sensitization and exposure to cockroach allergen has been associated with frequent exacerbations and health-care use among inner-city children who have asthma. (4) Decreasing cockroach antigen in the home often requires an intensive integrated pest management program. Because cockroaches require food and water, basic elimination strategies include placing food and garbage in closed containers, fixing water leaks, and keeping food out of the bedroom. For children who are sensitized to pets, animal dander can be a significant asthma trigger, and efforts should be made to remove pets from the home.

Exercise is a common precipitant of asthma symptoms in children. For some individuals, exercise-induced bronchospasm (EIB) may be the only manifestation of asthma. Children who have EIB experience cough, shortness of breath, and rarely, wheezing, which begins during vigorous activity, reaches a peak 5 to 10 minutes after stopping exercise, and resolves 20 to 30 minutes later. Bronchospasm occurs as a result of hyperventilation of air that is cooler or dryer than the air found in the respiratory tract, which leads to loss of heat or water from the lung. Air pollutants, including ground-level ozone, nitrogen dioxide, and small particulate matter, are airway irritants and worsen the severity of EIB. Current guidelines recommend that individuals afflicted with asthma "avoid, to the extent possible, exertion or exercise outside when levels of air pollution are high." (1) The symptoms of EIB can be prevented or diminished by the administration of a SABA or sodium cromolyn 15 to 20 minutes prior to vigorous activity. Brief warm-up periods prior to vigorous activity may lessen the severity of EIB. Although exercise-associated asthma symptoms are not considered when determining asthma severity, severe or poorly controlled EIB often is a sign of persistent or poorly controlled asthma. Use of daily inhaled corticosteroids often results in improvement of EIB.

Comorbid conditions can affect asthma outcomes adversely. The pediatrician should screen for these conditions both at the initial assessment and as part of ongoing care for children who have asthma. Common comorbid conditions include infection, obesity, depression in child or parent, gastroesophageal reflux, allergies, and obstructive sleep apnea.

Medical Management

Long-term Control Medications

Two types of medications are used to treat asthma: long-term control ("prevention") medications and quick-relief medications, which reverse acute airflow obstruction. All children who have persistent asthma should be started on a long-term control ("prevention") medication. Such anti-inflammatory medications are taken daily to reduce airway inflammation. The recommended type and dose of long-term control medication depends on the level of asthma severity and the age of the child. The 2007 Guidelines provide tables with treatment recommendations (Tables 1 to 3).

Inhaled corticosteroids (ICSs) are the medication of choice for all individuals suffering persistent asthma. ICSs are the most effective anti-inflammatory medication for asthma (evidence level A). ICSs reduce asthma symptoms, improve lung function, reduce acute exacerbations of asthma, and reduce the risk of death from asthma. Recent data show that ICSs are well-tolerated, safe medications at the recommended dosages (Table 4). A recent review provides additional information about ICSs. (5)

ICSs act topically on lung epithelium to inhibit cell migration and activation and to reduce airway hyperresponsiveness. ICSs block the late-phase (inflammatory) reaction to allergen, but not the early-phase (bronchospasm) reaction. With daily administration, some effects from ICSs may be seen within 1 to 2 weeks, but the full anti-inflammatory effect may not be seen for 4 weeks. Similarly, if a child stops taking ICSs, some protective anti-inflammatory effects continue for several weeks after the medication has been stopped. Potential local adverse effects of ICS include oral candidiasis (thrush), dysphonia (hoarseness), reflex cough, and bronchospasm. Such

Table 4. Estimated Comparative Daily Dosages for Inhaled Corticosteroids

	Low Dose			Medium Dose			High Dose		
Inhaled Steroid	0 to 4 yr	5 to 11 yr	12 yr to adult	0 to 4 yr	5 to 11 yr	12 yr to adult	0 to 4 yr	5 to 11 yr	12 yr to adult
Beclomethasone HFA (QVAR®)[1] 40 or 80 mcg/puff	NA	80 to 160 mcg	80 to 240 mcg	NA	>160 to 320 mcg	>240 to 480 mcg	NA	>320 mcg	>480 mcg
Budesonide DPI* (Pulmicort Flexhaler™)[2] 90 or 180 mcg	NA	180 to 400 mcg	180 to 600 mcg	NA	>400 to 800 mcg	>600 to 1,200 mcg	NA	>800 mcg	>1,200 mcg
Budesonide nebulizer* (Pulmicort Respules®)[2] 0.25 mg; 0.5 mg/respule	0.25 to 0.5 mg	0.5 mg	NA	>0.5 to 1 mg	1 mg	NA	>1 mg	2 mg	NA
Flunisolide HFA (Aerospan HFA™)[3] 80 mcg/puff	NA	160 mcg	320 mcg	NA	320 mcg	>320 to 640 mcg	NA	≥640 mcg	>640 mcg
Fluticasone (Flovent HFA®)[4] MDI: 44, 110, 220 mcg/puff	176 mcg	88 to 176 mcg	88 to 264 mcg	>176 to 352 mcg	>176 to 352 mcg	>264 to 440 mcg	>352 mcg	>352 mcg	>440 mcg
Fluticasone (Flovent Diskus®)[4] DPI: 50 mcg/puff	NA	100 to 200 mcg	100 to 300 mcg	NA	>200 to 400 mcg	>300 to 500 mcg	NA	>400 mcg	>500 mcg
Mometasone DPI* (Asmanex Twisthaler®)[5] 110 or 220 mcg/inhalation	NA		200 mcg	NA		400 mcg	NA		>400 mcg

DPI=dry powder inhaler, HFA=hydrofluoroalkane, MDI=metered dose inhaler, NA=not available (either not approved, no data available, or safety/efficacy not established for this age group)
*Approved for once/day dosing
[1]IVAX Corporation, Inc, Miami, Fla.
[2]AstraZeneca LP, Wilmington, De.
[3]Forest Pharmaceuticals, Inc, St. Louis, Mo.
[4]GlaxoSmithKline, Research Triangle Park, NC.
[5]Schering Corporation, Kenilworth, NJ.
Adapted from the National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma, 2007.* NIH Publication No. 07-4051. Bethesda, Md: National Heart, Lung, and Blood Institute; 2007.

adverse effects may be minimized by using a valved holding chamber (VHC) ("spacer") with metered dose inhalers (MDIs) (evidence level A), slowing the rate of inhalation, as well as rinsing the mouth with water ("rinse and spit") following inhalation.

In general, the effectiveness of ICSs far outweighs the potential adverse effects. A low-to-medium dose of ICS may have a small adverse effect on linear growth velocity. Data from the Childhood Asthma Management Program study show that this effect occurs in the first few months of treatment, is usually small, and is not progressive. (6) No data suggest that ICSs affect final adult height. High doses of ICSs may have a greater potential to decrease growth velocity. Because of the potential risk of decreased growth velocity, height should be monitored closely in children taking ICSs, VHCs always should be used to decrease systemic absorption, and the ICS dose should be titrated to the lowest possible effective dose. ICSs have not been shown to decrease bone mineral density or to cause cataracts in children. Low-to-medium doses of ICSs have little, if any, effect on hypothalamic-pituitary-adrenal axis function in children. However, some individuals may be more sensitive to adverse effects of ICSs, even at recommended doses.

Cromolyn sodium and nedocromil are anti-inflammatory medications that stabilize mast cells and interfere with chloride channel function. They prevent both the early- and late-phase response to inhaled allergens. These agents are alternative medications for long-term control in children who have mild persistent asthma and can be used to prevent EIB. Despite their excellent safety profile, these medications are not preferred for long-term control therapy because they are less effective than ICSs.

Leukotriene modifiers interfere with the action of leukotrienes, potent inflammatory mediators that are released from mast cells, eosinophils, and basophils. Two types of medications are available: the leukotriene receptor antagonists (LTRAs), which include montelukast and zafirlukast, and the 5-lipoxygenase inhibitor zileuton. LTRAs are alternative, not preferred, therapy for children who have mild persistent asthma. They also can be used as "add-on" therapy for patients who do not achieve good control with medium-dose ICSs. However, for individuals 12 years of age and older, long-acting $beta_2$ agonists (LABAs) are preferred adjunctive therapy with ICSs because of demonstrated superiority compared with the addition of LTRAs to ICSs. LTRAs can decrease the severity of EIB.

LABAs provide at least 12 hours of bronchodilation by stimulating $beta_2$ receptors in the airway, which increases the concentration of cyclic adenosine monophosphate, causing relaxation of airway smooth muscle. LABAs are available in a dry powder inhaler (DPI) (formoterol) and in combination with ICSs as either DPI (salmeterol) or MDI (salmeterol and formoterol). Recent studies have raised concerns about the safety of LABAs and about the potential for increased risk of exacerbations and adverse events in individuals taking these medications. The United States Food and Drug Administration requires a black box warning on any medication containing LABAs. LABAs are not anti-inflammatory medications and should not be used as monotherapy in asthma. They should not be used to treat acute exacerbations. These medications prevent EIB, but the duration of this effect deteriorates with long-term administration. Therefore, LABAs are not recommended for chronic use before exercise.

LABAs are used along with ICSs for children who have severe persistent asthma and do not achieve good control and for those who have moderate persistent asthma and do not achieve good control with medium-dose inhaled ICSs (Step 3 level care or higher for children 5 years of age and older; Step 4 level care for children 0 to 4 years of age, although few data are available on the use of LABAs in this age group). LABAs are the preferred adjunctive therapy to be added to ICSs for youth 12 years of age and older and for adults (Table 5).

Theophylline is a phosphodiesterase inhibitor that increases cyclic adenosine monophosphate and causes bronchodilation. It may have a small anti-inflammatory effect. Theophylline is an alternative, not preferred, monotherapy for children 5 years of age and older who have mild persistent asthma and an alternative adjunctive therapy to combine with ICS. Theophylline is primarily a bronchodilator and is much less effective than ICSs for long-term control. For these reasons and because of concerns about potential toxicity, theophylline has a limited role in the treatment of childhood asthma.

Omalizumab is a monoclonal anti-IgE antibody that prevents binding of IgE to receptors on basophils and mast cells. This medication can be used as adjunctive therapy for patients 12 years of age and older who have demonstrated sensitivity to aeroallergens and severe persistent asthma that is not controlled well with high-dose ICSs and LABAs. Because severe allergic reactions may occur following infusion of omalizumab, physicians who administer this medication must be prepared to treat anaphylaxis.

Table 5. **Stepwise Approach for Managing Asthma: Preferred Therapy by Age Group**

Age	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
0 to 4 yr	SABA PRN	Low-dose ICS	Medium-dose ICS	Medium-dose ICS + either LABA or montelukast	High-dose ICS + either LABA or montelukast	High-dose ICS + OCS + either LABA or montelukast
5 to 11 yr	SABA PRN	Low-dose ICS	Low-dose ICS + either LABA, LTRA, or theophylline *OR* Medium-dose ICS	Medium-dose ICS + LABA	High-dose ICS + LABA	High-dose ICS + LABA + OCS
12 yr to adult	SABA PRN	Low-dose ICS	Low-dose ICS + LABA *OR* Medium-dose ICS	Medium-dose ICS + LABA	High-dose ICS + LABA*	High-dose ICS + LABA + OCS*

ICS=inhaled corticosteroid, LABA=long-acting beta agonist, LTRA=leukotriene receptor antagonist, OCS=oral corticosteroids, SABA=short-acting beta$_2$ agonist
All patients need quick-relief medication (SABA).
Each Step: Patient education, environmental control, and management of comorbidities.
Steps 2–4 (5 yr to adult): Consider subcutaneous allergen immunotherapy for patients who have persistent, allergic asthma.
*Steps 5–6 (12 yr to adult): Consider omalizumab for patients who have allergies.
Adapted from the National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma, 2007*. NIH Publication No. 07-4051. Bethesda, Md: National Heart, Lung, and Blood Institute; 2007.

Quick-relief Medications

Quick-relief medications are used in all patients who have asthma to reverse acute airway obstruction. This category of medication includes the SABAs and anticholinergic medications. Systemic corticosteroids also are included in the category of quick-relief medications. Although systemic corticosteroids have a more delayed onset of action, they are used to treat acute exacerbations of asthma (see 2007 Guidelines for detailed dosage recommendations).

The SABAs (albuterol, levalbuterol, pirbuterol) relax airway smooth muscle, resulting in bronchodilation within minutes of administration. Peak effect is seen within 15 to 30 minutes and wears off within 4 to 6 hours. SABAs are the treatment of choice for acute exacerbations of asthma and are used to prevent EIB. Common adverse effects include tachycardia, tremulousness, and irritability. With prolonged use or at high doses, these medications can cause hypokalemia. Excessive or frequent use of SABAs (>2 days/wk) is associated with poorly controlled asthma and an increased risk of hospitalization and death.

The anticholinergic medications (eg, ipratropium) act as bronchodilators by inhibiting muscarinic cholinergic receptors and reducing vagal tone of the airways. They are used in acute, moderate, or severe exacerbations of asthma. Anticholinergics are effective adjuvant therapy in combination with inhaled albuterol during the initial emergency treatment of moderate or severe exacerbations of asthma and are not recommended for the inpatient setting.

Systemic corticosteroids are used in the treatment of moderate or severe exacerbations of asthma. They improve airway responsiveness to SABAs, improve lung function, and decrease the risk of relapse from an acute exacerbation. Onset of action is within 4 to 6 hours of administration; oral administration is as effective as intravenous administration. The adverse effects from systemic corticosteroids depend on the dose and duration of use. Most studies report few adverse effects from short "bursts" (3 to 10 days). Frequent use of systemic corticosteroids (eg, daily or >2 "bursts" per year) is a sign of poorly controlled asthma and may be associated with mild adrenal suppression. Table 5 summarizes a stepwise approach to managing asthma in different age groups.

Some families use complementary and alternative medical therapies to treat their children's asthma. A recent review provides additional information about the safety and effectiveness of such therapies. (7)

Medication Delivery Devices

Asthma medications can be administered from a variety of aerosol delivery devices, including MDIs, breath-actuated MDIs, DPIs, and nebulizers. MDIs should be used with a VHC, which is interposed between the MDI and the child. VHCs improve deposition of medication in the airways and reduce the amount of medication deposited in the mouth and throat, thereby decreasing local and systemic adverse effects.

Hydrofluoroalkane has replaced chlorofluorocarbon as the propellant in all MDIs produced in the United States. Hydrofluoroalkane produces a slightly softer, less forceful spray compared with the older propellants.

VHCs are available with a mouthpiece or with a facemask. Effective use of a VHC with a mouthpiece requires that the child be able to: exhale, seal his or her lips around the mouthpiece, actuate the MDI (with help), take a slow (3 to 5 sec) and controlled inhalation, and hold his or her breath for 5 to 10 seconds. Thus, this device is most appropriate for school-age children. A VHC with facemask can be used even in very young children, with the help of an adult. This device is placed on the face, with the mask covering the nose and mouth. After the MDI has been actuated, the child is allowed to take 6 to 8 breaths with the mask in place.

Currently, one quick-relief medication (pirbuterol) is available in a breath-actuated MDI, which is used without a spacer. The child must be able to seal his or her lips around the inhaler mouthpiece and take a controlled inhalation, which triggers the release of medication from the device.

Several types of inhaled corticosteroids as well as combination medicines (ICS + LABA) are available in DPIs. DPIs offer the convenience of a compact device that does not require use of a spacer. Although most of the DPI devices are approved for children 4 years of age and older, use of these devices requires coordination and the ability to generate inspiratory flow, obviating their use by most preschool-age children. The device must be "loaded" prior to use so an aliquot of dry powder is available for inhalation. To use a DPI, the child must exhale away from the device, seal his or her lips around the mouthpiece, and take a 2- to 3-second inhalation with an inspiratory flow rate of 60 to 90 L/min.

Both long-term control and quick-relief medications are available as solutions that can be nebulized. Jet nebulizers can be used by children of all ages with either a mouthpiece or face mask. If a child is capable of holding the mouthpiece correctly, this is the preferred method of use. If a mask is used, it should fit tightly around the nose and mouth to maximize medication delivery to the airways. The "blow-by" method (administration of nebulized medication without using a face mask or mouthpiece) is not effective and should not be used. Jet nebulizers are useful for very young children or cognitively impaired children who have difficulty using other devices. However, because each nebulizer treatment takes 10 to 15 minutes to administer and because the machines may be more difficult to use away from home, most children should be instructed in the use of an MDI with VHC to deliver quick-relief medication. Quick-relief medications delivered by MDIs with VHCs are equivalent to nebulizer therapy for children who have acute asthma (evidence level A). (8) (Albuterol 4 puffs by MDI is equivalent to albuterol 2.5 mg nebulized.) Additional information on asthma devices is available in the Summary Report of the 2007 Guidelines and in online materials (see Additional Resources).

The Physician–family Partnership for Care

Effective partnership between physicians and families is critical in effective asthma management. Interventions to improve physician communication and patient education skills result in improved patient satisfaction and health outcomes. (9) At each visit, the clinician should elicit family treatment goals and their concerns about asthma and medications used to treat asthma. Key educational messages include: basic facts about asthma, the role of medications (quick relief versus long-term control), and patient skills (how to take medications correctly, how to minimize exposure to asthma "triggers," and the use of a written asthma action plan). Providing pediatric asthma self-management education improves lung function, reduces school absenteeism, and reduces emergency department visits (evidence level A). (10)(11)

All patients should be given a written asthma action plan that includes instructions for how to control asthma every day and how to recognize and manage asthma symptoms as well as a list of signs and symptoms that indicate the need to seek immediate medical care. Some plans also include instructions about air quality alert days and permission for children to self-carry and self-administer asthma medications. Symptom-based plans are just as effective as peak flow-based plans (evidence level A). (12) Sample asthma action plan templates are provided in the 2007 Guidelines. Additional information about how to prepare a written asthma action plan as well as an electronic template can be found in the online resources (see Additional Resources).

Table 6. **Asthma Control**

	Well-controlled	Not Well-controlled	Very Poor Control
Child 0 to 11 Years			
Day symptoms	≤2 days/wk	>2 days/wk	Throughout
Night symptoms	0 to 1/month	≥2/mo	≥2/wk
FEV_1 percent predicted	>80%	60% to 80%	<60%
FEV_1/FVC ratio	>80%	75% to 80%	<75%
Exacerbations	0 to 1/yr	≥2/yr	≥2/yr (>3/yr for 0 to 4 yr)
Action	Maintain; consider step down (if well-controlled for 3 months)	Review ICE	Review ICE
		Step up	Step up 1 to 2 steps
	Recheck in 1 to 6 months	Recheck in 2 to 6 weeks	Consider OCS
			Recheck in 2 to 6 weeks
12 years to Adult			
Day symptoms	≤2 days/wk	>2 days/wk	Throughout
Night symptoms	0 to 2/month	1 to 3/wk	≥4/wk
FEV_1 percent predicted	>80%	60% to 80%	<60%
Exacerbations	0 to 1/yr	≥2/yr	≥2/yr
Action	Maintain; consider step down (if well-controlled for 3 months)	Review ICE	Review ICE
		Step up 1 step	Step up 1 to 2 steps
	Recheck in 1 to 6 months	Recheck in 2 to 6 weeks	Consider OCS
			Recheck in 2 weeks

ICE=inhaler technique, compliance, environmental control and comorbidities, FEV_1=forced expiratory volume in 1 second, FVC=forced vital capacity, OCS=oral corticosteroids

Adapted from the National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma, 2007.* NIH Publication No. 07-4051. Bethesda, Md: National Heart, Lung, and Blood Institute; 2007.

Periodic Monitoring

All patients who have persistent asthma should be monitored at regular intervals (1 to 6 months, depending on the category of asthma severity and asthma control). Routine spirometry should be undertaken every 1 to 2 years to assess airway function or more frequently during periods of poor asthma control. At each visit, the clinician should determine the level of asthma control (Table 6). Asthma control is based on impairment (daytime and nighttime symptoms, interference with normal activity, use of SABA, and lung function) as well as risk (frequency of exacerbations requiring oral corticosteroids). Excessive use of SABAs can be a sign of poorly controlled asthma and is associated with increased mortality.

If control is poor, the clinician should assess medication administration technique, adherence to therapy, and environmental controls. Factors contributing to poor asthma control should be addressed first, before adjusting therapy. If no obvious explanation for poor asthma control is identified, therapy should be "stepped up" to the next level. For very poor control, a short course of oral corticosteroids as well as a "step-up" in therapy should be considered. The patient should be re-evaluated in 2 to 6 weeks. If control has been good for at least 3 months, a "step down" in care and re-evaluation in 4 to 6 weeks should be considered. Daily peak flow monitoring or monitoring during exacerbations should be considered for patients who have a history of severe exacerbations, who have moderate-to-severe persistent asthma, or who have difficulty perceiving airway obstruction.

Management of Acute Exacerbations

Patients who have any degree of asthma severity can have a severe exacerbation. Signs and symptoms of a severe exacerbation include dyspnea at rest, peak flow rate less than 40% of predicted or personal best, accessory muscle use, and failure to respond to initial treatment. The initial management of an acute exacerbation should include a brief assessment, followed by administration of a SABA either as repeated doses or continuously to reverse airway obstruction. Inhaled anticholinergic medications, given in combination with a SABA for moderate-to-severe exacerbations in the acute-care setting, reduce the risk of hospitalization. Oxygen should be administered to most patients, particularly those experiencing hypoxemia or a moderate or severe exacerbation. Systemic corticosteroids should be administered early in the treatment of moderate or severe exacerbations and to any patient who does not respond promptly to initial treatment. Corticosteroids improve airway sensitivity to $beta_2$ agonists and

decrease inflammation; their effect is seen 4 to 6 hours following administration. Small areas of atelectasis are common during an acute exacerbation and do not require specific treatment. Similarly, antibiotics are not indicated unless there is evidence of a bacterial infection. At discharge from the emergency department, patients should be given instructions for administration of a SABA at home and a 3- to 10-day course of oral corticosteroids. Medical follow-up should be scheduled within 1 week.

Summary

- Initial management of asthma includes assignment of severity category, identification of asthma "triggers," and development of a treatment plan based on degree of severity.
- Inhaled corticosteroids are the medication of choice for treatment of persistent asthma (evidence level A).
- Environmental control is an important component of asthma management.
- Patient education, including how to use a written asthma action plan, is critical in managing asthma (evidence level A).

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Additional Resources

Note: Readers should investigate these websites to see which of the resources are best suited to their practice needs. Addresses are case sensitive.

2007 Guidelines: http://www.nhlbi.nih.gov/guidelines/asthma/

American Academy of Pediatrics. *Children's Health Survey for Asthma. Parent and Child-Report Versions*: http://www.aap.org/research/CHSA.htm

American Academy of Pediatrics. *Devices to Help Deliver Asthma Medications* (patient handout): http://www.aap.org/sections/allergy/gadgetschild.pdf

American Academy of Pediatrics. Education in Quality Improvement for Pediatric Practice (EQIPP): *Diagnosing and Managing Asthma in Pediatrics.* An exercise for evaluating and improving practitioners' management skills: http://www.pedialink.org/cme/EQIPPasthma/

American Academy of Pediatrics. Questionnaires, office forms, sample Asthma Action Plan: http://www.aap.org/schooledinasthma/tools.htm

American College of Chest Physicians. *Patient Instructions for Inhaled Devices in English and Spanish* (handouts): http://www.chestnet.org/patients/guides/inhaledDevices.php

Asthma Coalition of Texas: http://www.texasasthma.org

Asthma Coalition of Texas. *Asthma Action Plan* (interactive electronic template): English: http://www.texasasthma.org/attachments/wysiwyg/539/AAPEnglishFinalelectronic-2.pdf; Spanish: http://www.texasasthma.org/attachments/wysiwyg/539/AAPSpanishFinal_041708.pdf

Asthma Coalition of Texas. *Asthma Devices.* (PowerPoint instructional module): Part 1: http://www.texasasthma.org/attachments/wysiwyg/539/4-AsthmaDevices_rev080408GCCWpt1.pdf; Part 2: http://www.texasasthma.org/attachments/wysiwyg/539/4-AsthmaDevices_rev080408GCCWpt2.pdf

Asthma Coalition of Texas. *How to Control Things That Make Your Asthma Worse.* (handout from 2007 Guidelines): English: http://www.texasasthma.org/attachments/wysiwyg/539/AsthmaTriggerChecklistEnglish0808.pdf; Spanish: http://www.texasasthma.org/attachments/wysiwyg/539/AsthmaTriggerChecklistSpanish0307.pdf

California Asthma Public Health Initiative. *Using Asthma Medicines Correctly* (video): http://www.betterasthmacare.org/#videos

Mayo Clinic. *How to Use a Peak Flow Meter* (video): http://www.mayoclinic.com/health/asthma/MM00399

National Heart Lung and Blood Institute. Full Report of Expert Panel Guidelines for the Diagnosis and Management of Asthma (additional information about long-acting beta agonist inhalers): http://www.nhlbi.nih.gov/guidelines/asthma/evid_tbls.htm

PIR Quiz

Quiz also available online at pedsinreview.aappublications.org.

1. An 8-year-old boy who has had asthma since the age of 2 years presents with increasingly frequent cough and shortness of breath for the past 3 months. He was being treated with low-dose inhaled corticosteroid and albuterol inhalations. His symptoms occur daily, they get worse when playing soccer, and they wake him at night three to four times per week. What is the *best* description of the severity of his asthma?

   A. Chronic recurrent.
   B. Intermittent.
   C. Mild persistent.
   D. Moderate persistent.
   E. Severe persistent.

2 An 8-year-old boy who has had asthma since the age of 2 years presents with increasingly frequent cough and shortness of breath for the past 3 months. He was being treated with low-dose inhaled corticosteroid and albuterol inhalations. His symptoms occur daily, they worsen when he plays soccer, and they wake him at night 3 to 4 times per week. Which of the following is the *best* course of action at this time?

   A. Continue current regimen while suspending playing soccer until symptoms improve.
   B. Increase the frequency of albuterol inhalations to every 4 hours.
   C. Increase inhaled corticosteroid therapy to medium-dose.
   D. Institute omalizumab therapy.
   E. Start on sodium cromolyn inhalations prior to playing soccer.

3. A 4-year-old-girl is being treated for moderate persistent asthma with a medium-dose inhaled corticosteroid and long-acting $beta_2$ agonist. She continues to have cough and wheezing 3 to 4 days a week and 1 night a week. Which of the following will be accomplished by the addition of montelukast to her regimen?

   A. Inhibition of leukotriene receptor responsiveness.
   B. Inhibition of phosphodiesterase activity.
   C. Prevention of binding of IgE to receptors on basophils.
   D. Stabilization of mast cell membrane.
   E. Stimulation of adenyl cyclase activity.

4. A 7-year-old girl is being treated for severe persistent asthma with high-dose inhaled corticosteroids along with a long-acting beta agonist and montelukast. Which of the following is the *most* important to monitor during follow-up visits?

   A. Bone mineral density.
   B. Fasting blood glucose.
   C. Left ventricular wall thickness.
   D. Rate of increase in height.
   E. Subcapsular cataracts.

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