National Asthma Education and Prevention Program

CLINICAL PRACTICE GUIDELINES

EXPERT PANEL REPORT 2

Guidelines for the Diagnosis and Management of Asthma

NATIONAL INSTITUTES OF HEALTH
NATIONAL HEART, LUNG, AND BLOOD INSTITUTE

EXPERT PANEL REPORT 2

CLINICAL PRACTICE GUIDELINES

Guidelines for the Diagnosis and Management of Asthma

NIH PUBLICATION
NO. 97-4051
JULY 1997

NATIONAL INSTITUTES OF HEALTH
National Heart, Lung, and Blood Institute

CONTENTS

SECOND EXPERT PANEL ON THE MANAGEMENT OF ASTHMA

*Shirley Murphy, M.D., *Chair*
Professor and Chair
Department of Pediatrics
University of New Mexico
School of Medicine
Albuquerque, New Mexico

Eugene R. Bleecker, M.D.
Professor of Medicine
School of Medicine
University of Maryland
Baltimore, Maryland

*Homer Boushey, M.D.
Chief, Asthma Clinical
Research Center
and Division of Allergy and
Immunology
Professor of Medicine
Department of Medicine
University of California at
San Francisco
San Francisco, California

*A. Sonia Buist, M.D.
Professor of Medicine and Physiology
Head, Pulmonary and
Critical Care Division
Oregon Health Sciences University
Portland, Oregon

*William Busse, M.D.
Professor of Medicine
Medicine/Allergy and
Immunology Department
University of Wisconsin
Madison, Wisconsin

Noreen M. Clark, Ph.D.
Professor and Dean
University of Michigan School
of Public Health
Ann Arbor, Michigan

Howard Eigen, M.D.
Director
Section of Pulmonology and
Intensive Care
Professor and Associate Chairman
for Clinical Affairs
Department of Pediatrics
Riley Hospital for Children
Indianapolis, Indiana

Jean G. Ford, M.D.
Chief, Division of Pulmonary Medicine
Harlem Hospital Center
Assistant Professor of Medicine and
Public Health (Environmental Health
Sciences)
Columbia University
New York, New York

*Susan Janson, D.N.Sc., R.N.
Professor
Department of Community Health
School of Nursing
University of California, San Francisco
San Francisco, California

*H. William Kelly, Pharm.D.
Professor of Pharmacy and Pediatrics
College of Pharmacy
University of New Mexico
Albuquerque, New Mexico

Robert F. Lemanske, Jr., M.D.
Professor of Medicine and Pediatrics
University of Wisconsin
Hospital and Clinics
Madison, Wisconsin

Carolyn C. Lopez, M.D.
Chief, Department of Family Practice
Cook County Hospital
Associate Professor, Department
of Family Medicine
Rush Medical College
Chicago, Illinois

Fernando Martinez, M.D.
Associate Professor of Pediatrics
Director, Respiratory Sciences Center
University of Arizona Medical Center
Tucson, Arizona

*Harold S. Nelson, M.D.
Senior Staff Physician
Department of Medicine
National Jewish Medical and
Research Center
Denver, Colorado

Richard Nowak, M.D., M.B.A.
Vice Chairman
Department of Emergency Medicine
Henry Ford Hospital
Detroit, Michigan

Thomas A.E. Platts-Mills, M.D., Ph.D.
Director
UVA Asthma and Allergy Disease
Center
Head, Division of Allergic and
Clinical Immunology
University of Virginia School
of Medicine
Charlottesville, Virginia

Gail G. Shapiro, M.D.
Clinical Professor of Pediatrics
University of Washington
School of Medicine
Seattle, Washington

Stuart Stoloff, M.D.
Private Family Practice
Clinical Associate Professor of Family
and Community Medicine
University of Nevada
School of Medicine
Reno, Nevada

Kevin Weiss, M.D., M.P.H.
Director
Center for Health Services Research
Rush Primary Care Institute
Chicago, Illinois

FEDERAL LIAISON REPRESENTATIVES

Clive Brown, M.B.B.S., M.P.H.
Epidemiologist
Air Pollution and Respiratory
Health Branch
Centers for Disease Control
and Prevention
Atlanta, Georgia

Peter J. Gergen, M.D.
(formerly with the National Institute
of Allergy and Infectious Diseases)
Medical Officer
Center for Primary Care Research
Agency for Health Care
Policy and Research
Bethesda, Maryland

Edward L. Petsonk, M.D.
Clinical Section Chief
Clinical Investigations Branch
Division of Respiratory Disease Studies
National Institute for Occupational
Safety and Health
Morgantown, West Virginia

* Executive Committee Member

Acknowledgments

The Expert Panel acknowledges the following consultants for their review of an early draft of the report: David Evans, Ph.D.; James Fish, M.D.; Mark Liu, M.D.; Guillermo Mendoza, M.D.; Gary Rachelefsky, M.D.; Albert Sheffer, M.D.; Stanley Szefler, M.D.; and Pamela Wood, M.D.

National Heart, Lung, and Blood Institute Staff

Ted Buxton, M.P.H.
Special Expert
National Asthma Education and Prevention Program

Robinson Fulwood, M.S.P.H.
Coordinator
National Asthma Education and Prevention Program

Michele Hindi-Alexander, Ph.D.
Health Scientist Administrator
Division of Lung Diseases

Suzanne S. Hurd, Ph.D.
Director
Division of Lung Diseases

Virginia S. Taggart, M.P.H.
Health Scientist Administrator
Division of Lung Diseases

R.O.W. Sciences, Inc., Support Staff

Ruth Clark

Cathy Hageman

Lisa Marcellino

Maria New

Donna Selig

Keith Stanger

Donna Tharpe

Sonia Van Putten

Eileen Zeller, M.P.H.

NATIONAL ASTHMA EDUCATION AND PREVENTION PROGRAM COORDINATING COMMITTEE

Claude Lenfant, M.D., *Chair*
National Heart, Lung, and Blood Institute

Lynn A. Bosco, M.D., M.P.H.
Agency for Health Care Policy and Research

Nancy J. Sander
Allergy and Asthma Network/Mothers of Asthmatics, Inc.

Albert L. Sheffer, M.D.
American Academy of Allergy, Asthma, and Immunology

Gary S. Rachelefsky, M.D.
American Academy of Pediatrics

Barbara Senske Heier, PA-C
American Academy of Physician Assistants

Thomas J. Kallstrom, R.R.T.
American Association for Respiratory Care

Eloise Branche, R.N., C.O.H.N.-S.
American Association of Occupational Health Nurses

Allan T. Luskin, M.D.
American College of Allergy, Asthma, and Immunology

Robert A. Barbee, M.D., F.C.C.P.
American College of Chest Physicians

Richard M. Nowak, M.D., M.B.A., F.A.C.E.P.
American College of Emergency Physicians

Noreen M. Clark, Ph.D.
American Lung Association

Paul V. Williams, M.D.
American Medical Association

Barbara M. Santamaria, R.N., M.P.H., C.F.N.P.
American Nurses Association, Inc.

Dennis M. Williams, Pharm.D.
American Pharmaceutical Association

Pamela J. Luna, M.Ed., Dr.P.H.
American Public Health Association

Lani S.M. Wheeler, M.D., F.A.A.P., F.A.S.H.A.
American School Health Association

Leslie Hendeles, Pharm.D.
American Society of Health-System Pharmacists

A. Sonia Buist, M.D.
American Thoracic Society

Barbara L. Hager, M.P.H., C.H.E.S.
Association of State and Territorial Directors of Health Promotion and Public Health Education

Mary E. Worstell, M.P.H.
Asthma and Allergy Foundation of America

Mary Vernon, M.D., M.P.H.
Centers for Disease Control and Prevention

Vivian Haines, R.N., M.A., S.N.P.
National Association of School Nurses

Susan B. Clark, R.N., M.N.
National Black Nurses Association, Inc.

Ruth A. Etzel, M.D., Ph.D.
National Center for Environmental Health

Kathryn Silbersiepe, M.D., M.S.
National Center for Health Statistics

Ruth I. Quartey, M.A., R.R.T.
NHLBI Ad Hoc Committee on Minority Populations

Gregory R. Wagner, M.D.
National Institute for Occupational Safety and Health

Lawrence J. Prograis, Jr., M.D.
National Institute of Allergy and Infectious Diseases

Sheila A. Newton, Ph.D.
National Institute of Environmental Health Sciences

Michael Lenoir, M.D.
National Medical Association

L. Kay Bartholomew, Ed.D., M.P.H.
Society for Public Health Education

Kimberly Green Goldsborough, M.S.
U.S. Environmental Protection Agency

John K. Jenkins, M.D.
U.S. Food and Drug Administration

Olivia Carter-Pokras, Ph.D.
U.S. Public Health Service

NATIONAL ASTHMA EDUCATION AND PREVENTION PROGRAM SCIENCE BASE COMMITTEE

Albert L. Sheffer, M.D., *Chair*
Brigham and Women's Hospital
Boston, Massachusetts

A. Sonia Buist, M.D.
Oregon Health Sciences University
Portland, Oregon

William Busse, M.D.
University of Wisconsin
Madison, Wisconsin

Noreen M. Clark, Ph.D.
University of Michigan
Ann Arbor, Michigan

Shirley Murphy, M.D.
University of New Mexico
Albuquerque, New Mexico

Harold S. Nelson, M.D.
National Jewish Medical and Research Center
Denver, Colorado

Kevin Weiss, M.D., M.P.H.
Rush Primary Care Institute
Chicago, Illinois

INTERNATIONAL SCIENCE BASE COMMITTEE

Romain Pauwels, M.D., Ph.D., *Chair*
University Hospital
Ghent, *Belgium*

Jean Bousquet, M.D., Ph.D.
Hopital Arnaud de Villeneuve
Montpellier, *France*

Timothy J. H. Clark, M.D.
National Heart and Lung Institute
London, *England*

Leonardo M. Fabbri, M.D.
University of Ferrara
Ferrara, *Italy*

Stephen T. Holgate, M.D., D.Sc.
Southampton General Hospital
Southampton, *England*

Martyn R. Partridge, M.D.
Whipps Cross Hospital
London, *England*

Søren Pedersen, M.D.
Kolding Hospital
Kolding, *Denmark*

Ann J. Woolcock, A.O., M.D., F.R.A.C.P.
Royal Prince Alfred Hospital
Camperdown, New South Wales, *Australia*

PREFACE

In 1991, under the auspices of the National Asthma Education and Prevention Program (NAEPP), the first Expert Panel on the Management of Asthma published *Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma*. This landmark report redefined commonly held beliefs about asthma care, thus setting the stage for nationwide improvements in the clinical management of asthma and stimulating a variety of novel research. An enormous amount of work has been done since the release of the report to deepen our understanding of the pathogenesis of asthma and increase our knowledge about effective approaches to asthma diagnosis, monitoring, pharmacologic and environmental management, and patient education. Accordingly, the decision was made to update and revise the 1991 report to identify progress made over the last 6 years.

Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma (EPR-2) is the culmination of more than 3 years of preparatory analysis, meetings, and writing and review cycles involving many individuals, not the least of whom were the members of the second Expert Panel. Under the able leadership of Dr. Shirley Murphy, Panel chair, the second Expert Panel diligently met its charge of producing an accurate, up-to-date source of information for clinicians on asthma diagnosis and management. Panel members conducted their work not only with skill and a depth of clinical and academic knowledge, but also with a commitment to quality and an impressive spirit of collaboration. The National Heart, Lung, and Blood Institute and the organizations that comprise the NAEPP Coordinating Committee sincerely appreciate the work of Dr. Murphy, the Expert Panel, and all others who participated in the preparation of this report.

The task before us is to explore innovative methods to broadly disseminate and encourage implementation of these updated asthma care recommendations. The first steps will be to adapt the EPR-2 into formats that meet the needs of various health professionals and then to disseminate these materials. However, these national-level efforts will have an impact on asthma care only if they occur in concert with local activities to encourage use of EPR-2 materials. Ultimately, broad change in clinical practice depends on the influence of local physicians and other health professionals who not only provide state-of-the-art care to their patients, but also communicate to their peers the importance of doing the same. We are optimistic that over the next several years, the joint efforts of the NAEPP, its Coordinating Committee member organizations, and committed professionals at the local level will result in extensive implementation of the recommendations in the EPR-2. We ask for the assistance of every reader in reaching our ultimate goal: improving asthma care and the quality of life for every patient with asthma and their families.

Publications from the National Asthma Education and Prevention Program can be ordered through the National Heart, Lung, and Blood Institute Information Center, P.O. Box 30105, Bethesda, MD 20824-0105. Publications are also available through the Internet at http://www.nhlbi.nih.gov/nhlbi/nhlbi.htm.

Claude Lenfant, M.D., Director
National Heart, Lung, and Blood Institute
Chair, National Asthma Education and
Prevention Program Coordinating Committee

INTRODUCTION

Asthma is a chronic inflammatory disease of the airways. In the United States, asthma affects 14 million to 15 million persons. It is the most common chronic disease of childhood, affecting an estimated 4.8 million children (Adams and Marano 1995; Centers for Disease Control and Prevention 1995). People with asthma collectively have more than 100 million days of restricted activity and 470,000 hospitalizations annually. More than 5,000 people die of asthma annually. Asthma hospitalization rates have been highest among blacks and children, while death rates for asthma were consistently highest among blacks aged 15 to 24 years (Centers for Disease Control and Prevention 1996). These rates have increased or remained stable over the past decade. This report describes the appropriate use of the available therapies in the management of asthma.

To help health care professionals bridge the gap between current knowledge and practice, the National Heart, Lung, and Blood Institute's (NHLBI) National Asthma Education and Prevention Program (NAEPP) has convened two Expert Panels to prepare guidelines for the diagnosis and management of asthma. The NAEPP Coordinating Committee, under the leadership of Claude Lenfant, M.D., director of the NHLBI, convened the first Expert Panel in 1989. The charge to this Panel was to develop a report that would provide a general approach to diagnosing and managing asthma based on current science. The *Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma* (NAEPP 1991) was published in 1991, and the recommendations for the treatment of asthma were organized around four components of effective asthma management:

- Use of objective measures of lung function to assess the severity of asthma and to monitor the course of therapy
- Environmental control measures to avoid or eliminate factors that precipitate asthma symptoms or exacerbations
- Comprehensive pharmacologic therapy for long-term management designed to reverse and prevent the airway inflammation characteristic of asthma as well as pharmacologic therapy to manage asthma exacerbations
- Patient education that fosters a partnership among the patient, his or her family, and clinicians

The principles addressed within these four components of asthma management served as the starting point for the development of two additional reports prepared by asthma experts from many countries in cooperation with the NHLBI: the *International Consensus Report on Diagnosis and Management of Asthma* (NHLBI 1992) and the *Global Initiative for Asthma* (NHLBI/WHO 1995). The *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma* (EPR-2) is the latest report from the National Asthma Education and Prevention Program and updates the 1991 Expert Panel Report. The second Expert Panel critically reviewed and built upon the reports listed above.

This report presents basic recommendations for the diagnosis and management of asthma that will help clinicians and patients make appropriate decisions about asthma care. Of course, the clinician and patient need to develop individual treatment plans that are tailored to the specific needs and circumstances of the patient. The NAEPP, and all who participated in the development of this latest report, hope that the patient with asthma will be the beneficiary of the recommendations in this document. This report is not an official regulatory document of any Government agency.

METHODS USED TO DEVELOP THIS REPORT

The NAEPP Coordinating Committee established a Science Base Committee of U.S. asthma experts who began work in early 1994 to monitor the scientific literature and advise the Coordinating Committee when an update of the 1991 *Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma* was needed. The Science Base Committee, along with international members of the Global Initiative for Asthma, examined all the relevant literature on asthma in human subjects published in English between 1991 and mid-1995, obtained through a series of MEDLINE database searches. More than 5,000 abstracts were reviewed. In 1995, the Science Base Committee recommended to the NAEPP Coordinating Committee that sufficient new information had been published since 1991 to convene a panel of experts to update the first Expert Panel Report.

The second Expert Panel is a multidisciplinary group of clinicians and scientists with expertise in asthma management. The Panel includes health professionals in the areas of general medicine, family practice, pediatrics, emergency medicine, allergy, pulmonary medicine, nursing, pharmacy, and health education. Among the Panel members are individuals who served on either the Science Base Committee or the 1991 Expert Panel. Other members were chosen based on names submitted by NAEPP Coordinating Committee member organizations. Several Expert Panel members are themselves members of the Coordinating Committee. Representatives from several Federal agencies also have participated.

The charge to the Panel was to prepare recommendations for use by clinicians working in diverse health care settings that address the practical decisionmaking issues in the diagnosis and management of asthma. The Panel also was requested to develop specific aids to facilitate implementation of the recommendations.

Panel members were asked to base their recommendations on their review of the scientific literature and to cite studies that support the recommendations. When a clear recommendation could not be extracted from the studies (e.g., studies were not available, were conflicting, or were equivocal), the Panel was asked to label the recommendation as "based on the opinion of the Expert Panel," "recommended by the Expert Panel," or similar terminology. When a whole section was "based on the opinion of the Expert Panel," this was indicated at the beginning of the section (e.g., see component 1-Initial Assessment and Diagnosis).

This report was prepared in a systematic and iterative process. In addition to the Science Base Committee review of the scientific literature, the Panel conducted in-depth reviews of the literature in selected areas it considered controversial. In interpreting the literature, the Panel considered the nature and quality of the study designs and analyses. Given the complexities of several issues, the Panel chose not to use the strict evidence ranking system used in the guidelines development procedures of the U.S. Preventive Services Task Force. However, this procedure was applied in the area of peak flow monitoring. The Panel submitted their interpretation of the literature and related recommendations for multiple reviews by their fellow Expert Panel members and outside reviewers.

The development of EPR-2 was directed by an Executive Committee; each member of the Executive Committee headed a subcommittee assigned to prepare a specific chapter. Each member of the Panel was assigned to one of the subcommittees. The subcommittees were responsible for reviewing the pertinent literature and drafting the recommendations with the supporting evidence for the full Panel to review. Once the subcommittee reports were prepared, the full Panel critically reviewed the evidence and rationale for each recommendation, discussed revisions, and reached final agreement on each recommendation. A vote was taken to confirm the consensus of the Panel. The final report was approved by the NAEPP Coordinating Committee via mail. Box 1 summarizes the draft, review, and consensus-building process.

The development of this report was *entirely* funded by the National Heart, Lung, and Blood Institute, National Institutes of Health. Panel members and reviewers participated as volunteers and were compensated only for travel expenses related to the two Expert Panel meetings and the Executive Committee meetings.

BOX 1. MAJOR EVENTS IN THE DEVELOPMENT OF EPR-2

First Expert Panel meeting	June 1995
Executive Committee meeting	November 1995
Executive Committee meeting (by phone)	February 1996
Second Expert Panel meeting and review by outside experts	May 1996
Review by NAEPP Coordinating Committee member organizations	August 1996
Executive Committee meeting	October 1996
Mail Review, Expert Panel	December 1996
Mail Review and Approval, NAEPP Coordinating Committee	January 1997

The goal of the *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma* is to serve as a comprehensive guide to diagnosing and managing asthma. Implementation of EPR-2 recommendations is likely to increase some costs of asthma care by increasing the number of primary care visits for asthma and the use of asthma medications, environmental control products and services, and equipment (e.g., spacer/holding chamber devices). However, asthma diagnosis and management are expected to improve, which should reduce the numbers of lost school and work days, hospitalizations and emergency department visits, and deaths due to asthma. A net reduction in total health care costs should result. The NAEPP encourages research to evaluate the impact of implementing the recommendations in this report.

OVERVIEW OF THE REPORT

Each section of EPR-2 begins with a list of "Key Points" and "Differences From 1991 Expert Panel Report." A brief overview of each section is provided below.

Pathogenesis and Definition

In the 1991 Expert Panel Report, the role of inflammation in the pathogenesis of asthma was emphasized although the scientific evidence for the involvement of inflammation in asthma was just emerging. Now in 1997, although the role of inflammation is still evolving as a concept, a much firmer scientific basis exists to indicate that asthma results from complex interactions among inflammatory cells, mediators, and the cells and tissues resident in the airways.

Thus, asthma is now defined as a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role, in particular, mast cells, eosinophils, T lymphocytes, neutrophils, and epithelial cells. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and cough, particularly at night and in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The inflammation also causes an associated increase in the existing bronchial hyperresponsiveness to a variety of stimuli.

COMPONENT 1: Measures of Assessment and Monitoring

Initial Assessment and Diagnosis of Asthma

Making the correct diagnosis of asthma is extremely important. Clinical judgment is required because signs and symptoms vary widely from patient to patient as well as within each patient over time. To establish the diagnosis of asthma, the clinician must determine that:

- Episodic symptoms of airflow obstruction are present.
- Airflow obstruction is at least partially reversible.
- Alternative diagnoses are excluded.

This section differs from the 1991 Expert Panel Report in several ways. Asthma severity classifications have been changed from mild, moderate, and severe to mild intermittent, mild persistent, moderate persistent, and severe persistent to more accurately reflect the clinical manifestations of

asthma. The Panel emphasizes that patients at any level of severity can have mild, moderate, or severe exacerbations. In addition, information on wheezing in infancy and vocal cord dysfunction has been expanded in the differential diagnosis section in component 1. Situations that may warrant referral to an asthma specialist have been refined with input from specialty and primary care physicians.

Periodic Assessment and Monitoring

To establish whether the goals of asthma therapy have been achieved, ongoing monitoring and periodic assessment are needed. The goals of asthma therapy are to:

- Prevent chronic and troublesome symptoms
- Maintain (near) "normal" pulmonary function
- Maintain normal activity levels (including exercise and other physical activity)
- Prevent recurrent exacerbations of asthma and minimize the need for emergency department visits or hospitalizations
- Provide optimal pharmacotherapy with minimal or no adverse effects
- Meet patients' and families' expectations of and satisfaction with asthma care

Several types of monitoring are recommended: signs and symptoms, pulmonary function, quality of life/functional status, history of asthma exacerbations, pharmacotherapy, and patient-provider communication and patient satisfaction.

The Panel recommends that patients, especially those with moderate-to-severe persistent asthma or a history of severe exacerbations, be given a written action plan based on signs and symptoms and/or peak expiratory flow. As in the 1991 report, daily peak flow monitoring is recommended for patients with moderate-to-severe persistent asthma. In addition, the Panel states that any patient who develops severe exacerbations may benefit from peak flow monitoring. A complete review of the literature on peak flow monitoring was conducted, evidence tables were prepared, and the results of this analysis are summarized in the report.

COMPONENT 2: Control of Factors Contributing to Asthma Severity

Exposure of sensitive patients to inhalant allergens has been shown to increase airway inflammation, airway hyperresponsiveness, asthma symptoms, need for medication, and death due to asthma. Substantially reducing exposures significantly reduces these outcomes. Environmental tobacco smoke is a major precipitant of asthma symptoms in children, increases symptoms and the need for medications, and reduces lung function in adults. Increased air pollution levels of respirable particulates, ozone, SO_2, and NO_2 have been reported to precipitate asthma symptoms and increase emergency department visits and hospitalizations for asthma. Other factors that can contribute to asthma severity include rhinitis and sinusitis, gastroesophageal reflux, some medications, and viral respiratory infections. EPR-2 discusses environmental control and other measures to reduce the effects of these factors.

COMPONENT 3: Pharmacologic Therapy

EPR-2 offers an extensive discussion of the pharmacologic management of patients at all levels of asthma severity. It is noted that asthma pharmacotherapy should be instituted in conjunction with environmental control measures that reduce exposure to factors known to increase the patient's asthma symptoms.

As in the 1991 report, a stepwise approach to pharmacologic therapy is recommended, with the type and amount of medication dictated by asthma severity. EPR-2 continues to emphasize that persistent asthma requires daily long-term therapy in addition to appropriate medications to manage asthma exacerbations. To clarify this concept, the EPR-2 now categorizes medications into two general classes: *long-term-control medications* to achieve and maintain control of persistent asthma and *quick-relief medications* to treat symptoms and exacerbations.

Observations into the basic mechanisms of asthma have had a tremendous influence on therapy. Because inflammation is considered an early and persistent component of asthma, therapy for persistent asthma must be directed toward long-term

suppression of the inflammation. Thus, EPR-2 continues to emphasize that the most effective medications for long-term control are those shown to have anti-inflammatory effects. For example, early intervention with inhaled corticosteroids can improve asthma control and normalize lung function, and preliminary studies suggest that it may prevent irreversible airway injury.

An important addition to EPR-2 is a discussion of the management of asthma in infants and young children that incorporates recent studies on wheezing in early childhood. Another addition is discussions of long-term-control medications that have become available since 1991—long-acting inhaled beta$_2$-agonists, nedocromil, zafirlukast, and zileuton.

Recommendations for managing asthma exacerbations are similar to those in the 1991 Expert Panel Report. However, the treatment recommendations are now on a much firmer scientific basis because of the number of studies addressing the treatment of asthma exacerbations in children and adults in the past 6 years.

COMPONENT 4:

Education for a Partnership in Asthma Care

As in the 1991 Expert Panel Report, education for an active partnership with patients remains the cornerstone of asthma management and should be carried out by health care providers delivering asthma care. Education should start at the time of asthma diagnosis and be integrated into every step of clinical asthma care. Asthma self-management education should be tailored to the needs of each patient, maintaining a sensitivity to cultural beliefs and practices. New emphasis is placed on evaluating outcomes in terms of patient perceptions of improvement, especially quality of life and the ability to engage in usual activities. Health care providers need to systematically teach and frequently review with patients how to manage and control their asthma. Patients also should be provided with and taught to use a written daily self-management plan and an action plan for exacerbations. It is especially important to give a written action plan to patients with moderate-to-severe persistent asthma or a history of severe exacerbations. Appropriate patients should also receive a daily asthma diary. Adherence should be encouraged by promoting open communication; individualizing, reviewing, and adjusting plans as needed; emphasizing goals and outcomes; and encouraging family involvement.

In summary, the 1997 *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma* reflects the experience of the past 6 years as well as the increasing scientific base of published articles on asthma. The Expert Panel hopes this new report will assist the clinician in forming a valuable partnership with patients to achieve excellent asthma control and outcomes.

REFERENCES

Adams PF, Marano MA. Current estimates from the National Health Interview Survey, 1994. *Vital Health Stat* 1995;10:94.

Centers for Disease Control and Prevention. Asthma mortality and hospitalization among children and young adults—United States, 1990-1993. *MMWR* 1996;45:350-353.

Centers for Disease Control and Prevention. Asthma-United States, 1989-1992. *MMWR* 1995;43:952-5.

National Asthma Education and Prevention Program. *Expert Panel Report: Guidelines for the Diagnosis and Management of Asthma.* National Institutes of Health pub no 91-3642. Bethesda, MD, 1991.

National Heart, Lung, and Blood Institute. *International Consensus Report on Diagnosis and Management of Asthma.* National Institutes of Health pub no 92-3091. Bethesda, MD, 1992.

National Heart, Lung, and Blood Institute and World Health Organization. *Global Initiative for Asthma.* National Institutes of Health pub no 95-3659. Bethesda, MD, 1995.

U.S. Preventive Services Task Force. *Guide to Clinical Preventive Health Services.* Baltimore: Williams and Wilkins, 1989.

PATHOGENESIS AND DEFINITION

KEY POINTS

- Asthma, whatever the severity, is a chronic inflammatory disorder of the airways. This has implications for the diagnosis, management, and potential prevention of the disease.

- The immunohistopathologic features of asthma include:
  - Denudation of airway epithelium
  - Collagen deposition beneath basement membrane
  - Edema
  - Mast cell activation
  - Inflammatory cell infiltration
    - Neutrophils (especially in sudden-onset, fatal asthma exacerbations)
    - Eosinophils
    - Lymphocytes (TH2-like cells)

- Airway inflammation contributes to airway hyperresponsiveness, airflow limitation, respiratory symptoms, and disease chronicity.

- Airway inflammation also contributes to several forms of airflow limitation, including acute bronchoconstriction, airway edema, mucus plug formation, and airway wall remodeling. These features lead to bronchial obstruction.

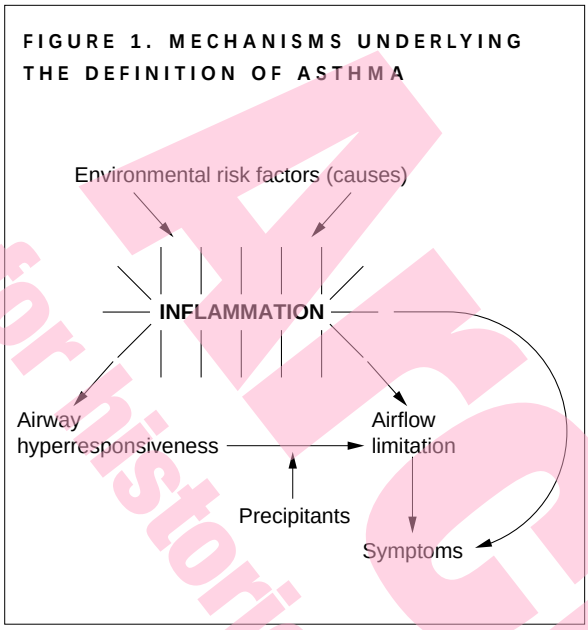
- Atopy, the genetic predisposition for the development of an IgE-mediated response to common aeroallergens, is the strongest identifiable predisposing factor for developing asthma.

DIFFERENCES FROM 1991 EXPERT PANEL REPORT

- The critical role of inflammation in asthma has been further substantiated by research. It is recognized that asthma results from complex interactions among inflammatory cells, mediators, and other cells and tissues resident in the airway.

- Evidence indicates that subbasement membrane fibrosis may occur in some patients and that these changes contribute to persistent abnormalities in lung function. The importance of airway remodeling and the development of persistent airflow limitation need further exploration and may have significant implications for the treatment of asthma.

FIGURE 1. MECHANISMS UNDERLYING THE DEFINITION OF ASTHMA



Adapted with permission from Stephen T. Holgate, M.D., D.Sc.

The clinician, physiologist, immunologist, and pathologist all may have different perspectives on asthma based on their individual viewpoints and experience. The merging of these different perspectives into an acceptable definition of asthma has begun to occur and is important for more specific and effective treatment of this disease and for investigation into its pathogenesis. Furthermore, even though this disorder affects virtually the entire spectrum of life, asthma has certain age-specific characteristics and differential diagnosis issues that need to be considered in both its treatment and its etiology.

Based on current knowledge, a working definition of asthma is: *Asthma is a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role, in particular, mast cells, eosinophils, T lymphocytes, macrophages, neutrophils, and epithelial cells. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The inflammation also causes an associated increase in the existing bronchial hyperresponsiveness to a variety of stimuli* (NHLBI 1995). Moreover, recent evidence indicates that subbasement membrane fibrosis may occur in some patients with asthma and that these changes contribute to persistent abnormalities in lung function (Roche 1991).

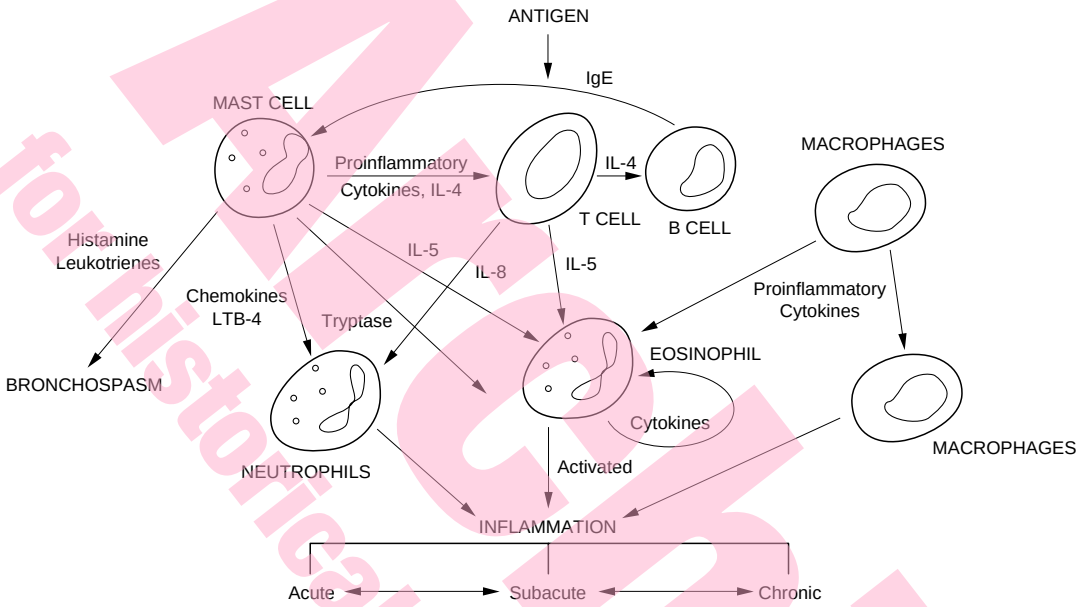
This working definition and its expanded recognition of key features of asthma have been derived from studying how airway changes in asthma relate to various factors associated with the development of allergic inflammation (e.g., allergens, respiratory viruses, and some occupational exposures, as illustrated in figure 1). From this approach has come a more comprehensive understanding of asthma pathogenesis, the development of persistent airway inflammation, and the profound implications these issues have for the diagnosis, treatment, and potential prevention of asthma.

AIRWAY PATHOLOGY AND ASTHMA

Until recently, information on airway pathology in asthma has come largely from post-mortem examination (Dunnill 1960), which shows that both large and small airways often contain plugs composed of mucus, serum proteins, inflammatory cells, and cellular debris. Viewed microscopically, airways are infiltrated with eosinophils and mononuclear cells, and there is vasodilation and evidence of microvascular leakage and epithelial disruption. The airway smooth muscle is often hypertrophied, which is characterized by new vessel formation, increased numbers of epithelial goblet cells, and deposition of interstitial collagens beneath the epithelium. These features of airway wall remodeling further underscore the importance of chronic, recurrent inflammation in asthma and its effects on the airway. Moreover, these morphologic changes may not be completely reversible. Consequently, research is currently focused on determining whether these changes can be prevented or modified by early diagnosis, avoidance of factors that contribute to asthma severity, and pharmacologic therapy directed at suppressing airway inflammation.

Establishing the relationship between the pathologic changes and the clinical features of asthma has been difficult. Fiberoptic bronchoscopy with lavage and biopsy provide new insight into mechanisms of airway disease and features that link altered lung function to a specific type of mucosal inflammation (Laitinen et al. 1985; Beasley et al. 1989; Jeffery et al. 1989). From such studies, evidence has emerged that mast cells, eosinophils, epithelial cells, macrophages, and activated T cells are key features of the inflammatory process of asthma (Djukanovic et al. 1990), as illustrated in figure 2. These cells can influence airway function through secretion of preformed and newly synthe-

FIGURE 2. CELLULAR MECHANISMS INVOLVED IN AIRWAY INFLAMMATION



sized mediators that act either directly on the airway or indirectly through neural mechanisms (Emanuel and Howarth 1995). Furthermore, with the use of cellular and molecular biological techniques, subpopulations of T lymphocytes (TH2) have been identified as important cells that may regulate allergic inflammation in the airway through the release of selective cytokines and also establish disease chronicity (Robinson et al. 1992). In addition, constituent cells of the airway, including fibroblasts, endothelial cells, and epithelial cells, also contribute to this process by releasing cytokines and chemokines.

The above factors may be important in both initiating and maintaining the level of airway inflammation (Robinson et al. 1993). It is hypothesized that airway inflammation can be acute, subacute, and chronic. The acute inflammatory response is represented by the early recruitment of cells to the airway. In the subacute phase, recruited and resident cells are activated to cause a more persistent pattern of inflammation. Chronic inflammation is characterized by a persistent level of cell damage and an ongoing repair process, changes that may cause permanent abnormalities in the airway.

Finally, it is recognized that specific adhesion proteins, found in the vascular tissue, lung matrix, and bronchial epithelium, may be critical in directing and anchoring cells in the airway, thus causing the inflammatory changes noted (Albelda 1991). From these studies of the histological features associated with asthma has come evidence of an association between airway inflammation and markers of airway disease severity and an indication that this process is multicellular, redundant, and self-amplifying.

Cell-derived mediators can influence airway smooth muscle tone, modulate vascular permeability, activate neurons, stimulate mucus secretion, and produce characteristic structural changes in the airway (Horwitz and Busse 1995). These mediators can target ciliated airway epithelium to cause injury or disruption. As a consequence, epithelial cells and myofibroblasts—present beneath the epithelium—proliferate and begin to deposit interstitial collagens in the lamina reticularis of the basement membrane. This may explain apparent basement membrane thickening and the irreversible airway changes that may occur in some asthma patients (Roche 1991). Other changes, including hypertrophy and hyperplasia of airway smooth muscle, increases in goblet cell number, enlargement of submucous glands, and remodeling of the airway connective tissue, are

components of asthma that need to be recognized in both its pathogenesis and treatment. This inflammatory process is redundant in its ability to alter airway physiology and architecture.

Child-Onset Asthma

Asthma often begins in childhood, and when it does, it is frequently found in association with atopy, which is the genetic susceptibility to produce IgE directed toward common environmental allergens, including house-dust mites, animal proteins, and fungi (Larsen 1992). With the production of IgE antibodies, mast cells and possibly other airway cells (e.g., lymphocytes) are sensitized and become activated when they encounter specific antigens. Although atopy has been found in 30 to 50 percent of the general population, it is frequently found in the absence of asthma. Nevertheless, atopy is one of the strongest predisposing factors in the development of asthma (Sporik et al. 1990). Furthermore, among infants and young children who have wheezing with viral infections, allergy or family history of allergy is the factor that is most strongly associated with continuing asthma through childhood (Martinez et al. 1995).

Adult-Onset Asthma

Although asthma begins most frequently in childhood and adolescence, it can develop at anytime in life. Adult-onset asthma can occur in a variety of situations. In adult-onset asthma, allergens may continue to play an important role. However, in some adults who develop asthma, IgE antibodies to allergens or a family history of asthma are not detected. These individuals often have coexisting sinusitis, nasal polyps, and sensitivity to aspirin or related nonsteroidal anti-inflammatory drugs. The mechanisms of nonallergic, or intrinsic, asthma are less well established, although the inflammatory process is similar (but not identical) to that seen in atopic asthma (Walker et al. 1992).

Occupational exposure to workplace materials (animal products; biological enzymes; plastic resin; wood dusts, particularly cedar; and metals) (see component 2) can cause airway inflammation, bronchial hyperresponsiveness, and clinical signs of asthma (Chan-Yeung and Malo 1994; Fabbri et al. 1994). Identification of the causative agent and its removal from the workplace can reduce symptoms; however, some individuals will have persistent asthma even though exposure to the causative agent is eliminated. The mechanisms of this form of asthma are not clearly established.

RELATIONSHIP OF AIRWAY INFLAMMATION AND LUNG FUNCTION

Airway Hyperresponsiveness

An important feature of asthma is an exaggerated bronchoconstrictor response to a wide variety of stimuli. The propensity for airways to narrow too easily and too much is a major, but not necessarily unique, feature of asthma. Airway hyperresponsiveness leads to clinical symptoms of wheezing and dyspnea after exposure to allergens, environmental irritants, viral infections, cold air, or exercise. Research indicates that airway hyperresponsiveness is important in the pathogenesis of asthma and that the level of airway responsiveness usually correlates with the clinical severity of asthma.

Airway hyperresponsiveness can be measured by inhalation challenge testing with methacholine or histamine, as well as after exposure to such nonpharmacologic stimuli as hyperventilation with cold dry air, inhalation of hypotonic or hypertonic aerosols, or after exercise (O'Connor et al. 1989). In addition, variability between morning and evening peak expiratory flow (PEF) appears to reflect airway hyperresponsiveness and may serve as a measure of airway hyperresponsiveness, asthma instability, or asthma severity.

The factors contributing to airway inflammation in asthma are multiple and involve a variety of different inflammatory cells (as illustrated in figure 2) (Busse et al. 1993). It is also apparent that asthma is not caused by either a single cell or a single inflammatory mediator but rather results from complex interactions among inflammatory cells, mediators, and other cells and tissues resident in airways. An initial trigger in asthma may be the release of inflammatory mediators from bronchial mast cells, macrophages, T lymphocytes, and epithelial cells. These substances direct the migration and activation of other inflammatory cells, such as eosinophils and neutrophils, to the airway where they cause injury, such as alterations in epithelial integrity, abnormalities in autonomic neural control of airway tone, mucus hypersecretion, change in mucociliary function, and increased airway smooth muscle responsiveness.

The importance of the airway inflammatory response to airway hyperresponsiveness is substantiated by several observations. First, airway markers of inflammation correlate with bronchial hyperresponsiveness. Second, treatment of asthma and modification of airway inflammatory markers not only reduce symptoms but also diminish airway responsiveness. However, the relationship between airway inflammation and airway responsiveness is complex. Some investigations have shown that although anti-inflammatory therapy reduced airway hyperresponsiveness, it did not eradicate it. A small study found that control of airway inflammation did not control bronchial hyperresponsiveness (Lundgren et al. 1988). Thus, factors in addition to inflammation may contribute to airway hyperresponsiveness.

Airflow Obstruction

Airflow limitation in asthma is recurrent and caused by a variety of changes in the airway. These include:

- Acute bronchoconstriction. Allergen-induced acute bronchoconstriction results from an IgE-dependent release of mediators from the mast cell that include histamine, tryptase, leukotrienes, and prostaglandins (Marshall and Bienenstock 1994), which directly contract airway smooth muscle. Aspirin and other nonsteroidal anti-inflammatory drugs (see component 2) can also cause acute airflow obstruction in some patients, and evidence indicates that this non-IgE-dependent response also involves mediator release from airway cells (Fischer et al. 1994). In addition, other stimuli, including exercise, cold air, and irritants, can cause acute airflow obstruction. The mechanisms regulating the airway response to these factors are less well defined, but the intensity of the response appears related to underlying airway inflammation (Busse et al. 1993). There is emerging evidence that stress can play a role in precipitating asthma exacerbations. The mechanisms involved have yet to be established and may include enhanced generation of proinflammatory cytokines (Friedman et al. 1994).

- Airway edema. Airway wall edema, even without smooth muscle contraction or bronchoconstriction, limits airflow in asthma. Increased microvascular permeability and leakage caused by released mediators also contribute to mucosal thickening and swelling of the airway. As a consequence, swelling of the airway wall causes the airway to become more rigid and interferes with airflow.

- Chronic mucus plug formation. In severe intractable asthma, airflow limitation is often persistent. In part, this change may arise as a consequence of mucus secretion and the formation of inspissated mucus plugs.

- Airway remodeling. In some patients with asthma, airflow limitation may be only partially reversible. The etiology of this component is not as well studied as other features of asthma but may relate to structural changes in the airway matrix that may accompany longstanding and severe airway inflammation. There is evidence that a histological feature of asthma in some patients is an alteration in the amount and composition of the extracellular matrix in the airway wall (Djukanovic et al. 1990; Laitinen and Laitinen 1994). As a consequence of these changes, airway obstruction may be persistent and not responsive to treatment. Regulation of this repair and remodeling process is not well established, but both the process of repair and its regulation are likely to be key events in explaining the persistent nature of the disease and limitations to a therapeutic response. Although yet to be fully explored, the importance of airway remodeling and the development of persistent airflow limitation suggest a rationale for early intervention with anti-inflammatory therapy.

RELEVANCE OF CHRONIC AIRWAY INFLAMMATION TO ASTHMA THERAPY

Although inflammation can be used to describe a variety of conditions in various diseases, the inflammatory response in asthma has special features that include eosinophil infiltration, mast cell degranulation, interstitial airway wall injury, and lymphocyte activation. Furthermore, there is evidence that a TH2 lymphocyte cytokine profile (i.e., IL-4 and IL-5) is instrumental in initiating and sustaining the inflammatory process (James and Kay 1995; Ricci et al. 1993) (see figure 2). These observations also have become important in directing treatment in asthma. It is hypothesized that inflammation is an early and persistent component of asthma. As a consequence, therapy to suppress the inflammation must be long term. Furthermore, preliminary evidence suggests that early intervention with anti-inflam-

matory therapy may modify the disease process (Agertoft and Pedersen 1994; Laitinen et al. 1992; Djukanovic et al. 1992).

Observations into the basic mechanisms of asthma have had tremendous impact and influence on therapy. Studies have shown that improvements in asthma control achieved with high doses of inhaled corticosteroids are associated with improvement in markers of airway inflammation (Laitinen et al. 1992; Djukanovic et al. 1992). These observations indicate that a strong link may exist between features of airway inflammation, bronchial hyperresponsiveness, and asthma symptoms and severity. Furthermore, insight into the mechanisms of asthma with airway inflammation and bronchial wall repair has become a driving factor in designing logical, and hopefully effective, treatment paradigms.

Another area that needs clarification is the classification of compounds as anti-inflammatory in nature. Because many factors contribute to the inflammatory response in asthma, many drugs may fit this category. At present, corticosteroids are the anti-inflammatory compounds that have been demonstrated to modify histopathological features of asthma (Barnes 1995). It may be necessary to evaluate each new compound for the specificity of its "anti-inflammatory" action and determine from appropriate observations whether the compound is indeed anti-inflammatory and what consequences this has on the clinical features of the disease.

REFERENCES

Agertoft L, Pedersen S. Effects of long-term treatment with an inhaled corticosteroid on growth and pulmonary function in asthmatic children. *Respir Med* 1994;88:373-81.

Albelda SM. Endothelial and epithelial cell adhesion molecules. *Am J Respir Cell Mol Biol* 1991;4:195-203.

Barnes PJ. Inhaled glucocorticosteroid for asthma. *N Engl J Med* 1995;332:868-75.

Beasley R, Roche WR, Roberts TA, Holgate ST. Cellular events in the bronchi in mild asthma and bronchial provocation. *Am Rev Respir Dis* 1989;139:806-17.

Busse WW, Calhoun WJ, Sedgwick JD. Mechanisms of airway inflammation in asthma. *Am Rev Respir Dis* 1993;147:S20-S24.

Chan-Yeung M, Malo JL. Aetiological agents in occupational asthma. *Eur Respir J* 1994;7:346-71.

Djukanovic R, Roche WR, Wilson JW, et al. Mucosal inflammation in asthma. *Am Rev Respir Dis* 1990;142:434-57.

Djukanovic R, Wilson TW, Britten KM, et al. Effect of an inhaled corticosteroid on airway inflammation and symptoms of asthma. *Am Rev Respir Dis* 1992;145:669-74.

Dunnill MS. The pathology of asthma, with special reference to changes in the bronchial mucosa. *J Clin Pathol* 1960;13:27-33.

Emanuel MB, Howarth PH. Asthma and anaphylaxis: a relevant model for chronic disease? An historical analysis of directions in asthma research. *Clin Exp Allergy* 1995;25:15-26.

Fabbri LM, Maestrelli P, Saetta M, Mapp CM. Mechanisms of occupational asthma. *Clin Exp Allergy* 1994;24:628-35.

Fischer AR, Rosenberg MA, Lilly CM, et al. Direct evidence for a role of the mast cell in the nasal response to aspirin in aspirin-sensitive asthma. *J Allergy Clin Immunol* 1994;94:1046-56.

Friedman EM, Coe CL, Ershler WB. Bidirectional effects of interleukin-1 on immune responses in rhesus monkeys. *Brain Behav Immunol* 1994;8:87-99.

Horwitz RJ, Busse WW. Inflammation and asthma. *Clin Chest Med* 1995;16:583-602.

James DG, Kay AB. Are you TH-1 or TH-2? [editorial] *Clin Exp Allergy* 1995;25:389-90.

Jeffery PK, Wardlaw AJ, Nelson FC, Collins JV, Kay AB. Bronchial biopsies in asthma. An ultrastructural, qualitative study and correlation with hyperreactivity. *Am Rev Respir Dis* 1989;140:1745-53.

Laitinen A, Laitinen LA. Airway morphology: endothelium/basement membrane. *Am J Respir Crit Care Med* 1994;150:S14-S17.

Laitinen LA, Heino M, Laitinen A, Kava T, Haahtela T. Damage of the airway epithelium and bronchial reactivity in patients with asthma. *Am Rev Respir Dis* 1985;131:599-606.

Laitinen LA, Laitinen A, Haahtela T. A comparative study of the effects of an inhaled corticosteroid, budesonide, and a β_2-agonist, terbutaline, on airway inflammation in newly diagnosed asthma: a randomized, double-blind, parallel-group controlled trial. *J Allergy Clin Immunol* 1992;90:32-42.

Larsen GL. Asthma in children. *N Engl J Med* 1992;326:1540-5.

Lundgren R, Söderberg M, Horstedt P, et al. Morphological studies of bronchial biopsies from asthmatics before and after 10 years of treatment with inhaled steroids. *Eur Respir J* 1988;1:883-9.

Marshall JS, Bienenstock J. The role of mast cells in inflammatory reactions of the airways, skin and intestine. *Curr Opin Immunol* 1994;6:853-9.

Martinez FD, Wright AL, Taussig LM, Holberg CJ, Halonen M, Morgan WJ, Group Health Medical Associates. Asthma and wheezing in the first six years of life. *N Engl J Med* 1995;332:133-8.

National Heart, Lung, and Blood Institute. *Global Initiative for Asthma*. National Institutes of Health pub no 95-3659. 1995.

O'Connor GT, Sparrow D, Weiss ST. The role of allergy and nonspecific airway hyperresponsiveness in the pathogenesis of chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1989;140:225-52.

Ricci M, Rossi O, Bertoni M, Matucci A. The importance of TH2-like cells in the pathogenesis of airway allergic inflammation. *Clin Exp Allergy* 1993;23:360-9.

Robinson DS, Durham SR, Kay AB. Cytokines in asthma. *Thorax* 1993;48:845-53.

Robinson DS, Hamid Q, Ying S, et al. Predominant TH2-like bronchoalveolar T-lymphocyte population in atopic asthma. *N Engl J Med* 1992;326:298-304.

Roche WR. Fibroblasts and asthma. *Clin Exp Allergy* 1991;21:545-8.

Sporik R, Holgate ST, Platts-Mills TA, Cogswell JJ. Exposure to house-dust mite allergen (Der pI) and the development of asthma in childhood. A prospective study. *N Engl J Med* 1990;323:502-7.

Walker C, Bode E, Boer L, Hausel TT, Blaser K, Virchow JC Jr. Allergic and nonallergic asthmatics have distinct patterns of T-cell activation and cytokine production in peripheral blood and bronchoalveolar lavage. *Am Rev Respir Dis* 1992;146:109-15.

COMPONENT 1:
MEASURES OF ASSESSMENT AND MONITORING

Initial Assessment and Diagnosis of Asthma

KEY POINTS

- To establish a diagnosis of asthma, the clinician should determine that:
  - Episodic symptoms of airflow obstruction are present.
  - Airflow obstruction is at least partially reversible.
  - Alternative diagnoses are excluded.
- Recommended mechanisms to establish the diagnosis are:
  - Detailed medical history
  - Physical exam focusing on the upper respiratory tract, chest, and skin
  - Spirometry to demonstrate reversibility
- Additional studies may be considered to:
  - Evaluate alternative diagnoses
  - Identify precipitating factors
  - Assess severity
  - Investigate potential complications
- Recommendations are presented for referral for consultation or care to a specialist in asthma care.

DIFFERENCES FROM 1991 EXPERT PANEL REPORT

- Severity classifications were changed from mild, moderate, and severe to mild intermittent, mild persistent, moderate persistent, and severe persistent.
- Examples of questions to use for diagnosis and initial assessment of asthma were added.
- Information on wheezing in infancy and vocal cord dysfunction was expanded in the differential diagnosis section.
- Criteria for referral were refined with input from specialty and primary care physicians.
- More specific recommendations for measuring peak expiratory flow (PEF) diurnal variation are made.

The guidelines to help establish a diagnosis of asthma presented in this component are based on the opinion of the Expert Panel.

The clinician trying to establish a diagnosis of asthma should determine that:

- Episodic symptoms of airflow obstruction are present.
- Airflow obstruction is at least partially reversible.
- Alternative diagnoses are excluded.

A careful medical history, physical examination, pulmonary function tests, and additional tests will provide the information needed to ensure a correct diagnosis of asthma (see box 1). Each of these methods of assessment is described in this section.

Clinical judgment is needed in conducting the assessment for asthma. Patients with asthma are heterogeneous and present signs and symptoms that vary widely from patient to patient as well as within each patient over time.

BOX 1. KEY INDICATORS FOR CONSIDERING A DIAGNOSIS OF ASTHMA

Consider asthma and performing spirometry if any of these indicators are present.* These indicators are not diagnostic by themselves, but the presence of multiple key indicators increases the probability of a diagnosis of asthma. Spirometry is needed to establish a diagnosis of asthma.

- Wheezing—high-pitched whistling sounds when breathing out—especially in children. (Lack of wheezing and a normal chest examination do not exclude asthma.)
- History of any of the following:
  - Cough, worse particularly at night
  - Recurrent wheeze
  - Recurrent difficulty in breathing
  - Recurrent chest tightness
- Reversible airflow limitation and diurnal variation as measured by using a peak flow meter, for example:
  - Peak expiratory flow (PEF) varies 20 percent or more from PEF measurement on arising in the morning (before taking an inhaled short-acting beta$_2$-agonist) to PEF measurement in the early afternoon (after taking an inhaled short-acting beta$_2$-agonist).
- Symptoms occur or worsen in the presence of:
  - Exercise
  - Viral infection
  - Animals with fur or feathers
  - House-dust mites (in mattresses, pillows, upholstered furniture, carpets)
  - Mold
  - Smoke (tobacco, wood)
  - Pollen
  - Changes in weather
  - Strong emotional expression (laughing or crying hard)
  - Airborne chemicals or dusts
  - Menses
- Symptoms occur or worsen at night, awakening the patient.

*Eczema, hay fever, or a family history of asthma or atopic diseases are often associated with asthma, but they are not key indicators.

MEDICAL HISTORY

A detailed medical history of the new patient known or thought to have asthma should address the items listed in figure 1-1. The medical history can help:

- *Identify the symptoms likely to be due to asthma.* See figure 1-2 for sample questions.
- *Support the likelihood of asthma* (e.g., patterns of symptoms, family history of asthma or allergies).
- *Assess the severity of asthma* (e.g., symptom frequency and severity, exercise tolerance, hospitalizations, current medications). See figure 1-3 for a description of the levels of asthma severity.
- *Identify possible precipitating factors* (e.g., viral respiratory infections; exposure at home, work, day care, or school to inhalant allergens or irritants such as tobacco smoke). See component 2, Control of Factors Contributing to Asthma Severity, for more details.

PHYSICAL EXAMINATION

The upper respiratory tract, chest, and skin are the focus of the physical examination for asthma. Physical findings that increase the probability of asthma include:

- *Hyperexpansion of the thorax,* especially in children; use of accessory muscles; appearance of hunched shoulders; and chest deformity.
- *Sounds of wheezing during normal breathing, or a prolonged phase of forced exhalation* (typical of airflow obstruction). Wheezing during forced exhalation is not a reliable indicator of airflow limitation. In mild intermittent asthma, or between exacerbations, wheezing may be absent.
- *Increased nasal secretion, mucosal swelling, and nasal polyps.*
- *Atopic dermatitis/eczema* or any other manifestation of an allergic skin condition.

PULMONARY FUNCTION TESTING (SPIROMETRY)

Spirometry measurements (FEV_1, FVC, FEV_1/FVC) before and after the patient inhales a short-acting bronchodilator should be undertaken for patients in whom the diagnosis of asthma is being considered (Bye et al. 1992; Li and O'Connell 1996). This helps determine whether there is airflow obstruction and whether it is reversible over the short term (see box 2 for further information). Spirometry is generally valuable in children over age 4; however, some children cannot conduct the maneuver adequately until after age 7.

Spirometry typically measures the maximal volume of air forcibly exhaled from the point of maximal inhalation (forced vital capacity, FVC) and the volume of air exhaled during the first second of the FVC (forced expiratory volume in 1 second, FEV_1). Airflow obstruction is indicated by reduced FEV_1 and FEV_1/FVC values relative to reference or predicted values. Significant reversibility is indicated by an increase of ≥12 percent and 200 mL in FEV_1 after inhaling a short-acting bronchodilator (American Thoracic Society 1991) (see figure 1-4 for example of a spirometric curve for this test). A 2- to 3-week trial of oral corticosteroid therapy may be required to demonstrate reversibility. The spirometry measures that establish reversibility may not indicate the patient's best lung function.

Abnormalities of lung function are categorized as restrictive and obstructive defects. A reduced ratio of FEV_1/FVC (i.e., <65 percent) indicates obstruction to the flow of air from the lungs, whereas a reduced FVC with a normal FEV_1/FVC ratio suggests a restrictive pattern. The severity of abnormality of spirometric measurements is evaluated by comparison of the patient's results with reference values based on age, height, sex, and race (American Thoracic Society 1991).

Although asthma is typically associated with an obstructive impairment that is reversible, neither this finding nor any other single test or measure is adequate to diagnose asthma. Many diseases are associated with this pattern of abnormality. The patient's pattern of symptoms (along with other information from the patient's medical history) and exclusion of other possible diagnoses also are needed to establish a diagnosis of asthma. In severe cases, the FVC may also be reduced, due to trapping of air in the lungs.

FIGURE 1-1. SUGGESTED ITEMS FOR MEDICAL HISTORY*

A detailed medical history of the new patient who is known or thought to have asthma should address the following items:

1. Symptoms
   - Cough
   - Wheezing
   - Shortness of breath
   - Chest tightness
   - Sputum production

2. Pattern of symptoms
   - Perennial, seasonal, or both
   - Continual, episodic, or both
   - Onset, duration, frequency (number of days or nights, per week or month)
   - Diurnal variations, especially nocturnal and on awakening in early morning

3. Precipitating and/or aggravating factors
   - Viral respiratory infections
   - Environmental allergens, indoor (e.g., mold, house-dust mite, cockroach, animal dander or secretory products) and outdoor (e.g., pollen)
   - Exercise
   - Occupational chemicals or allergens
   - Environmental change (e.g., moving to new home; going on vacation; and/or alterations in workplace, work processes, or materials used)
   - Irritants (e.g., tobacco smoke, strong odors, air pollutants, occupational chemicals, dusts and particulates, vapors, gases, and aerosols)
   - Emotional expressions (e.g., fear, anger, frustration, hard crying or laughing)
   - Drugs (e.g., aspirin; beta-blockers, including eye drops; nonsteroidal anti-inflammatory drugs; others)
   - Food, food additives, and preservatives (e.g., sulfites)
   - Changes in weather, exposure to cold air
   - Endocrine factors (e.g., menses, pregnancy, thyroid disease)

4. Development of disease and treatment
   - Age of onset and diagnosis
   - History of early-life injury to airways (e.g., bronchopulmonary dysplasia, pneumonia, parental smoking)
   - Progress of disease (better or worse)
   - Present management and response, including plans for managing exacerbations
   - Need for oral corticosteroids and frequency of use
   - Comorbid conditions

5. Family history
   - History of asthma, allergy, sinusitis, rhinitis, or nasal polyps in close relatives

6. Social history
   - Characteristics of home including age, location, cooling and heating system, wood-burning stove, humidifier, carpeting over concrete, presence of molds or mildew, characteristics of rooms where patient spends time (e.g., bedroom and living room with attention to bedding, floor covering, stuffed furniture)
   - Smoking (patient and others in home or day care)
   - Day care, workplace, and school characteristics that may interfere with adherence
   - Social factors that interfere with adherence, such as substance abuse
   - Social support/social networks
   - Level of education completed
   - Employment (if employed, characteristics of work environment)

7. Profile of typical exacerbation
   - Usual prodromal signs and symptoms
   - Usual patterns and management (what works?)

8. Impact of asthma on patient and family
   - Episodes of unscheduled care (emergency department, urgent care, hospitalization)
   - Life-threatening exacerbations (e.g., intubation, intensive care unit admission)
   - Number of days missed from school/work
   - Limitation of activity, especially sports and strenuous work
   - History of nocturnal awakening
   - Effect on growth, development, behavior, school or work performance, and lifestyle
   - Impact on family routines, activities, or dynamics
   - Economic impact

9. Assessment of patient's and family's perceptions of disease
   - Patient, parental, and spouse's or partner's knowledge of asthma and belief in the chronicity of asthma and in the efficacy of treatment
   - Patient perception and beliefs regarding use and long-term effects of medications
   - Ability of patient and parents, spouse, or partner to cope with disease
   - Level of family support and patient's and parents', spouse's, or partner's capacity to recognize severity of an exacerbation
   - Economic resources
   - Sociocultural beliefs

*This list does not represent a standardized assessment or diagnostic instrument. The validity and reliability of this list have not been assessed.

FIGURE 1-2. SAMPLE QUESTIONS* FOR THE DIAGNOSIS AND INITIAL ASSESSMENT OF ASTHMA

A "yes" answer to any question suggests that an asthma diagnosis is likely.

In the past 12 months, . . .

- Have you had a sudden severe episode or recurrent episodes of coughing, wheezing (high-pitched whistling sounds when breathing out), or shortness of breath?
- Have you had colds that "go to the chest" or take more than 10 days to get over?
- Have you had coughing, wheezing, or shortness of breath during a particular season or time of the year?
- Have you had coughing, wheezing, or shortness of breath in certain places or when exposed to certain things (e.g., animals, tobacco smoke, perfumes)?
- Have you used any medications that help you breathe better? How often?
- Are your symptoms relieved when the medications are used?

In the past 4 weeks, have you had coughing, wheezing, or shortness of breath . . .

- At night that has awakened you?
- In the early morning?
- After running, moderate exercise, or other physical activity?

*These questions are examples and do not represent a standardized assessment or diagnostic instrument. The validity and reliability of these questions have not been assessed.

Office-based physicians who care for asthma patients should have access to spirometry, which is useful in both diagnosis and periodic monitoring. Spirometry should be performed using equipment and techniques that meet standards developed by the American Thoracic Society (1995). Correct technique, calibration methods, and maintenance of equipment are necessary to achieve consistently accurate test results. Maximal patient effort in performing the test is required to avoid important errors in diagnosis and management.

Training courses in the performance of spirometry that are approved by the National Institute for Occupational Safety and Health are available (800-35NIOSH). When office spirometry shows severe abnormalities, or if questions arise regarding test accuracy or interpretation, the Expert Panel recommends further assessment in a specialized pulmonary function laboratory.

ADDITIONAL STUDIES

Even though additional studies are not routine, they may be considered. No one test or set of tests is appropriate for every patient. However, the following procedures may be useful when considering alternative diagnoses, identifying precipitating factors, assessing severity, and investigating potential complications:

- *Additional pulmonary function studies* (e.g., lung volumes and inspiratory and expiratory flow volume loops) may be indicated, especially if there are questions about coexisting chronic obstructive pulmonary disease, a restrictive defect, or possible central airway obstruction. A *diffusing capacity test* is helpful in differentiating between asthma and emphysema in patients at risk for both illnesses, such as smokers and older patients.
- *Assessment of diurnal variation in peak expiratory flow over 1 to 2 weeks* is recommended when patients have asthma symptoms but normal spirometry (Enright et al. 1994). PEF is generally lowest on

FIGURE 1-3. CLASSIFICATION OF ASTHMA SEVERITY

Clinical Features Before Treatment*

	Symptoms**	Nighttime Symptoms	Lung Function
STEP 4 Severe Persistent	■ Continual symptoms ■ Limited physical activity ■ Frequent exacerbations	Frequent	■ FEV_1 or PEF ≤60% predicted ■ PEF variability >30%
STEP 3 Moderate Persistent	■ Daily symptoms ■ Daily use of inhaled short-acting $beta_2$-agonist ■ Exacerbations affect activity ■ Exacerbations ≥2 times a week; may last days	>1 time a week	■ FEV_1 or PEF >60% –<80% predicted ■ PEF variability >30%
STEP 2 Mild Persistent	■ Symptoms >2 times a week but <1 time a day ■ Exacerbations may affect activity	>2 times a month	■ FEV_1 or PEF ≥80% predicted ■ PEF variability 20–30%
STEP 1 Mild Intermittent	■ Symptoms ≤2 times a week ■ Asymptomatic and normal PEF between exacerbations ■ Exacerbations brief (from a few hours to a few days); intensity may vary	≤2 times a month	■ FEV_1 or PEF ≥80% predicted ■ PEF variability <20%

* The presence of one of the features of severity is sufficient to place a patient in that category. An individual should be assigned to the most severe grade in which any feature occurs. The characteristics noted in this figure are general and may overlap because asthma is highly variable. Furthermore, an individual's classification may change over time.

** Patients at any level of severity can have mild, moderate, or severe exacerbations. Some patients with intermittent asthma experience severe and life-threatening exacerbations separated by long periods of normal lung function and no symptoms.

BOX 2. IMPORTANCE OF SPIROMETRY IN ASTHMA DIAGNOSIS

Objective assessments of pulmonary function are necessary for the diagnosis of asthma because medical history and physical examination are not reliable means of excluding other diagnoses or of characterizing the status of lung impairment. Although physicians generally seem able to identify a lung abnormality as obstructive (Russell et al. 1986), they have a poor ability to assess the degree of airflow obstruction (Shim and Williams 1980) or to predict whether the obstruction is reversible (Russell et al. 1986).

For diagnostic purposes, spirometry is generally recommended over measurements by a peak flow meter in the clinician's office because there is wide variability even in the best published peak expiratory flow reference values. Reference values need to be specific to each brand of peak flow meter, and such normative brand-specific values currently are not available for most brands. Peak flow meters are designed as monitoring, not as diagnostic, tools in the office (see component 1-Periodic Assessment and Monitoring). However, peak flow monitoring can establish peak flow variability and thus aid in the determination of asthma severity when patients have asthma symptoms and normal spirometry (see Additional Studies section, page 19).

FIGURE 1-4a. SAMPLE SPIROMETRY VOLUME TIME AND FLOW VOLUME CURVES

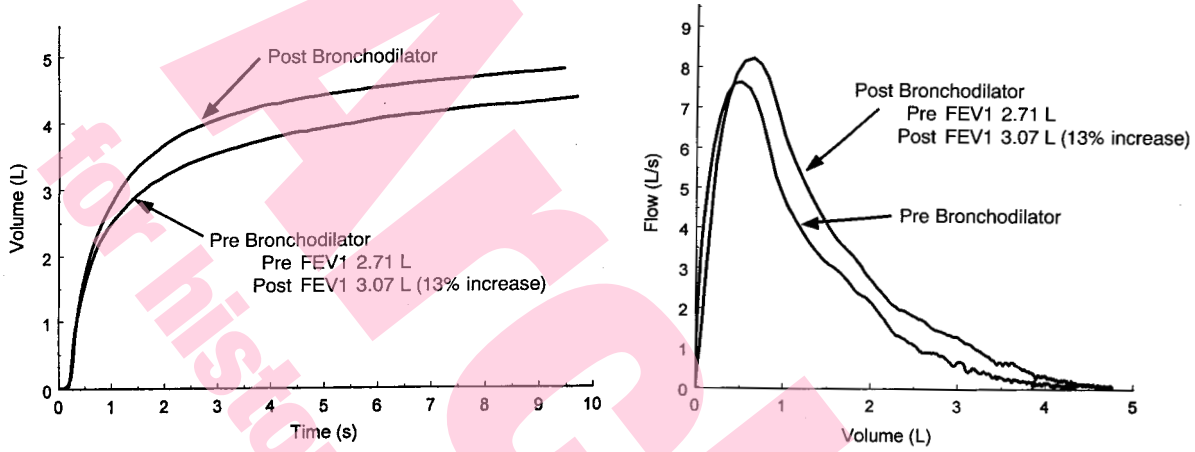


FIGURE 1-4b. REPORT OF SPIROMETRY FINDINGS PRE AND POST BRONCHODILATOR

Pre Bronchodilator

Study: bronch	ID:	Test date: 8/7/96	Time: 9:38 am
Age: 59	Height: 175 cm	Sex: M	System: 7 20 17

Trial	FVC	FEV1	FEV1/FVC%
1	4.34	2.68	61.8%
2	4.40	2.59	58.9%
3	4.44	2.62	58.9%
4	4.56	2.69	58.9%
5	4.55	2.71	59.6%
Best Values	4.56	2.71	59.4%
Predicted Values-1	4.23	3.40	80.5%
LLN-2	3.10	2.62	69.9%
Percent Predicted	107.8%	79.7%	73.8%

Interpretations: Pre-shift
FEV_1/FVC are below normal range. The reduced rate which air is exhaled indicates obstruction to airflow.
1- Predicted values from Knudson et al., *Am Rev Respir Dis* 1983.
2- LLN is the Lower Limit of the Normal range (95th percentile).

Post Bronchodilator

Study: bronch	ID:	Test date: 8/7/96	Time: 11:42 am
Age: 59	Height: 175 cm	Sex: M	System: 7 20 17

Trial	FVC	FEV1	FEV1/FVC%
1	4.68	3.00	64.0%
2	4.73	2.94	62.2%
3	4.59	2.95	64.3%
4	4.76	3.07	64.5%
5	4.78	3.04	63.5%
Best values	4.78	3.07	64.3%
Reference Values	4.56	2.71	
Difference (L)	0.22	0.36	
Difference (%)	4.8%	13.4%	

Interpretations: Bronchodilator Response

Significant increases in FEV_1, with bronchodilator (≥12% increase after bronchodilator indicates a significant change).

first awakening and highest several hours before the midpoint of the waking day (e.g., between noon and 2 p.m.) (Quackenboss et al. 1991). Optimally, PEF should be measured close to those two times, before taking an inhaled short-acting $beta_2$-agonist in the morning and after taking one in the afternoon. A 20 percent difference between morning and afternoon measurements suggests asthma. Measuring PEF on waking and in the evening may be more practical and feasible, but values will tend to underestimate the actual diurnal variation.

- *Bronchoprovocation* with methacholine, histamine, or exercise challenge may be useful when asthma is suspected and spirometry is normal or near normal. For safety reasons, bronchoprovocation testing should be carried out by a trained individual in an appropriate facility and is not generally recommended if the FEV_1 is <65 percent predicted. A negative bronchoprovocation may be helpful to rule out asthma.
- *Chest x ray* may be needed to exclude other diagnoses.
- *Allergy testing* (see component 2).
- *Evaluation of the nose for nasal polyps and sinuses for sinus disease.*
- *Evaluation for gastroesophageal reflux* (Harding and Richter 1992) (see component 2).

FIGURE 1-5. DIFFERENTIAL DIAGNOSTIC POSSIBILITIES FOR ASTHMA

Infants and Children

Upper airway diseases

- Allergic rhinitis and sinusitis

Obstructions involving large airways

- Foreign body in trachea or bronchus
- Vocal cord dysfunction
- Vascular rings or laryngeal webs
- Laryngotracheomalacia, tracheal stenosis, or bronchostenosis
- Enlarged lymph nodes or tumor

Obstructions involving small airways

- Viral bronchiolitis or obliterative bronchiolitis
- Cystic fibrosis
- Bronchopulmonary dysplasia
- Heart disease

Other causes

- Recurrent cough not due to asthma
- Aspiration from swallowing mechanism dysfunction or gastroesophageal reflux

Adults

- Chronic obstructive pulmonary disease (chronic bronchitis or emphysema)
- Congestive heart failure
- Pulmonary embolism
- Laryngeal dysfunction
- Mechanical obstruction of the airways (benign and malignant tumors)
- Pulmonary infiltration with eosinophilia
- Cough secondary to drugs (angiotensin-converting enzyme [ACE] inhibitors)
- Vocal cord dysfunction

The usefulness of measurements of biomarkers of inflammation (e.g., total and differential cell count and mediator assays) in sputum, blood, or urine as aids to the diagnosis of asthma is currently being evaluated in clinical research trials.

DIFFERENTIAL DIAGNOSIS OF ASTHMA

Recurrent episodes of cough and wheezing are almost always due to asthma in both children and adults. Underdiagnosis of asthma is a frequent problem, especially in children who wheeze when they have respiratory infections. These children are often labeled as having bronchitis, bronchiolitis, or pneumonia even though the signs and symptoms are most compatible with a diagnosis of asthma. However, the clinician needs to be aware of other causes of airway obstruction leading to wheezing (see figure 1-5).

There are two general patterns of wheezing in infancy: nonallergic and allergic. Nonallergic infants wheeze when they have an acute upper respiratory viral infection, but as their airways grow larger in the preschool years the wheezing disappears. Allergic infants also wheeze with viral infections, but they are more likely to have asthma that will continue throughout childhood. This group may have eczema, allergic rhinitis, or food allergy as other manifestations of allergy. Both groups may benefit from asthma treatment (see Infants and Young Children section, page 94, in component 3-Managing Asthma Long Term).

Vocal cord dysfunction often mimics asthma. Patients with vocal cord dysfunction can present with recurrent severe shortness of breath and wheezing. Vocal cord dysfunction may even cause alveolar hypoventilation, with increases in PCO_2 that prompt urgent intubation and mechanical ventilation. Vocal cord dysfunction that mimics asthma is more common in young adults with psychological disorders. It should be suspected when physical examination reveals a monophonic wheeze heard loudest over the glottis. Further evaluation by flow-volume curve revealing inspiratory flow limitation strongly supports the diagnosis of vocal cord dysfunction. Definitive diagnosis—and exclusion of organic causes of vocal cord narrowing—requires direct visualization of the vocal cords. Treatment with speech therapy that teaches techniques for relaxed throat breathing is often effective (Newman et al. 1995; Bucca et al. 1995; Christopher et al. 1983).

GENERAL GUIDELINES FOR REFERRAL TO AN ASTHMA SPECIALIST

Criteria for the referral of an asthma patient have been developed (Spector and Nicklas 1995; Shuttari 1995). Based on the opinion of the Expert Panel, referral for consultation or care to a specialist in asthma care (usually, a fellowship-trained allergist or pulmonologist; occasionally, other physicians with expertise in asthma management developed through additional training and experience) is recommended when:

- Patient has had a life-threatening asthma exacerbation.
- Patient is not meeting the goals of asthma therapy (see component 1-Periodic Assessment and Monitoring) after 3 to 6 months of treatment. An earlier referral or consultation is appropriate if the physician concludes that the patient is unresponsive to therapy.
- Signs and symptoms are atypical or there are problems in differential diagnosis.
- Other conditions complicate asthma or its diagnosis (e.g., sinusitis, nasal polyps, aspergillosis, severe rhinitis, vocal cord dysfunction, gastroesophageal reflux, chronic obstructive pulmonary disease).
- Additional diagnostic testing is indicated (e.g., allergy skin testing, rhinoscopy, complete pulmonary function studies, provocative challenge, bronchoscopy).
- Patient requires additional education and guidance on complications of therapy, problems with adherence, or allergen avoidance.
- Patient is being considered for immunotherapy.
- Patient has severe persistent asthma, requiring step 4 care (referral may be considered for patients requiring step 3 care; see component 3-Managing Asthma Long Term).
- Patient requires continuous oral corticosteroid therapy or high-dose inhaled corticosteroids or has required more than two bursts of oral corticosteroids in 1 year.
- Patient is under age 3 and requires step 3 or 4 care (see component 3-Managing Asthma Long Term). When patient is under age 3 and requires step 2 care or initiation of daily long-term therapy, referral should be considered.
- Patient requires confirmation of a history that suggests that an occupational or environmental inhalant or ingested substance is provoking or contributing to asthma. Depending on the complexities of diagnosis, treatment, or the intervention required in the work environment, it may be appropriate in some cases for the specialist to manage the patient over a period of time or comanage with the primary care provider.

In addition, patients with significant psychiatric, psychosocial, or family problems that interfere with their asthma therapy may need referral to an appropriate mental health professional for counseling or treatment. These characteristics have been shown to interfere with a patient's ability to adhere to treatment (Strunk 1987; Strunk et al. 1985)

REFERENCES

American Thoracic Society. Lung function testing: selection of reference values and interpretive strategies. *Am Rev Respir Dis* 1991;144:1202-18.

American Thoracic Society. Standardization of spirometry: 1994 update. *Am J Respir Crit Care Med* 1995;152:1107-36.

Bucca C, Rolla G, Brussino L, De Rose V, Bugiani M. Are asthma-like symptoms due to bronchial or extrathoracic airway dysfunction? *Lancet* 1995;346:791-5.

Bye MR, Kerstein D, Barsh E. The importance of spirometry in the assessment of childhood asthma. *Am J Dis Child* 1992;146:977-8.

Christopher KL, Wood RP 2nd, Eckert RC, Blager FB, Raney RA, Souhrada JF. Vocal cord dysfunction presenting as asthma. *N Engl J Med* 1983;308:1566-70.

Enright PL, Lebowitz MD, Cockroft DW. Physiologic measures: pulmonary function tests. Asthma outcome. *Am J Respir Crit Care Med* 1994;149:S9-18.

Harding SM, Richter JE. Gastroesophageal reflux disease and asthma. *Semin Gastrointest Dis* 1992;3:139-50.

Knudson RJ, Lebowitz MD, Holberg CJ, Burrows B. Changes in the normal maximal expiratory flow-volume curve with growth and aging. *Am Rev Respir Dis* 1983;127:725-34.

Li JT, O'Connell EJ. Clinical evaluation of asthma. *Ann Allergy Asthma Immunol* 1996;76:1-13.

Newman KB, Mason UG 3rd, Schmaling KB. Clinical features of vocal cord dysfunction. *Am J Respir Crit Care Med* 1995;152:1382-6.

Quackenboss JJ, Lebowitz MD, Krzyzanowski M. The normal range of diurnal changes in peak expiratory flow rates. Relationship to symptoms and respiratory disease. *Am Rev Respir Dis* 1991;143:323-30.

Russell NJ, Crichton NJ, Emerson PA, Morgan AD. Quantitative assessment of the value of spirometry. *Thorax* 1986;41:360-3.

Shim CS, Williams MH Jr. Evaluation of the severity of asthma: patients versus physicians. *Am J Med* 1980;68:11-13.

Shuttari MF. Asthma: diagnosis and management. *Am Fam Physician* 1995;52:2225-35.

Spector SL, Nicklas RA, eds. Practice parameters for the diagnosis and treatment of asthma. *J Allergy Clin Immunol* 1995;96:729-31.

Strunk RC. Asthma deaths in childhood: identification of patients at risk and intervention. *J Allergy Clin Immunol* 1987;80:472-7.

Strunk RC, Mrazek DA, Wolfson Fuhrmann GS, LaBrecque JF. Physiologic and psychological characteristics associated with deaths due to asthma in childhood. A case-controlled study. *JAMA* 1985;254:1193-8.

Periodic Assessment and Monitoring: Essential for Asthma Management

KEY POINTS

- The goals of therapy are to:
  - Prevent chronic and troublesome symptoms (e.g., coughing or breathlessness in the night, in the early morning, or after exertion)
  - Maintain (near) "normal" pulmonary function
  - Maintain normal activity levels (including exercise and other physical activity)
  - Prevent recurrent exacerbations of asthma and minimize the need for emergency department visits or hospitalizations
  - Provide optimal pharmacotherapy with least amount of adverse effects
  - Meet patients' and families' expectations of and satisfaction with asthma care

- Periodic assessments and ongoing monitoring of asthma are recommended to determine if the goals of therapy are being met. Measurements of the following are recommended:
  - Signs and symptoms of asthma
  - Pulmonary function
  - Quality of life/functional status
  - History of asthma exacerbations
  - Pharmacotherapy
  - Patient-provider communication and patient satisfaction

- Clinician assessment and patient self-assessment are the primary methods for monitoring asthma. Population-based assessment is beginning to be used by managed care organizations.

- Spirometry tests are recommended (1) at the time of initial assessment, (2) after treatment is initiated and symptoms and PEF have stabilized, and (3) at least every 1 to 2 years.

- Patients should be given a written action plan based on signs and symptoms and/or PEF; this is especially important for patients with moderate-to-severe persistent asthma or a history of severe exacerbations.

- Patients should be trained to recognize symptom patterns indicating inadequate asthma control and the need for additional therapy.

- Recommendations on how and when to do peak flow monitoring are presented.

DIFFERENCES FROM 1991 EXPERT PANEL REPORT

- The new report includes an additional goal of therapy (meet patients' and families' expectations of and satisfaction with asthma care) that was not listed in the 1991 report.

- Periodic assessment of six domains of patient health that correspond with the goals of asthma therapy are now recommended, including signs and symptoms, pulmonary function, quality of life, history of exacerbations, pharmacotherapy, and patient-provider communication and patient satisfaction.

- The following changes affecting peak flow monitoring have been made:
  - The recommendation for peak flow monitoring was changed from twice daily to morning. If the morning reading is less than 80 percent of personal best PEF, more frequent peak flow monitoring may be desired.

  - Discussion of inconsistencies in measurement among peak flow meters was added.
  - Use of the individual patient's personal best PEF is emphasized strongly.

- The recommendation for patients at all severity levels to monitor symptoms to recognize early signs of deterioration is emphasized.

- Sample questions to use in periodic assessments were added.

GOALS OF THERAPY

The purpose of periodic assessment and ongoing monitoring is to determine whether the goals of asthma therapy are being achieved. The goals of therapy are as follows:

- Prevent chronic and troublesome symptoms (e.g., coughing or breathlessness in the night, in the early morning, or after exertion)
- Maintain (near) "normal" pulmonary function
- Maintain normal activity levels (including exercise and other physical activity)
- Prevent recurrent exacerbations of asthma and minimize the need for emergency department visits or hospitalizations
- Provide optimal pharmacotherapy with minimal or no adverse effects
- Meet patients' and families' expectations of and satisfaction with asthma care

ASSESSMENT MEASURES

The Expert Panel recommends ongoing monitoring in the six areas listed below to determine whether the goals of therapy are being met. The assessment measures for monitoring these six areas are described in this section and are recommended based on the opinion of the Expert Panel.

- Monitoring signs and symptoms of asthma
- Monitoring pulmonary function
  - Spirometry
  - Peak flow monitoring
- Monitoring quality of life/functional status
- Monitoring history of asthma exacerbations
- Monitoring pharmacotherapy
- Monitoring patient-provider communication and patient satisfaction

Monitoring Signs and Symptoms of Asthma

Every patient with asthma should be taught to recognize symptom patterns that indicate inadequate asthma control (see Patient Self-Assessment section, page 38, and component 4). Symptom monitoring should be used as a means to determine the need for intervention, including additional medication, in the context of an action plan (see figure 4-5).

Symptoms and clinical signs of asthma should be assessed at each health care visit through physical examination and appropriate questions. This is crucial to optimal asthma care. A description of the important elements of an asthma-related physical examination can be found in component 1-Initial Assessment and Diagnosis, which also discusses the variability in the types of symptoms associated with asthma.

Detailed patient recall of symptoms decreases over time; therefore, the Expert Panel recommends that any detailed symptoms history be based on a short (2 to 4 weeks) recall period. For example, the clinician may choose to assess over a 2-week, 3-week, or 4-week recall period. Symptom assessment for periods longer than 4 weeks should reflect more global symptom assessment, such as inquiring whether the patient's asthma has been better or worse since the last visit and inquiring whether the patient has encountered any particular difficulties during specific seasons or events. Figure 1-6 provides an example of a set of questions that can be used to characterize both global (long-term recall) and recent (short-term recall) asthma symptoms.

In addition, any assessment of the patient's symptom history should include at least three key symptom expressions:

- Daytime asthma symptoms (including wheezing, cough, chest tightness, or shortness of breath)

FIGURE 1-6. COMPONENTS OF THE CLINICIAN'S FOLLOWUP ASSESSMENT: SAMPLE ROUTINE CLINICAL ASSESSMENT QUESTIONS*

Monitoring Signs and Symptoms

(Global assessment) "Has your asthma been better or worse since your last visit?"
(Recent assessment) "In the past 2 weeks, how many days have you:
- Had problems with coughing, wheezing, shortness of breath, or chest tightness during the day?"
- Awakened at night from sleep because of coughing or other asthma symptoms?"
- Awakened in the morning with asthma symptoms that did not improve within 15 minutes of inhaling a short-acting inhaled beta$_2$-agonist?"
- Had symptoms while exercising or playing?"

Monitoring Pulmonary Function

Lung Function
"What is the highest and lowest your peak flow has been since your last visit?"
"Has your peak flow dropped below ____ L/min (80 percent of personal best) since your last visit?"
"What did you do when this occurred?"

Peak Flow Monitoring Technique
"Please show me how you measure your peak flow."
"When do you usually measure your peak flow?"

Monitoring Quality of Life/Functional Status

"Since your last visit, how many days has your asthma caused you to:
- Miss work or school?"
- Reduce your activities?"
- (For caregivers) Change your activity because of your child's asthma?"

"Since your last visit, have you had any unscheduled or emergency department visits or hospital stays?"

Monitoring Exacerbation History

"Since your last visit, have you had any episodes/times when your asthma symptoms were a lot worse than usual?"

If yes - "What do you think caused the symptoms to get worse?"
If yes - "What did you do to control the symptoms?"

"Have there been any changes in your home or work environment (e.g., new smokers or pets)?"

Monitoring Pharmacotherapy

Medications
"What medications are you taking?"
"How often do you take each medication?"
"How much do you take each time?"
"Have you missed or stopped taking any regular doses of your medications for any reason?"
"Have you had trouble filling your prescriptions (e.g., for financial reasons, not on formulary)?"
"How many puffs of your short-acting inhaled beta$_2$-agonist (quick-relief medicine) do you use per day?"
"How many [name short-acting inhaled beta$_2$-agonist] inhalers [or pumps] have you been through in the past month?"
"Have you tried any other medicines or remedies?"

Side Effects
"Has your asthma medicine caused you any problems?"
- Shakiness, nervousness, bad taste, sore throat, cough, upset stomach

Inhaler Technique
"Please show me how you use your inhaler."

Monitoring Patient-Provider Communication and Patient Satisfaction

"What questions have you had about your asthma daily self-management plan and action plan?"
"What problems have you had following your daily self-management plan? Your action plan?"
"Has anything prevented you from getting the treatment you need for your asthma from me or anyone else?"
"Have the costs of your asthma treatment interfered with your ability to get asthma care?"
"How satisfied are you with your asthma care?"
"How can we improve your asthma care?"
"Let's review some important information:"
- "When should you increase your medications? Which medication(s)?"
- "When should you call me [your doctor or nurse practitioner]? Do you know the after-hours phone number?"
- "If you can't reach me, what emergency department would you go to?"

* These questions are examples and do not represent a standardized assessment instrument. The validity and reliability of these questions have not been assessed.

- Nocturnal awakening as a result of asthma symptoms

- Asthma symptoms early in the morning that are not improved 15 minutes after inhaling a short-acting beta$_2$-agonist

Monitoring Pulmonary Function

In addition to assessing symptoms, it is also important to periodically assess pulmonary function. The main methods are spirometry and peak flow monitoring.

Regular monitoring of pulmonary function is particularly important for asthma patients who do not perceive their symptoms until airflow obstruction is severe. Currently, there is no readily available method of detecting the "poor perceivers." The literature reports that patients who had a near-fatal asthma exacerbation, as well as older patients, are more likely to have poor perception of airflow obstruction (Kikuchi et al. 1994; Connolly et al. 1992).

Spirometry

The Expert Panel recommends that spirometry tests be done (1) at the time of initial assessment; (2) after treatment is initiated and symptoms and peak expiratory flow (PEF) have stabilized, to document attainment of (near) "normal" airway function; and (3) at least every 1 to 2 years to assess the maintenance of airway function.

Spirometry may be indicated more often than every 1 to 2 years, depending on the clinical severity and response to management. Spirometry with measurement of the FEV_1 is also useful:

- As a periodic (e.g., yearly) check on the accuracy of the peak flow meter (Miles et al. 1995)

- When more precision is desired in measuring lung function (e.g., when evaluating response to bronchodilator or nonspecific airway responsiveness or when assessing response to a "step down" in pharmacotherapy)

- When PEF results are unreliable (e.g., in some very young or elderly patients or when neuromuscular or orthopedic problems are present) and the physician needs the quality checks that are available only with spirometry (Hankinson and Wagner 1993).

For routine monitoring at most outpatient visits, measurement of PEF with a peak flow meter is generally a sufficient assessment of pulmonary function, particularly in mild intermittent, mild persistent, and moderate persistent asthma.

Peak Flow Monitoring

Peak expiratory flow provides a simple, quantitative, and reproducible measure of the existence and severity of airflow obstruction. PEF can be measured with inexpensive and portable peak flow meters. *It must be stressed that peak flow meters are designed as tools for ongoing monitoring, not diagnosis.* Because the measurement of PEF is dependent on effort and technique, patients need instructions, demonstrations, and frequent reviews of technique (see figure 1-7, the patient handout How To Use Your Peak Flow Meter).

Peak flow monitoring can be used for short-term monitoring, managing exacerbations, and daily long-term monitoring. When used in these ways, the patient's measured personal best is the most appropriate reference value. Four studies (Woolcock et al. 1988; Ignacio-Garcia and Gonzalez-Santos 1995; Lahdensuo et al. 1996; Beasley et al. 1989) have found that comprehensive asthma self-management programs, in which peak flow monitoring was a component, achieved significant improvements in health outcomes. Thus far, the few studies that have isolated a comparison of peak flow and symptom monitoring have not been sufficient to assess the relative contributions of each to asthma management (see box 1, Peak Flow Monitoring Literature Review). The literature does suggest which patients may benefit most from peak flow monitoring. The Expert Panel concludes, on the basis of this literature and the Panel's opinion, that:

- Patients with moderate-to-severe persistent asthma should learn how to monitor their PEF and have a peak flow meter at home.

- Peak flow monitoring during exacerbations of asthma is recommended for patients with moderate-to-severe persistent asthma to:

  — Determine severity of the exacerbation

  — Guide therapeutic decisions (see component 3-Managing Exacerbations and figure 4-5) in the home, clinician's office, or emergency department

Figure 1-7

How To Use Your Peak Flow Meter

A peak flow meter is a device that measures how well air moves out of your lungs. During an asthma episode, the airways of the lungs usually begin to narrow slowly. The peak flow meter may tell you if there is narrowing in the airways hours—sometimes even days—before you have any asthma symptoms.

By taking your medicine(s) early (before symptoms), you may be able to stop the episode quickly and avoid a severe asthma episode. Peak flow meters are used to check your asthma the way that blood pressure cuffs are used to check high blood pressure.

The peak flow meter also can be used to help you and your doctor:

- Learn what makes your asthma worse
- Decide if your treatment plan is working well
- Decide when to add or stop medicine
- Decide when to seek emergency care

A peak flow meter is most helpful for patients who must take asthma medicine daily. Patients age 5 and older are usually able to use a peak flow meter. Ask your doctor or nurse to show you how to use a peak flow meter.

How To Use Your Peak Flow Meter

- Do the following five steps with your peak flow meter:

  1. Move the indicator to the bottom of the numbered scale.
  2. Stand up.
  3. Take a deep breath, filling your lungs completely.
  4. Place the mouthpiece in your mouth and close your lips around it. Do not put your tongue inside the hole.
  5. Blow out as hard and fast as you can in a single blow.

- Write down the number you get. But if you cough or make a mistake, don't write down the number. Do it over again.
- Repeat steps 1 through 5 two more times and write down the best of the three blows in your asthma diary.

Find Your Personal Best Peak Flow Number

Your personal best peak flow number is the highest peak flow number you can achieve over a 2- to 3-week period when your asthma is under good control. Good control is when you feel good and do not have any asthma symptoms.

Each patient's asthma is different, and your best peak flow may be higher or lower than the peak flow of someone of your same height, weight, and sex. This means that it is important for you to find your own personal best peak flow number. Your treatment plan needs to be based on your own personal best peak flow number.

To find out your personal best peak flow number, take peak flow readings:

- At least twice a day for 2 to 3 weeks.
- When you wake up and between noon and 2:00 p.m.
- Before and after you take your short-acting inhaled beta$_2$-agonist for quick relief, if you take this medicine.
- As instructed by your doctor.

The Peak Flow Zone System

Once you know your personal best peak flow number, your doctor will give you the numbers that tell you what to do. The peak flow numbers are put into zones that are set up like a traffic light. This will help you know what to do when your peak flow number changes. For example:

Green Zone (more than ___ L/min [80 percent of your personal best number]) signals *good control*. No asthma symptoms are present. Take your medicines as usual.

Yellow Zone (between ___ L/min and ___ L/min [50 to less than 80 percent of your personal best number]) signals *caution*. You must take a short-acting inhaled beta$_2$-agonist right away. Also, your asthma may not be under good day-to-day control. Ask your doctor if you need to change or increase your daily medicines.

Red Zone (below ___ L/min [50 percent of your personal best number]) signals a *medical alert*. You must take a short-acting inhaled beta$_2$-agonist (quick-relief medicine) right away. Call your doctor or emergency room and ask what to do, or go directly to the hospital emergency room.

Record your personal best peak flow number and peak flow zones in your asthma diary.

Use the Diary To Keep Track of Your Peak Flow

Measure your peak flow when you wake up, *before* taking medicine. Write down your peak flow number in the diary every day, or as instructed by your doctor.

Actions To Take When Peak Flow Numbers Change

- PEF goes between ___L/min and ___L/min (50 to less than 80 percent of personal best, yellow zone).
  ACTION: Take a short-acting inhaled beta$_2$-agonist (quick-relief medicine) as prescribed by your doctor.

- PEF increases 20 percent or more when measured before and after taking a short-acting inhaled beta$_2$-agonist (quick-relief medicine).
  ACTION: Talk to your doctor about adding more medicine to control your asthma better (for example, an anti-inflammatory medication).

Source: *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma.* National Asthma Education and Prevention Program, National Heart, Lung, and Blood Institute, 1997.

BOX 1. PEAK FLOW MONITORING LITERATURE REVIEW

Seven intervention studies on the use of daily peak flow monitoring for asthma management were identified, six through a MEDLINE search from 1980 to 1995 and reviews of reference lists and one from the 1996 literature.

Three randomized controlled trials (Woolcock et al. 1988, N = 24; Ignacio-Garcia and Gonzalez-Santos 1995, N = 70; Lahdensuo et al. 1996, N = 115) and an uncontrolled pretest/posttest study (Beasley et al. 1989, N = 36) tested comprehensive asthma interventions that included self-management medication plans, medications, education, and peak flow monitoring. These studies reported significant improvements in lung function, symptoms, and medication use after 6 months (Beasley et al. 1989; Ignacio-Garcia and Gonzalez-Santos 1995) and 18 months (Woolcock et al. 1988). However, these studies could not determine the relative importance of peak flow monitoring to the effectiveness of the comprehensive asthma intervention.

Three randomized controlled trials compared the use of daily peak flow monitoring with symptom monitoring (Charlton et al. 1990, N = 115 adults and children) or usual care (Grampian Asthma Study 1994, N = 569 adults; Jones et al. 1995, N = 72 adults). These studies found no significant differences between the experimental and control groups in the outcomes measured: lung function, symptom frequency, quality of life, hospitalizations, medication use, and medical consultations. However, one of these studies involved patients with mild asthma (Jones et al. 1995), a population not expected to benefit as much from peak flow monitoring.

Almost all the peak flow monitoring studies available had study design and execution problems (e.g., selection bias, unequal control and experimental groups, small sample sizes, high loss to followup). More studies of daily long-term peak flow monitoring among patients with moderate and severe persistent asthma are urgently needed. Nonetheless, some issues suggested by the few studies available warrant consideration:

- Among patients with mild intermittent or mild persistent asthma, there appears to be no significant advantage of peak flow monitoring over usual care without peak flow monitoring (Jones et al. 1995).
- Patients with moderate-to-severe persistent asthma or unstable asthma are more likely to benefit from long-term daily peak flow monitoring. For example, the Grampian study authors conducted an observational study of 89 patients disqualified from the original study because their asthma was too severe and found that those who used peak flow meters took oral corticosteroids more often (action plan told patients to take oral corticosteroids at specific PEF levels) and had significantly fewer days of limited activity than those who did not use a peak flow meter.
- Short-term daily peak flow monitoring is helpful for assessing the severity of a patient's asthma and evaluating response to chronic maintenance therapy.
- Short-term peak flow monitoring is also helpful during exacerbations for assessing the severity of acute airflow obstruction and evaluating the patient's response to bronchodilator therapy. Janson-Bjerklie and Shnell (1988) found that patients used medications less frequently when they monitored PEF during symptomatic periods.
- Additional studies are needed to clarify the role of long-term daily peak flow monitoring in detecting early signs of deterioration, especially for patients with moderate-to-severe persistent asthma. Studies have found that 15 percent of asthma patients (Rubinfeld and Pain 1976), 24 to 27 percent of elderly patients (Connolly et al. 1992), and patients who had near-fatal asthma exacerbations (Kikuchi et al. 1994) could not perceive significant reductions in FEV_1 provoked by methacholine challenge. A recent study in a general community setting found that for 60 percent of patients, their PEF did not correlate with the perception of how well their asthma was controlled (i.e., patients felt their asthma was better than the PEF readings indicated) (Kendrick et al. 1993). However, symptom monitoring and peak flow monitoring were found to be equally effective in identifying exacerbations that were confirmed by FEV_1 measurements in a randomized controlled, crossover study (Malo et al. 1993). Although peak flow monitoring for children may be

BOX 1. PEAK FLOW MONITORING LITERATURE REVIEW (CONTINUED)

helpful, one study points out that the variability of individual PEF measurements between different brands of peak flow meters and in comparison to spirometry warrants caution about teaching how to use peak flow meters and interpret the measurements. Emphasis should be placed on observing *differences* between readings over time rather than on a single reading (Sly et al. 1994).

- Patient preferences regarding peak flow monitoring vary. One study found that most patients felt that peak flow monitoring was helpful (Jones et al. 1995), another found that most patients felt symptom monitoring was helpful (Garrett et al. 1994), and another study found that most patients felt that both forms of monitoring combined were helpful (D'Souza et al. 1994). In an observational study of children attending a community clinic, 70 percent of the parents of children using peak flow monitoring reported it to be very useful, especially for judging the severity of an exacerbation and the child's response to inhaled short-acting beta$_2$-agonist (Lloyd and Ali 1992).

- Linking peak flow monitoring to specific asthma management plans and providing appropriate instruction and feedback to the patient will influence the effectiveness and perceived usefulness of peak flow monitoring.

Due to the limited number and quality of the studies on peak flow monitoring reported thus far, the Expert Panel believes that more research is urgently needed in this area. Recent studies do offer some guidance on which patients are most likely to benefit from daily peak flow monitoring; see text of the report for recommendations.

- Long-term daily peak flow monitoring is helpful in managing patients with moderate-to-severe persistent asthma to:
  - Detect early changes in disease status that require treatment
  - Evaluate responses to changes in therapy
  - Provide assessment of severity for patients with poor perception of airflow obstruction
  - Afford a quantitative measure of impairment
- If long-term daily peak flow monitoring is not used, a short-term (2 to 3 weeks) period of peak flow monitoring is recommended to:
  - Evaluate responses to changes in chronic maintenance therapy
  - Identify temporal relationship between changes in PEF and exposure to environmental or occupational irritants or allergens. It may be necessary to record PEF four or more times a day (Chan-Yeung 1995).
  - Establish the individual patient's personal best PEF
- The Expert Panel does not recommend long-term daily peak flow monitoring for patients with mild intermittent or mild persistent asthma unless the patient/family and/or clinician find it useful in guiding therapeutic decisions. Any patient who develops severe exacerbations may benefit from peak flow monitoring.

Limitations of long-term peak flow monitoring include:

- Difficulty in maintaining adherence to monitoring (Reeder et al. 1990; Chmelik and Doughty 1994; Malo et al. 1993), often due to inconvenience, lack of required level of motivation, or lack of a specific treatment plan based on PEF
- Potential for incorrect readings related to poor technique, misinterpretation, or device failure

Whether peak flow monitoring, symptom monitoring, or a combination of approaches is used, the Expert Panel believes that self-monitoring is important to the effective self-management of asthma. The nature and intensity of self-monitoring should be individualized, based on such factors as asthma severity, patient's ability to perceive airflow obstruction, availability of peak flow meters, and patient preferences.

It is the opinion of the Expert Panel that, regardless of the type of monitoring used, patients should be given a written action plan and be instructed to use it (see figure 4-5). The Panel believes it is especially important to give a written action plan to patients with moderate-to-severe persistent asthma and any patient with a history of severe exacerbations. The action plan will describe the actions patients should take based on their signs and symptoms and/or PEF. The clinician should periodically review the plan, revise it as necessary, and confirm that the patient knows what to do if his or her asthma gets worse.

Recommendations on How To Monitor Peak Flow. The Expert Panel recommends that patients who are using a peak flow meter be instructed on how to establish their personal best peak expiratory flow (figure 1-7) and use it as the basis of their action plan (figure 4-5). Meters used to measure PEF should meet American Thoracic Society recommendations for monitoring devices (American Thoracic Society 1995).

The patient's personal best PEF can be estimated after a 2- to 3-week period in which the patient records PEF two to four times per day. The personal best value is usually achieved in the early afternoon measurement after maximal therapy has stabilized the patient (Quackenboss et al. 1991). A course of oral corticosteroids may be needed to establish the personal best PEF. The patient's personal best value should be reassessed periodically to account for progression of disease in children and adults and for growth in children. Occasionally, a PEF value is recorded that is markedly higher than other values. This may be due to "spitting" (especially if the peak flow meter mouthpiece is small) or coughing into the peak flow meter, as well as other reasons that are not well understood. Therefore, caution should be used in establishing a personal best value when an outlying value is observed. Children with moderate-to-severe persistent asthma should repeat the short-term monitoring period every 6 months to establish changes in personal best PEF that occur with growth.

Patients requiring daily peak flow monitoring should measure their PEF on waking from sleep in the morning before taking a bronchodilator, if the patient uses a bronchodilator (Reddel et al. 1995; Morris et al. 1994). When the morning PEF is below 80 percent of the patient's personal best, PEF should be measured more than once a day (again, before taking a bronchodilator). This recommendation is based not on scientific data, but on the logic of reducing delays in treatment. The additional measurements of PEF during the day will enable patients to detect if their asthma is continuing to worsen or is improving after taking medication. If their asthma is worsening, they will have the opportunity to quickly respond to this. In addition, periodically having patients take their PEF first thing in the morning and in the early afternoon for 1 to 2 weeks will assess airflow variability, which is an indicator of the current level of the patient's asthma severity (see figure 1-3 and Additional Studies section, page 19).

It is the Expert Panel's opinion that, in general, PEF below 80 percent of the patient's personal best before bronchodilator inhalation indicates a need for additional medication. PEF below 50 percent indicates a severe asthma exacerbation (see component 3 for recommended treatment). These cutpoints of 80 and 50 percent of the personal best are somewhat arbitrary. The emphasis is not on a specific PEF value but, rather, on a patient's change from personal best or from one reading to the next. Cutpoints should be tailored to individual patients' needs and PEF patterns.

Cutpoints may be easier to use and remember when they are adapted to a traffic light system (see figure 4-5) (Lewis et al. 1984; Mendoza et al. 1988; Plaut 1995). In this system, for example, the green zone (80 to 100 percent of personal best) signals good control, the yellow zone (50 to less than 80 percent of personal best) signals caution, and the red zone (below 50 percent of personal best) signals a medical alert (see figure 1-7). Because the yellow zone includes a wide spectrum of asthma severity, clinicians may consider recommending different interventions for a high yellow zone (e.g., 65 to less than 80 percent of personal best) and a low yellow zone (e.g., 50 to less than 65 percent of personal best).

BOX 2. DIFFERENCES IN PEAK FLOW ACROSS RACIAL AND ETHNIC POPULATIONS

Currently available normative standards for PEF use standing height as well as age and sex as predictors. However, for a given height, African Americans have longer legs, shorter trunks, and smaller thoracic diameters (Woolcock et al. 1972; Coultas et al. 1994). The normal ranges of lung function in Hispanics, Asians, and Native Americans have received less attention (Coultas et al. 1994). Differences have been reported among Caucasians and Japanese Americans (Marcus et al. 1988; Coultas et al. 1994), Native Americans (Wall et al. 1982; Crapo et al. 1988; Marcus et al. 1988), and Latinos (Hsu et al. 1979; Coultas et al. 1988, 1994). But these results are inconsistent, especially for Hispanics and Native Americans (Coultas et al. 1994). In general, lung function for these groups tends to be intermediate between those of Caucasians and African Americans.

Because predicted normal lung function varies across racial and ethnic populations, it is the opinion of the Expert Panel that (1) normative standards for PEF derived from a given racial or ethnic group cannot be readily extrapolated to other groups and that (2) the most clinically useful standard for ongoing monitoring of asthma is the patient's personal best PEF value.

The Expert Panel recommends that patients use the same peak flow meter over time and bring their peak flow meter for use at every followup visit. Using the same brand of meter is recommended because different brands of meters can give significantly different values (Jackson 1995; Enright et al. 1995; Hegewald et al. 1995; Sly et al. 1994; Miller et al. 1992) and because lung function varies across racial and ethnic populations. (See box 2, Differences in Peak Flow Across Racial and Ethnic Populations.) Thus, there is no universal normative standard for PEF. In addition, brand-specific normative values are not available for most peak flow meters.

Despite this variability across different brands of peak flow meters, measurements from the same meter and meters of the same brand are fairly consistent in measuring PEF (Jackson 1995; Enright et al. 1995; Hegewald et al. 1995; Sly et al. 1994; Miller et al. 1992). Thus, once patients establish their personal best PEF on their own meter, they can obtain reliable and clinically meaningful readings of their PEF. However, at each visit, the patient's peak flow meter should be inspected. At least once a year, or any time there is a question about the validity of peak flow meter readings, PEF values from the portable peak flow meter and from laboratory spirometry should be compared.

When patients replace their peak flow meter, it is prudent to have them reestablish their personal best PEF with the new meter, regardless of whether the replacement meter is the same brand as the original. Action plan cutpoints also may need to be modified. The durability and consistency over time of peak flow meters have not been adequately studied to provide guidance on when a peak flow meter needs to be replaced.

Monitoring Quality of Life/Functional Status

To determine whether the goals of asthma therapy are being met, it is crucial to examine how the disease expression and control are affecting the patient's quality of life. Several dimensions of quality of life may be important to track, including physical function, role function, and mental health function. Several comprehensive survey instruments, such as the SF-36 (Stewart et al. 1988 for adult measure; Landgraf et al. 1996 for child measure), have been developed for general use for patient populations. In addition, a number of asthma-specific quality-of-life survey instruments have been developed (Creer et al. 1989; Hyland et al. 1991; Juniper et al. 1992; Marks et al. 1993; Richards and Hemstreet 1994), several of which appear promising. However, certain concerns preclude the Expert Panel from recommending the general adoption of these instruments at this time, such as the lack of experience with the use of the instruments in clinical practice and the time involved in administering the surveys. The Expert Panel does recommend that at least several key areas of quality of life be periodically assessed for each person with asthma. These include:

- Any missed work or school due to asthma
- Any reduction in usual activities (either home/work/school or recreation/exercise)
- Any disturbances in sleep due to asthma
- Any change in caregiver activities due to a child's asthma (for caregivers of children with asthma)

Figure 1-6 provides a set of questions that the Expert Panel recommends for use in characterizing quality-of-life concerns for persons with asthma (also see figure 4-2).

Monitoring History of Asthma Exacerbations

Exacerbations of asthma are characterized by periods of increased symptoms and reduced lung function, which may result in diminished ability to perform usual activities. Exacerbations may be brought on by exposures to irritants or sensitizers in the home, work, or general environment. Infections, certain medications, and a number of other medical conditions, as well as insufficient or ineffective therapy, also may trigger exacerbations (see component 2).

During periodic assessments, clinicians should question the patient and evaluate any records of patient self-monitoring (figures 1-8 and 1-9) to detect exacerbations, both self-treated and those treated by other health care providers. It is important to evaluate the frequency, severity, and causes of exacerbations. The patient should be asked about precipitating exposures and other factors. Specific inquiry into unscheduled visits to providers, telephone calls for assistance, and use of urgent or emergency care facilities may be helpful. Severity can be estimated by the increased need for oral corticosteroids. Control of asthma can be assessed by the increased need for short-acting beta$_2$-agonist. Finally, any hospitalizations should be documented, including the facility, duration of stay, and any use of critical care or intubation. The clinician then can request summaries of all care received to facilitate continuity of care.

Monitoring Pharmacotherapy

To ensure the effectiveness of pharmacotherapy, it is essential that the drug regimen be based on a sound rationale and that it be monitored on an ongoing basis. Based on the opinion of the Expert Panel, the following factors should be monitored: patient adherence to the regimen, inhaler technique, level of usage of as-needed inhaled short-acting beta$_2$-agonist, frequency of oral corticosteroid "burst" therapy, changes in dosage of inhaled anti-inflammatory or other long-term-control medications, and side effects of medications (see assessment questions in figure 1-6). It is also critical that the clinician determine that the patient is on the appropriate step of pharmacotherapy (see component 3-Managing Asthma Long Term) and has an up-to-date, written daily self-management plan and action plan (see figures 4-4 and 4-5).

Monitoring Patient-Provider Communication and Patient Satisfaction

Health care providers should routinely assess the effectiveness of patient/provider communication (see figure 1-6). Open and unrestricted communication among the clinician, the patient, and the family is essential to ensure successful self-management by the patient with asthma. Every effort should be made to encourage open discussion of concerns and expectation of therapy. See component 4 for specific strategies to enhance communication and patient adherence to the treatment plan.

Patient satisfaction with their asthma care and resolution of fears and concerns are important goals and will increase adherence to the treatment plan (Haynes et al. 1979; Meichenbaum and Turk 1987). Two aspects of patient satisfaction should be monitored: satisfaction with asthma control and satisfaction with the quality of care. See figures 1-6, 1-8, and 4-2 for examples of questions to use in monitoring patient satisfaction.

ASSESSMENT METHODS

Each of the key measures used in the periodic assessment of asthma (i.e., signs and symptoms, pulmonary function, quality of life, history of exacerbations, pharmacotherapy, and patient-provider communication and patient satisfaction) can be obtained by several methods. The principal methods include clinician assessment and patient (and/or parent or caregiver) self-assessment. In addition, population-based assessment of asthma care is being developed in the managed care field.

Clinician Assessment

Clinical assessment of asthma should be obtained via medical history and physical examination with appropriate pulmonary function testing. Optimal history assessment may be best achieved via a consistent set of questions (figure 1-6); physical examination for asthma is reviewed in component 1-Initial Assessment and Diagnosis. Patients with mild intermittent or mild persistent asthma that has been under control for at least 3 months should be seen by a clinician about every 6 months. This is a rough guideline based on the opinion of the Expert Panel.

FIGURE 1-8. SAMPLE* PATIENT SELF-ASSESSMENT SHEET FOR FOLLOWUP VISITS

Name:_____ **Date:**_____

How many days in the past week have you had chest tightness, cough, shortness of breath, or wheezing (whistling in your chest)?
_____0 _____1 _____2 _____3 _____4 _____5 _____6 _____7

How many nights in the past week have you had chest tightness, cough, shortness of breath, or wheezing (whistling in your chest)?
_____0 _____1 _____2 _____3 _____4 _____5 _____6 _____7

Do you perform peak flow readings at home?
_____yes _____no

If yes, did you bring your peak flow chart?
_____yes _____no

How many days in the past week has asthma restricted your physical activity?
_____0 _____1 _____2 _____3 _____4 _____5 _____6 _____7

Have you had any asthma attacks since your last visit?
_____yes _____no

Have you had any unscheduled visits to a doctor, including to the emergency department, since your last visit?
_____yes _____no

How many puffs of your short-acting inhaled beta$_2$-agonist (quick-relief medicine) do you use per day?
_____
Average number of puffs per day

How many of your short-acting inhaled beta$_2$-agonist inhalers did you go through over the past month?
_____
Number of inhalers in past month

What questions or concerns would you like to discuss with the doctor?

_____

_____

_____

How well controlled is your asthma in your opinion?
_____very well controlled
_____somewhat controlled
_____not well controlled

How satisfied are you with your asthma care?
_____very satisfied
_____somewhat satisfied
_____not satisfied

* These questions are examples and do not represent a standardized assessment instrument. The validity and reliability of these questions have not been assessed.

FIGURE 1-9. PATIENT SELF-ASSESSMENT: EXAMPLE OF PATIENT DIARY

Date	Wheeze	Cough	Activity	Sleep	Quick Relief: $Beta_2$ – Agonist	Cromolyn/Nedocromil	Inhaled Steroids	Other – Inhaled	Oral Steroids	Theophylline	Peak Flow			Comments
											AM	PM	Other Times	

Wheeze	None = 0	Some = 1	Medium = 2	Severe = 3
Cough	None = 0	Occasional = 1	Frequent = 2	Continuous = 3
Activity	Normal = 0	Can run short distance or climb 3 flights of stairs = 1	Can walk only = 2	Missed school or work or stayed indoors = 3
Sleep	Fine = 0	Slept well, slight wheeze or cough = 1	Awake 2-3 times, wheeze or cough = 2	Bad night, awake most of the time = 3

Adapted with permission from Plaut 1991.

This diary is provided as an example for clinicians.

The exact frequency of clinician visits is a matter of clinical judgment. Patients with uncontrolled and/or severe persistent asthma and those needing additional supervision to help them follow their treatment plan need to be seen more often.

Patient Self-Assessment

Self-assessment by the patient and/or family is important to determine from *their* perspective whether the asthma is well controlled. Two methods are recommended: a daily diary (see figure 1-9 for an example) and a periodic self-assessment form to be filled out by the patient and/or family member at the time of the followup visits to the clinician (figure 1-8).

- The daily diary should include the key factors to be monitored at home: symptoms and/or peak flow, medication use, and restricted activity.

- The periodic self-assessment sheet completed at office visits is intended to capture the patient's and family's impression of asthma control, self-management skills, and overall satisfaction with care.

Patients are less likely to see completion of diaries and forms as a burden if they receive feedback from the clinician that allows them to see value in self-monitoring. Monitoring with a daily diary will be most useful to patients whose asthma is not yet under control and who are trying new treatments. It is also useful for those who need help identifying environmental or occupational exposures that make their asthma worse.

Population-Based Assessment

Asthma care is of increasing interest in various health care settings. Important regulatory organizations for the industry (e.g., the National Committee on Quality Assurance) have included the care of persons with asthma as a key indicator of quality of managed care. In this context, periodic population-based assessment of asthma care has begun to emerge as an issue for patients and their clinical providers. This type of assessment often uses population experience, such as hospitalization or emergency department visit rates, to examine care within different clinical settings and among different providers. Complex standardized population surveys (including lengthy health status instruments) are being tested experimentally in the managed care setting.

REFERENCES

American Thoracic Society. Standardization of spirometry: 1994 update. *Am J Respir Crit Care Med* 1995;152:1107-36.

Beasley R, Cushley M, Holgate ST. A self-management plan in the treatment of adult asthma. *Thorax* 1989;44:200-4.

Chan-Yeung M. Assessment of asthma in the workplace. American College of Chest Physicians Consensus Statement. *Chest* 1995;108:1084-117.

Charlton I, Charlton G, Broomfield J, Mullee MA. Evaluation of peak flow and symptoms only self-management plans for control of asthma in general practice. *BMJ* 1990;301:1355-9.

Chmelik F, Doughty A. Objective measurements of compliance in asthma treatment. *Ann Allergy* 1994;73:527-32.

Connolly MJ, Crowley JJ, Charan NB, Nielson CP, Vestal RE. Reduced subjective awareness of bronchoconstriction provoked by methacholine in elderly asthmatic and normal subjects as measured on a simple awareness scale. *Thorax* 1992;47:410-3.

Coultas DB, Howard CA, Skipper BJ, Samet JM. Spirometric prediction equations for Hispanic children and adults in New Mexico. *Am Rev Respir Dis* 1988;138:1386-92.

Coultas DB, Gong H Jr, Grad R, et al. Respiratory diseases in minorities of the United States. *Am J Respir Crit Care Med* 1994;149:S93-S131.

Crapo RO, Lockey J, Aldrich V, Jensen RL, Elliott CG. Normal spirometric values in healthy American Indians. *J Occup Med* 1988;30:556-60.

Creer TL, Kotses H, Reynolds RV. Living with asthma. Part II. Beyond CARIH. *J Asthma* 1989;26:31- 52.

D'Souza W, Crane J, Burgess C, et al. Community-based asthma care: trial of a "credit card" asthma self- management plan. *Eur Respir J* 1994;7:1260-5.

Enright PL, Sherrill DL, Lebowitz MD. Ambulatory monitoring of peak expiratory flow. Reproducibility and quality control. *Chest* 1995;107:657-61.

Garrett J, Fenwick JM, Taylor G, Mitchell E, Rea H. Peak expiratory flow meters (PEFMs)—who uses them and how does education affect the pattern of utilisation? *Aust N Z J Med* 1994;24:521-9.

Grampian Asthma Study of Integrated Care. Effectiveness of routine self-monitoring of peak flow in patients with asthma. *BMJ* 1994;308:564-7.

Hankinson JL, Wagner GR. Medical screening using periodic spirometry for detection of chronic lung disease. *Occup Med* 1993;8:353-61.

Haynes RB, Taylor DW, Sackett DL, eds. *Compliance in Health Care*. Baltimore: Johns Hopkins University Press, 1979.

Hegewald MJ, Crapo RO, Jensen RL. Intraindividual peak flow variability. *Chest* 1995;107:156-61.

Hsu KH, Jenkins DE, Hsi BP, et al. Ventilatory functions of normal children and young adults—Mexican American, white, and black. I. Spirometry. *J Pediatr* 1979;95:14-23.

Hyland ME, Finnis S, Irvine SH. A scale for assessing quality of life in adult asthma sufferers. *J Psychosom Res* 1991;35:99-110.

Ignacio-Garcia JM, Gonzalez-Santos P. Asthma self-management education program by home monitoring of peak expiratory flow. *Am J Respir Crit Care Med* 1995;151:353-9.

Jackson AC. Accuracy, reproducibility, and variability of portable peak flow meters. *Chest* 1995;107:648-51.

Janson-Bjerklie S, Shnell S. Effect of peak flow information on patterns of self-care in adult asthma. *Heart Lung* 1988;17:543-9.

Jones KP, Mullee MA, Middleton M, Chapman E, Holgate ST. Peak flow based asthma self-management: a randomised controlled study in general practice. British Thoracic Society Research Committee. *Thorax* 1995;50:851-7.

Juniper EF, Guyatt GH, Epstein RS, Ferrie PJ, Jaeschke R, Hiller TK. Evaluation of impairment of health related quality of life in asthma: development of a questionnaire for use in clinical trials. *Thorax* 1992;47:76-83.

Kendrick AH, Higgs CM, Whitfield MJ, Laszlo G. Accuracy of perception of severity of asthma: patients treated in general practice. *BMJ* 1993;307:422-4.

Kikuchi Y, Okabe S, Tamura G, et al. Chemosensitivity and perception of dyspnea in patients with a history of near-fatal asthma. *N Engl J Med* 1994;330:1329-34.

Lahdensuo A, Haahtela T, Herrala J, et al. Randomised comparison of guided self management and traditional treatment of asthma over one year. *BMJ* 1996;312:748-52.

Landgraf JM, Abetz L, Ware JE. *The CHQ User's Manual.* First edition. Boston, MA: The Health Institute, New England Medical Center, 1996.

Lewis CE, Rachelefsky G, Lewis MA, de la Sota A, Kaplan M. A randomized trial of A.C.T. (Asthma Care Training) for kids. *Pediatrics* 1984;74:478-86.

Lloyd BW, Ali MH. How useful do parents find home peak flow monitoring for children with asthma? *BMJ* 1992;305:1128-9.

Malo JL, L'Archeveque J, Trudeau C, d'Aquino C, Cartier A. Should we monitor peak expiratory flow rates or record symptoms with a simple diary in the management of asthma? *J Allergy Clin Immunol* 1993;91:702-9.

Marcus EB, MacLean CJ, Curb JD, Johnson LR, Vollmer WM, Buist AS. Reference values for FEV_1 in Japanese-American men from 45 to 68 years of age. *Am Rev Respir Dis* 1988;138:1393-7.

Marks GB, Dunn SM, Woolcock AJ. An evaluation of an asthma quality of life questionnaire as a measure of change in adults with asthma. *J Clin Epidemiol* 1993;46:1103-11.

Meichenbaum D, Turk DC. *Facilitating Treatment Adherence: A Practitioner's Guidebook*. New York: Plenum Press, 1987.

Mendoza GR, Sander N, Scherrer D. *A User's Guide to Peak Flow Monitoring*. Mothers of Asthmatics, Inc., 1988.

Miles JF, Bright P, Ayres JG, Cayton RM, Miller MR. The performance of Mini Wright peak flow meters after prolonged use. *Respir Med* 1995;89:603-5.

Miller MR, Dickinson SA, Hitchings DJ. The accuracy of portable peak flow meters. *Thorax* 1992;47:904-9.

Morris NV, Abramson MJ, Strasser RP. Adequacy of control of asthma in a general practice. Is maximum peak expiratory flow rate a valid index of asthma severity? *Med J Aust* 1994;160:68-71.

National Heart, Lung, and Blood Institute. *Nurses: Partners in Asthma Care*. National Institutes of Health publication no. 95-3708. Bethesda, MD, 1995.

Plaut TF. *Children With Asthma: A Manual for Parents*. Amherst, MA: Pedipress, 1995, pp. 94-108.

Plaut TF. *One Minute Asthma: What You Need To Know.* Amherst, MA: Pedipress, 1991, pp. 12-13.

Quackenboss JJ, Lebowitz MD, Krzyzanowski M. The normal range of diurnal changes in peak expiratory flow rates. Relationship to symptoms and respiratory disease. *Am Rev Respir Dis* 1991;143:323-30.

Reddel HK, Salome CM, Peat JK, Woolcock AJ. Which index of peak expiratory flow is most useful in the management of stable asthma? *Am J Respir Crit Care Med* 1995;151:1320-5.

Reeder KP, Dolce JJ, Duke L, Raczynski JM, Bailey WC. Peak flow meters: are they monitoring tools or training devices? *J Asthma* 1990;27:219-27.

Richards JM Jr, Hemstreet MP. Measures of life quality, role performance, and functional status in asthma research. *Am J Respir Crit Care Med* 1994;149:S31-9.

Rubinfeld AR, Pain MC. Perception of asthma. *Lancet* 1976;1:882-4.

Sly PD, Cahill P, Willet K, Burton P. Accuracy of mini peak flow meters in indicating changes in lung function in children with asthma. *BMJ* 1994;308:572-4.

Stewart AL, Hays RD, Ware JE Jr. The MOS short-form general health survey. Reliability and validity in a patient population. *Med Care* 1988;26:724-35.

Wall MA, Olson D, Bonn BA, Creelman T, Buist AS. Lung function in North American Indian children: reference standards for spirometry, maximal expiratory flow volume curves, and peak expiratory flow. *Am Rev Respir Dis* 1982;125:158-62.

Woolcock AJ, Colman MH, Blackburn CR. Factors affecting normal values for ventilatory lung function. *Am Rev Respir Dis* 1972;106:692-709.

Woolcock AJ, Yan K, Salome CM. Effect of therapy on bronchial hyperresponsiveness in the long-term management of asthma. *Clin Allergy* 1988;18:165-76.

COMPONENT 2:
CONTROL OF FACTORS CONTRIBUTING TO ASTHMA SEVERITY

KEY POINTS

- Exposure of asthma patients to irritants or allergens to which they are sensitive has been shown to increase asthma symptoms and precipitate asthma exacerbations.

- For at least those patients with persistent asthma on daily medications, the clinician should:
  - Identify allergen exposures
  - Use the patient's history to assess sensitivity to seasonal allergens
  - Use skin testing or in vitro testing to assess sensitivity to perennial indoor allergens
  - Assess the significance of positive tests in context of patient's medical history

- Patients with asthma at any level of severity should avoid:
  - Exposure to allergens to which they are sensitive.
  - Exposure to environmental tobacco smoke.
  - Exertion when levels of air pollution are high.
  - Use of beta-blockers.
  - Sulfite-containing and other foods to which they are sensitive.

- Adult patients with severe persistent asthma, nasal polyps, or a history of sensitivity to aspirin or nonsteroidal anti-inflammatories should be counseled regarding the risk of severe and even fatal exacerbations from using these drugs.

- Patients should be treated for rhinitis, sinusitis, and gastroesophageal reflux, if present.

- Patients with persistent asthma should be given an annual influenza vaccine.

DIFFERENCES FROM 1991 EXPERT PANEL REPORT

- Skin testing or in vitro testing is now specifically recommended for at least those patients with persistent asthma exposed to perennial indoor allergens.

- Adult patients with severe persistent asthma, nasal polyps, or a history of sensitivity to aspirin or nonsteroidal anti-inflammatories are to be counseled regarding the risk of severe and even fatal exacerbations from using these drugs. In the 1991 report, all asthma patients were recommended to avoid aspirin.

- Routine use of chemicals to kill house-dust mites and denature the antigen is no longer recommended as a control measure.

- The discussion of tartrazine sensitivity in the 1991 version was deleted.

- Annual influenza vaccinations are now specifically recommended for patients with persistent asthma. The recommendation to consider pneumococcal vaccine was deleted.

For successful long-term asthma management, it is essential to identify and reduce exposures to relevant allergens and irritants and to control other factors that have been shown to increase asthma symptoms and/or precipitate asthma exacerbations. These factors fall into four categories: inhalant allergens, occupational exposures, nonallergic factors, and other factors. Ways to reduce the effects of these factors on asthma are discussed in this component.

- Inhalant allergens:
  - Animal allergens
  - House-dust mites
  - Cockroach allergens
  - Indoor fungi (molds)
  - Outdoor allergens
- Occupational exposures
- Irritants:
  - Tobacco smoke
  - Indoor/outdoor pollution and irritants
- Other factors that can influence asthma severity:
  - Rhinitis/sinusitis
  - Gastroesophageal reflux
  - Sensitivity to aspirin, other nonsteroidal anti-inflammatory drugs, and sulfites
  - Topical and systemic beta-blockers
  - Viral respiratory infections

INHALANT ALLERGENS

Exposure of an asthma patient to inhalant allergens to which the patient is sensitive increases airway inflammation and symptoms. Substantially reducing such exposure will result in significantly reduced inflammation, symptoms, and need for medication (see a summary of the evidence in box 1). In the opinion of the Expert Panel, patients with asthma at any level of severity should be queried about exposures to inhalant allergens.

Diagnosis—Determine Relevant Inhalant Sensitivity

Demonstrating a patient's relevant sensitivity to inhalant allergens will enable the clinician to recommend specific environmental controls to reduce exposures. It will also help the patient understand the pathogenesis of asthma and the value of allergen avoidance. Given the importance of allergens and

BOX 1. THE STRONG ASSOCIATION BETWEEN SENSITIZATION TO ALLERGIES AND ASTHMA: A SUMMARY OF THE EVIDENCE

The association of asthma and allergy has long been recognized. Recent studies confirm that sensitization among genetically susceptible populations to certain indoor allergens such as house-dust mite, animal dander, and cockroach or to the outdoor fungus *Alternaria* is a risk for developing asthma in children (Peat et al. 1993, 1994; Sears et al. 1993a, 1993b; Sporik et al. 1990). Sensitization to outdoor pollens carries less risk for asthma (Sears et al. 1989), although grass (Reid et al. 1986) and ragweed (Creticos et al. 1996) pollen exposure has been associated with seasonal asthma. It is widely accepted that the importance of inhalant sensitivity as a cause of asthma declines with advancing age (Pollart et al. 1989).

An allergic reaction in the airways caused by natural exposure to allergens has been shown to lead to an increase in inflammatory reaction, increased airway hyperresponsiveness (Boulet et al. 1983; Peroni et al. 1994; Piacentini et al. 1993), and increased eosinophils in bronchoalveolar lavage (Rak et al. 1991). Other research has demonstrated that asthma symptoms, pulmonary function, and need for medication in mite-sensitive asthma patients correlate with the level of house-dust mite exposure (Vervloet et al. 1991; Zock et al. 1994) and that reducing house-dust mite exposure reduces asthma symptoms, nonspecific bronchial hyperresponsiveness, and evidence of active inflammation (Peroni et al. 1994; Piacentini et al. 1993; Simon et al. 1994). Inhalant allergen exposure to seasonal outdoor fungal spores (Targonski et al. 1995; O'Hollaren et al. 1991) and to indoor allergens (Call et al. 1994) has also been implicated in fatal exacerbations of asthma. These reports emphasize that allergen exposure must be considered in the treatment of asthma.

The important allergens for children and adults appear to be those that are inhaled. Food allergens are not a common precipitant of asthma symptoms. Foods are an important cause of anaphylaxis in adults and children (Golbert et al. 1969; Sampson et al. 1992), but significant lower respiratory tract symptoms are uncommon even with positive double-blind food challenges (James et al. 1994).

their control to asthma morbidity and asthma management, the Expert Panel recommends that patients with persistent asthma who require daily therapy be evaluated for allergens as possible contributing factors as follows:

1. Determine the patient's exposure to allergens (see relevant questions in figure 2-1).

2. Assess sensitivity to the allergens to which the patient is exposed.
   — Use the patient's medical history, which is usually sufficient, to determine sensitivity to seasonal allergens.

   — Use skin testing or in vitro testing to determine the presence of specific IgE antibodies to the indoor allergens to which the patient is exposed year round (see figure 2-2 for a comparison of skin and in vitro tests). Allergy testing is the only reliable way to determine sensitivity to perennial indoor allergens (see box 2 for further explanation).

   (For selected patients with asthma at any level of severity, detection of specific IgE sensitivity to seasonal or perennial allergens may be indicated as a basis for avoidance, for immunotherapy, or to characterize the patient's atopic status.)

3. Assess the clinical significance of positive allergy tests in the context of the patient's medical history (see figure 2-3).

Management—Reduce Exposure

The first and most important step in controlling allergen-induced asthma is to reduce exposure to relevant indoor and outdoor allergens. Effective ways patients can reduce their exposures to indoor and outdoor allergens are discussed below and summarized in figure 2-4, which also addresses irritants. Although these recommendations focus on the home environment, reductions in exposures to allergens and irritants are also appropriate in other environments where the patient spends extended periods of time, such as school, work, or day care. For information about companies that distribute products to help reduce allergen exposure, contact the Asthma and Allergy Foundation of America at 800-727-8462 or the Allergy and Asthma Network/Mothers of Asthmatics at 800-878-4403.

- *Animal Allergens.* All warm-blooded pets, including small rodents and birds, produce dander, urine, feces, and saliva that can cause allergic reactions (Swanson et al. 1985; de Blay et al. 1991a). No studies have been published on the effect of animal allergen avoidance on asthma symptoms; however, based on the opinion of the Expert Panel, the following actions to control animal antigens are recommended:

  — If the patient is sensitive, remove the animal and products made of feathers from the home to eliminate exposure.

  — If removal of the animal is not acceptable:

    – Keep the pet out of the patient's bedroom.

    – Keep the patient's bedroom door closed. Consider placing dense filtering material over forced air outlets to trap airborne dander particles.

    – Remove upholstered furniture and carpets from the home or isolate the pet from them to the extent possible.

  Weekly washing of the pet may decrease the amount of dander and dried saliva the animal contributes to the environment (de Blay et al. 1991b; Klucka et al. 1995).

- *House-Dust Mite Allergen.* House-dust mites are universal in areas of high humidity (most areas of the United States) but are usually not present at high altitudes or in arid areas unless moisture is added to the indoor air. Mites depend on atmospheric moisture and human dander for survival. High levels of mites can be found in dust from mattresses, pillows, carpets, upholstered furniture, bed covers, clothes, and soft toys. The patient's bed is the most important source of dust mites to control. Recommended mite control measures are listed below (Platts-Mills et al. 1982).

  Essential actions to control mites include:

  — Encase the mattress in an allergen-impermeable cover.

  — Encase the pillow in an allergen-impermeable cover or wash it weekly.

FIGURE 2-1. ASSESSMENT QUESTIONS* FOR ENVIRONMENTAL AND OTHER FACTORS THAT CAN MAKE ASTHMA WORSE

Inhalant Allergens

Does the patient have symptoms year round? (If yes, ask the following questions. If no, see next set of questions.)

- Does the patient keep pets indoors? What type?
- Does the patient have moisture or dampness in any room of his or her home (e.g., basement)? (Suggests house-dust mites, molds.)
- Does the patient have mold visible in any part of his or her home? (Suggests molds.)
- Has the patient seen cockroaches in his or her home in the past month? (Suggests significant cockroach exposure.)
- Assume exposure to house-dust mites unless patient lives in a semiarid region. However, if a patient living in a semiarid region uses a swamp cooler, exposure to house dust mites must still be assumed.

Do symptoms get worse at certain times of the year? (If yes, ask when symptoms occur.)

- Early spring? (trees)
- Late spring? (grasses)
- Late summer to autumn? (weeds)
- Summer and fall? (*Alternaria*, *Cladosporium*)

Tobacco Smoke

- Does the patient smoke?
- Does anyone smoke at home or work?
- Does anyone smoke at the child's day care?

Indoor/Outdoor Pollutants and Irritants

- Is a wood-burning stove or fireplace used in the patient's home?
- Are there unvented stoves or heaters in the patient's home?
- Does the patient have contact with other smells or fumes from perfumes, cleaning agents, or sprays?

Workplace Exposures

- Does the patient cough or wheeze during the week, but not on weekends when away from work?
- Do the patient's eyes and nasal passages get irritated soon after arriving at work?
- Do coworkers have similar symptoms?
- What substances are used in the patient's worksite? (Assess for sensitizers.)

Rhinitis

- Does the patient have constant or seasonal nasal congestion and/or postnasal drip?

Gastroesophageal Reflux

- Does the patient have heartburn?
- Does food sometimes come up into the patient's throat?
- Has the patient had coughing, wheezing, or shortness of breath at night in the past 4 weeks?
- Does the infant vomit followed by cough or have wheezy cough at night? Are symptoms worse after feeding?

Sulfite Sensitivity

- Does the patient have wheezing, coughing, or shortness of breath after eating shrimp, dried fruit, or processed potatoes or after drinking beer or wine?

Medication Sensitivities and Contraindications

- What medications does the patient use now (prescription and nonprescription)?
- Does the patient use eyedrops? What type?
- Does the patient use any medications that contain beta-blockers?
- Does the patient ever take aspirin or other nonsteroidal anti-inflammatory drugs?
- Has the patient ever had symptoms of asthma after taking any of these medications?

* These questions are examples and do not represent a standardized assessment or diagnostic instrument. The validity and reliability of these questions have not been assessed.

FIGURE 2-2. COMPARISON OF SKIN TESTS WITH IN VITRO TESTS

Advantages of skin tests:

- Less expensive than in vitro tests
- Results are available within 1 hour.
- More sensitive than in vitro tests
- Results are visible to the patient. This may encourage compliance with environmental control measures.

Advantages of RAST and other in vitro tests:

- Do not require knowledge of skin testing technique
- Do not require availability of allergen extracts
- Can be performed on patients who are taking medications that suppress the immediate skin test (antihistamines, antidepressants)
- No risk of systemic reactions
- Can be done for patients with extensive eczema

BOX 2. RATIONALE FOR ALLERGY TESTING FOR PERENNIAL INDOOR ALLERGENS

Determination of sensitivity to a perennial indoor allergen is usually not possible with a patient medical history alone (Murray and Milner 1995). Increased symptoms during vacuuming or bed making and decreased symptoms when away from home on a business trip or vacation are suggestive but not sufficient. Allergy skin or in vitro tests are reliable in determining the presence of specific IgE (Adinoff et al. 1990), but these tests do not determine whether the specific IgE is responsible for the patient's symptoms. That is why patients should only be tested for sensitivity to the allergens to which they are exposed and why the third step in evaluating patients for allergen sensitivity calls for assessing the clinical relevance of the sensitivity.

The recommendation to do skin or in vitro tests for patients with persistent asthma exposed to perennial indoor allergens will result in a limited number of allergy tests for about half of all asthma patients. This is based on the prevalence of persistent asthma and the level of exposure to indoor allergens. It is estimated that about half of all asthma patients have persistent asthma based on data on children in the United States (Taylor and Newacheck 1992) and on adults in Australia (Boston Consulting Group 1992). About 80 percent of the U.S. population is exposed to house-dust mites (Nelson and Fernandez-Caldas 1995), 60 percent to cat or dog, and a much smaller percentage to both animals (Ingram et al. 1995). Cockroaches are a consideration only in the inner city and southern parts of the United States.

Skin or in vitro tests for patients exposed to perennial allergens are essential to justify the expense and effort involved in implementing environmental controls. In addition, patient adherence to maintaining environmental controls (e.g., with regard to pets) is likely to be poor without proof of the patient's sensitivity.

FIGURE 2-3. PATIENT INTERVIEW QUESTIONS* FOR ASSESSING THE CLINICAL SIGNIFICANCE OF POSITIVE ALLERGY TESTS

- *Animal Dander.* If there are pets in the patient's home and the patient is sensitive to dander of that species of animal, the likelihood that animal dander allergy is contributing to asthma symptoms is increased if answers to the following questions are affirmative. However, absence of positive responses does not exclude a contribution of animal dander to the patient's symptoms.
  - — Do nasal, eye, or chest symptoms appear in a room where carpets are being or have just been vacuumed?
  - — Do nasal, eye, or chest symptoms improve when away from home for a week or longer?
  - — Do the symptoms become worse the first 24 hours after returning home?
- *House-Dust Mites.* Mite allergy is more likely to be a contributing factor to asthma severity if answers to the following questions are affirmative. However, absence of a positive response does not exclude a contribution of mite allergen to the patient's symptoms.
  - — Do nasal, eye, or chest symptoms appear in a room where carpets are being or have just been vacuumed?
  - — Does making a bed cause nasal, eye, or chest symptoms?
- *Outdoor Allergens (Pollens and Outdoor Molds).* Contribution of pollens and outdoor molds in causing asthma symptoms is suggested by a positive answer to this question:
  - — Is asthma consistently worse in spring, summer, fall, or parts of the growing season?

  Usually, if pollen or mold spores are causing increased asthma symptoms, the patient will also have symptoms of allergic rhinitis—sneezing, itching nose and eyes, runny and obstructed nose.
- *Indoor Fungi (Molds).* Contribution of indoor molds in causing asthma symptoms is suggested by a positive answer to this question:
  - — Do nasal, eye, or chest symptoms appear in damp or moldy rooms, such as basements?

* These questions are provided as examples for the clinician. The validity and reliability of these questions have not been assessed.

  - — Wash the sheets and blankets on the patient's bed weekly in hot water. A temperature of ≥130 °F is necessary for killing house-dust mites.

Desirable actions to control mites include:

  - — Reduce indoor humidity to less than 50 percent.
  - — Remove carpets from the bedroom.
  - — Avoid sleeping or lying on upholstered furniture.
  - — Remove from the home carpets that are laid on concrete.
  - — In children's beds, minimize the number of stuffed toys and wash the toys weekly in hot water.

  Chemical agents are available for killing mites and denaturing the antigen; however, the effects are not dramatic and do not appear to be maintained for long periods. Therefore, use of these agents in the homes of house-dust mite-sensitive asthma patients should not be recommended routinely (Woodfolk et al. 1995). Vacuuming removes mite allergen from carpets but is inefficient at removing live mites.

- *Cockroach Allergen.* Cockroach sensitivity and exposure are common among patients with asthma who live in inner cities (Kang et al. 1993; Call et al. 1992). In an inner-city asthma study, asthma severity increased with increasing levels of cockroach antigen in the bedroom of sensitized children (Rosenstreich et al. 1997). Although no studies have been published that report the effect of cockroach reduction on asthma symptoms, it is the opinion of the Expert Panel that control measures need to be instituted when the patient is sensitive to cockroaches and infestation is present in the home. Patients should not leave food or garbage exposed. Poison baits, boric acid, and traps are preferred to chemical agents because the latter can be irritating when inhaled by asthma patients. If chemical agents are used, the home should be well ventilated and the patient should not return to the home until the odor has dissipated.

FIGURE 2-4. SUMMARY OF CONTROL MEASURES FOR ENVIRONMENTAL FACTORS THAT CAN MAKE ASTHMA WORSE

Allergens:

Reduce or eliminate exposure to the allergen(s) the patient is sensitive to, including:

- Animal dander: Remove animal from house or, at a minimum, keep animal out of patient's bedroom and seal or cover with a filter air ducts that lead to bedroom.
- House-dust mites:
  - —Essential: Encase mattress in an allergen-impermeable cover; encase pillow in an allergen-impermeable cover or wash it weekly; wash sheets and blankets on the patient's bed in hot water weekly (water temperature of ≥130 °F is necessary for killing mites).
  - —Desirable: Reduce indoor humidity to less than 50 percent; remove carpets from the bedroom; avoid sleeping or lying on upholstered furniture; remove carpets that are laid on concrete.
- Cockroaches: Use poison bait or traps to control. Do not leave food or garbage exposed.
- Pollens (from trees, grass, or weeds) and outdoor molds: To avoid exposures, adults should stay indoors with windows closed during the season in which they have problems with outdoor allergens, especially during the afternoon.
- Indoor mold: Fix all leaks and eliminate water sources associated with mold growth; clean moldy surfaces. Consider reducing indoor humidity to less than 50 percent.

Tobacco Smoke:

Advise patients and others in the home who smoke to stop smoking or to smoke outside the home. Discuss ways to reduce exposure to other sources of tobacco smoke, such as from day care providers and the workplace.

Indoor/Outdoor Pollutants and Irritants:

Discuss ways to reduce exposures to the following:

- Wood-burning stoves or fireplaces
- Unvented stoves or heaters
- Other irritants (e.g., perfumes, cleaning agents, sprays)

- *Indoor Fungi (Molds)*. Indoor fungi are particularly prominent in humid environments and homes that have dampness problems. Children living in homes with dampness have increased respiratory symptoms (Cuijpers et al. 1995; Verhoeff et al. 1995), but the relative contribution of fungi, house-dust mites, or irritants is not clear. Because an association between indoor fungi and respiratory and allergic disease is suggested by some studies (Bjornsson et al. 1995; Smedje et al. 1996; Strachan 1988), measures to control dampness or fungal growth in the home may be beneficial.
- *Outdoor Allergens (Tree, Grass, and Weed Pollens and Seasonal Mold Spores)*. Patients can reduce exposure by staying indoors with windows closed in an air-conditioned environment (Solomon et al. 1980), particularly during the midday and afternoon when pollen and some spore counts are highest (Long and Kramer 1972; Smith and Rooks 1954; Mullins et al. 1986). Conducting outdoor activities shortly after sunrise will result in less pollen exposure. These actions may not be realistic for some patients, especially children.

Immunotherapy

Allergen immunotherapy may be considered for asthma patients when (1) there is clear evidence of a relationship between symptoms and exposure to an unavoidable allergen to which the patient is sensitive, (2) symptoms occur all year or during a major portion of the year, and (3) there is difficulty controlling symptoms with pharmacologic management either because the medication is ineffective, multiple medications are required, or the patient is not accepting of medication. This recommendation is based on the opinion of the Expert Panel and the evidence described below. If use of allergen immunotherapy is elected, it should be administered only in a physician's office where facilities and trained personnel are available to treat any life-threatening reaction that can, but rarely does, occur (AAAI Board of Directors 1994; Frew 1993). Controlled studies of immunotherapy, usually conducted with single allergens, have demonstrated reduction in asthma symptoms caused by exposure to grass, cat, house-dust mite, ragweed, *Cladosporium*, and *Alternaria* (Reid et al. 1986; Malling et al. 1986; Creticos et al. 1996; Horst et al. 1990). A meta-analysis of 20 randomized, placebo-controlled studies has confirmed the effectiveness of immunotherapy in asthma (Abramson et al. 1995). Few studies have

been reported on multiple allergen mixes, which are commonly employed in clinical practice.

The course of allergen immunotherapy is typically of 3 to 5 years' duration. Reactions to immunotherapy, especially bronchoconstriction, are more frequent among patients with asthma, particularly those with poorly controlled asthma, compared with those with allergic rhinitis (Reid et al. 1993). For this reason, enthusiasm for the use of immunotherapy differs considerably among experts (Abramson et al. 1995; Canadian Society of Allergy and Clinical Immunology 1995; Frew 1993).

Assessment of Devices That May Modify Indoor Air

- Vacuuming carpets once or twice a week is essential to reduce accumulation of house dust. Patients sensitive to components of house dust should avoid using conventional vacuum cleaners, and these patients should stay out of rooms where a vacuum cleaner is being or has just been used (Murray et al. 1983). If patients vacuum, they can use a dust mask, a central cleaner with the collecting bag outside the home, or a cleaner fitted with a HEPA (high-efficiency particulate air) filter or with a double bag (Woodfolk et al. 1993).

- Humidifiers and evaporative (swamp) coolers are *not* recommended for use in the homes of house-dust mite-sensitive patients with asthma. These are potentially harmful because increased humidity may encourage the growth of both mold (Solomon 1976) and house-dust mites (Ellingson et al. 1995). In addition, humidifiers may pose a problem if not properly cleaned because they can harbor and aerosolize mold spores (Solomon 1974).

- Air conditioning during warm weather is recommended for asthma patients because it allows windows and doors to stay closed, which prevents entry of outdoor allergens (Solomon et al. 1980). Regular use of central air conditioning also will usually control humidity sufficiently to reduce house-dust mite growth (Lintner and Brame 1993).

- Use of a dehumidifier will reduce house-dust mite levels in areas where the humidity of the outside air remains high for most of the year (Cabrera et al. 1995).

- Indoor air-cleaning devices cannot substitute for the more effective measures described previously (see page 43, Management—Reduce Exposure). However, air-cleaning devices (i.e., HEPA and electrostatic precipitating filters) have been shown to reduce airborne cat dander (de Blay et al. 1991b), mold spores (Maloney et al. 1987), and particulate tobacco smoke (U.S. Environmental Protection Agency 1990). Air cleaners cannot significantly reduce exposure to house-dust mite and cockroach allergens because these heavy particles do not remain airborne (de Blay et al. 1991a). Most studies of air cleaners have failed to demonstrate an effect on asthma symptoms or pulmonary function (Nelson et al. 1988; Reisman et al. 1990; Warner et al. 1993; Warburton et al. 1994).

- Air-duct cleaning of heating/ventilation/air conditioning systems has been reported to decrease levels of airborne fungi in residences (Garrison et al. 1993). The effect on levels of house-dust mite or animal dander has not been studied. Limited evidence precludes the Expert Panel from making a recommendation in this area.

OCCUPATIONAL EXPOSURES

Early recognition and control of exposures are particularly important in occupationally induced asthma, because the likelihood of complete resolution of symptoms decreases with time (Chan-Yeung et al. 1987; Pisati et al. 1993). Occupational asthma is suggested by a correlation between asthma symptoms and work, with improvement when away from work for several days. Other indications of workplace exposure are listed in figure 2-5. The patient may fail to recognize the work relationship, because symptoms often begin several hours after exposure. Serial peak flow records at work and away from work can confirm the work association (Moscato et al. 1995).

Workplace exposure to sensitizing chemicals or dusts can induce asthma, which often persists after the exposures are terminated (Chan-Yeung et al. 1987; Pisati et al. 1993). This should be distinguished from allergen- or irritant-induced aggravation of preexisting asthma. Acute exposure to irritant gases, dusts, or fumes can cause an asthma-like condition (reactive airway dysfunction syndrome) (Brooks et al. 1985).

Patient confidentiality issues are particularly important in work-related asthma. Because even general

inquiries about the potential adverse health effects of work exposures may occasionally result in reprisals against the patient (e.g., job loss), asthma patients need to be informed of this possibility and be full partners in the decision to approach management regarding the effects or control of workplace exposures.

IRRITANTS

In the opinion of the Expert Panel, patients with asthma at any level of severity should be queried about exposures to irritants. Sample assessment questions are in figure 2-1.

Environmental Tobacco Smoke

Asthma patients should not smoke or be exposed to environmental tobacco smoke (Marquette et al. 1992). Tobacco smoke is the most important environmental indoor irritant and is a major precipitant of asthma symptoms in children and adults (Abbey et al. 1993; Greer et al. 1993; Jindal et al. 1994; Leuenberger et al. 1994). Jindal and colleagues (1994) found that exposure of adults to environmental tobacco smoke is associated with decreased levels of pulmonary function, increased requirements for medication, and more frequent absences from work. In addition, exposure to maternal smoke has been shown to be a risk factor for the development of asthma in infancy (Arshad and Hide 1992) and childhood (Frischer et al. 1992; Schmitzberger et al. 1993; Gortmaker et al. 1982; Henderson et al. 1995; Soyseth et al. 1995; Martinez et al. 1995; Agudo et al. 1994), although not for persistence of childhood asthma into adulthood (Roorda et al. 1993).

Indoor/Outdoor Air Pollution and Irritants

Asthma patients should avoid exertion or exercise outside to the extent possible when levels of air pollution are high. Increased pollution levels, particularly of respirable particulates (Abbey et al. 1993; Koenig et al. 1993; Pope et al. 1991; Walters et al. 1994; Schwartz et al. 1993; Ostro et al. 1995) and ozone (Abbey et al. 1993; Cody et al. 1992; Ponka 1991; Thurston et al. 1992; Ostro et al. 1995; Romieu et al. 1995; Kesten et al. 1995; White et al. 1994), but also of SO_2 (Moseholm et al. 1993) and NO_2 (Moseholm et al. 1993; Kesten et al. 1995), have been reported to precipitate symptoms of asthma (Abbey et al. 1993; Koenig et al. 1987; Moseholm et al. 1993; Pope et al. 1991) and to increase emergency department visits and hospitaliza-

FIGURE 2-5. EVALUATION AND MANAGEMENT OF WORK-AGGRAVATED ASTHMA AND OCCUPATIONAL ASTHMA

Evaluation

Potential for workplace-related symptoms:

- Recognized sensitizers (e.g., isocyanates, plant or animal products).
- Irritants* or physical stimuli (e.g., cold/heat, dust, humidity).
- Coworkers may have similar symptoms.

Patterns of symptoms (in relation to work exposures):

- Improvement during vacations or days off (may take a week or more).
- Symptoms may be immediate (<1 hour), delayed (most commonly, 2 to 8 hours after exposure), or nocturnal.
- Initial symptoms may occur after high-level exposure (e.g., spill).

Documentation of work-relatedness of airflow limitation:

- Serial charting for 2 to 3 weeks (2 weeks at work and up to 1 week off work as needed to identify or exclude work-related changes in peak expiratory flow):
  - Record when symptoms and exposures occur.
  - Record when a bronchodilator is used.
  - Measure and record peak flow every 2 hours while awake.
- Immunologic tests.
- Referral for further confirmatory evaluation (e.g., bronchial challenges).

Management

Work-aggravated asthma:

- Work with onsite health care providers or managers/supervisors.
- Discuss avoidance, ventilation, respiratory protection, tobacco smoke-free environment.

Occupationally induced asthma:

- Recommend complete cessation of exposure to initiating agent.

* Material Safety Data Sheets may be helpful for identifying respiratory irritants, but many sensitizers are not listed.

tions for asthma (Walters et al. 1994; Schwartz et al. 1993; Cody et al. 1992; Ponka 1991; Thurston et al. 1992; Romieu et al. 1995; Kesten et al. 1995; White et al. 1994).

Patients also should avoid exposure to fumes from unvented gas, oil, or kerosene stoves; wood-burning appliances or fireplaces (Ostro et al. 1994); sprays; and strong odors because they irritate the lungs and can precipitate asthma symptoms.

OTHER FACTORS THAT CAN INFLUENCE ASTHMA SEVERITY

Rhinitis/Sinusitis

Treatment of upper respiratory tract symptoms is an integral part of asthma management. Intranasal corticosteroids are recommended for the treatment of chronic rhinitis in patients with persistent asthma. Antihistamine/decongestant combinations also may be used; they provide symptomatic relief but have not been shown to have a protective effect on the lower airways secondary to their action on the nose. Intranasal corticosteroids reduce nasal inflammation, obstruction, and discharge and have been shown to reduce lower airway hyperresponsiveness and asthma symptoms (Aubier et al. 1992; Watson et al. 1993; Corren et al. 1992; Welsh et al. 1987). Intranasal cromolyn has been shown to reduce symptoms of asthma during the ragweed season, but to a lesser extent than intranasal corticosteroids in the same study (Welsh et al. 1987).

Treatment of sinusitis includes medical measures to promote drainage (Zeiger 1992) and the use of antibiotics when complicating acute bacterial infection is present (Wald 1992; Gwaltney et al. 1992). In cases of subacute or chronic sinusitis, physicians need to make a judgment regarding the appropriateness of antibiotic therapy. Antibiotic therapy was not shown to be of clear benefit in children who had nasal symptoms or cough for longer than 3 weeks and who had abnormal sinus x rays but no fever (Dohlman et al. 1993).

Asthma is commonly associated with perennial and seasonal rhinitis and sinusitis. Studies indicate that inflammation of the upper airway contributes to lower airway hyperresponsiveness and asthma symptoms (Watson et al. 1993; Corren et al. 1992; Welsh et al. 1987). The histopathology in the chronically thickened mucosa of the paranasal sinuses is similar to that in the nose and bronchi, with a primarily eosinophilic infiltrate that, in most patients, is notably lacking in neutrophils (Harlin et al. 1988; Demoly et al. 1994).

Gastroesophageal Reflux

Medical management of gastroesophageal reflux should be instituted for any patients with asthma complaining of frequent heartburn or pyrosis, particularly those with frequent episodes of nocturnal asthma. Medical management of gastroesophageal reflux includes:

- Avoiding food and drink within 3 hours of retiring (Nelson 1984)
- Elevating the head of the bed on 6- to 8-inch blocks (Nelson 1984)
- Using appropriate pharmacologic therapy (Hixson et al. 1992)

For patients who have persistent symptoms following optimal therapy, further evaluation is indicated.

For patients with poorly controlled asthma, particularly with a nocturnal component, investigation for gastroesophageal reflux may be warranted even in the absence of suggestive symptoms (Irwin et al. 1989).

The symptoms of gastroesophageal reflux are common in both children and adults with asthma (Nelson 1984). Reflux during sleep can contribute to nocturnal asthma (Martin et al. 1982; Davis et al. 1983). Both medical (Ekstrom et al. 1989) and surgical (Perrin-Fayolle et al. 1989) therapy of gastroesophageal reflux have been reported to reduce the symptoms of asthma.

Aspirin Sensitivity

Adult patients with asthma should be questioned regarding precipitation of bronchoconstriction by aspirin and other nonsteroidal anti-inflammatory drugs. If they have experienced a reaction to any of these drugs, they should be informed of the potential for all these drugs to precipitate severe and even fatal exacerbations. Adult patients with severe persistent asthma or nasal polyps should be counseled regarding the risk of using these drugs. Usually safe alternatives to aspirin include acetaminophen or salsalate (Szczeklik et al. 1977; Settipane et al. 1995).

From 3 percent of patients with asthma seen in a private allergy practice (Chafee and Settipane 1974) to 39 percent of adults with asthma admitted to an asthma referral hospital (Spector et al. 1979) have been reported to experience severe and even fatal exacerbations of asthma after taking aspirin or certain other nonsteroidal anti-inflammatory drugs. The prevalence of aspirin sensitivity increases with increasing age and severity of asthma (Chafee and Settipane 1974; Spector et al. 1979).

Sulfite Sensitivity

Patients who have asthma symptoms associated with eating processed potatoes, shrimp, or dried fruit or with drinking beer or wine should avoid these products (Taylor et al. 1988). These products contain sulfites, which are used to preserve foods and beverages. They have caused severe asthma exacerbations, particularly in patients with severe persistent asthma.

Beta-Blockers

Nonselective beta-blockers, including those in ophthalmological preparations, can cause asthma symptoms and should be avoided by asthma patients (Odeh et al. 1991; Schoene et al. 1984), although cardioselective beta-blockers, such as betaxolol, may be tolerated (Dunn et al. 1986).

Infections

Annual influenza vaccinations are recommended for patients with persistent asthma (Bell et al. 1978; CDC 1993). It is well established that viral respiratory infections can exacerbate asthma, particularly in children with asthma under the age of 10 (Busse et al. 1993). Respiratory syncytial virus, rhinovirus, and influenza virus have been implicated (Busse et al. 1993), with rhinovirus being implicated in the majority of the exacerbations of asthma in children (Johnston et al. 1995). The role of infections causing exacerbations of asthma also appears to be important in adults (Nicholson et al. 1993).

Viral infections are the most frequent precipitants of asthma exacerbations in infancy. In the majority of cases, young children are predisposed to have bronchial obstruction during viral infections because of very small airway size (Martinez et al. 1995) and will not have further exacerbations after infancy. However, chronic asthma also may start as early as the first year of life among infants with a family history of asthma, persistent rhinorrhea, atopic dermatitis, or high IgE levels. Early identification of these infants allows institution of environmental controls to reduce exposure to tobacco smoke, animal dander, and house-dust mites.

PREVENTING THE ONSET OF ASTHMA

Primary prevention of asthma (preventing initial development) is an accepted approach for occupational asthma (Venables 1994; Chan-Yeung et al. 1987) but remains unproven outside the workplace. Recent studies indicate that exposures to high levels of house-dust mite antigen (Sporik et al. 1990; Peat et al. 1993, 1994) and environmental tobacco smoke (Martinez et al. 1995; Kuehr et al. 1995) are associated with an increased incidence of asthma among infants. This suggests that reducing these exposures may result in reduction in the incidence of asthma. Prolonged breast feeding and avoidance of early introduction of allergenic foods have been reported to reduce eczema and food sensitization but not to reduce the prevalence of asthma (Zeiger 1994).

REFERENCES

Adinoff AD, Rosloniec DM, McCall LL, Nelson HS. Immediate skin test reactivity to Food and Drug Administration-approved standardized extracts. *J Allergy Clin Immunol* 1990;86:766-74.

American Academy of Allergy and Immunology Board of Directors. Guidelines to minimize the risk from systemic reactions caused by immunotherapy with allergenic extracts. *J Allergy Clin Immunol* 1994;93:811-2.

Abbey DE, Petersen F, Mills PK, Beeson WL. Long-term ambient concentrations of total suspended particulates, ozone, and sulfur dioxide and respiratory symptoms in a nonsmoking population. *Arch Environ Health* 1993;48:33-46.

Abramson MJ, Puy RM, Weiner JM. Is allergen immunotherapy effective in asthma? A meta-analysis of randomized controlled trials. *Am J Respir Crit Care Med* 1995;151:969-74.

Agudo A, Bardagí S, Romero PV, González CA. Exercise-induced airways narrowing and exposure to environmental tobacco smoke in schoolchildren. *Am J Epidemiol* 1994;140:409-17.

Arshad SH, Hide DW. Effect of environmental factors on the development of allergic disorders in infancy. *J Allergy Clin Immunol* 1992;90:235-41.

Aubier M, Levy J, Clerici C, Neukirch F, Herman D. Different effects of nasal and bronchial glucocorticosteroid administration on bronchial hyperresponsiveness in patients with allergic rhinitis. *Am Rev Respir Dis* 1992;146:122-6.

Bell TD, Chai H, Berlow B, Daniels G. Immunization with killed influenza virus in children with chronic asthma. *Chest* 1978;73:140-5.

Bjornsson E, Norback D, Janson C, et al. Asthmatic symptoms and indoor levels of micro-organisms and house-dust mites. *Clin Exp Allergy* 1995;25:423-31.

Boston Consulting Group. Report on the cost of asthma in Australia. New South Wales, Australia, National Asthma Campaign. 1992.

Boulet LP, Cartier A, Thomson NC, Roberts RS, Dolovich J, Hargreave FE. Asthma and increases in nonallergic bronchial responsiveness from seasonal pollen exposure. *J Allergy Clin Immunol* 1983;71:399-406.

Brooks SM, Weiss MA, Bernstein IL. Reactive airways dysfunction syndrome (RADS). Persistent asthma syndrome after high level irritant exposures. *Chest* 1985;88:376-84.

Busse WW, Lemanske RF Jr, Stark JM, Calhoun WJ. The role of respiratory infections in asthma. In: Holgate ST, Austen KF, Lichtenstein LM, Kay AB, eds. *Asthma: Physiology, Immunopharmacology, and Treatment.* London: Academic Press, 1993. Ch. 26, pp. 345-53.

Cabrera P, Julia-Serda G, Rodriguez de Castro F, Caminero J, Barber D, Carrillo T. Reduction of house dust mite allergens after dehumidifier use. *J Allergy Clin Immunol* 1995;95:635-6.

Call RS, Smith TF, Morris E, Chapman MD, Platts-Mills TAE. Risk factors for asthma in inner city children. *J Pediatr* 1992;121:862-6.

Call RS, Ward G, Jackson S, Platts-Mills TAE. Investigating severe and fatal asthma. *J Allergy Clin Immunol* 1994;94:1065-72.

Canadian Society of Allergy and Clinical Immunology. Guidelines for the use of allergen immunotherapy. *Can Med Assoc J* 1995;152:1413-9.

Centers for Disease Control and Prevention. Prevention and control of influenza. Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR* 1993;42(No. RR-6):1-14.

Chafee FH, Settipane GA. Aspirin intolerance. I. Frequency in an allergic population. *J Allergy Clin Immunol* 1974;53:193-9.

Chan-Yeung M, MacLean L, Paggiaro PL. Follow-up study of 232 patients with occupational asthma caused by western red cedar (Thuja plicata). *J Allergy Clin Immunol* 1987;79:792-6.

Cody RP, Weisel CP, Birnbaum G, Lioy PJ. The effect of ozone associated with summertime photochemical smog on the frequency of asthma visits to hospital emergency departments. *Environ Res* 1992;58:184-94.

Corren J, Adinoff AD, Buchmeier AD, Irvin CG. Nasal beclomethasone prevents the seasonal increase in bronchial responsiveness in patients with allergic rhinitis and asthma. *J Allergy Clin Immunol* 1992;90:250-6

Creticos PS, Reed CE, Norman PS, et al. Ragweed immunotherapy in adult asthma. *N Engl J Med* 1996;334(8):501-6.

Cuijpers CE, Swaen GM, Wesseling G, Sturmans F, Wouters EF. Adverse effects of the indoor environment on respiratory health in primary school children. *Environ Res* 1995;68:11-23.

Davis RS, Larsen GL, Grunstein MM. Respiratory response to intraesophageal acid infusion in asthmatic children during sleep. *J Allergy Clin Immunol* 1983;72:393-8.

de Blay F, Chapman MD, Platts-Mills TAE. Airborne cat allergen (Fel d I): environmental control with the cat in situ. *Am Rev Respir Dis* 1991b;143:1334-9.

de Blay F, Heymann PW, Chapman MD, Platts-Mills TAE. Airborne dust mite allergens: comparison of group II allergens with group I mite allergen and cat-allergen Fel d I. *J Allergy Clin Immunol* 1991a;88:919-26.

Demoly P, Crampette L, Mondain M, et al. Assessment of inflammation in noninfectious chronic maxillary sinusitis. *J Allergy Clin Immunol* 1994;94:95-108.

Dohlman AW, Hemstreet MP, Odrezin GT, Bartolucci AA. Subacute sinusitis: are antimicrobials necessary? *J Allergy Clin Immunol* 1993;91:1015-23.

Dunn TL, Gerber MJ, Shen AS, Fernandez E, Iseman MD, Cherniack RM. The effect of topical ophthalmic instillation of timolol and betaxolol on lung function in asthmatic subjects. *Am Rev Respir Dis* 1986;133:264-8.

Ekstrom T, Lindgren BR, Tibbling L. Effects of ranitidine treatment on patients with asthma and a history of gastro-oesophageal reflux: a double-blind crossover study. *Thorax* 1989;44:19-23.

Ellingson AR, LeDoux RA, Vedanthan PK, Weber RW. The prevalence of Dermatophagoides mite allergen in Colorado homes utilizing central evaporative coolers. *J Allergy Clin Immunol* 1995;96:473-9.

Frew AJ. Injection immunotherapy. British Society for Allergy and Clinical Immunology Working Party. *BMJ* 1993;307:919-23.

Frischer T, Kuehr J, Meinert R, et al. Maternal smoking in early childhood: a risk factor for bronchial responsiveness to exercise in primary-school children. *J Pediatr* 1992;121:17-22.

Garrison RA, Robertson LD, Koehn RD, Wynn SR. Effect of heating-ventilation-air conditioning system sanitation on airborne fungal populations in residential environments. *Ann Allergy* 1993;71:548-56.

Golbert TM, Patterson R, Pruzansky JJ. Systemic allergic reactions to ingested antigens. *J Allergy* 1969;44:96-107.

Gortmaker SL, Walker DK, Jacobs FH, Ruch-Ross H. Parental smoking and the risk of childhood asthma. *Am J Public Health* 1982;72:574-9.

Greer JR, Abbey DE, Burchette RJ. Asthma related to occupational and ambient air pollutants in nonsmokers. *J Occup Med* 1993;35:909-15.

Gwaltney JM Jr., Scheld WM, Sande MA, Sydnor A. The microbial etiology and antimicrobial therapy of adults with acute community-acquired sinusitis: a fifteen-year experience at the University of Virginia and review of other selected studies. *J Allergy Clin Immunol* 1992;90:457-61.

Harlin SL, Ansel DG, Lane SR, Myers J, Kephart GM, Gleich GJ. A clinical and pathologic study of chronic sinusitis: the role of the eosinophil. *J Allergy Clin Immunol* 1988;81:867-75.

Henderson FW, Henry MM, Ivins SS, et al. Correlates of recurrent wheezing in school-age children. The physicians of Raleigh Pediatric Associates. *Am J Respir Crit Care Med* 1995;151:1786-93.

Hixson LJ, Kelly CL, Jones WN, Tuohy CD. Current trends in the pharmacotherapy for gastroesophageal reflux disease. *Arch Intern Med* 1992;152:717-23.

Horst M, Hejjaoui A, Horst V, Michel FB, Bousquet J. Double-blind, placebo-controlled rush immunotherapy with a standardized *Alternaria* extract. *J Allergy Clin Immunol* 1990;85:460-72.

Ingram JM, Sporik R, Rose G, Honsinger R, Chapman MD, Platts-Mills TAE. Quantitative assessment of exposure to dog (Can f 1) and cat (Fel d 1) allergens: relation to sensitization and asthma among children living in Los Alamos, New Mexico. *J Allergy Clin Immunol* 1995;96:449-56.

Irwin RS, Zawacki JK, Curley FJ, French CL, Hoffman PJ. Chronic cough as the sole presenting manifestation of gastroesophageal reflux. *Am Rev Respir Dis* 1989;140:1294-1300.

James JM, Bernhisel-Broadbent J, Sampson HA. Respiratory reactions provoked by double-blind food challenges in children. *Am J Respir Crit Care Med* 1994;149:59-64.

Jindal SK, Gupta D, Singh A. Indices of morbidity and control of asthma in adult patients exposed to environmental tobacco smoke. *Chest* 1994;106:746-9.

Johnston SL, Pattemore PK, Sanderson G, et al. Community study of role of viral infections in exacerbations of asthma in 9 to 11 year old children. *BMJ* 1995;310:1225-9.

Kang BC, Johnson J, Veres-Thorner C. Atopic profile of inner-city asthma with a comparative analysis on the cockroach-sensitive and ragweed-sensitive subgroups. *J Allergy Clin Immunol* 1993;92:802-11.

Kesten S, Szalai J, Dzyngel B. Air quality and the frequency of emergency room visits for asthma. *Ann Allergy Asthma Immunol* 1995;74:269-73.

Klucka CV, Ownby DR, Green J, Zoratti E. Cat shedding of Fel d I is not reduced by washings, Allerpet-C spray, or acepromazine. *J Allergy Clin Immunol* 1995;95:1164-71.

Koenig JQ, Covert DS, Marshall SG, Van Belle G, Pierson WE. The effects of ozone and nitrogen dioxide on pulmonary function in healthy and in asthmatic adolescents. *Am Rev Respir Dis* 1987;136:1152-7.

Koenig JQ, Larson TV, Hanley QS, et al. Pulmonary function changes in children associated with fine particulate matter. *Environ Res* 1993;63:26-38.

Kuehr J, Frischer T, Meinert R, et al. Sensitization to mite allergens is a risk factor for early and late onset of asthma and for persistence of asthmatic signs in children. *J Allergy Clin Immunol* 1995;95(3):655-62.

Leuenberger P, Schwartz J, Ackermann-Liebrich U, et al. Passive smoking exposure in adults and chronic respiratory symptoms (SAPALDIA Study). Swiss Study on Air Pollution and Lung Diseases in Adults, SAPALDIA Team. *Am J Respir Crit Care Med* 1994;150:1221-8.

Lintner TJ, Brame KA. The effects of season, climate, and air conditioning on the prevalence of Dermatophagoides mite allergens in household dust. *J Allergy Clin Immunol* 1993;91:862-7.

Long DL, Kramer CL. Air spora of two contrasting ecological sites in Kansas. *J Allergy Clin Immunol* 1972;49:255-66.

Malling HJ, Dreborg S, Weeke B. Diagnosis and immunotherapy of mould allergy. V. Clinical efficacy and side effects of immunotherapy with *Cladosporium* herbarum. *Allergy* 1986;41:507-19.

Maloney MJ, Wray BB, DuRant RH, Smith L, Smith L. Effect of an electronic air cleaner and negative ionizer on the population of indoor mold spores. *Ann Allergy* 1987;59:192-4.

Marquette CH, Saulnier F, Leroy O, et al. Long-term prognosis of near-fatal asthma. A 6-year follow-up study of 145 asthmatic patients who underwent mechanical ventilation for a near-fatal attack of asthma. *Am Rev Respir Dis* 1992;146:76-81.

Martin ME, Grunstein MM, Larsen GL. The relationship of gastroesophageal reflux to nocturnal wheezing in children with asthma. *Ann Allergy* 1982;49:318-22.

Martinez FD, Wright AL, Taussig LM, Holberg CJ, Halonen M, Morgan WJ. Asthma and wheezing in the first six years of life. The Group Health Medical Associates. *N Engl J Med* 1995;332:133-8.

Moscato G, Godnic-Cvar J, Maestrelli P. Statement on self-monitoring of peak expiratory flows in the investigation of occupational asthma. Subcommittee on Occupational Allergy of European Academy of Allergy and Clinical Immunology. *J Allergy Clin Immunol* 1995;96:295-301.

Moseholm L, Taudorf E, Frosig A. Pulmonary function changes in asthmatics associated with low-level SO_2 and NO_2 air pollution, weather, and medicine intake. An 8-month prospective study analyzed by neural networks. *Allergy* 1993;48:334-44.

Mullins J, White J, Davies BH. Circadian periodicity of grass pollen. *Ann Allergy* 1986;57:371-4.

Murray AB, Milner RA. The accuracy of features in the clinical history for predicting atopic sensitization to airborne allergens in children. *J Allergy Clin Immunol* 1995;96:588-96.

Murray AB, Ferguson AC, Morrison BJ. Diagnosis of house dust mite allergy in asthmatic children: what constitutes a positive history? *J Allergy Clin Immunol* 1983;71:21-8.

Nelson HS. Gastroesophageal reflux and pulmonary disease. *J Allergy Clin Immunol* 1984;73:547-56.

Nelson HS, Fernandez-Caldas E. Prevalence of house-dust mites in the Rocky Mountain States. *Ann Allergy Asthma Immunol* 1995;75:337-9.

Nelson HS, Hirsch SR, Ohman JL Jr, Platts-Mills TAE, Reed CE, Solomon WR. Recommendations for the use of residential air-cleaning devices in the treatment of allergic respiratory diseases. *J Allergy Clin Immunol* 1988;82:661-9.

Nicholson KG, Kent J, Ireland DC. Respiratory viruses and exacerbations of asthma in adults. *BMJ* 1993;307:982-6.

Odeh M, Oliven A, Bassan H. Timolol eyedrop-induced fatal-bronchospasm in an asthmatic patient. *J Fam Pract* 1991;32:97-8.

O'Hollaren MT, Yunginger JW, Offord KP, et al. Exposure to an aeroallergen as a possible precipitating factor in respiratory arrest in young patients with asthma. *N Engl J Med* 1991;324:359-63.

Ostro BD, Lipsett MJ, Mann JK, Braxton-Owens H, White MC. Air pollution and asthma exacerbations among African-American children in Los Angeles. *Inhal Toxicol* 1995;7:711-22.

Ostro BD, Lipsett MJ, Mann JK, Wiener MB, Selner J. Indoor air pollution and asthma. Results from a panel study. *Am J Respir Crit Care Med* 1994;149:1400-6.

Peat JK, Tovey E, Gray EJ, Mellis CM, Woolcock AJ. Asthma severity and morbidity in a population sample of Sydney schoolchildren: part II—importance of house dust mite allergens. *Aust N Z J Med* 1994;24:270-6.

Peat JK, Tovey E, Mellis CM, Leeder SR, Woolcock AJ. Importance of house dust mite and *Alternaria* allergens in childhood asthma: an epidemiological study in two climatic regions of Australia. *Clin Exp Allergy* 1993;23:812-20.

Peroni DG, Boner AL, Vallone G, Antolini I, Warner JO. Effective allergen avoidance at high altitude reduces allergen-induced bronchial hyperresponsiveness. *Am J Respir Crit Care Med* 1994;149:1442-6.

Perrin-Fayolle M, Gormand F, Braillon G, et al. Long-term results of surgical treatment for gastroesophageal reflux in asthmatic patients. *Chest* 1989;96:40-5.

Piacentini GL, Martinati L, Fornari A, et al. Antigen avoidance in a mountain environment: influence on basophil releasability in children with allergic asthma. *J Allergy Clin Immunol* 1993;92(5):644-50.

Pisati G, Baruffini A, Zedda S. Toluene diisocyanate induced asthma: outcome according to persistence or cessation of exposure. *Br J Ind Med* 1993;50:60-4.

Platts-Mills TAE, Tovey ER, Mitchell EB, et al. Reduction of bronchial hyperreactivity during prolonged allergen avoidance. *Lancet* 1982;2:675-8.

Pollart SM, Chapman MD, Fiocco GP, Rose G, Platts-Mills TAE. Epidemiology of acute asthma: IgE antibodies to common inhalant allergens as a risk factor for emergency room visits. *J Allergy Clin Immunol* 1989;83:875-82.

Ponka A. Asthma and low level air pollution in Helsinki. *Arch Environ Health* 1991;46:262-70.

Pope CA 3d, Dockery DW, Spengler JD, Raizenne ME. Respiratory health and PM10 pollution. A daily time series analysis. *Am Rev Respir Dis* 1991;144:668-74.

Rak S, Bjornson A, Hakanson L, Sorenson S, Venge P. The effect of immunotherapy on eosinophil accumulation and production of eosinophil chemotatic activity in the lung of subjects with asthma during natural pollen exposure. *J Allergy Clin Immunol* 1991;88:878-88.

Reid MJ, Lockey RF, Turkeltaub PC, Platts-Mills TAE. Survey of fatalities from skin testing and immunotherapy 1985-1989. *J Allergy Clin Immunol* 1993;92:6-15.

Reid MJ, Moss RB, Hsu YP, Kwasnicki JM, Commerford TM, Nelson BL. Seasonal asthma in northern California: allergic causes and efficacy of immunotherapy. *J Allergy Clin Immunol* 1986;78:590-600.

Reisman RE, Mauriello PM, Davis GB, Georgitis JW, DeMasi JM. A double-blind study of the effectiveness of a high-efficiency particulate air (HEPA) filter in the treatment of patients with perennial allergic rhinitis and asthma. *J Allergy Clin Immunol* 1990;85:1050-7.

Romieu I, Meneses F, Sienra-Monge JJ, et al. Effects of urban air pollutants on emergency visits for childhood asthma in Mexico City. *Am J Epidemiol* 1995;141:546-53.

Roorda RJ, Gerritsen J, Van Aalderen WM, et al. Risk factors for the persistence of respiratory symptoms in childhood asthma. *Am Rev Respir Dis* 1993;148:1490-5.

Rosenstreich, Eggleston P, Kattan M, et al. for the National Cooperative Inner-City Asthma Study. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. *N Engl J Med* 1997;336:1356-63.

Sampson HA, Mendelson L, Rosen JP. Fatal and near-fatal anaphylactic reactions to food in children and adolescents. *N Engl J Med* 1992;327:380-4.

Schmitzberger R, Rhomberg K, Buchele H, et al. Effects of air pollution on the respiratory tract of children. *Pediatr Pulmunol* 1993;15:68-74.

Schoene RB, Abuan T, Ward RL, Beasley CH. Effects of topical-betaxolol, timolol, and placebo on pulmonary function in asthmatic bronchitis. *Am J Ophthalmol* 1984;97:86-92.

Schwartz J, Slater D, Larson TV, Pierson WE, Koenig JQ. Particulate air pollution and hospital emergency room visits for asthma in Seattle. *Am Rev Respir Dis* 1993;147:826-31.

Sears MR, Burrows B, Flannery EM, Herbison GP, Holdaway MD. Atopy in childhood. I. Gender and allergen related risks for development of hay fever and asthma. *Clin Exp Allergy* 1993b;23:941-8.

Sears MR, Burrows B, Herbison GP, Holdaway MD, Flannery EM. Atopy in childhood. II. Relationship to airway responsiveness, hay fever, and asthma. *Clin Exp Allergy* 1993a;23:949-56.

Sears MR, Herbison GP, Holdaway MD, Hewitt CJ, Flannery EM, Silva PA. The relative risks of sensitivity to grass pollen, house dust mite, and cat dander in the development of childhood asthma. *Clin Exp Allergy* 1989;19:419-24.

Settipane RA, Schrank PJ, Simon RA, Mathison DA, Christiansen SC, Stevenson DD. Prevalence of cross-sensitivity with acetaminophen in aspirin-sensitive asthmatic subjects. *J Allergy Clin Immunol* 1995;96:480-5.

Simon HU, Grotzer M, Nikolaizik WH, Blaser K, Schoni MH. High altitude climate therapy reduces peripheral blood T lymphocyte activation, eosinophilia, and bronchial obstruction in children with house-dust mite allergic asthma. *Pediatr Pulmonol* 1994;17:304-11.

Smith RD, Rooks R. The diurnal variation of air-borne ragweed pollen as determined by a continuous recording particle sampler and implications of the study. *J Allergy* 1954;25:36-45.

Smedje G, Norbäck D, Wessén B, Edling C. Asthma among school employees in relation to the school environment. Indoor Air 96, the 7th International Conference on Indoor Air Quality and Climate, July 21-6, 1996, Nagoya, Japan. Proceedings; vol. 1:611-6.

Solomon WR. Fungus aerosols arising from cold-mist vaporizers. *J Allergy Clin Immunol* 1974;54:222-8.

Solomon WR. A volumetric study of winter fungus prevalence in the air of midwestern homes. *J Allergy Clin Immunol* 1976;57:46-55.

Solomon WR, Burge HA, Boise JR. Exclusion of particulate allergens by window air conditioners. *J Allergy Clin Immunol* 1980;65:305-8.

Soyseth V, Kongerud J, Boe J. Postnatal maternal smoking increases the prevalence of asthma but not of bronchial hyperresponsiveness or atopy in their children. *Chest* 1995;107:389-94.

Spector SL, Wangaard CH, Farr RS. Aspirin and concomitant idiosyncrasies in adult asthmatic patients. *J Allergy Clin Immunol* 1979;64:500-6.

Sporik R, Holgate ST, Platts-Mills TAE, Cogswell JJ. Exposure to house-dust mite allergen (Der p I) and the development of asthma in childhood. A prospective study. *N Engl J Med* 1990;323:502-7.

Strachan DP. Damp housing and childhood asthma: validation of reporting of symptoms. *BMJ* 1988; 297:1223-6.

Swanson MC, Agarwal MK, Reed CE. An immunochemical approach to indoor aeroallergen quantitation with a new volumetric air sampler: studies with mite, roach, cat, mouse and guinea pig antigens. *J Allergy Clin Immunol* 1985;76:724-9.

Szczeklik A, Gryglewski RJ, Czerniawska-Mysik G. Clinical patterns of hypersensitivity to nonsteroidal anti-inflammatory drugs and their pathogenesis. *J Allergy Clin Immunol* 1977;60:276-84.

Targonski PV, Persky VW, Ramekrishnan V. Effect of environmental molds on risk of death from asthma during the pollen season. *J Allergy Clin Immunol* 1995;95:955-61.

Taylor SL, Bush RK, Selner JC, et al. Sensitivity to sulfited foods among sulfite-sensitive subjects with asthma. *J Allergy Clin Immunol* 1988;81:1159-67.

Taylor WR, Newacheck PW. Impact of childhood asthma on health. *Pediatrics* 1992;90:657-62.

Thurston GD, Ito K, Kinney PL, Lippmann M. A multi-year study of air pollution and respiratory hospital admissions in three New York State metropolitan areas: results for 1988 and 1989 summers. *J Expo Anal Environ Epidemiol* 1992;2:429-50.

U.S. Environmental Protection Agency. *Residential Air-Cleaning Devices: A Summary of Available Information*. Washington, DC: Office of Air and Radiation, U.S. Environmental Protection Agency, 1990.

Venables KM. Prevention of occupational asthma. *Eur Respir J* 1994;7:768-78.

Verhoeff AP, van Strien RT, van Wijnen JH, Brunekreef B. Damp housing and childhood respiratory symptoms: the role of sensitization to dust mites and molds. *Am J Epidemio*1995;141:103-10.

Vervloet D, Charpin D, Haddi E, et al. Medication requirements and house dust mite exposure in mite-sensitive asthmatics. *Allergy* 1991;46:554-8.

Wald ER. Microbiology of acute and chronic sinusitis in children. *J Allergy Clin Immunol* 1992;90:452-6.

Walters S, Griffiths RK, Ayres JG. Temporal association between hospital admissions for asthma in Birmingham and ambient levels of sulphur dioxide and smoke. *Thorax* 1994;49:133-40.

Warburton CJ, Niven RM, Pickering CA, Fletcher AM, Hepworth J, Francis HC. Domiciliary air filtration units, symptoms and lung function in atopic asthmatics. *Respir Med* 1994;88(10):771-6.

Warner JA, Marchant JL, Warner JO. Double blind trial of ionisers in children with asthma sensitive to the house dust mite. *Thorax* 1993;48:330-3.

Watson WT, Becker AB, Simons FE. Treatment of allergic rhinitis with intranasal corticosteroids in patients with mild asthma; effect on lower airway responsiveness. *J Allergy Clin Immunol* 1993;91:97- 101.

Welsh PW, Stricker WE, Chu CP, et al. Efficacy of beclomethasone nasal solution, flunisolide, and cromolyn in relieving symptoms of ragweed allergy. *Mayo Clin Proc* 1987;62:125-34.

White MC, Etzel RA, Wilcox WD, Lloyd C. Exacerbations of childhood asthma and ozone pollution in Atlanta. *Environ Res* 1994;65(1):56-68.

Woodfolk JA, Hayden ML, Couture N, Platts-Mills TAE. Chemical treatment of carpets to reduce allergen: comparison of the effects of tannic acid and other treatments on proteins derived from dust mites and cats. *J Allergy Clin Immunol* 1995;96:325-33.

Woodfolk JA, Luczynska CM, de Blay F, Chapman MD, Platts-Mills TAE. The effect of vacuum cleaners on the concentration and particle size distribution of airborne cat allergen. *J Allergy Clin Immunol* 1993;91:829-37.

Zeiger RS. Dietary manipulations in infants and their mothers and the natural course of atopic disease. *Pediatr Allergy Immunol* 1994;5:33-43.

Zeiger RS. Prospects for ancillary treatment of sinusitis in the1990s. *J Allergy Clin Immunol* 1992;90:478-95.

Zock JP, Brunekreef B, Hazebroek-Kampschreur AA, Roosjen CW. House dust mite allergen in bedroom floor dust and respiratory health of children with asthmatic symptoms. *Eur Respir J* 1994;7:1254-9.

COMPONENT 3:
PHARMACOLOGIC THERAPY

KEY POINTS

- Underdiagnosis and inappropriate therapy are major contributors to asthma morbidity and mortality.
- Goals of asthma therapy are:
  - Prevent chronic and troublesome symptoms (e.g., coughing or breathlessness in the night, in the early morning, or after exertion)
  - Maintain (near) "normal" pulmonary function
  - Maintain normal activity levels (including exercise and other physical activity)
  - Prevent recurrent exacerbations of asthma and minimize the need for emergency department visits or hospitalizations
  - Provide optimal pharmacotherapy with minimal or no adverse effects
  - Meet patients' and families' expectations of and satisfaction with asthma care
- Persistent asthma is most effectively controlled with daily anti-inflammatory therapy.
- A stepwise approach to pharmacologic therapy is recommended:
  - The amount and frequency of medication is dictated by asthma severity and directed toward suppression of increasing airway inflammation.
  - Initiate therapy at a higher level at the onset to establish prompt control and then step down.
  - Continual monitoring is essential to ensure that asthma control is achieved.
  - Step down therapy cautiously once control is achieved and sustained.
  - Step-down therapy is necessary to identify the minimum medication necessary to maintain control.
- Regular followup visits (at 1- to 6-month intervals) are essential to maintain control and consider appropriate step down in therapy.
- Therapeutic strategies should be considered in concert with clinician-patient partnership strategies; education of patients is essential for achieving optimal asthma control.
- At each step, patients should be advised to avoid or control allergens, irritants, or other factors that make the patient's asthma worse.
- Referral to an asthma specialist for consultation or comanagement is recommended if there are difficulties achieving or maintaining control of asthma or if the patient requires step 4 care. Referral may be considered for patients who require step 3 care. For patients younger than 3 years of age, referral is *recommended* if the patient requires step 3 or 4 care and should be *considered* if the patient requires step 2 care.
- New medications are available.
  - Long-acting inhaled beta$_2$-agonists
    - Effective 12-hour bronchodilator
    - Adjunctive therapy to inhaled corticosteroids for maintaining control, especially helpful for nighttime symptoms
    - Not to be used to treat acute symptoms or exacerbations
  - Nedocromil
    - Similar role in therapy as cromolyn sodium, with similar safety profile
  - Leukotriene modifiers
    - Zafirlukast, leukotriene receptor antagonist, and zileuton, 5-lipoxygenase inhibitor
    - May be considered alternative daily long-term-control medications for patients with mild persistent asthma who are 12 years of age and older, but further clinical experience and study are needed to establish their roles in therapy

- Increased understanding of inhaled corticosteroids notes that:
  - Inhaled corticosteroids are the most potent inhaled anti-inflammatory agent currently available.
  - Early intervention with inhaled corticosteroids can improve asthma control and normalize lung function and may prevent irreversible airway injury.
  - Higher doses of inhaled corticosteroids may be associated with possible, but not predictable, growth retardation in children. The clinical significance of this potential systemic effect has yet to be determined.
  - Issues regarding clinical comparability and bioavailability of different preparations and different delivery systems indicate the need to adjust doses accordingly.
- Management of asthma exacerbations includes:
  - Inhaled beta$_2$-agonist to provide prompt relief of airflow obstruction
  - Systemic corticosteroid, for moderate-to-severe exacerbations, to suppress and reverse airway inflammation
  - Oxygen to relieve hypoxia for moderate-to-severe exacerbations
  - Monitoring response to therapy with serial measurements of lung function

DIFFERENCES FROM 1991 EXPERT PANEL REPORT

- Medications are now categorized into two general classes: long-term-control medications used to achieve and maintain control of persistent asthma and quick-relief medications used to treat acute symptoms and exacerbations. *However, the updated report continues to emphasize that the most effective medications for long-term therapy are those shown to have anti-inflammatory effects.*
- New medications are available—long-acting inhaled beta$_2$-agonists, nedocromil, zafirlukast, and zileuton—that have positions in therapy for long-term control and prevention of symptoms.
- There is an increased understanding of inhaled corticosteroids and their significant role in asthma therapy. An estimated clinical comparability of different inhaled corticosteroid preparations is presented.
- The stepwise approach to asthma therapy emphasizes initiating higher level therapy at the onset to establish prompt control and then stepping down.
- A new section on asthma in infants and young children incorporates recent studies on wheezing in early childhood.

Selecting the appropriate pharmacologic therapy to achieve and maintain control of asthma involves several considerations: the medications and their routes of administration, a stepwise approach to managing asthma long term as a chronic disorder, and a protocol for managing exacerbations. Each will be discussed in this component. In addition, substantial reports in the literature since publication of the 1991 Expert Panel Report have commented on the safety of regular administration of inhaled beta$_2$-agonists and the potential adverse effects of inhaled corticosteroids. Because of the importance of these two classes of compounds in the treatment of asthma, it is the opinion of the Panel that special emphasis should be given to these issues. A summary is presented in this component.

The therapeutic strategies provided in this component should be considered in concert with the clinician-patient partnership strategies provided in component 4. Effective communication with, and education of, patients will increase the benefits of the therapeutic regimen.

Pharmacologic Therapy: The Medications

KEY POINTS: THE MEDICATIONS

Long-term-control medications

- Corticosteroids: Most potent and effective anti-inflammatory medication currently available. Inhaled form is used in the long-term control of asthma. Systemic corticosteroids are often used to gain prompt control of the disease when initiating long-term therapy.
- Cromolyn sodium and nedocromil: Mild-to-moderate anti-inflammatory medications. May be used as initial choice for long-term-control therapy for children. Can also be used as preventive treatment prior to exercise or unavoidable exposure to known allergens.
- Long-acting beta$_2$-agonists: Long-acting bronchodilator used concomitantly with anti-inflammatory medications for long-term control of symptoms, especially nocturnal symptoms. Also prevents exercise-induced bronchospasm (EIB).
- Methylxanthines: Sustained-release theophylline is a mild-to-moderate bronchodilator used principally as adjuvant to inhaled corticosteroids for prevention of nocturnal asthma symptoms. May have mild anti-inflammatory effect.
- Leukotriene modifiers: Zafirlukast, a leukotriene receptor antagonist, or zileuton, a 5-lipoxygenase inhibitor, may be considered an alternative therapy to low doses of inhaled corticosteroids or cromolyn or nedocromil for patients ≥12 years of age with mild persistent asthma, although further clinical experience and study are needed to establish their roles in asthma therapy.

Quick-relief medications

- Short-acting beta$_2$-agonists: Therapy of choice for relief of acute symptoms and prevention of EIB.
- Anticholinergics: Ipratropium bromide may provide some additive benefit to inhaled beta$_2$-agonists in severe exacerbations. May be an alternative bronchodilator for patients who do not tolerate inhaled beta$_2$-agonists.
- Systemic corticosteroids: Used for moderate-to-severe exacerbations to speed recovery and prevent recurrence of exacerbations.

OVERVIEW OF THE MEDICATIONS

Pharmacologic therapy is used to prevent and control asthma symptoms, reduce the frequency and severity of asthma exacerbations, and reverse airflow obstruction. Recommendations in this component reflect the scientific concept that asthma is a chronic disorder with recurrent episodes of airflow limitation, mucus production, and cough. Asthma medications are thus categorized into two general classes: *long-term-control* medications taken daily on a long-term basis to achieve and maintain control of persistent asthma (these medications are also known as long-term preventive, controller, or maintenance medications) and *quick-relief* medications taken to provide prompt reversal of acute airflow obstruction and relief of accompanying bronchoconstriction (these medications are also known as reliever or acute rescue medications). Patients with persistent asthma require both classes of medication. Figures 3-1 and 3-2 present summaries of the indications, mechanisms, potential adverse effects, and therapeutic issues for currently available long-term-control and quick-relief medications.

Long-Term-Control Medications

Long-term-control medications are taken daily on a long-term basis to achieve and maintain control of persistent asthma. They include anti-inflammatory agents, long-acting bronchodilators, and leukotriene modifiers. Because eosinophilic inflammation is a constant feature of the mucosa of the airways in asthma, the most effective long-term-control medications are those that attenuate inflammation (Haahtela et al. 1991; Kerrebijn et al. 1987; van Essen-Zandvliet et al. 1992). The Expert Panel defines anti-inflammatory medications as those that cause a reduction in the markers of airway inflammation in airway tissue or airway secretions (e.g., eosinophils, mast cells, activated lymphocytes, macrophages, and cytokines; or eosinophilic cationic protein and tryptase; or extravascular leakage of albumin, fibrinogen, or other vascular protein) and thus decrease the intensity of airway hyperresponsiveness. Because many factors contribute to the inflammatory response in asthma, many

drugs may be considered anti-inflammatory. It is not yet established, however, which anti-inflammatory actions are responsible for therapeutic effects, such as reduction in symptoms, improvement in expiratory flow, reduction in airway hyperresponsiveness, prevention of exacerbations, or prevention of airway wall remodeling.

Corticosteroids

Corticosteroids are the most potent and consistently effective long-term-control medication for asthma. Their broad action on the inflammatory process may account for their efficacy as preventive therapy. Their clinical effects include reduction in severity of symptoms, improvement in peak expiratory flow and spirometry, diminished airway hyperresponsiveness, prevention of exacerbations, and possibly the prevention of airway wall remodeling (Barnes et al. 1993; Jeffery et al. 1992; Dahl et al. 1993; Fabbri et al. 1993; Gustafsson et al. 1993; Haahtela et al. 1991; Kamada et al. 1996; Rafferty et al. 1985; van Essen-Zandvliet et al. 1992). Which of these clinical effects depend on specific anti-inflammatory actions of corticosteroids is not yet clear. Corticosteroids suppress the generation of cytokines, recruitment of airway eosinophils, and release of inflammatory mediators. These anti-inflammatory actions of corticosteroids have been noted in clinical trials and analyses of airway histology (Busse 1993; Booth et al. 1995; Laitinen et al. 1992; Djukanovic et al. 1992; Duddridge et al. 1993; Laitinen et al. 1991; Levy et al. 1995; McGill et al. 1995).

Dosages for inhaled corticosteroids vary depending upon the specific product and delivery devices (see figure 3-5b). For many patients, a twice-a-day dosing schedule maintains control of asthma; even high doses of some preparations are effective when given twice a day (Noonan et al. 1995). Some studies show that once-daily dosing is effective in mild persistent asthma (Jones et al. 1994; Pincus et al. 1995).

Cromolyn Sodium and Nedocromil

Although cromolyn and nedocromil have distinct properties (Clark 1993), they have similar anti-inflammatory actions. Their mechanism appears to involve the blockade of chloride channels (Alton and Norris 1996), and they modulate mast cell mediator release and eosinophil recruitment (Eady 1986). They also inhibit the early and late asthmatic response to allergen challenge and exercise-induced bronchospasm (EIB) (Novembre et al. 1994; Alton and Norris 1996; Thompson 1989; Gonzalez and Brogden 1987).

The two compounds are equally effective against allergen challenge (Gonzalez and Brogden 1987), although nedocromil appears to be more potent than cromolyn in inhibiting bronchospasm provoked by exercise (Novembre et al. 1995; deBenedictis et al. 1995), by cold dry air (Juniper et al. 1987), and by bradykinin aerosol (Dixon and Barnes 1989).

Both compounds have been shown to reduce asthma symptoms, improve morning peak flow, and reduce need for quick-relief beta$_2$-agonists (Lal et al. 1993; Schwartz et al. 1996). Two large clinical trials comparing nedocromil MDI 4 mg qid to cromolyn MDI 2 mg qid demonstrated that they are generally comparable in mild allergic patients and that nedocromil was more effective than cromolyn in nonallergic patients using inhaled corticosteroids. Furthermore, nedocromil may have a modest effect in helping reduce the dose requirements for inhaled corticosteroids (Lal et al. 1993; O'Hickey and Rees 1994; Svendsen and Jorgensen 1991), although some studies did not demonstrate this effect (Wong et al. 1993).

Dosing recommendations for both drugs are for administration four times a day, although nedocromil has been shown to be clinically effective with twice-daily dosing (Creticos et al. 1995).

The clinical response to cromolyn and nedocromil is less predictable than the response to inhaled corticosteroids. Both compounds have a strong safety profile.

Long-Acting Beta$_2$-Agonists (Beta-Adrenergic Agonists)

The principal action of beta$_2$-agonists is to relax airway smooth muscle by stimulating beta$_2$-receptors, which increases cyclic AMP and produces functional antagonism to bronchoconstriction. Long-acting inhaled beta$_2$-agonists have a duration of bronchodilation of at least 12 hours after a single dose (Becker and Simons 1989; D'Alonzo et al. 1994). This class of medication is *not* to be used for exacerbations. Rather, it is used as an adjunct to anti-inflammatory therapy for providing long-term control of symptoms, especially nocturnal symptoms (Yates et al. 1995) and to prevent exercise-induced bronchospasm. The use and safety of beta$_2$-agonists are discussed on page 67, Special Issues Regarding Safety.

FIGURE 3-1. LONG-TERM-CONTROL MEDICATIONS

Name/Products	Indications/Mechanisms	Potential Adverse Effects	Therapeutic Issues
Corticosteroids (Glucocorticoids) *Inhaled:* Beclomethasone dipropionate Budesonide Flunisolide Fluticasone propionate Triamcinolone acetonide	*Indications* ■ Long-term prevention of symptoms; suppression, control, and reversal of inflammation. ■ Reduce need for oral corticosteroid. *Mechanisms* ■ Anti-inflammatory. Block late reaction to allergen and reduce airway hyperresponsiveness. Inhibit cytokine production, adhesion protein activation, and inflammatory cell migration and activation. ■ Reverse beta$_2$-receptor down-regulation. Inhibit microvascular leakage.	■ Cough, dysphonia, oral thrush (candidiasis). ■ In high doses (see figure 3-5b), systemic effects may occur, although studies are not conclusive, and clinical significance of these effects has not been established (e.g., adrenal suppression, osteoporosis, growth suppression, and skin thinning and easy bruising) (Barnes and Pedersen 1993; Kamada et al. 1996).	■ Spacer/holding chamber devices and mouth washing after inhalation decrease local side effects and systemic absorption. ■ Preparations are not absolutely interchangeable on a mcg or per puff basis (see figure 3-5c for estimated clinical comparability). New delivery devices may provide greater delivery to airways, which may affect dose. ■ The risks of uncontrolled asthma should be weighed against the limited risks of inhaled corticosteroids. The potential but small risk of adverse events is well balanced by their efficacy. (See text.) ■ Dexamethasone is not included because it is highly absorbed and has long-term suppressive side effects.
Systemic: Methylprednisolone Prednisolone Prednisone	*Indications* ■ For short-term (3–10 days) "burst": to gain prompt control of inadequately controlled persistent asthma. ■ For long-term prevention of symptoms in severe persistent asthma: suppression, control, and reversal of inflammation. *Mechanisms* ■ Same as inhaled.	■ Short-term use: reversible, abnormalities in glucose metabolism, increased appetite, fluid retention, weight gain, mood alteration, hypertension, peptic ulcer, and rarely aseptic necrosis of femur. ■ Long-term use: adrenal axis suppression, growth suppression, dermal thinning, hypertension, diabetes, Cushing's syndrome, cataracts, muscle weakness, and—in rare instances—impaired immune function. ■ Consideration should be given to coexisting conditions that could be worsened by systemic corticosteroids, such as herpes virus infections, varicella, tuberculosis, hypertension, peptic ulcer, and *Strongyloides*.	Use at lowest effective dose. For long-term use, alternate-day a.m. dosing produces least toxicity. If daily doses are required, one study shows improved efficacy with no increase in adrenal suppression when administered at 3 p.m. rather than in the morning (Beam et al. 1992).

FIGURE 3-1. LONG-TERM-CONTROL MEDICATIONS (CONTINUED)

Name/Products	Indications/Mechanisms	Potential Adverse Effects	Therapeutic Issues
Cromolyn Sodium and Nedocromil	*Indications* ■ Long-term prevention of symptoms; may modify inflammation. ■ Preventive treatment prior to exposure to exercise or known allergen. *Mechanisms* ■ Anti-inflammatory. Block early and late reaction to allergen. Interfere with chloride channel function. Stabilize mast cell membranes and inhibit activation and release of mediators from eosinophils and epithelial cells. ■ Inhibit acute response to exercise, cold dry air, and SO_2.	15 to 20 percent of patients complain of an unpleasant taste from nedocromil.	■ Therapeutic response to cromolyn and nedocromil often occurs within 2 weeks, but a 4- to 6-week trial may be needed to determine maximum benefit. ■ Dose of cromolyn MDI (1 mg/puff) may be inadequate to affect airway hyperresponsiveness. Nebulizer delivery (20 mg/ampule) may be preferred for some patients ■ Safety is the primary advantage of these agents.
Long-Acting Beta$_2$-Agonists *Inhaled:* Salmeterol	*Indications* ■ Long-term prevention of symptoms, especially nocturnal symptoms, added to anti-inflammatory therapy ■ Prevention of exercise-induced bronchospasm. ■ *Not to be used to treat acute symptoms or exacerbations.* *Mechanisms* ■ Bronchodilation. Smooth muscle relaxation following adenylate cyclase activation and increase in cyclic AMP producing functional antagonism of bronchoconstriction. ■ In vitro, inhibit mast cell mediator release, decrease vascular permeability, and increase mucociliary clearance. ■ Compared to short-acting inhaled beta$_2$-agonist, salmeterol (but not formoterol) has slower onset of action (15 to 30 minutes) but longer duration (>12 hours).	■ Tachycardia, skeletal muscle tremor, hypokalemia, prolongation of QT_C interval in overdose. ■ A diminished bronchoprotective effect may occur within 1 week of chronic therapy. Clinical significance has not been established. ■ See text for additional discussion.	■ Not to be used to treat acute symptoms or exacerbations. ■ Clinical significance of potentially developing tolerance is uncertain because studies show symptom control and bronchodilation are maintained. ■ Should not be used in place of anti-inflammatory therapy. ■ May provide more effective symptom control when added to standard doses of inhaled corticosteriod compared to increasing the corticosteriod dosage.
Oral: Albuterol, sustained-release			■ *Inhaled long-acting beta$_2$-agonists are preferred because they are longer acting and have fewer side effects than oral sustained-release agents.*

FIGURE 3-1. LONG-TERM-CONTROL MEDICATIONS (CONTINUED)

Name/Products	Indications/Mechanisms	Potential Adverse Effects	Therapeutic Issues
Methylxanthines Theophylline, sustained-release tablets and capsules	*Indications* ▪ Long-term control and prevention of symptoms, especially nocturnal symptoms. *Mechanisms* ▪ Bronchodilation. Smooth muscle relaxation from phosphodiesterase inhibition and possibly adenosine antagonism ▪ May affect eosinophilic infiltration into bronchial mucosa as well as decrease T-lymphocyte numbers in epithelium. ▪ Increases diaphragm contractility and mucociliary clearance.	▪ Dose-related acute toxicities include tachycardia, nausea and vomiting, tachyarrhythmias (SVT), central nervous system stimulation, headache, seizures, hematemesis, hyperglycemia, and hypokalemia. ▪ Adverse effects at usual therapeutic doses include insomnia, gastric upset, aggravation of ulcer or reflux, increase in hyperactivity in some children, difficulty in urination in elderly males with prostatism.	▪ Maintain steady-state serum concentrations between 5 and 15 mcg/mL. Routine serum concentration monitoring is essential due to significant toxicities, narrow therapeutic range, and individual differences in metabolic clearance. Absorption and metabolism may be affected by numerous factors (see figure 3-5a), which can produce significant changes in steady-state serum theophylline concentrations. ▪ Not generally recommended for exacerbations. There is minimal evidence for added benefit to optimal doses of inhaled $beta_2$-agonists. Serum concentration monitoring is mandatory.
Leukotriene Modifiers			
Zafirlukast tablets	*Indications* ▪ Long-term control and prevention of symptoms in mild persistent asthma for patients ≥12 years of age. *Mechanisms* ▪ Leukotriene receptor antagonist; selective competitive inhibitor of LTD4 and LTE4 receptors.	▪ No specific adverse effects to date. As with any new drug, there is possibility of rare hypersensitivity or idiosyncratic reactions that cannot usually be detected in initial premarketing trials. One reported case of reversible hepatitis and hyperbilirubinemia; high concentrations may develop in patients with liver impairment.	▪ Administration with meals decreases bioavailability; take at least 1 hour before or 2 hours after meals. ▪ Inhibits the metabolism of warfarin and increases prothrombin time; it is a competitive inhibitor of the CYP2C9 hepatic microsomal isozymes. (It has not affected elimination of terfenadine, theophylline, or ethinyl estradiol drugs metabolized by the CYP3A4 isozymes.)
Zileuton tablets	*Indications* ▪ Long-term control and prevention of symptoms in mild persistent asthma for patients ≥12 years of age. *Mechanisms* ▪ 5-lipoxygenase inhibitor.	▪ Elevation of liver enzymes has been reported. Limited case reports of reversible hepatitis and hyperbilirubinemia.	▪ Zileuton is microsomal CYP3A4 enzyme inhibitor that can inhibit the metabolism of terfenadine, warfarin, and theophylline. Doses of these drugs should be monitored accordingly. ▪ Monitor hepatic enzymes (ALT).

FIGURE 3-2. QUICK-RELIEF MEDICATIONS

Name/Products	Indications/Mechanisms	Potential Adverse Effects	Therapeutic Issues
Short-Acting Inhaled Beta$_2$-Agonists Albuterol Bitolterol Pirbuterol Terbutaline	*Indications* ■ Relief of acute symptoms; quick-relief medication. ■ Preventive treatment prior to exercise for exercise-induced bronchospasm. *Mechanisms* ■ Bronchodilation. Smooth muscle relaxation following adenylate cyclase activation and increase in cyclic AMP producing functional antagonism of bronchoconstriction.	Tachycardia, skeletal muscle tremor, hypokalemia, increased lactic acid, headache, hyperglycemia. Inhaled route, in general, causes few systemic adverse effects. Patients with preexisting cardiovascular disease, especially the elderly, may have adverse cardiovascular reactions with inhaled therapy.	■ Drugs of choice for acute bronchospasm. Inhaled route has faster onset, fewer adverse effects, and is more effective than systemic routes. The less beta$_2$-selective agents (isoproterenol, metaproterenol, isoetharine, and epinephrine) are not recommended due to their potential for excessive cardiac stimulation, especially in high doses. Albuterol liquid is not recommended. ■ For patients with mild intermittent asthma, regularly scheduled daily use neither harms nor benefits asthma control (Drazen et al. 1996). Regularly scheduled daily use is not generally recommended. ■ Increasing use or lack of expected effect indicates inadequate asthma control. >1 canister a month (e.g., albuterol-200 puffs per canister) may indicate overreliance on this drug; ≥2 canisters in 1 month poses additional adverse risks. ■ For patients frequently using beta$_2$-agonist, anti-inflammatory medication should be initiated or intensified.
Anticholinergics Ipratropium bromide	*Indications* ■ Relief of acute bronchospasm (see Therapeutic Issues column). *Mechanisms* ■ Bronchodilation. Competitive inhibition of muscarinic cholinergic receptors. ■ Reduces intrinsic vagal tone to the airways. May block reflex bronchoconstriction secondary to irritants or to reflux esophagitis. ■ May decrease mucus gland secretion.	Drying of mouth and respiratory secretions, increased wheezing in some individuals, blurred vision if sprayed in eyes.	■ Reverses only cholinergically mediated bronchospasm; does not modify reaction to antigen. Does not block exercise-induced bronchospasm. ■ May provide additive effects to beta$_2$-agonist but has slower onset of action. ■ Is an alternative for patients with intolerance to beta$_2$-agonists. ■ Treatment of choice for bronchospasm due to beta-blocker medication.

FIGURE 3-2. QUICK-RELIEF MEDICATIONS (CONTINUED)

Name/Products	Indications/Mechanisms	Potential Adverse Effects	Therapeutic Issues
Corticosteroids *Systemic:* Methylprednisolone Prednisolone Prednisone	*Indications* ■ For moderate-to-severe exacerbations to prevent progression of exacerbation, reverse inflammation, speed recovery, and reduce rate of relapse. *Mechanisms* ■ Anti-inflammatory. See figure 3-1.	■ Short-term use: reversible abnormalities in glucose metabolism, increased appetite, fluid retention, weight gain, mood alteration, hypertension, peptic ulcer, and rarely aseptic necrosis of femur. ■ Consideration should be given to coexisting conditions that could be worsened by systemic corticosteroids, such as herpes virus infections, varicella, tuberculosis, hypertension, peptic ulcer, and *Strongyloides*.	■ Short-term therapy should continue until patient achieves 80% PEF personal best or symptoms resolve. This usually requires 3 to 10 days but may require longer. ■ There is no evidence that tapering the dose following improvement prevents relapse.

Methylxanthines

Theophylline, the principally used methylxanthine, provides mild-to-moderate bronchodilation in asthma. Although its mechanism of action has yet to be established (Weinberger and Hendeles 1996; Hendeles et al. 1995), recent evidence suggests that low serum concentrations of theophylline are mildly anti-inflammatory (Sullivan et al. 1994; Kidney et al. 1995; Pauwels 1989). Sustained-release theophylline's main use is as adjuvant therapy, and it is particularly effective for controlling nocturnal asthma symptoms. Sustained-release theophylline may be considered as an alternative, but not preferred, long-term preventive therapy when issues arise concerning cost or adherence to regimens using inhaled medication. Monitoring serum concentration levels is essential to ensure that therapeutic, but not toxic, doses are achieved.

Leukotriene Modifiers

Leukotrienes are potent biochemical mediators released from mast cells, eosinophils, and basophils that contract airway smooth muscle, increase vascular permeability, increase mucus secretions, and attract and activate inflammatory cells in the airways of patients with asthma (Henderson 1994). Two leukotriene modifiers—zafirlukast and zileuton—have recently become available as oral tablets for the treatment of asthma.

From the information currently available, it appears that leukotriene modifiers improve lung function (Gaddy et al. 1992) and diminish symptoms and the need for short-acting inhaled beta$_2$-agonists. The majority of trials have been conducted in mild-to-moderate asthma, and the improvements noted have been modest. Leukotriene modifiers may be considered an alternative to low-dose inhaled corticosteroid therapy for patients with mild persistent asthma, although increased clinical experience and further study in a wide range of patients are needed to determine those patients most likely to benefit from leukotriene modifiers and to establish a more specific role for leukotriene modifiers in asthma therapy.

Zafirlukast, a leukotriene receptor antagonist, has been demonstrated to attenuate the late response to inhaled allergen and post-allergen induced bronchial responsiveness (Dahlen et al. 1994; Taylor et al. 1991). Studies comparing zafirlukast to placebo in patients with mild-to-moderate asthma demonstrated that patients treated with zafirlukast experienced modest improvement in FEV$_1$ (mean improvement of 11 percent above placebo), improved symptom scores, and reduced albuterol use (average decline of 1 puff/day) (Spector et al. 1994). In a small study of healthy

males, 60 mg a day of zafirlukast caused a significant increase in the half-life of warfarin. Consequently, for those individuals receiving zafirlukast and warfarin, it will be necessary to closely monitor prothrombin times and adjust doses of warfarin accordingly.

Zileuton, a 5-lipoxygenase inhibitor, has been demonstrated to provide immediate and sustained improvements in FEV_1 (mean increase of 15 percent above placebo) in placebo-controlled trials in patients with mild-to-moderate asthma (Israel et al. 1993, 1996). Compared to placebo, the patients with moderate asthma treated with zileuton experienced significantly fewer exacerbations requiring oral corticosteroids (Israel et al. 1996), thus suggesting anti-inflammatory action. Finally, zileuton is capable of attenuating bronchoconstriction from exercise (Meltzer et al. 1996) and from aspirin in aspirin-sensitive individuals (Israel et al. 1993). Because liver toxicity has been found in some subjects receiving zileuton, it is recommended that hepatic enzymes (ALT) be monitored in patients who take this medication. Zileuton is a microsomal CYP3A4 enzyme inhibitor that can inhibit the metabolism of terfenadine, warfarin, and theophylline. Doses of these drugs should be monitored accordingly.

Quick-Relief Medications

Quick-relief medications are used to provide prompt relief of bronchoconstriction and its accompanying acute symptoms such as cough, chest tightness, and wheezing. They include short-acting $beta_2$-agonists and anticholinergics. Although the onset of action is slow (>4 hours), systemic corticosteroids are important in the treatment of moderate-to-severe exacerbations because they prevent progression of the exacerbation, speed recovery, and prevent early relapses.

Short-Acting $Beta_2$-Agonists

Short-acting $beta_2$-agonists relax airway smooth muscle and cause a prompt (within 30 minutes) increase in airflow. Inhaled short-acting $beta_2$-agonists are the drug of choice for treating acute asthma symptoms and exacerbations and for preventing EIB. Concerns about the safety of short-acting $beta_2$-agonists are discussed in another section of this component (see page 67, Special Issues Regarding Safety).

Anticholinergics

Cholinergic innervation is an important factor in the regulation of airway smooth muscle tone. Ipratropium bromide is a quaternary derivative of atropine that does not have atropine's side effects. Ipratropium bromide may provide some additive benefit with inhaled $beta_2$-agonists in severe asthma exacerbations. Its effectiveness in long-term management of asthma has not been demonstrated (Kerstjens et al. 1992; Gross 1988; Storms et al. 1986).

Systemic Corticosteroids

Systemic corticosteroids can speed resolution of airflow obstruction and reduce the rate of relapse (Fanta et al. 1983; Rowe et al. 1992; Scarfone et al. 1993; Connett et al. 1994; Chapman et al. 1991).

Medications To Reduce Oral Systemic Corticosteroid Dependence

Troleandomycin, Cyclosporine, Methotrexate, Gold, Intravenous Immunoglobulin, Dapsone, and Hydroxychloroquine

These regimens to reduce oral systemic corticosteroid dependence should be used only in selected patients who are under the supervision of an asthma specialist. Although some of the compounds have corticosteroid-sparing effects, their use in asthma remains complicated because of highly variable effects, potential toxicity, and limited clinical experience (Bernstein et al. 1996; Jarjour et al. 1996; Mullarkey et al. 1988; Shiner et al. 1990; Erzurum et al. 1991; Muranaka et al. 1978; Klaustermeyer et al. 1987; Kamada et al. 1993; Nelson et al. 1993; Alexander et al. 1992; Mazer and Gelfand 1991). Colchicine is not considered effective in reducing need for oral systemic or high doses of inhaled corticosteroids (Newman et al. 1997).

Complementary Alternative Medicine

Alternative healing methods are not substitutes for recommended pharmacologic therapy. Although alternative healing methods may be popular with selected patients and of some interest to investigators, their scientific basis has not been established.

The most widely known complementary alternative medicine methods are acupuncture, homeopathy, herbal medicine, and Ayurvedic medicine (which includes transcendental meditation, herbs, and yoga).

A review of multiple trials on the use of acupuncture in asthma concluded that the trials lacked quality and that the effectiveness of acupuncture in treating asthma has not been established (Kleijnen et al. 1991). One trial, however, demonstrated benefit in EIB (Fung et al. 1986). Homeopathy, based on the "law of similars" and the use of infinitesimally small doses, is as yet unproven for asthma (Reilly et al. 1986); some homeopathic remedies may contain potent unidentified pharmacologic agents (Morice 1986). No controlled clinical trials have been reported on herbal medicines, and the claims of effectiveness of western plant derivatives for asthma remain unsubstantiated (Dorsch and Wagner 1991; Ziment and Stein 1993). Because complementary alternative medicine is reported to be used by as much as one-third of the U.S. population (Eisenberg et al. 1993), it may be important to inquire about all the medications a patient uses and advise the patient accordingly (see component 4).

ROUTE OF ADMINISTRATION

Medications for asthma can be administered either by inhaled or systemic routes. Systemic routes are oral (ingested) or parenteral (subcutaneous, intramuscular, or intravenous). The major advantages of delivering drugs directly into the lungs via inhalation are that higher concentrations can be delivered more effectively to the airways and that systemic side effects are avoided or minimized (Newhouse and Dolovich 1986). Furthermore, the onset of action of inhaled bronchodilators is substantially shorter than that of oral bronchodilators.

Inhaled medications, or aerosols, are available in a variety of devices that differ in technique required and quantity of drug delivered to the lung. See figure 3-3 for a summary of issues to consider for different devices. Whatever device is selected, patients should be instructed in its use and their technique checked regularly.

Most inhaled medications currently used for asthma are available as metered-dose inhalers (MDIs). Historically, MDI technology has utilized chlorofluorocarbons (CFCs) as propellants. CFCs usually constitute 95 percent or more of the formulation emitted from an MDI; CFCs are metabolically stable and even the portion of an actuation that is systemically absorbed is quickly excreted unchanged via exhalation. However, CFCs have been found to deplete stratospheric ozone and have been banned internationally. Although a temporary medical exemption has been granted, it is expected that CFC-propelled MDIs will eventually be phased out completely. Alternatives include MDIs with other propellants (nonchlorinated propellants such as hydrofluoroalkane [HFA] 134a do not have ozone-depleting properties), multidose dry powder inhalers, and other hand-held devices with convenience and delivery characteristics similar to current MDIs. An MDI for albuterol with HFA 134a has been approved for use; additional non-CFC products and delivery systems are expected in the future. The Food and Drug Administration approval process requires that the replacement products demonstrate comparability to the corresponding CFC products so that clinicians and patients can anticipate similar effectiveness and safety with the new products. During the phaseout of CFC products, clinicians will need to be informed of the alternatives and assist their patients in the transition to non-CFC products (see component 4).

SPECIAL ISSUES REGARDING SAFETY

Short-Acting Inhaled Beta$_2$-Agonists

KEY POINTS: SHORT-ACTING INHALED BETA$_2$-AGONISTS

- Short-acting beta$_2$-agonists are the most effective medication for relieving acute bronchospasm.
- Increasing use of short-acting beta$_2$-agonists or the use of more than one canister in 1 month indicates inadequate control of asthma and the need for initiating or intensifying anti-inflammatory therapy.
- Regularly scheduled, daily use of short-acting beta$_2$-agonists is generally not recommended.

Short-acting inhaled beta$_2$-agonists (e.g., albuterol) are the medications of choice for treating exacerbations of asthma and for preventing EIB. Prior to 1990, many clinicians prescribed short-acting beta$_2$-agonists on a regularly scheduled basis in the belief that this treatment regimen improved overall asthma symptom control. Some recent reports, however, have modified these beliefs. For example, in *moderate* asthma, regular use of a potent inhaled beta$_2$-agonist (fenoterol) produced a significant diminution in asthma control and objective measurements of pulmonary function (Sears et al. 1990). In *mild* asthma, regularly scheduled use of albuterol compared to use on an as-needed basis only resulted in no significant differences in a variety of

FIGURE 3-3. AEROSOL DELIVERY DEVICES

Device/Drugs	Population	Optimal Technique*	Therapeutic Issues
Metered-dose inhaler (MDI) Beta$_2$-agonists Corticosteroids Cromolyn sodium and nedocromil Anticholinergics	>5 years	Actuation during a slow (30 L/min or 3-5 seconds) deep inhalation, followed by 10-second breath-holding. Under laboratory conditions, open-mouth technique (holding MDI 2 inches away from open mouth) enhances delivery to the lung. However, it has not consistently been shown to enhance clinical benefit compared to closed-mouth technique (closing lips around MDI mouthpiece).	Slow inhalation may be difficult. Difficulty with coordination of actuation and inhalation, particularly in young children and elderly. Patients may incorrectly stop inhalation at actuation. Deposition of 80 percent of actuated dose in oropharynx. Mouth washing is effective in reducing systemic absorption (Selroos and Halme 1991).
Breath-actuated MDI Beta$_2$-agonists	>5 years	Slow (30 L/min or 3-5 seconds) inhalation followed by 10-second breath-holding.	Indicated for patients unable to coordinate inhalation and actuation. May be particularly useful in elderly (Newman et al. 1991). Slow inhalation may be difficult and patients may incorrectly stop inhalation at actuation. Requires more rapid inspiration to activate than is optimal for deposition. Cannot be used with currently available spacer/holding chamber devices.
Dry powder inhaler (DPI) Beta$_2$-agonists Corticosteroids		Rapid (60 L/min or 1-2 seconds), deep inhalation. Minimally effective inspiratory flow is device dependent.	Dose lost if patient exhales through device. Delivery may be ≥MDI depending on device and technique. Can be used in children 4 years old, but effects are more consistent with children >5 (Pedersen et al. 1990; Goren et al. 1994; Kemp et al. 1989; Kesten et al. 1994). Most appear to have similar delivery efficiency as MDI either with or without spacer/holding chamber, but some may have delivery >MDI (Thorsson et al. 1994; Agertoft and Pedersen 1993; Kemp et al. 1989; Melchor et al. 1993; Vidgren et al. 1983). Mouth washing is effective in reducing systemic absorption (Selroos and Halme 1991).

FIGURE 3-3. AEROSOL DELIVERY DEVICES (CONTINUED)

Device/Drugs	Population	Optimal Technique*	Therapeutic Issues
Spacer/holding chamber	>4 years ≤4 years with face mask	Slow (30 L/min or 3-5 seconds) inhalation or tidal breathing immediately following actuation. Actuation only once into spacer/holding chamber per inhalation (O'Callaghan et al. 1994). If face mask is used, allow 3-5 inhalations per actuation (Everard et al. 1992).	Easier to use than MDI alone. With a face mask, enables MDI to be used with small children (Everard et al. 1992; Connett et al. 1993). Simple tubes do not obviate coordinating actuation and inhalation. Bulky. Output may be reduced in some devices after cleaning. The larger volume spacers/holding chambers (>600 cc) may increase lung delivery over MDI alone in patients with poor MDI technique. The effect of a spacer/holding chamber on output from an MDI is dependent on both MDI and spacer type; thus data from one combination should not be extrapolated to all others (Ahrens et al. 1995; Kim et al. 1987). Spacers/holding chambers decrease oropharyngeal deposition and will reduce potential system absorption of inhaled corticosteroid preparations that have higher oral bioavailability (Newman et al. 1984; Brown et al. 1990; Lipworth 1995; Selroos and Halme 1991). Spacers/holding chambers are recommended for all patients on medium-to-high doses of inhaled corticosteroids. May be as effective as nebulizer in delivering high doses of $beta_2$-agonists during severe exacerbations.
Nebulizer $Beta_2$-agonists Cromolyn Anticholinergics Corticosteroids	≤2 years Patients of any age who cannot use MDI with spacer/holding chamber or spacer and face mask (e.g., during exacerbations)	Slow tidal breathing with occasional deep breaths. Tightly fitting face mask for those unable to use mouthpiece.	Less dependent on patient coordination or cooperation. Delivery method of choice for cromolyn in children and for high-dose $beta_2$-agonists and anticholinergics in moderate-to-severe exacerbations in all patients. Expensive; time consuming; bulky; output is device dependent; and there are significant internebulizer and intranebulizer output variances.

* See figure 4-3 for description of MDI and DPI techniques.

Sources: Agertoft and Pedersen 1993; Ahrens et al. 1995; Brown et al. 1990; Connett et al. 1993; Higgins et al. 1987; Crompton and Duncan 1989; Everard et al. 1992; Fuglsang and Pedersen 1986; Goren et al. 1994; Kemp et al. 1989; Kesten et al. 1994; Kim et al. 1987; Lipworth 1995; Melchor et al. 1993; Newman et al. 1981, 1984, 1991; O'Callaghan et al. 1994; Pedersen et al. 1990; Pedersen and Mortensen 1990; Prahl and Jenson 1987; Rossing et al. 1980; Ruggins et al. 1993; Schecker et al. 1993; Selroos and Halme 1991; Selroos et al. 1995; Thorsson et al. 1994; Vidgren et al. 1983.

outcome indices. Although regularly scheduled use of beta$_2$-agonists in mild asthma produced no harmful effects in a 4-month period, it also produced no demonstrable benefits (Drazen et al. 1996). Similar findings were noted in studies with moderate asthma (D'Alonzo et al. 1994; Pearlman et al. 1992). Based on these and other observations (Cockcroft et al. 1993; van Schayck et al. 1991; O'Connor et al. 1992; Mullen et al. 1993; Ernst et al. 1993; Suissa et al. 1994), the regularly scheduled, daily use of short-acting beta$_2$-agonists is not generally recommended.

The frequency of beta$_2$-agonist use can be clinically useful as a barometer of disease activity because increasing use of beta$_2$-agonists has been associated with increased risk for death or near death in patients with asthma (Spitzer et al. 1992). The use of more than one beta$_2$-agonist canister (e.g., albuterol, 200 puffs per canister) predominantly for quick-relief treatment during a 1-month period most likely indicates overreliance on this drug and suggests inadequate asthma control (Spitzer et al. 1992).

Long-Acting Inhaled Beta$_2$-Agonists

KEY POINTS: LONG-ACTING INHALED BETA$_2$-AGONISTS

- Long-acting beta$_2$-agonists (salmeterol) can be beneficial to patients when added to inhaled corticosteroid therapy, especially to control nighttime symptoms (Greening et al. 1994; Woolcock et al. 1996). Daily use of long-acting beta$_2$-agonists should generally not exceed 84 mcg (salmeterol; four puffs).
- *Salmeterol is not to be used for treatment of acute symptoms or exacerbations.*
- Patient education regarding correct use of salmeterol is critical.
- Patients should be instructed not to stop anti-inflammatory therapy while taking salmeterol even though their symptoms may significantly improve.

Long-acting beta$_2$-agonists have several beneficial clinical properties. They attenuate EIB for longer time periods than do short-acting beta$_2$-agonists (Green and Price 1992; Henriksen et al. 1992) and improve nocturnal asthma symptoms (Fitzpatrick et al. 1990; Maesen et al. 1990). Recent studies suggest that for patients with inadequate symptom control who are receiving low-to-medium doses of inhaled corticosteroids, it may be more beneficial to add salmeterol than to increase the dose of inhaled corticosteroids (Greening et al. 1994; Woolcock et al. 1996). Furthermore, in one study, salmeterol resulted in statistically significant increases in overall quality of life (Juniper et al. 1995) although the clinical significance of the reported differences is not certain.

Several studies report that patients do not appear to develop a tolerance to the bronchodilator action of salmeterol even after months of regular treatment (D'Alonzo et al. 1994; Lotvall et al. 1992; Pearlman et al. 1992; Ullman et al. 1990). In contrast, in bronchoprovocation studies following chronic administration of either short-acting or long-acting beta$_2$-agonists, a decrease was demonstrated in the bronchoprotective effect against exercise (Ramage et al. 1994), allergen (Cockcroft et al. 1993, 1995; Bhagat et al. 1996), and methacholine (Bhagat et al. 1996; Cheung et al. 1992). However, the bronchoprotective effect over time, although diminished, was still significantly greater than placebo. Thus, the clinical importance of the reported decrease in bronchoprotective effect remains uncertain (McFadden 1995).

Following the introduction of salmeterol into clinical practice, case reports of sudden severe attacks of asthma (Clark et al. 1993) raised concerns that in certain asthma patients, under certain conditions, the use of salmeterol may cause a sudden worsening of symptoms and possibly death. A recent randomized study in England compared more than 16,000 patients who received regular salmeterol for a 16-week period with more than 8,000 patients receiving regular (qid) albuterol therapy. The study found more deaths in the salmeterol group; however, the differences did not reach statistical significance (Castle et al. 1993). Nor did a prescription-event monitoring survey demonstrate a statistically significant difference in deaths (Mann et al. 1996). Several large studies have demonstrated that, overall, patients taking salmeterol do not experience an increase in the frequency of exacerbations (Britton et al. 1992; Lundback et al. 1993; Greening et al. 1994; Pearlman et al. 1992; Woolcock et al. 1996). There are ongoing longitudinal studies to determine if there might be risk for special populations. The potential for patients to incorrectly use salmeterol as a quick-relief medication warrants special attention by the clinician and appropriate patient education. Based on current information, long-acting inhaled beta$_2$-agonists should be used only in conjunction with anti-inflammatory medication. When added to inhaled corticosteroids, long-acting inhaled beta$_2$-agonists are helpful long-term-control therapy.

Inhaled Corticosteroids

KEY POINTS: INHALED CORTICOSTEROIDS

- Inhaled corticosteroids are the most effective long-term therapy available for mild, moderate, or severe persistent asthma; in general, inhaled corticosteroids are well tolerated and safe at the recommended dosages.
- The potential but small risk of adverse events from the use of inhaled corticosteroids is well balanced by their efficacy.
- To reduce the potential for adverse effects, the following measures are recommended:
  - Administer inhaled corticosteroids with spacers/holding chambers.
  - Advise patients to rinse their mouths (rinse and spit) following inhalation.
  - Use the lowest possible dose of inhaled corticosteroid to maintain control.
  - To maintain control of asthma (especially for nocturnal symptoms), consider adding a long-acting inhaled $beta_2$-agonist to a low-to-medium dose of inhaled corticosteroid rather than using a higher dose of inhaled corticosteroid.
  - For children, monitor growth (see box on page 72).
  - For postmenopausal women, consider supplements of calcium (1,000 to 1,500 mg per day) and vitamin D (400 units a day). Estrogen replacement therapy, where appropriate, may be considered for patients on doses that exceed 1,000 mcg of inhaled corticosteroid a day.

Inhaled corticosteroids are the most effective long-term therapy available for patients with persistent asthma. In general, inhaled corticosteroids are well tolerated and safe at the recommended dosages (Barnes 1995; van Essen-Zandvliet et al. 1992; Tinkelman et al. 1993). Systemic effects have been identified, particularly at high doses (see figure 3-5b for a definition of high-, medium-, and low-dose inhaled corticosteroids), but their clinical significance remains unclear. Furthermore, there may be interindividual variations in dose-response effects, and thus some patients may experience effects at lower doses. (See Key Points above for a summary of recommendations to minimize the potential for adverse effects.) In general, the potential for adverse effects must be weighed against the risk of uncontrolled asthma; to date evidence supports the use of inhaled corticosteroids, especially at low and medium doses.

Local Adverse Effects

Oral candidiasis (thrush) is one of the most common adverse effects of inhaled corticosteroids. Positive throat cultures of *Candida* can be identified in about 45 to 58 percent of patients, whereas clinical thrush is diagnosed in only 0 to 34 percent of patients (Rinehart et al. 1975; Toogood et al. 1980; Shaw and Edmunds 1986). With lower dosages of inhaled corticosteroids, candidiasis is uncommon (5 percent) (Rinehart et al. 1975), although it is more frequent in adults than in children. Prevention and treatment: Use a spacer/holding chamber to reduce the incidence of colonization and clinical thrush, rinse mouth with water after inhalation (Selroos and Halme 1991), and administer inhaled corticosteroids less frequently (bid vs. qid). Topical or oral antifungal agents should be used to treat active infections.

Dysphonia is reported in 5 to 50 percent of patients using inhaled corticosteroids and is associated with vocal stress and increasing dosages of inhaled corticosteroids (Toogood et al. 1980). Prevention and treatment: Use a spacer/holding chamber, temporarily reduce dosage, or rest for vocal stress.

Reflex cough and bronchospasm can be reduced by slower rates of inspiration and/or use of a spacer/holding chamber or pretreatment with an inhaled $beta_2$-agonist. There is no convincing evidence that the routine use of an inhaled $beta_2$-agonist prior to each dose of inhaled corticosteroids increases intrapulmonary delivery of the inhaled corticosteroid or reduces dosage requirement.

Systemic Adverse Effects

Linear Growth. The potential effects of inhaled corticosteroids on children's growth are important because the drugs are more likely to be used for longer periods of time, although it is recognized that poorly controlled asthma itself may result in retarded linear growth. Growth in children with asthma who have not received any form of corticosteroid therapy may be influenced by concomitant atopy, asthma severity, and being male, among other factors (Kamada and Szefler 1995; Allen 1996). Indeed, childhood asthma appears to be associated with

KEY POINTS: INHALED CORTICOSTEROIDS AND LINEAR GROWTH IN CHILDREN

- The potential risks of inhaled corticosteroids are well balanced by their benefits.
- Growth rates are highly variable in children. Short-term evaluations may not be predictive of attaining final adult height.
- Poorly controlled asthma may delay growth in children.
- In general, children with asthma tend to have longer periods of reduced growth rates prior to puberty (males > females).
- The potential for adverse effects on linear growth from inhaled corticosteroids appears to be dose dependent. In treating children with *mild-to-moderate persistent asthma*, medium-dose inhaled corticosteroid therapy may be associated with a possible, but not predictable, adverse effect on linear growth. The clinical significance of this potential systemic effect has yet to be determined. High doses of inhaled corticosteroids have greater potential for growth suppression.
- Use of high doses of inhaled corticosteroids with children with *severe persistent asthma* has significantly less potential for having an adverse effect on linear growth than oral systemic corticosteroids.
- A majority of studies of the use of inhaled corticosteroids by children have not demonstrated an effect on growth, but a few have identified growth delay. Some caution (e.g., monitoring growth, stepping down therapy when possible) is suggested while this issue is studied further.

delayed maturation and a longer period of reduced growth prior to puberty. Although this could be viewed as growth suppression, these delays do not appear to compromise the attainment of final predicted adult heights (Balfour-Lynn 1986; Allen 1996).

Because of these numerous confounding factors, evaluating the effects of systemic or inhaled corticosteroids on growth in children with asthma has been challenging and has led to contradictory findings.

A few studies of children with asthma have identified some growth delay in those treated with inhaled corticosteroids, suggesting that some caution may be prudent until this important issue can be studied further. A 1-year controlled trial comparing children with mild-to-moderate asthma receiving either inhaled beclomethasone (400 mcg per day, administered without a spacer/holding chamber) or oral theophylline demonstrated slower growth in children receiving beclomethasone (Tinkelman et al. 1993). In a placebo-controlled, community-based 7-month study of 7- to 9-year-old children to determine the effect on growth during treatment with beclomethasone at 400 mcg/day, growth was significantly decreased in both males and females, and there was no evidence of catchup growth during a 5-month washout period (Doull et al. 1995). However, the results of this short-term study may not reflect effects on long-term growth.

A recent meta-analysis of the influence of inhaled beclomethasone in the attainment of expected adult height did not find any significant adverse effects regardless of dose, duration of asthma, or disease severity (Allen et al. 1994). An uncontrolled followup study (mean duration of 2.7 years, range of 1 to 5 years) of prepubertal children with moderate asthma found no effect of inhaled budesonide (800 mcg mean daily dose) on long-term growth (Ninan and Russell 1992). A majority of studies do not demonstrate a negative effect on growth with dosages of 400 to 800 mcg a day (Wolthers 1996; Kamada et al. 1996; Kamada and Szefler 1995; Barnes and Pederson 1993).

Bone Metabolism/Osteoporosis. The few published observations regarding the effect of inhaled corticosteroids on bone metabolism and osteoporosis are complicated by oral corticosteroid use and small patient populations (Jennings et al. 1991a, 1991b; Toogood et al. 1991). The effects of inhaled corticosteroid on markers of skeletal metabolism—serum osteocalcin, serum alkaline phosphatase, and urinary hydroxyproline:creatinine ratio—are equivocal (Hodsman et al. 1991; Jennings et al. 1991a; Ali et al. 1991). The clinical implications in terms of risk of osteoporosis and fracture after long-term use of inhaled corticosteroids are still unknown (Jennings et al. 1991b; Pouw et al. 1991). Although low and medium dosages of inhaled corticosteroids appear to have no major adverse effects on any clinically important measure of bone metabolism (Toogood et al. 1991, 1995), a dose-dependent, yet significant, reduction in bone mineral content of subjects with asthma has been associated with inhaled corticosteroid use (Packe et al. 1992; Puolijoki et al. 1992; Toogood

et al. 1988). Elderly female patients may be more at risk due to preexisting osteoporosis, previous use of oral corticosteroids, a sedentary lifestyle, and the normal changes of estrogen in aging that affect calcium utilization. However, the risk of uncontrolled asthma, which may unnecessarily limit the patient's mobility and activities, must be weighed against the limited risks of using inhaled corticosteroids. Prevention and treatment: Concurrent treatment with calcium supplements and vitamin D (and estrogen replacement where appropriate) is reasonable.

Disseminated Varicella. Although high doses of inhaled corticosteroids theoretically present risks similar to those of systemic corticosteroids, the reports of disseminated varicella in patients receiving only inhaled corticosteroids are rare, causality is not clear, and there is no evidence that recommended doses of inhaled corticosteroids are immunosuppressive. Cases have been reported of children with severe persistent asthma on immunosuppressive doses of systemic corticosteroids developing fatal disseminated disease from varicella infection (Kasper and Howe 1990; Silk et al. 1988). Other case reports indicate complications for patients with *Strongyloides* or tuberculosis who take high doses of systemic corticosteroids. Prevention and treatment: Children who require episodic therapy with systemic corticosteroids who have not had clinical varicella should receive the varicella vaccine. The vaccine should not be administered to patients who are receiving immunosuppressive doses of systemic corticosteroids (2 mg/kg or more of prednisone equivalent or 20 mg/day of prednisone for more than 1 month), unless this dosage is discontinued for at least 1 month. Children who have completed a short prednisone course may receive varicella vaccine without delay (American Academy of Pediatrics 1995; CDC 1994). Children and adults on treatment with immunosuppressive doses of corticosteroids who have not been immunized against varicella and are exposed to varicella infection are candidates for zoster immunoglobulin and therapy with oral acyclovir. Should they develop clinical varicella, intravenous acyclovir with or without zoster immunoglobulin should be given.

Dermal thinning and increased ease of skin bruising have been observed in elderly subjects treated with inhaled corticosteroids. The effect is dose dependent, but the threshold dose is variable (Capewell et al. 1990).

Hypothalamic Pituitary Axis (HPA) Function. The issue of inhaled corticosteroid effects on HPA function is complex and requires further study. Several studies indicate that low-to-medium doses of inhaled corticosteroids do not appear to have significant effects on HPA function (Doull et al. 1995; Goldstein and Konig 1983). However, some studies showed that, compared with placebo, both beclomethasone and budesonide reduced the 24-hour urinary cortisol excretion even in doses as low as 400 to 500 mcg daily (Tabachnik and Zadik 1991; Prahl 1991). At higher doses, there appears to be a dose-dependent effect on different measures of HPA function (Kamada et al. 1996; Brown et al. 1993). Fluticasone caused greater adrenal suppression at doses of 400 to 2,000 mcg than budesonide in equivalent doses (Clark et al. 1996; Boorsma et al. 1996). The clinical significance, if any, of these findings is not known.

Cataracts. Although cataracts are a documented adverse effect of systemic corticosteroids, there appears to be no association between inhaled corticosteroids and posterior subcapsular cataracts in adults (Toogood et al. 1993) or children (Simons et al. 1993; Rooklin et al. 1979).

Glucose Metabolism. In a study of children, inhaled corticosteroids at dosages from 400 to 1,000 mcg/day (budesonide) failed to affect fasting glucose or glycated hemoglobin (Turpeinen et al. 1991). At 1,000 mcg/day, a significantly greater rise in fasting serum insulin levels and glucose during a glucose tolerance test was noted, but results remained within normal limits.

REFERENCES

Agertoft L, Pedersen S. Importance of the inhalation device on the effect of budesonide. *Arch Dis Child* 1993;69:130-3.

Ahrens R, Lux C, Bahl T, Han SH. Choosing the metered-dose inhaler spacer or holding chamber that matches the patient's need: evidence that the specific drug being delivered is an important consideration. *J Allergy Clin Immunol* 1995;96:288-94.

Alexander AG, Barnes NC, Kay AB. Trial of cyclosporin in corticosteroid-dependent chronic severe asthma. *Lancet* 1992;339:324-8.

Ali NJ, Capewell J, Ward MJ. Bone turnover during high dose inhaled corticosteroid treatment. *Thorax* 1991;46:160-4.

Allen DB. Growth suppression by glucocorticoid therapy. In: Vassallo J, ed. *Endocrinology and Metabolism Clinics in North America*. Philadelphia: W.B. Saunders Co. 1996;699-717.

Allen DB, Mullen M, Mullen B. A meta-analysis of the effect of oral and inhaled corticosteroids on growth. *J Allergy Clin Immunol* 1994;93:967-76.

Alton E, Norris AA. Chloride transport and the actions of nedocromil sodium and cromolyn sodium in asthma. *J Allergy Clin Immunol* 1996;98:S102-6.

American Academy of Pediatrics Committee on Infectious Diseases. Recommendations for the use of live attenuated varicella vaccine. *Pediatrics* 1995;5:791-6.

Balfour-Lynn L. Growth and childhood asthma. *Arch Dis Child* 1986;61(11):1049-55.

Barnes NC, Marone G, Di Maria GU, Visser S, Utama I, Payne SL. A comparison of fluticasone propionate, 1 mg daily, with beclomethasone dipropionate, 2 mg daily, in the treatment of severe asthma. *Eur Respir J* 1993;6:877-85.

Barnes PJ, Pedersen S. Efficacy and safety of inhaled corticosteroids in asthma. *Am Rev Respir Dis* 1993;148:S1-S26.

Beam WR, Weiner DE, Martin RJ. Timing of prednisone and alterations of airways inflammation in nocturnal asthma. *Am Rev Respir Dis* 1992;146(6):1524-30.

Becker AB, Simons FE. Formoterol, a new long-acting selective beta$_2$-adrenergic receptor agonist: double-blind comparison with salbutamol and placebo in children with asthma. *J Allergy Clin Immunol* 1989;84:891-5.

Bernstein IL, Bernstein DI, Dubb JW, Faiferman I, Wallin B, and participants of the Auranofin Multicenter Drug Trial. A placebo-controlled multicenter study of auranofin in the treatment of patients with corticosteroid-dependent asthma. *J Allergy Clin Immunol* 1996;98:317-24.

Bhagat R, Swystun VA, Cockcroft DW. Salbutamol-induced increased airway responsiveness to allergen and reduced protection versus methacholine: dose response. *J Allergy Clin Immunol* 1996;97:47-52.

Boorsma M, Andersson N, Larsson P, Ullman A. Assessment of the relative systemic potency of inhaled fluticasone and budesonide. *Eur Respir J* 1996;9:1427-32.

Booth H, Richmond I, Ward C, Gardiner PV, Harkawat R, Walters EH. Effect of high dose inhaled fluticasone propionate on airway inflammation in asthma. *Am J Respir Crit Care Med* 1995;152:45-52.

Britton MG, Earnshaw JS, Palmer JBD. A twelve month comparison of salmeterol with salbutamol in asthmatic patients. *Eur Respir J* 1992;5:1062-7.

Brown PH, Matusiewicz SP, Shearing C, Tibi L, Greening AP, Crompton GK. Systemic effects of high dose inhaled steroids: comparison of beclomethasone dipropionate and budesonide in healthy subjects. *Thorax* 1993;48:967-73.

Brown PH, Blundell G, Greening AP, Crompton GK. Do large volume spacer devices reduce the systemic effects of high dose inhaled corticosteroids? *Thorax* 1990;45:736-9.

Busse WW. What role for inhaled steroids in chronic asthma? *Chest* 1993;104:1565-71.

Capewell S, Reynolds S, Shuttleworth D, Edwards C, Finlay AY. Purpura and dermal thinning associated with high dose inhaled corticosteroids. *BMJ* 1990;300:1548-51.

Castle W, Fuller R, Hall J, Palmer J. Serevent nationwide surveillance study: comparison of salmeterol with salbutamol in asthmatic patients who require regular bronchodilator treatment. *BMJ* 1993;306:1034- 7.

Centers for Disease Control and Prevention. General recommendations on immunization. *Morb Mortal Wkly Rep* 1994;Jan 28;43(RR-1):1-38.

Chapman KR, Verbeek PR, White JG, Rebuck AS. Effect of a short course of prednisone in the prevention of early relapse after the emergency room treatment of acute asthma. *N Engl J Med* 1991;324:788-94.

Cheung D, Timmers MC, Zwinderman AH, Bel EH, Dijkman JH, Sterk PJ. Long-term effects of a long-acting beta$_2$-adrenoceptor agonist, salmeterol, on airway hyperresponsiveness in patients with mild asthma. *N Engl J Med* 1992;327:1198-203.

Clark B. General pharmacology, pharmacokinetics, and toxicology of nedocromil sodium. *J Allergy Clin Immunol* 1993;92:200-2.

Clark CE, Ferguson AD, Siddorn JA. Respiratory arrests in young asthmatics on salmeterol. *Respir Med* 1993;87(3):227-8.

Clark DJ, Grove A, Cargill RI, Lipworth BJ. Comparative adrenal suppression with inhaled budesonide and fluticasone propionate in adult asthmatic patients. *Thorax* 1996;51:262-6.

Cockcroft DW, McParland CP, Britto SA, Swystun Va, Rutherford BC. Regular inhaled salbutamol and airway responsiveness to allergen. *Lancet* 1993;342:833-7.

Cockroft DW, O'Byrne PM, Swystun VA, Bhagat R. Regular use of inhaled albuterol and the allergen-induced late asthmatic response. *J Allergy Clin Immunol* 1995;96:44-9.

Connett GJ, Warde C, Wooler E, Lenney W. Use of budesonide in severe asthmatics aged 1-3 years. *Arch Dis Child* 1993;69:351-5.

Connett GJ, Warde C, Wooler E, Lenney W. Prednisolone and salbutamol in the hospital treatment of acute asthma. *Arch Dis Child* 1994;70:170-3.

Creticos P, Burk J, Smith L, Comp R, Norman P, Findlay S. The use of twice daily nedocromil sodium in the treatment of asthma. *J Allergy Clin Immunol* 1995;95:829-36.

Crompton G, Duncan J. Clinical assessment of a new breath-actuated inhaler. *Practitioner* 1989;233:268-9.

D'Alonzo GE, Nathan RA, Henochowicz S, Morris RJ, Ratner P, Rennard SI. Salmeterol xinafoate as maintenance therapy compared with albuterol in patients with asthma. *JAMA* 1994;271:1412-6.

Dahl R, Lundback E, Malo JL, et al. A dose-ranging study of fluticasone propionate in adult patients with moderate asthma. *Chest* 1993;104:1352-8.

Dahlen B, Zetterstrom O, Bjorck T, Dahlen SE. The leukotriene-antagonist IC:204, 219 inhibits the early airway reaction to cumulative bronchial challenge with allergen in atopic asthmatics. *Eur Respir J* 1994;7:324-31.

de Benedictis FM, Tuteri G, Pazzelli P, Bertotto A, Bruni L. Vaccaro R. Cromolyn versus nedocromil: duration of action in exercise-induced asthma in children. *J Allergy Clin Immunol* 1995;96:510-4.

Dixon CMS, Barnes PJ. Bradykinin-induced bronchoconstriction: inhibition by nedocromil sodium and sodium cromoglycate. *Br J Clin Pharmacol* 1989;27:831-6.

Djukanovic R, Wilson TW, Britten KM, et al. Effect of an inhaled corticosteroid on airway inflammation and symptoms of asthma. *Am Rev Respir Dis* 1992;145:669-74.

Dorsch W, Wagner H. New antiasthmatic drugs from traditional medicine? *Int Arch Allergy Anal Immunol* 1991;94:262-5.

Doull IJM, Freezer NJ, Holgate ST. Growth of pre-pubertal children with mild asthma treated with inhaled beclomethasone dipropionate. *Am J Respir Crit Care Med* 1995;151:1715-9.

Drazen JM, Israel E, Boushey HA, et al. Comparison of regularly scheduled with as-needed use of albuterol in mild asthma. *N Engl J Med* 1996;335:841-7.

Duddridge M, Ward C, Hendrick DJ, Walters EH. Changes in bronchoalveolar lavage inflammatory cells in asthmatic patients with high dose inhaled beclomethasone dipropionate. *Eur Respir J* 1993;6:487-97.

Eady RP. The pharmacology of nedocromil sodium. *Eur J Respir Dis* 1986;147(Suppl):112-9.

Eisenberg DM, Kessler REC, Foster C, Norlock FE, Calkins DR, Delbannco TL. Unconventional medicine in the United States. Prevalence, costs, and patterns of use. *N Engl J Med* 1993;328:246-52.

Ernst P, Habbick B, Suissa S, et al. Is the association between inhaled beta-agonist use and life-threatening asthma because of confounding by severity? *Am Rev Respir Dis* 1993;148:75-9.

Erzurum SC, Leff JA, Cochran JE, et al. Lack of benefit of methotrexate in severe, steroid-dependent asthma. *Ann Intern Med* 1991;114:353-60.

Everard ML, Clark AR, Milner AD. Drug delivery from holding chambers with attached facemask. *Arch Dis Child* 1992;67:580-5.

Fabbri L, Burge PS, Croonenborgh L, et al. on behalf of an International Study Group. Comparison of fluticasone propionate with beclomethasone dipropionate in moderate to severe asthma treated for one year. *Thorax* 1993;48:817-23.

Fanta CH, Rossing TH, McFadden ER Jr. Glucocorticoids in acute asthma. A critical controlled trial. *Am J Med* 1983;74:845-51.

Fitzpatrick MF, Mackay T, Driver H, Douglas NJ. Salmeterol in nocturnal asthma: a double blind, placebo controlled trial of a long acting inhaled beta$_2$-agonist. *BMJ* 1990;301:1365-8.

Fuglsang G, Pedersen S. Comparison of Nebuhaler and nebulizer treatment of acute severe asthma in children. *Eur J Respir Dis* 1986;69:109-13.

Fung KP, Chow OK, So SY. Attenuation of exercise-induced asthma by acupuncture. *Lancet* 1986;2:1419-22.

Gaddy JN, Margolskee DJ, Bush RK, Williams VC, Busse WW. Bronchodilation with a potent and selective leukotriene D4 (LTD4) receptor antagonist (MK-571) in patients with asthma. *Am Rev Respir Dis* 1992;146(2):358-63.

Goldstein DE, Konig P. Effect of inhaled beclomethasone dipropionate on hypothalamic-pituitary-adrenal axis function in children with asthma. *Pediatrics* 1983;72:60-4.

Gonzalez JP, Brogden RN. Nedocromil sodium. A preliminary review of its pharmacodynamic and pharmacokinetic properties, and therapeutic efficacy in the treatment of reversible obstructive airways disease. *Drugs* 1987;34:560-77.

Goren A, Noviski N, Avital A, et al. Assessment of the ability of young children to use a powder inhaler device (Turbuhaler). *Pediatr Pulmonol* 1994;18:77-80.

Green CP, Price JF. Prevention of exercise induced asthma by inhaled salmeterol xinafoate. *Arch Dis Child* 1992;67:1014-7.

Greening AP, Wind P, Northfield M, Shaw G. Added salmeterol versus higher-dose corticosteroid in asthma patients with symptoms on existing inhaled corticosteroid. *Lancet* 1994;344:219-24.

Gross NJ. Ipratropium bromide. *N Engl J Med* 1988;319:486-94.

Gustafsson P, Tsanakas J, Gold M, Primhak R, Radford M, Gillies E. Comparison of the efficacy and safety of inhaled fluticasone 200 mcg/day with inhaled beclomethasone dipropionate 400 mcg/day in mild and moderate asthma. *Arch Dis Child* 1993;69:206-11.

Haahtela T, Jarvinen M, Kava T, et al. Comparison of a beta$_2$-agonist, terbutaline, with an inhaled corticosteroid, budesonide, in newly detected asthma. *N Engl J Med* 1991;325:388-92.

Hendeles L, Harman E, Huang D, O'Brien R, Blake K, Delafuente J. Theophylline attenuation of airway responses to allergen: comparison with cromolyn metered-dose inhaler. *J Allergy Clin Immunol* 1995;95:505-14.

Henderson WR Jr. The role of leukotrienes in inflammation. *Ann Intern Med* 1994;121:684-97.

Henriksen JM, Agertoft L, Pedersen S. Protective effect and duration of action of inhaled formoterol and salbutamol on exercise-induced asthma in children. *J Allergy Clin Immunol* 1992;89:1176-82.

Higgins RM, Cookson W, Lane DJ, John SM, McCarthy GL, McCarthy ST. Cardiac arrythmias caused by nebulized beta-agonist therapy. *Lancet* 1987;2:863-4.

Hodsman AB, Toogood JH, Jennings B, Fraher LJ, Baskerville JC. Differential effects of inhaled budesonide and oral prednisolone on serum osteocalcin. *J Clin Endocrinol Metab* 1991;72:530-40.

Israel E, Fischer AR, Rosenberg MA, et al. The pivotal role of 5-lipoxygenase products in the reaction of aspirin-sensitive asthmatics to aspirin. *Am Rev Respir Dis* 1993;148:1447-51.

Israel E, Cohn J, Dubé L, Drazen JM. Effect of treatment with zileuton, a 5-lipoxygenase inhibitor, in patients with asthma. *JAMA* 1996;275:931-6.

Jarjour N, Gelfand E, McGill K, Busse WW. Alternative anti-inflammatory and immunomodulatory therapy. In: Szefler J, Leung DYM, eds. *Severe Asthma. Pathogenesis and Clinical Management.* New York: Marcel Dekker, 1996, pp. 333-69.

Jeffery PK, Godfrey RW, Adelroth E, Nelson F, Rogers A, Johansson SA. Effects of treatment on airway inflammation and thickening of basement membrane reticular collagen in asthma. *Am Rev Respir Dis* 1992;145:890-9.

Jennings BH, Andersson KE, Johansson SA. The assessment of the systemic effects of inhaled glucocorticosteroids. The effects of inhaled budesonide vs oral prednisolone on calcium metabolism. *Eur J Clin Pharmacol* 1991a;41:11-6.

Jennings BH, Andersson KE, Johansson SA. Assessment of systemic effects of inhaled glucocorticosteroids: comparison of the effects of inhaled budesonide and oral prednisolone on adrenal function and markers of bone turnover. *Eur J Clin Pharmacol* 1991b;40:77-82.

Jones AH, Langdon CG, Lee PS, et al. Pulmicort Turbuhaler once daily as initial prophylactic therapy for asthma. *Respir Med* 1994;88:293-9.

Juniper EF, Kline PA, Morris MM, Hargreave FE. Airway constriction by isocapnic hyperventilation of cold, dry air: comparison of magnitude and duration of protection by nedocromil sodium and sodium cromoglycate. *Clin Allergy* 1987;17:523-8.

Juniper EF, Johnston PR, Borkhoff CM, Guyatt GH, Boulet LP, Haukioja A. Quality of life in asthma clinical trials: comparison of salmeterol and salbutamol. *Am J Respir Crit Care Med* 1995;151:66-70.

Kamada AK, Hill MR, Ikle DN, Brenner AM, Szefler SJ. Efficacy and safety of low-dose troleandomycin therapy in children with severe, steroid-requiring asthma. *J Allergy Clin Immunol* 1993;91;873-82.

Kamada AK, Szefler SJ. Glucocorticoids and growth in asthmatic children. *Pediatr Allergy Immunol* 1995;6:145-54.

Kamada AK, Szefler SJ, Martin RJ, et al. and the Athma Clinical Research Network. Issues in the use of inhaled glucocorticoids. *Am J Respir Crit Care Med* 1996;153:1739-48.

Kasper WJ, Howe PM. Fatal varicella after a single course of corticosteroids. *Pediatr Infect Dis J* 1990;9:729-32.

Kemp JP, Furukawa CT, Bronsky EA, et al. Albuterol treatment for children with asthma: a comparison of inhaled powder and aerosol. *J Allergy Clin Immunol* 1989;83:697-702.

Kerrebijn KF, van Essen-Zandvliet EE, Neijens HJ. Effect of long-term treatment with inhaled corticosteroids and beta-agonists on the bronchial responsiveness in children with asthma. *J Allergy Clin Immunol* 1987;79(4):653-9.

Kerstjens HA, Brand PL, Hughes MD, et al. A comparison of bronchodilator therapy with or without inhaled corticosteroid therapy for obstructive airways disease. *N Engl J Med* 1992;327:1413-9.

Kesten S, Elias M, Cartier A, Chapman KR. Patient handling of a multidose dry powder inhalation device for albuterol. *Chest* 1994;105:1077-81.

Kidney J, Dominguez M, Taylor PM, Rose M, Chung KF, Barnes PJ. Immunomodulation by theophylline in asthma. *Am J Respir Crit Care Med* 1995;151:1907-14.

Kim CS, Eldridge MA, Sackner MA. Oropharyngeal deposition and delivery aspects of metered-dose inhaler aerosols. *Am Rev Respir Dis* 1987;135:157-64.

Klaustermeyer WB, Noritake DT, Kwong FK. Chrysotherpay in the treatment of corticosteroid-dependent asthma. *J Allergy Clin Immunol* 1987;79:720-5.

Kleijnen J, ter Riet G, Knipschild P. Acupuncture and asthma: a review of controlled trials. *Thorax* 1991;46:799-802.

Laitinen LA, Laitinen A, Haahtela T. A comparative study of the effects of an inhaled corticosteroid, budesonide, and a beta$_2$-agonist, terbutaline, on airway inflammation in newly diagnosed asthma: a randomized, double-blind, parallel-group controlled trial. *J Allergy Clin Immunol* 1992;90:32-42.

Laitinen LA, Laitinen A, Heino M, Haahtela T. Eosinophilic airway inflammation during exacerbation of asthma and its treatment with inhaled corticosteroid. *Am Rev Respir Dis* 1991;143(2):423-7.

Lal S, Dorow PD, Venho KK, Chatterjee SS. Nedocromil sodium is more effective than cromolyn sodium for the treatment of chronic reversible obstructive airway disease. *Chest* 1993;104:438-47.

Levy J, Zalkinder I, Kuperman O, et al. Effect of prolonged use of inhaled steroids on the cellular immunity of children with asthma. *J Allergy Clin Immunol* 1995;95:806-12.

Lipworth BJ. New perspectives on inhaled drug delivery and systemic bioactivity. *Thorax* 1995;50:105- 10.

Lotvall J, Lunde H, Ullman A, Tornqvist H, Svedmyr N. Twelve months treatment with inhaled salmeterol in asthmatic patients. Effects on beta$_2$-receptor function and inflammatory cells. *Allergy* 1992;47:477-83.

Lundback B, Rawlinson DW, Palmer JB. Twelve month comparison of salmeterol and salbutamol as dry powder formulations in asthmatic patients. European Study Group. *Thorax* 1993;48(2):148-53.

Maesen FP, Smeets JJ, Gubbelmans HL, Zweers PG. Formoterol in the treatment of nocturnal asthma. *Chest* 1990;98:866-70.

Mann RD, Kubota K, Pearce G Wilton L. Salmeterol: a study by prescription-event monitoring in a UK cohort of 15,407 patients. *J Clin Epidemiol* 1996;49(2):247-50.

Mazer BD, Gelfand EW. An open-label study of high-dose intravenous immunoglobin in severe childhood asthma. *J Allergy Clin Immunol* 1991;87:976-83.

McFadden ER Jr. Perspectives in beta$_2$-agonist therapy: vox clamantis in deserto vel lux in tenebris? *J Allergy Clin Immunol* 1995;95:641-51.

McGill KA, Joseph B, Busse WW. Corticosteroids in the treatment of asthma. Practical recommendations. *Clin Immunother* 1995;4:16-48.

Melchor R, Biddiscombe MF, Mak VHF, Short MD, Spiro SG. Lung deposition patterns of directly labelled salbutamol in normal subjects and in patients with reversible airflow obstruction. *Thorax* 1993;48:506-11.

Meltzer SS, Hasday JD, Cohn J, Bleecker ER. Inhibition of exercise-induced bronchospasm by zileuton: a 5-lipoxygenase inhibitor. *Am J Respir Crit Care Med* 1996;153:931-5.

Morice A. Adulterated "homeopathic" care for asthma. *Lancet* 1986;1:862-3.

Mullarkey ME, Blumenstein BA, Andrade WP, Bailey GA, Olason I, Wetzel CE. Methotrexate in the treatment of corticosteroid-dependent asthma. *N Engl J Med* 1988;318:603-7.

Mullen ML, Mullen B, Carey M. The association between beta$_2$-agonist use and death from asthma. *JAMA* 1993;270:1842-5.

Muranaka M, Miyamoto T, Shida T, et al. Gold salt in the treatment of bronchial asthma—a double-blind study. *Ann Allergy* 1978;40:132-7.

Nelson HS, Hamilos DL, Corsello PR, Levesque NV, Buchmeier AD, Bucher BL. A double-blind study of troleandomycin and methylprednisolone in asthmatic subjects who require daily corticosteroids. *Am Rev Respir Dis* 1993;147:398-404.

Newhouse MT, Dolovich MB. Control of asthma by aerosols. *N Engl J Med* 1986;315:870-4.

Newman KB, Mason UG, Buchmeier A, Schmaling KB, Corsello P, Nelson HS. Failure of colchicine to reduce inhaled triamcinolone in patients with asthama. *J Allergy Clin Immunol* 1997;99:176-8.

Newman SP, Millar AB, Lennard-Jones TR, Moren F, Clarke SW. Improvement of pressurized aerosol deposition with Nebuhaler spacer device. *Thorax* 1984;39:935-41.

Newman SP, Moren F, Pavla D, Little F, Clarke SW. Deposition of pressurized suspension aerosols inhaled through extension devices. *Am Rev Respir Dis* 1981;124:317-20.

Newman SP, Weisz AWB, Talaee N, Clarke SW. Improvement of drug delivery with a breath actuated pressurised aerosol for patients with poor inhaler technique. *Thorax* 1991;46:712-6.

Ninan TK, Russell G. Asthma, inhaled corticosteroid treatment, and growth. *Arch Dis Child* 1992;67(6):703-5.

Noonan M, Chervinsky P, Busse WW, et al. Fluticasone propionate reduces oral prednisone use while it improves asthma control and quality of life. *Am J Respir Crit Care Med* 1995;152:1467-73.

Novembre G, Frongia GF, Veneruso G, Vierucci A. Inhibition of exercise-induced asthma (EIA) by nedocromil sodium and sodium cromoglycate in children. *Pediatr Allergy Immunol* 1994;5:107-10.

O'Callaghan C, Cant M, Robertson C. Delivery of beclomethasone dipropionate from a spacer device: what dose is available for inhalation? *Thorax* 1994;49:961-4.

O'Connor BJ, Aikman SL, Barnes PJ. Tolerance to the non-bronchodilator effects of inhaled beta$_2$-agonists in asthma. *N Engl J Med* 1992;327:1204-8.

O'Hickey SP, Rees PJ. High-dose nedocromil sodium as an addition to inhaled corticosteroids in the treatment of asthma. *Respir Med* 1994;88:499-502.

Packe GE, Douglas JG, McDonald AF, Robins SP, Reid DM. Bone density in asthmatic patients taking high dose inhaled beclomethasone dipropionate and intermittent systemic corticosteroids. *Thorax* 1992;47(6):414-7.

Pauwels RA. New aspects of the therapeutic potential of theophylline in asthma. *J Allergy Clin Immunol* 1989;83:548-53.

Pearlman DS, Chervinsky P, LaForce C, et al. A comparison of salmeterol with albuterol in the treatment of mild-to-moderate asthma. *N Engl J Med* 1992;327:1420-5.

Pedersen S, Mortensen S. Use of different inhalation devices in children. *Lung* 1990;168(Suppl):653-7.

Pedersen S, Hansen OR, Fuglsang G. Influence of inspiratory flow rate upon the effect of a Turbuhaler. *Arch Dis Child* 1990;65:308-10.

Pedersen S, Hansen OR. Budesonide treatment of moderate and severe asthma in children: a dose-response study. *J Allergy Clin Immunol* 1995;95:29-33.

Pincus DJ, Szefler SJ, Ackerson LM, Martin RJ. Chronotherpay of asthma with inhaled steroids: the effect of dosage timing on drug efficacy. *J Allergy Clin Immunol* 1995;95:1172-8.

Pouw EM, Prummel MF, Oosting H, Roos CM, Endert E. Beclomethasone inhalation decreases serum osteocalcin concentrations. *BMJ* 1991;302:627-8.

Prahl P. Adrenocortical suppression following treatment with beclomethasone dipropionate and budesonide. *Clin Exp Allergy* 1991;21:145-6.

Prahl P, Jenson T. Decreased adrenocortical suppression utilizing the nebuhaler for inhalation of steroid aerosols. *Clin Allergy* 1987;17:393-8.

Puolijoki H, Liippo K, Herrala J, Salmi J, Tala E. Inhaled beclomethasone decreases serum osteocalcin in postmenopausal asthmatic women. *Bone* 1992;13(4):285-8.

Rafferty P, Tucker LG, Frame MH, Fergusson RJ, Biggs BA, Crompton GK. Comparison of budesonide and beclomethasone dipropionate in patients with severe chronic asthma: assessment of relative prednisolone-sparing effects. *Br J Dis Chest* 1985;79:244-50.

Ramage L, Lipworth BJ, Ingram CG, Cree IA, Dhillon DP. Reduced protection against exercise induced bronchoconstriction after chronic dosing with salmeterol. *Respir Med* 1994;88(5):363-8.

Reilly DT, McSharry C, Taylor MA, Aitchison T. Is homeopathy a placebo response? Controlled trial of homeopathic potency, with pollen in hayfever as model. *Lancet* 1986;2:881-6.

Rinehart JJ, Sagone AL, Balcerzak SP, Ackerman GA, LoBuglio AF. Effects of corticosteroid therapy on human monocyte function. *N Engl J Med* 1975;292:236-41.

Rooklin AR, Lampert SI, Jaeger EA, McGeady SJ, Mansmann HC Jr. Posterior subcapsular cataracts in steroid-requiring asthmatic children. *J Allergy Clin Immunol* 1979;63(6):383-6.

Rossing TH, Fanta CH, Goldstein DH, Snapper JR, McFadden ER Jr. Emergency therapy of asthma: comparison of the acute effects of parenteral and inhaled sympathomimetics and infused aminophylline. *Am Rev Respir Dis* 1980;122:365-71.

Rowe BH, Keller JL, Oxman AD. Effectiveness of steroid therapy in acute exacerbations of asthma: a meta-analysis. *Am J Emerg Med* 1992;10:301-10.

Ruggins NR, Milner AD, Swarbrick A. An assessment of a new breath actuated inhaler device in acutely wheezy children. *Arch Dis Child* 1993;68:477-80.

Scarfone RJ, Fuchs SM, Nager AL, Shane SA. Controlled trial of oral prednisone in the emergency department treatment of children with acute asthma. *Pediatrics* 1993;2:513-8.

Schecker MH, Wilson AF, Mukai DS, Hahn M, Crook D, Novey HS. A device for overcoming discoordination with metered-dose inhalers. *J Allergy Clin Immunol* 1993;92:783-9.

Schwartz HJ, Blumenthal M, Brady R, et al. A comparative study of the clinical efficacy of nedocromil sodium and placebo. *Chest* 1996;109:945-52.

Sears MR, Taylor DR, Print CG, et al. Regular inhaled beta-agonist treatment in bronchial asthma. *Lancet* 1990;336:1391-6.

Selroos O, Pietinalho A, Lofroos A, Riska H. Effect of early vs. late intervention with inhaled corticosteroids in asthma. *Chest* 1995;108:1228-34.

Selroos O, Halme M. Effect of a volumatic spacer and mouth rinsing on systemic absorption of inhaled corticosteroids from a metered dose inhaler and dry powder inhaler. *Thorax* 1991;46:891-4.

Shaw NJ, Edmunds AT. Inhaled beclomethasone and oral candidiasis. *Arch Dis Child* 1986;61:788-90.

Shiner RJ, Nunn AJ, Chung KF, Gedder DM. Randomised, double-blind, placebo-controlled trial of methotrexate in steroid-dependent asthma. *Lancet* 1990;336:137-40.

Silk HJ, Guay-Woodford L, Perez-Atayde AR, Geha RS, Broff MD. Fatal *varicella* in steroid-dependent asthma. *J Allergy Clin Immunol* 1988;81:47-51.

Simons FE, Persaud MP, Gillespie CA, Cheang M, Shuckett EP. Absence of posterior subcapsular cataracts in young patients treated with inhaled glucocorticoids. *Lancet* 1993;342:776-8.

Spector SL, Smith LJ, Glass M. Effects of 6 weeks of therapy with oral doses of ICI 204,219, a leukotriene D4 receptor antagonist, in subjects with bronchial asthma. *Am J Respir Crit Care Med* 1994;150:618-23.

Spitzer WO, Suissa S, Ernst P, et al. The use of beta-agonist and the risk of death and near death from asthma. *N Engl J Med* 1992;326:501-6.

Storms WW, Bodman SF, Nathan RA, et al. Use of ipratropium bromide in asthma. *Am J Med* 1986;81:61-6.

Suissa S, Ernst P, Boivin JP, et al. A cohort analysis of excess mortality in asthma and the use of inhaled beta-agonists. *Am J Respir Crit Care Med* 1994;149:604-10.

Sullivan P, Bekir S, Jaffar Z, Page C, Jeffrey P, Costello J. Anti-inflammatory effects of low-dose oral theophylline in atopic asthma. *Lancet* 1994;343:1006-8.

Svendsen UG, Jorgensen H. Inhaled nedocromil sodium as additional treatment to high dose inhaled corticosteroids in the management of bronchial asthma. *Eur Respir J* 1991;4:992-9.

Tabachnik E, Zadik Z. Diurnal cortisol secretion during therapy with inhaled beclomethasone dipropionate in children with asthma. *J Pediatr* 1991;118:294-7.

Taylor IK, O'Shaughensessy KM, Fuller RW, Dollery CT. Effect of cysteinyl-leukotriene receptor antagonist ICI 204.219 on allergen-induced bronchoconstriction and airway hyperreactivity in atopic subjects. *Lancet* 1991;337:690-4.

Thompson NC. Nedocromil sodium: an overview. *Respir Med* 1989;83:269-76.

Thorsson L, Edsbacker S, Conradson TB. Lung deposition of budesonide from Turbuhaler is twice that from a pressurized metered-dose inhaler P-MDI. *Eur Respir J* 1994;7:1839-44.

Tinkelman DG, Reed CE, Nelson HS, Offord KP. Aerosol beclomethasone dipropionate compared with theophylline as primary treatment of chronic, mild to moderately severe asthma in children. *Pediatrics* 1993;92:64-77.

Toogood JH, Jennings B, Greenway RW, Chuang L. Candidiasis and dysphonia complicating beclomethasone treatment of asthma. *J Allergy Clin Immunol* 1980;65:145-53.

Toogood JH, Baskerville JC, Markov AE, et al. Bone mineral density and the risk of fracture in patients receiving long-term inhaled steroid therapy for asthma. *J Allergy Clin Immunol* 1995;96:157-66.

Toogood JH, Crilly RG, Jones G, Nadeau J, Wells GA. Effect of high-dose inhaled budesonide on calcium and phosphate metabolism and the risk of osteoporosis. *Am Rev Respir Dis* 1988;138(1):57-61.

Toogood JH, Jennings B, Hodsman AB, Baskerville J, Fraher LJ. Effects of dose and dosing schedule of inhaled budesonide on bone turnover. *J Allergy Clin Immunol* 1991;88:572-80.

Toogood JH, Markov AE, Baskerville J, Dyson C. Association of ocular cataracts with inhaled and oral steroid therapy during long-term treatment of asthma. *J Allergy Clin Immunol* 1993;91:571-9.

Turpeinen M, Sorva R, Juntunen-Backman K. Changes in carbohydrate and lipid metabolism in children with asthma inhaling budesonide. *J Allergy Clin Immunol* 1991;88:384-9.

Ullman A, Hedner J, Svedmyr N. Inhaled salmeterol and salbutamol in asthmatic patients. An evaluation of asthma symptoms and the possible development of tachyphalaxis. *Am Rev Respir Dis* 1990;142:571-5.

van Essen-Zandvliet EE, Hughes MD, Waalkens HJ, Duiverman EJ, Pocock SJ, Kerrebijn KF. Effects of 22 months of treatment with inhaled corticosteroids and/or beta$_2$-agonists on lung function, airway responsiveness, and symptoms in children with asthma. *Am Rev Respir Dis* 1992;146:547-54.

van Schayck CP, Dompeling E, van Herwaarden CL, et al. Bronchodilator treatment in moderate asthma or chronic bronchitis: continuous or on demand? A randomized controlled study. *BMJ* 1991;303:1426- 31.

Vidgren M, Kärkkäinen A, Karjalainen P, Nuutinen J, Paronen P. In vitro and in vivo deposition of drug particles from pressurized aerosol and dry powder inhaler. *Drug Devel Indust Pharm* 1983;14:2649-65.

Weinberger M, Hendeles L. Theophylline in asthma. *N Engl J Med* 1996;334:1380-8.

Wolthers OD. Long-, intermediate- and short-term growth studies in asthmatic children treated with inhaled glucocorticosteroids. *Eur Respir J* 1996:9:821-7.

Wong CS, Cooper S, Britton JR, Tattersfield AE. Steroid sparing effect of nedocromil sodium in asthmatic patients on high doses of inhaled steroids. *Clin Exp Allergy* 1993;23:370-6.

Woolcock A, Lundback B, Ringdal N, Jacques LA. Comparison of addition of salmeterol to inhaled steroids with doubling of the dose of inhaled steroid. *Am J Respir Crit Care Med* 1996;153:1481-8.

Yates DH, Sussman HS, Shaw MJ, Barnes PJ, Chung KF. Regular formoterol treatment in mild asthma. Effect on bronchial responsiveness during and after treatment. *Am J Respir Crit Care Med* 1995;152:1170-4.

Ziment I, Stein M. Inappropriate and unusual remedies. In: Weiss EB, Stein M, eds. *Bronchial Asthma*. Boston: Little, Brown and Company, 1993, pp. 1145-51.

Pharmacologic Therapy: Managing Asthma Long Term

KEY RECOMMENDATIONS FOR MANAGING ASTHMA LONG TERM

- Persistent asthma is most effectively controlled with daily long-term-control medication, specifically, anti-inflammatory therapy.
- A stepwise approach to pharmacologic therapy is recommended to gain and maintain control of asthma:
  - The amount and frequency of medication is dictated by asthma severity and directed toward suppression of airway inflammation.
  - Therapy should be initiated at a higher level than the patient's step of severity at the onset to establish prompt control and then stepped down.
  - Continual monitoring is essential to ensure that asthma control is achieved.
  - Step-down therapy is essential to identify the minimum medication necessary to maintain control.
- Regular followup visits (at 1- to 6-month intervals) are essential to ensure that control is maintained and the appropriate step down in therapy is considered.
- Therapeutic strategies should be considered in concert with clinician-patient partnership strategies; education of patients is essential for achieving optimal pharmacologic therapy.
- At each step, patients should be advised to avoid or control allergens, irritants, or other factors that make the patient's asthma worse.
- Referral to an asthma specialist for consultation or comanagement of the patient is recommended if there are difficulties achieving or maintaining control of asthma or if the patient requires step 4 care (see component 1-Initial Assessment and Diagnosis). Referral may be considered if the patient requires step 3 care. For infants and young children, referral is recommended if the patient requires step 3 or 4 care and should be considered if the patient requires step 2 care.

STEPWISE APPROACH FOR MANAGING ASTHMA IN ADULTS AND CHILDREN OLDER THAN 5 YEARS OF AGE

The aim of asthma therapy is to maintain control of asthma with the least amount of medication and hence minimal risk for adverse effects. Control of asthma is defined as:

- Preventing chronic and troublesome symptoms (e.g., coughing or breathlessness in the night, in the early morning, or after exertion)
- Maintaining (near) "normal" pulmonary function
- Maintaining normal activity levels (including exercise and other physical activity)
- Preventing recurrent exacerbations of asthma and minimizing the need for emergency department visits or hospitalizations
- Providing optimal pharmacotherapy with minimal or no adverse effects
- Meeting patients' and families' expectations of and satisfaction with asthma care

The stepwise approach to therapy, in which the dose and number of medications and frequency of administration are increased as necessary and decreased when possible, is used to achieve this control. This is illustrated in figures 3-4a and 3-4b. Figures 3-5a and 3-5d present usual medication dosages for therapy. Because asthma is a chronic inflammatory disorder of the airways with recurrent exacerbations, therapy for persistent asthma must emphasize efforts to suppress inflammation over the long term and prevent exacerbations. Recommendations in the stepwise approach to therapy are based on the Expert Panel's review of the literature (see component 3-Medications) and the Expert Panel's experience and opinion.

Gaining Control of Asthma

The clinician must judge individual patient needs and circumstances to determine at what step to initiate therapy. There are two appropriate approaches to gaining control of asthma:

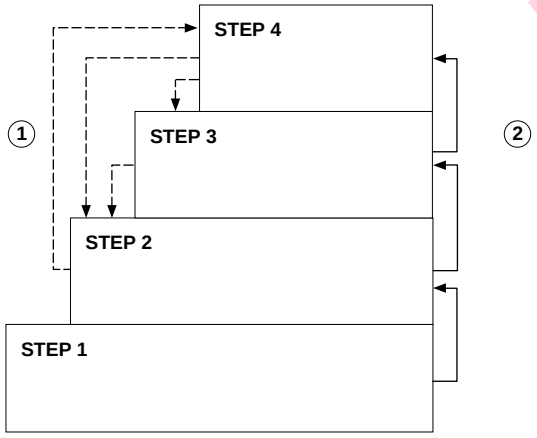
- Start treatment at the step appropriate to the severity of the patient's disease at the time of evaluation and gradually step up if control is not achieved.

OR

- At the onset, administer therapy at a level higher than the patient's step of severity to gain rapid control. This can be accomplished by either a short course of systemic corticosteroids (see figure 3-5a) along with inhaled corticosteroids or initiating a medium-to-high dose of inhaled corticosteroids. Once control is gained, step down the therapy.

The two approaches are illustrated by the solid and broken lines in the following diagram.

TWO APPROACHES TO GAINING CONTROL OF ASTHMA: (1) START WITH HIGH-DOSE THERAPY AND STEP DOWN OR (2) GRADUALLY STEP UP THERAPY



The more aggressive approach of gaining prompt control with a higher level of therapy is preferred, in the opinion of the Expert Panel. At present, there are no studies directly comparing the two approaches—the traditional step-up care (low dose to high) vs. step-down care (initial high dose to low). However, there is evidence supporting a more aggressive initial approach. First, asthma symptoms and altered pulmonary function are related to the level of ongoing airway inflammation. Suppression of airway inflammation is more likely to occur with higher doses of corticosteroids. Furthermore, studies indicate that the dose of inhaled or systemic corticosteroids can be reduced and the clinical benefits sustained once the disease is controlled (Haahtela et al. 1994; Agertoft and Pedersen 1994). A preliminary observation in a retrospective study of children suggests that initiating inhaled corticosteroids early in the course of the disease results in better clinical benefit and less accumulated corticosteroid dose over the long term (Agertoft and Pedersen 1994). Therefore, it is conceivable that a more aggressive approach in initial therapy will more rapidly suppress airway inflammation, restore pulmonary function, and allow for eventual asthma control at lower doses of anti-inflammatory therapy.

Continual monitoring is essential to ensure that asthma control is achieved. Control is indicated by, for example, peak expiratory flow (PEF) values indicating less than 10 to 20 percent variability or PEF consistently greater than 80 percent of the patient's personal best, minimal symptoms, minimal need for short-acting inhaled $beta_2$-agonist, absence of nighttime awakenings, and no activity limitations.

If control is not achieved with initial therapy (e.g., within 1 month), the pharmacologic management plan, and possibly the diagnosis, should be reevaluated (see Pharmacologic Steps, page 87).

Maintaining Control of Asthma

Once control is achieved and sustained for several weeks or months, a reduction in pharmacologic therapy—a step down—is appropriate and helpful to identify the minimum therapy for maintaining control. Reduction in therapy should be gradual because asthma can deteriorate at a highly variable rate and intensity.

In general, the last medication added to the medical regimen should be the first medication reduced. Although guidelines for the rate of reduction and intervals for evaluation have not been established, the opinion of the Expert Panel is that the dose of inhaled corticosteroids may be reduced about

FIGURE 3-4a. STEPWISE APPROACH FOR MANAGING ASTHMA IN ADULTS AND CHILDREN OLDER THAN 5 YEARS OF AGE

Goals of Asthma Treatment

- Prevent chronic and troublesome symptoms (e.g., coughing or breathlessness in the night, in the early morning, or after exertion)
- Maintain (near) "normal" pulmonary function
- Maintain normal activity levels (including exercise and other physical activity)
- Prevent recurrent exacerbations of asthma and minimize the need for emergency department visits or hospitalizations
- Provide optimal pharmacotherapy with minimal or no adverse effects
- Meet patients' and families' expectations of and satisfaction with asthma care

Classify Severity of Asthma

Clinical Features Before Treatment*

	Symptoms**	Nighttime Symptoms	Lung Function
STEP 4 Severe Persistent	▪ Continual symptoms ▪ Limited physical activity ▪ Frequent exacerbations	Frequent	▪ FEV_1 or PEF ≤60% predicted ▪ PEF variability >30%
STEP 3 Moderate Persistent	▪ Daily symptoms ▪ Daily use of inhaled short-acting $beta_2$-agonist ▪ Exacerbations affect activity ▪ Exacerbations ≥2 times a week; may last days	>1 time a week	▪ FEV_1 or PEF >60% –<80% predicted ▪ PEF variability >30%
STEP 2 Mild Persistent	▪ Symptoms >2 times a week but <1 time a day ▪ Exacerbations may affect activity	>2 times a month	▪ FEV_1 or PEF ≥ 80% predicted ▪ PEF variability 20–30%
STEP 1 Mild Intermittent	▪ Symptoms ≤2 times a week ▪ Asymptomatic and normal PEF between exacerbations ▪ Exacerbations brief (from a few hours to a few days); intensity may vary	≤2 times a month	▪ FEV_1 or PEF ≥80% predicted ▪ PEF variability <20%

* The presence of one of the features of severity is sufficient to place a patient in that category. An individual should be assigned to the most severe grade in which any feature occurs. The characteristics noted in this figure are general and may overlap because asthma is highly variable. Furthermore, an individual's classification may change over time.

** Patients at any level of severity can have mild, moderate, or severe exacerbations. Some patients with intermittent asthma experience severe and life-threatening exacerbations separated by long periods of normal lung function and no symptoms.

FIGURE 3-4b. STEPWISE APPROACH FOR MANAGING ASTHMA IN ADULTS AND CHILDREN OLDER THAN 5 YEARS OF AGE: TREATMENT

Preferred treatments are in bold print.

	Long-Term Control	Quick Relief	Education
STEP 4 Severe Persistent	Daily medications: ■ Anti-inflammatory: inhaled corticosteroid (high dose) AND ■ Long-acting bronchodilator: either long-acting inhaled beta$_2$-agonist, sustained-release theophylline, or long-acting beta$_2$-agonist tablets AND ■ Corticosteroid tablets or syrup long term (make repeat attempts to reduce systemic steroids and maintain control with high dose inhaled steroids)	■ Short-acting bronchodilator: inhaled beta$_2$-agonists as needed for symptoms. ■ Intensity of treatment will depend on severity of exacerbation; see component 3-Managing Exacerbations. ■ Use of short-acting inhaled beta$_2$-agonists on a daily basis, or increasing use, indicates the need for additional long-term-control therapy.	Steps 2 and 3 actions plus: ■ Refer to individual education/counseling
STEP 3 Moderate Persistent	Daily medication: ■ Either Anti-inflammatory: inhaled corticosteroid (medium dose) OR Inhaled corticosteroid (low-medium dose) and add a long-acting bronchodilator, especially for nighttime symptoms; either long-acting inhaled beta$_2$-agonist, sustained-release thephylline, or long-acting beta$_2$-agonist tablets. ■ If needed Anti-inflammatory: inhaled corticosteroids (medium-high dose) AND Long-acting bronchodilator, especially for nighttime symptoms; either long-acting inhaled beta$_2$-agonist, sustained-release theophylline, or long-acting beta$_2$-agonist tablets.	■ Short-acting bronchodilator: inhaled beta$_2$-agonists as needed for symptoms. ■ Intensity of treatment will depend on severity of exacerbation; see component 3-Managing Exacerbations. ■ Use of short-acting inhaled beta$_2$-agonists on a daily basis, or increasing use, indicates the need for additional long-term-control therapy.	Step 1 actions plus: ■ Teach self-monitoring ■ Refer to group education if available ■ Review and update self-management plan

FIGURE 3-4b. STEPWISE APPROACH FOR MANAGING ASTHMA IN ADULTS AND CHILDREN OLDER THAN 5 YEARS OF AGE: TREATMENT (CONTINUED)

Preferred treatments are in bold print.

	Long-Term Control	Quick Relief	Education
STEP 2 Mild Persistent	One daily medication: ■ Anti-inflammatory: either inhaled corticosteroid (low doses) or cromolyn or nedocromil (children usually begin with a trial of cromolyn or nedocromil). ■ Sustained-release theophylline to serum concentration of 5-15 mcg/mL is an alternative, but not preferred, therapy. Zafirlukast or zileuton may also be considered for patients ≥12 years of age, although their position in therapy is not fully established.	■ Short-acting bronchodilator: inhaled beta$_2$-agonists as needed for symptoms. ■ Intensity of treatment will depend on severity of exacerbation; see component 3-Managing Exacerbations. ■ Use of short-acting inhaled beta$_2$-agonists on a daily basis, or increasing use, indicates the need for additional long-term-control therapy.	Step 1 actions plus: ■ Teach self-monitoring ■ Refer to group education if available ■ Review and update self-management plan
STEP 1 Mild Intermittent	■ No daily medication needed.	■ Short-acting bronchodilator: inhaled beta$_2$-agonists as needed for symptoms. ■ Intensity of treatment will depend on severity of exacerbation; see component 3-Managing Exacerbations. ■ Use of short-acting inhaled beta$_2$-agonists more than 2 times a week may indicate the need to initiate long-term-control therapy.	■ Teach basic facts about asthma ■ Teach inhaler/spacer/holding chamber technique ■ Discuss roles of medications ■ Develop self-management plan ■ Develop action plan for when and how to take rescue actions, especially for patients with a history of severe exacerbations ■ Discuss appropriate environmental control measures to avoid exposure to known allergens and irritants (See component 4.)

Step down
Review treatment every 1 to 6 months; a gradual stepwise reduction in treatment may be possible.

Step up
If control is not maintained, consider step up. First, review patient medication technique, adherence, and environmental control (avoidance of allergens or other factors that contribute to asthma severity).

NOTE:

- The stepwise approach presents general guidelines to assist clinical decisionmaking; it is not intended to be a specific prescription. Asthma is highly variable; clinicians should tailor specific medication plans to the needs and circumstances of individual patients.
- Gain control as quickly as possible; then decrease treatment to the least medication necessary to maintain control. Gaining control may be accomplished by either starting treatment at the step most appropriate to the initial severity of the condition or starting at a higher level of therapy (e.g., a course of systemic corticosteroids or higher dose of inhaled corticosteroids).
- A rescue course of systemic corticosteroids may be needed at any time and at any step.
- Some patients with intermittent asthma experience severe and life-threatening exacerbations separated by long periods of normal lung function and no symptoms. This may be especially common with exacerbations provoked by respiratory infections. A short course of systemic corticosteroids is recommended.
- At each step, patients should control their environment to avoid or control factors that make their asthma worse (e.g., allergens, irritants); this requires specific diagnosis and education.
- Referral to an asthma specialist for consultation or comanagement is *recommended* if there are difficulties achieving or maintaining control of asthma or if the patient requires step 4 care. Referral may be *considered* if the patient requires step 3 care (see also component 1-Initial Assessment and Diagnosis).

FIGURE 3-5a. USUAL DOSAGES FOR LONG-TERM-CONTROL MEDICATIONS

Medication	Dosage Form	Adult Dose	Child Dose	Comments
Inhaled Corticosteroids (see figures 3-5b and 3-5c)				
Systemic Corticosteroids			(Applies to all three systemic corticosteroids)	
Methylprednisolone	2, 4, 8, 16, 32 mg tablets	▪ 7.5–60 mg daily in a single dose or qod as needed for control ▪ Short-course "burst": 40–60 mg per day as single or 2 divided doses for 3–10 days	▪ 0.25–2 mg/kg daily in single dose or qod as needed for control ▪ Short course "burst": 1–2 mg/kg/day, maximum 60 mg/day, for 3–10 days	▪ For long-term treatment of severe persistent asthma, administer single dose in a.m. either daily or on alternate days (alternate-day therapy may produce less adrenal suppression). If daily doses are required, one study suggests improved efficacy and no increase in adrenal suppression when administered at 3:00 p.m. (Beam et al. 1992). ▪ Short courses or "bursts" are effective for establishing control when initiating therapy or during a period of gradual deterioration. ▪ The burst should be continued until patient achieves 80% PEF personal best or symptoms resolve. This usually requires 3-10 days but may require longer. There is no evidence that tapering the dose following improvement prevents relapse.
Prednisolone	5 mg tablets, 5 mg/5 cc, 15 mg/5 cc			
Prednisone	1, 2.5, 5, 10, 20, 25 mg tablets; 5 mg/cc, 5 mg/5 cc			
Cromolyn and Nedocromil				
Cromolyn	MDI 1 mg/puff Nebulizer solution 20 mg/ampule	2–4 puffs tid-qid 1 ampule tid-qid	1–2 puffs tid-qid 1 ampule tid-qid	▪ One dose prior to exercise or allergen exposure provides effective prophylaxis for 1–2 hours.
Nedocromil	MDI 1.75 mg/puff	2–4 puffs bid-qid	1–2 puffs bid-qid	▪ See cromolyn above.
Long-Acting Beta$_2$-Agonists				
Salmeterol	*Inhaled* MDI 21 mcg/puff, 60 or 120 puffs DPI 50 mcg/blister	2 puffs q 12 hours 1 blister q 12 hours	1–2 puffs q 12 hours 1 blister q 12 hours	▪ May use one dose nightly for symptoms. ▪ Should not be used for symptom relief or for exacerbations.
Sustained-Release Albuterol	*Tablet* 4 mg tablet	4 mg q 12 hours	0.3–0.6 mg/kg/day, not to exceed 8 mg/day	
Methylxanthines				
Theophylline	Liquids, sustained-release tablets, and capsules	Starting dose 10 mg/kg/day up to 300 mg max; usual max 800 mg/day	Starting dose 10 mg/kg/day; usual max: ▪ <1 year of age: 0.2 (age in weeks) + 5 = mg/kg/day ▪ ≥1 year of age: 16 mg/kg/day	▪ Adjust dosage to achieve serum concentration of 5–15 mcg/mL at steady-state (at least 48 hours on same dosage). ▪ Due to wide interpatient variability in theophylline metabolic clearance, routine serum theophylline level monitoring is important. ▪ See factors on page 87 that can affect levels.
Leukotriene Modifiers				
Zafirlukast	20 mg tablet	40 mg daily (1 tablet bid)		▪ For zafirlukast, administration with meals decreases bioavailability; take at least 1 hour before or 2 hours after meals. ▪ For zileuton, monitor hepatic enzymes (ALT).
Zileuton	300 mg tablet 600 mg tablet	2,400 mg daily (two 300 mg tablets or one 600 mg tablet, qid)		

FIGURE 3-5a. USUAL DOSAGES FOR LONG-TERM-CONTROL MEDICATIONS (CONTINUED)

Factors Affecting Serum Theophylline Concentrations*

Factor	Decreases Theophylline Concentrations	Increases Theophylline Concentrations	Recommended Action
Food	↓ or delays absorption of some sustained-release theophylline (SRT) products	↑ rate of absorption (fatty foods) products	Select theophylline preparation that is not affected by food.
Diet	↑ metabolism (high protein)	↓ metabolism (high carbohydrate)	Inform patients that major changes in diet are not recommended while taking theophylline.
Systemic, febrile viral illness (e.g., influenza)		↓ metabolism	Decrease theophylline dose according to serum concentration level. Decrease dose by 50 percent if serum concentration measurement is not available.
Hypoxia, cor pulmonale, and decompensated congestive heart failure, cirrhosis		↓ metabolism	Decrease dose according to serum concentration level.
Age	↑ metabolism (1 to 9 years)	↓ metabolism (<6 months, elderly)	Adjust dose according to serum concentration level.
Phenobarbital, phenytoin, carbamazepine	↑ metabolism		Increase dose according to serum concentration level.
Cimetidine		↓ metabolism	Use alternative H_2 blocker (e.g., famotidine or ranitidine).
Macrolides: TAO, erythromycin, clarithromycin		↓ metabolism	Use alternative antibiotic or adjust theophylline dose.
Quinolones: ciprofloxacin, enoxacin, pefloxacin		↓ metabolism	Use alternative antibiotic or adjust theophylline dose. Circumvent with ofloxacin if quinolone therapy is required.
Rifampin	↑ metabolism		Increase dose according to serum concentration level.
Ticlopidine		↓ metabolism	Decrease dose according to serum concentration level.
Smoking	↑ metabolism		Advise patient to stop smoking; increase dose according to serum concentration level.

* This list is not all-inclusive; for discussion of other factors, see package inserts.

25 percent every 2 to 3 months to the lowest dose possible required to maintain control. It is likely that most patients with persistent asthma will continue to benefit from daily medication to suppress underlying airway inflammation. Patients may relapse when inhaled corticosteroids are completely discontinued (Waalkens et al. 1993).

Regular followup visits (at 1- to 6-month intervals) are essential. Clinicians need to assess whether control of asthma has been maintained and if a step down in therapy is appropriate. Clinicians also need to monitor and review the daily self-management and action plans, the medications, and the patient's self-management behaviors (e.g., inhaler and peak flow monitoring techniques, actions to control factors that aggravate their asthma) (see figure 4-2).

The Expert Panel *recommends* referral to an asthma specialist for consultation or comanagement of the patient if: there are difficulties achieving or maintaining control of asthma; immunotherapy is being considered; the patient requires step 4 care (step 3 or 4 care for infants and young children); or the patient has had a life-threatening exacerbation (see component 1-Initial Assessment and Diagnosis). Referral may be *considered* if a patient requires step 3 care (or step 2 care for infants and young children).

Pharmacologic Steps

The following recommendations for pharmacologic therapy at different steps of asthma severity (see figures 3-4a and 3-4b) are intended to be general guidelines for making therapeutic decisions. They are not

FIGURE 3-5b. ESTIMATED COMPARATIVE DAILY DOSAGES FOR INHALED CORTICOSTEROIDS

Adults

Drug	Low Dose	Medium Dose	High Dose
Beclomethasone dipropionate 42 mcg/puff 84 mcg/puff	168-504 mcg (4-12 puffs — 42 mcg) (2-6 puffs — 84 mcg)	504-840 mcg (12-20 puffs — 42 mcg) (6-10 puffs — 84 mcg)	>840 mcg (>20 puffs — 42 mcg) (>10 puffs — 84 mcg)
Budesonide DPI: 200 mcg/dose	200-400 mcg (1-2 inhalations)	400-600 mcg (2-3 inhalations)	>600 mcg (>3 inhalations)
Flunisolide 250 mcg/puff	500-1,000 mcg (2-4 puffs)	1,000-2,000 mcg (4-8 puffs)	>2,000 mcg (>8 puffs)
Fluticasone MDI: 44, 110, 220 mcg/puff	88-264 mcg (2-6 puffs — 44 mcg) OR (2 puffs — 110 mcg)	264-660 mcg (2-6 puffs — 110 mcg)	>660 mcg (>6 puffs — 110 mcg) OR (>3 puffs — 220 mcg)
DPI: 50, 100, 250 mcg/dose	(2-6 inhalations — 50 mcg)	(3-6 inhalations — 100 mcg)	(>6 inhalations — 100 mcg) OR (>2 inhalations — 250 mcg)
Triamcinolone acetonide 100 mcg/puff	400-1,000 mcg (4-10 puffs)	1,000-2,000 mcg (10-20 puffs)	>2,000 mcg (>20 puffs)

Children

Drug	Low Dose	Medium Dose	High Dose
Beclomethasone dipropionate 42 mcg/puff 84 mcg/puff	84-336 mcg (2-8 puffs — 42 mcg) (1-4 puffs — 84 mcg)	336-672 mcg (8-16 puffs — 42 mcg) (4-8 puffs — 84 mcg)	>672 mcg (>16 puffs — 42 mcg) (>8 puffs — 84 mcg)
Budesonide DPI: 200 mcg/dose	100-200 mcg	200-400 mcg (1-2 inhalations — 200 mcg)	>400 mcg (>2 inhalations — 200 mcg)
Flunisolide 250 mcg/puff	500-750 mcg (2-3 puffs)	1,000-1,250 mcg (4-5 puffs)	>1,250 mcg (>5 puffs)
Fluticasone MDI: 44, 110, 220 mcg/puff	88-176 mcg (2-4 puffs — 44 mcg)	176-440 mcg (4-10 puffs — 44 mcg) OR (2-4 puffs — 110 mcg)	>440 mcg (>4 puffs — 110 mcg) OR (>2 puffs — 220 mcg)
DPI: 50, 100, 250 mcg/dose	(2-4 inhalations — 50 mcg)	(2-4 inhalations — 100 mcg)	(>4 inhalations — 100 mcg) OR (>2 inhalations — 250 mcg)
Triamcinolone acetonide 100 mcg/puff	400-800 mcg (4-8 puffs)	800-1,200 mcg (8-12 puffs)	>1,200 mcg (>12 puffs)

Note:

- The most important determinant of appropriate dosing is the clinician's judgment of the patient's response to therapy. The clinician must monitor the patient's response on several clinical parameters and adjust the dose accordingly. The stepwise approach to therapy emphasizes that once control of asthma is achieved, the dose of medication should be carefully titrated to the minimum dose required to maintain control, thus reducing the potential for adverse effect.
- See figure 3-5c for an explanation of the rationale used for the comparative dosages. The reference point for the range in the dosages for children is data on the safety of inhaled corticosteroids in children, which, in general, suggest that the dose ranges are equivalent to beclomethasone dipropionate 200-400 mcg/day (low dose), 400-800 mcg/day (medium dose), and >800 mcg/day (high dose).
- Some dosages may be outside package labeling.
- Metered-dose inhaler (MDI) dosages are expressed as the actuater dose (the amount of drug leaving the actuater and delivered to the patient), which is the labeling required in the United States. This is different from the dosage expressed as the valve dose (the amount of drug leaving the valve, all of which is not available to the patient), which is used in many European countries and in some of the scientific literature. Dry powder inhaler (DPI) doses are expressed as the amount of drug in the inhaler following activation.

FIGURE 3-5c. ESTIMATED CLINICAL COMPARABILITY OF DOSES FOR INHALED CORTICOSTEROIDS

Data from in vitro and clinical trials suggest that the different inhaled corticosteroid preparations are not equivalent on a per puff or microgram basis. However, it is not entirely clear what implications these differences have for dosing recommendations in clinical practice because there are few data directly comparing the preparations. Relative dosing for clinical comparability is affected by differences in topical potency, clinical effects at different doses, delivery device, and bioavailability. *The Expert Panel developed recommended dose ranges (see figure 3-5b) for different preparations based on available data and the following assumptions and cautions about estimating relative doses needed to achieve comparable clinical effect.*

- Relative topical potency using human skin blanching
  - The standard test for determining relative topical anti-inflammatory potency is the topical vasoconstriction (MacKenzie skin blanching) test.
  - The MacKenzie topical skin blanching test correlates with binding affinities and binding half-lives for human lung corticosteroid receptors (see table below) (Dahlberg et al. 1984; Högger and Rohdewald 1994).
  - The relationship between relative topical anti-inflammatory effect and clinical comparability in asthma management is not certain. However, recent clinical trials suggest that different in vitro measures of anti-inflammatory effect correlate with clinical efficacy (Barnes and Pedersen 1993; Johnson 1996; Kamada et al. 1996; Ebden et al. 1986; Leblanc et al. 1994; Gustafsson et al. 1993; Lundback et al. 1993; Barnes et al. 1993; Fabbri et al. 1993; Langdon and Capsey 1994; Ayres et al. 1995; Rafferty et al. 1985; Bjorkander et al. 1982; Stiksa et al. 1982; Willey et al. 1982).

Medication	Topical Potency (Skin Blanching)*	Corticosteroid Receptor Binding Half-Life	Receptor Binding Affinity
Beclomethasone dipropionate (BDP)	600	7.5 hours	13.5
Budesonide (BUD)	980	5.1 hours	9.4
Flunisolide (FLU)	330	3.5 hours	1.8
Fluticasone propionate (FP)	1,200	10.5 hours	18.0
Triamcinolone acetonide (TAA)	330	3.9 hours	3.6

* Numbers are assigned in reference to dexamethasone, which has a value of "1" in the MacKenzie test.

- Relative doses to achieve similar clinical effects
  - Clinical effects are evaluated by a number of outcome parameters (e.g., changes in spirometry, peak flow rates, symptom scores, quick-relief beta$_2$-agonist use, frequency of exacerbations, airway responsiveness).
  - The daily dose and duration of treatment may affect these outcome parameters differently (e.g., symptoms and peak flow may improve at lower doses and over a shorter treatment time than bronchial reactivity) (van Essen-Zandvliet et al. 1992; Haahtela et al. 1991).
  - Delivery systems influence comparability. For example, the DPI delivery device for budesonide delivers approximately twice the amount of drug to the airway as the MDI, thus enhancing the clinical effect (Thorsson et al. 1994; Agertoft and Pedersen 1993).
  - *Individual patients may respond differently to different preparations, as noted by clinical experience.*

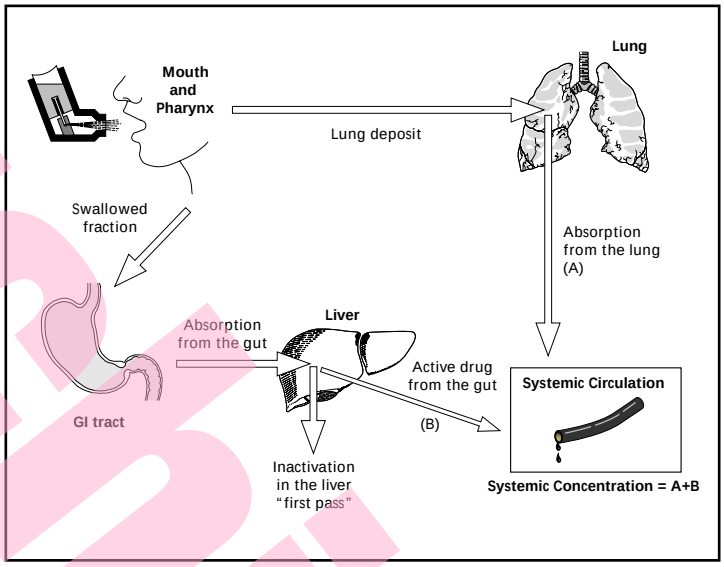
Clinical trials comparing effects in reducing symptoms and improving peak expiratory flow demonstrate:

- BDP and BUD achieved comparable effects at similar microgram doses by MDI (Bjorkander et al. 1982; Ebden et al. 1986; Rafferty et al. 1985).
- BDP achieved effects similar to twice the dose of TAA on a microgram basis.
- FP achieved effects similar to twice the dose of BDP and BUD via an MDI on a microgram basis (Gustaffson et al. 1993; Fabbri et al. 1993; Barnes et al. 1993; Dahl et al. 1993; Ayres et al. 1995).
- BUD by dry powder inhaler achieved effects similar to twice the dose delivered by MDI, thus implying greater bronchial delivery by the delivery device (Thorsson et al. 1994; Agertoft and Pedersen 1993).

FIGURE 3-5c. ESTIMATED CLINICAL COMPARABILITY OF DOSES FOR INHALED CORTICOSTEROIDS (CONTINUED)

■ Bioavailability

Both the relative potency and the relative bioavailability (systemic availability) determine the potential for systemic activity of an inhaled corticosteroid preparation. As illustrated here, the bioavailability of an inhaled corticosteroid is dependent on the absorption of the dose delivered to the lungs and the oral bioavailability of the swallowed portion of the dose received.



Adapted with permission from Barnes 1995.

— Absorption of the dose delivered to the lungs:
  – Approximately 10 to 30 percent of the dose from the MDI is delivered to the lungs. This amount varies among preparations and delivery devices.
  – Nearly all of the amount delivered to the lungs is bioavailable.
— Oral bioavailability of the swallowed portion of the dose received:
  – Approximately 80 percent of the dose from the MDI without a spacer/holding chamber is swallowed.
  – The oral bioavailability of this amount varies:
    Either a high first-pass liver metabolism or the use of a spacer/holding chamber with an MDI can decrease oral bioavailability, thus enhancing safety (Lipworth 1995).
    The approximate oral bioavailability of inhaled corticosteroids has been reported as: BDP 20%; FLU 21%; TAA 10.6%; BUD 11%; FP 1% (Chaplin et al. 1980; Check and Kaliner 1990; Clissold and Heel 1984; Davies 1993; Harding 1990; Heald et al. 1995; Martin et al. 1974; Mollman et al. 1985; Szefler 1991; Wurthwein andRohdewald 1990).

Although few clinical trials are available that compare systemic activity among preparations (Kamada et al. 1996), studies have found:

— As suggested by one cross-over comparison study, BDP, FLU, and TAA appear to have equivalent dose-dependent systemic activity, as measured by 24-hour urinary free cortisol excretion (McCubbin et al. 1995).
— Inconsistent results comparing BDP and BUD. Some show equivalent systemic activity (Kamada et al. 1996; Prahl 1991; Prahl et al. 1987); others show BUD having slightly less systemic activity than BDP (Barnes and Pedersen 1993; Pedersen and Fuglsang 1988; Bisgaard et al. 1988).
— FP had greater adrenal suppression at doses of 400 to 2,000 micrograms than BUD in equivalent microgram doses delivered by MDI and accompanied by mouth washing to prevent oral bioavailability (Clark et al. 1996). This confirms that there are differences in microgram potencies among preparations and that absorption through the lung can result in systemic activity.

FIGURE 3-5d. USUAL DOSAGES FOR QUICK-RELIEF MEDICATIONS

Medication	Dosage Form	Adult Dose	Child Dose	Comments
Short-Acting Inhaled Beta$_2$-Agonists				
	MDI			
Albuterol Albuterol HFA Bitolterol Pirbuterol Terbutaline	90 mcg/puff, 200 puffs 90 mcg/puff, 200 puffs 370 mcg/puff, 300 puffs 200 mcg/puff, 400 puffs 200 mcg/puff, 300 puffs	■ 2 puffs 5 minutes prior to exercise ■ 2 puffs tid-qid prn	■ 1-2 puffs 5 minutes prior to exercise ■ 2 puffs tid-qid prn	■ An increasing use or lack of expected effect indicates diminished control of asthma. ■ Not generally recommended for long-term treatment. Regular use on a daily basis indicates the need for additional long-term-control therapy. ■ Differences in potency exist so that all products are essentially equipotent on a per puff basis. ■ May double usual dose for mild exacerbations. ■ Nonselective agents (i.e., epinephrine, isoproterenol, metaproterenol) are not recommended due to their potential for excessivecardiac stimulation, especially in high doses.
	DPI			
Albuterol Rotahaler	200 mcg/capsule	1-2 capsules q 4-6 hours as needed and prior to exercise	1 capsule q 4-6 hours as needed and prior to exercise	
	Nebulizer solution			
Albuterol	5 mg/mL (0.5%)	1.25-5 mg (.25-1 cc) in 2-3 cc of saline q 4-8 hours	0.05 mg/kg (min 1.25 mg, max 2.5 mg) in 2-3 cc of saline q 4-6 hours	May mix with cromolyn or ipratropium nebulizer solutions. May double dose for mild exacerbations.
Bitolterol	2 mg/mL (0.2%)	0.5-3.5mg (.25-1 cc) in 2-3 cc of saline q 4-8 hours	Not established	May not mix with other nebulizer solutions.
Anticholinergics				
	MDI			
Ipratropium	18 mcg/puff, 200 puffs	2-3 puffs q 6 hours	1-2 puffs q 6 hours	Evidence is lacking for anticholinergics producing added benefit to beta$_2$-agonists in long-term asthma therapy.
	Nebulizer solution			
	.25 mg/mL (0.025%)	0.25 mg q 6 hours	0.25-0.5 mg q 6 hours	
Systemic Corticosteroids		(Applies to all three systemic corticosteroids)		
Methylprednisolone	2, 4, 8, 16, 32 mg tablets	■ Short course "burst": 40-60 mg/day as single or 2 divided doses for 3-10 days	■ Short course "burst": 1-2 mg/kg/day, maximum 60 mg/day, for 3-10 days	■ Short courses or "bursts" are effective for establishing control when initiating therapy or during a period of gradual deterioration. ■ The burst should be continued until patient achieves 80% PEF personal best or symptoms resolve. This usually requires 3-10 days but may require longer. There is no evidence that tapering the dose following improvement prevents relapse.
Prednisolone	5 mg tabs, 5 mg/5 cc, 15 mg/5 cc			
Prednisone	1, 2.5, 5, 10, 20, 25 mg tabs; 5 mg/cc, 5 mg/5 cc			

intended to be prescriptions for individual treatment. Specific therapy should be tailored to the needs and circumstances of individual patients. Pharmacologic therapy must be accompanied at every step by patient education and measures to control those factors that contribute to the severity of the asthma (see components 2 and 4).

If optimal control of asthma is not achieved and sustained at any step of care (nocturnal symptoms, urgent care visits, or an increased need for short-acting beta$_2$-agonists are key indications that asthma is not optimally controlled), several actions may be considered:

- Patient adherence and technique in using medications correctly should be assessed.
- A temporary increase in anti-inflammatory therapy may be indicated to reestablish control. A deterioration of asthma may be characterized by gradual reduction in PEF (approximately 20 percent), by failure of inhaled bronchodilators to produce a sustained response, by a reduced tolerance to activities or exercise, and by the development of increasing nocturnal symptoms. To regain control of asthma, a short course of oral prednisone (see figure 3-5a) is often effective. If asthma symptoms do not recur and pulmonary functions remain normal, no additional therapy is necessary. However, if the prednisone burst does not control symptoms, is effective only for a short period of time (e.g., less than 1 to 2 weeks), or is repeated frequently, the patient should be managed according to the next higher step of care.
- Other factors that diminish control may need to be identified and addressed. These factors include the presence of a coexisting condition (e.g., sinusitis), a new or increased exposure to allergens or irritants, patient or family barriers to adequate self-management behaviors, or psychosocial problems. In some cases, alternative diagnoses may need to be considered, such as vocal cord dysfunction.
- A step up to the next higher step of care may be necessary.
- Consultation with an asthma specialist may be indicated (see component 1-Initial Assessment and Diagnosis).

Intermittent Asthma

Step 1: Mild Intermittent Asthma. Short-acting inhaled beta$_2$-agonists taken as needed to treat symptoms are usually sufficient therapy for mild, intermittent asthma. If effective in relieving symptoms and normalizing pulmonary function, intermittent use of short-acting inhaled beta$_2$-agonists can continue to be used on an as-needed basis. If significant symptoms reoccur or beta$_2$-agonist is required for quick-relief treatment more than two times a week (with the exception of using beta$_2$-agonist for exacerbations caused by viral infections and for exercise-induced bronchospasm [EIB]), the patient should be moved to the next step of care.

Patients with intermittent asthma who experience EIB benefit from taking inhaled beta$_2$-agonists, cromolyn, or nedocromil shortly before exercise (see Exercise-Induced Bronchospasm, page 100). Cromolyn or nedocromil taken before unavoidable exposure to an aeroallergen known to exacerbate the patient's asthma may be beneficial (Cockcroft and Murdock 1987).

The Expert Panel recommends the following actions for managing exacerbations due to viral respiratory infections, which are especially common in children. If the symptoms are mild, inhaled beta$_2$-agonist (every 4 to 6 hours for 24 hours, longer with a physician consult) may be sufficient to control symptoms and improve lung function. If this therapy needs to be repeated more frequently than every 6 weeks, a step up in long-term care is recommended. If the viral respiratory infection provokes a moderate-to-severe exacerbation, a short course of systemic corticosteroids should be considered. For those patients with a history of severe exacerbations with viral respiratory infections, systemic corticosteroids should be initiated at the first sign of the infection.

The Expert Panel recommends that a detailed written action plan be developed for those patients with intermittent asthma who have a history of severe exacerbations (see figure 4-5). Intermittent asthma—infrequent exacerbations separated by periods of no symptoms and normal pulmonary function—is often mild. However, some patients with intermittent asthma experience sudden, severe, and life-threatening exacerbations. It is essential to treat these exacerbations accordingly. The patient's action plan should include indicators of worsening asthma (specific symptoms and PEF mea-

surements), as well as specific recommendations for using beta$_2$-agonist rescue therapy, early administration of systemic corticosteroids, and seeking medical care. Furthermore, periodic monitoring (see component 1-Periodic Assessment and Monitoring) of the patient is appropriate to evaluate whether the patient's asthma is indeed intermittent or whether a step up in long-term therapy is warranted.

Persistent Asthma

The Expert Panel recommends that patients with persistent asthma, either mild, moderate, or severe, receive daily long-term-control medication. The most effective long-term-control medications are those with anti-inflammatory effects, that is, those that diminish chronic airway inflammation and airway hyperresponsiveness. Evidence from clinical trials supports this recommendation (van Essen-Zandvliet et al. 1992; Kerstjens et al. 1992).

Step 2: Mild Persistent Asthma. The main characteristics of step 2 care are as follows:

- Step 2 care long-term-control medication is daily anti-inflammatory medication: either inhaled corticosteroids at a low dose (see figure 3-5b), cromolyn, or nedocromil. For children, a trial of cromolyn or nedocromil is often the initial long-term therapy due to the safety profiles of these medications.

- Sustained-release theophylline is an alternative, but not preferred, long-term-control medication. It is not preferred because its modest clinical effectiveness (theophylline is primarily a bronchodilator and its anti-inflammatory activity demonstrated thus far is modest) must be balanced against concerns about potential toxicity (see component 3-Medications). Theophylline remains a therapeutic option for certain patients due to expense or need for tablet-form medication.

  Sustained-release theophylline is given to achieve a serum concentration of between 5 and 15 mcg/mL. Periodic theophylline monitoring is necessary to maintain a therapeutic—but not toxic—level.

- Zafirlukast or zileuton may also be considered an alternative long-term-control medication for patients 12 years of age and older, although their position in therapy is not yet fully established. Initial experience in clinical trials and possible patient requirements for tablet-form medication make these new medications a therapeutic option. Further clinical experience and additional data are needed to establish the role of zafirlukast and zileuton in stepwise therapy.

- Quick-relief medication must be available. Inhaled short-acting beta$_2$-agonists should be taken as needed to relieve symptoms. The intensity of treatment will depend on the severity of the exacerbation (see component 3-Managing Exacerbations). Use of inhaled short-acting beta$_2$-agonists on a daily basis, or increasing use, indicates the need for additional long-term-control therapy.

Step 3: Moderate Persistent Asthma. Consultation with an asthma specialist may be considered because the therapeutic options at this juncture pose a number of challenging risk/benefit outcomes. There are at least three options for initiating step 3 therapy.

- Increase inhaled corticosteroids to medium dose. This strategy will benefit many patients. Adverse effects, although infrequent, may arise (see component 3-Medications).

OR

- Add a long-acting bronchodilator to a low-to-medium dose of inhaled corticosteroids. The long-acting bronchodilator may be either a long-acting inhaled beta$_2$-agonist (e.g., salmeterol) (Greening et al. 1994; Woolcock et al. 1996) or sustained-release theophylline (Nassif et al. 1981); although not preferred, long-acting beta$_2$-agonist tablets may be considered. This approach has been shown to improve symptom control and may be especially beneficial in patients who have significant nocturnal symptoms. Improved asthma control has been demonstrated with an inhaled long-acting beta$_2$-agonist and a medium-dose inhaled corticosteroid compared to a doubled dose of inhaled corticosteroid (Woolcock et al. 1996), but the potential for incorrectly using long-acting inhaled beta$_2$-agonists as a quick-relief medication needs to be considered. The approach of adding theophylline has the potential for adverse reactions related to fluctuations in theophylline serum concentrations.

OR

- Establish control with medium-dose inhaled corticosteroids, then lower the dose (but still within the medium-dose range) and add nedocromil. Nedocromil has a notable safety profile, and some studies (Lal et al. 1993; O'Hickey and Rees 1994; Svendsen and Jorgensen 1991) have shown that it has some, albeit modest, inhaled corticosteroid-sparing effects in adults. Other studies (e.g., Wong et al. 1993) did not demonstrate this. Therefore, this treatment option is not preferred. Furthermore, adding another inhaler into the patient's medication schedule may affect patient adherence. It will also affect the total cost of care.

If the patient's asthma is not optimally controlled with initial step 3 therapy, and medications are used correctly, additional step 3 therapy is recommended.

- Increase daily long-term-control medications to a high dose of inhaled corticosteroids,

AND

- Add a long-acting bronchodilator, especially to control nocturnal symptoms. The long-acting bronchodilator can be either long-acting inhaled beta$_2$-agonist or sustained-release theophylline. An evening dose of either bronchodilator may alleviate and prevent nocturnal symptoms and thus improve adherence to the overall therapeutic regimen.

Step 4: Severe Persistent Asthma. Patients whose asthma is not controlled on high doses of inhaled corticosteroids and the addition of long-acting bronchodilators will also need oral systemic corticosteroids on a regularly scheduled, long-term basis. For patients who require long-term systemic corticosteroids:

- Use the lowest possible dose (single dose daily or on alternate days).
- Monitor patients closely for corticosteroid adverse side effects (see component 3-Medications).
- When control of asthma is achieved, make persistent attempts to reduce systemic corticosteroids. High doses of inhaled corticosteroids are preferable to systemic corticosteroids because inhaled corticosteroids have fewer systemic effects.
- Consultation with an asthma specialist is recommended.

SPECIAL CONSIDERATIONS FOR MANAGING ASTHMA IN DIFFERENT AGE GROUPS

Infants and Young Children (5 Years of Age and Younger)

KEY RECOMMENDATIONS FOR MANAGING ASTHMA IN INFANTS AND YOUNG CHILDREN

- Diagnosing asthma in infants is often difficult, yet underdiagnosis and undertreatment are key problems in this age group. Thus, a diagnostic trial of inhaled bronchodilators and anti-inflammatory medications may be helpful.
- In general, infants and young children consistently requiring symptomatic treatment more than two times per week should be given daily anti-inflammatory therapy.
- When initiating daily anti-inflammatory therapy, a trial of cromolyn or nedocromil is often given due to the safety profile of these medications.
- Response to therapy should be carefully monitored. Once control of asthma symptoms is established and sustained, a careful step down in therapy should be attempted. If clear benefit is not observed, alternative therapies or diagnoses should be considered.

Diagnosis

Several studies show that as many as 50 to 80 percent of children with asthma develop symptoms before their fifth birthday. Diagnosis can be difficult in this age group and has important implications. On the one hand, asthma in early childhood is frequently underdiagnosed (receiving such labels as chronic bronchitis, wheezy bronchitis, recurrent pneumonia, gastroesophageal reflux, and recurrent upper respiratory tract infections), and thus many infants and young children do not receive adequate therapy. On the other hand, not all wheeze and cough are caused by asthma, and caution is needed to avoid giving infants and young children inappropriately prolonged asthma therapy. Episodic or

chronic wheeze, cough, and breathlessness also may be seen in other less common conditions, including cystic fibrosis, vascular ring, tracheomalacia, primary immunodeficiency, congenital heart disease, parasitic disease, and foreign body aspiration.

Among children 5 years of age and younger, the most common cause of asthma symptoms is viral respiratory infection. At present, the relative contributions of airway inflammation, bronchial smooth muscle abnormalities, or other structural factors in producing wheeze with acute viral upper respiratory infections are unknown. There appear to be two general patterns of illness in infants and children who have wheezing with acute viral upper respiratory infections: a remission of symptoms in the preschool years and persistence of asthma throughout childhood. There are no clear markers to predict the prognosis for an individual child; however, the factors more strongly associated with continuing asthma are allergy, a family history of allergy or asthma, and perinatal exposure to passive smoke and aeroallergens (Pullan and Hey 1982; Sporik et al. 1991; Martinez et al. 1995; Martinez 1995).

Diagnosis is complicated by the difficulty in obtaining objective measurements of lung function in this age group. Essential elements in the evaluation include the history, symptoms, physical examination, and assessment of quality of life. A therapeutic trial with medications listed in figure 3-5d will also aid in the diagnosis.

Treatment

Figure 3-6 illustrates the Expert Panel's recommendations for a stepwise approach to managing acute and chronic asthma symptoms, regardless of the prognosis for the wheezing infant or young child.

It is the opinion of the Expert Panel that, in general, infants and young children consistently requiring symptomatic treatment more than two times per week should be given daily anti-inflammatory medication.

At present there are few studies of medications in children younger than 3 years of age. A therapeutic trial of anti-inflammatory medications should be monitored carefully. Treatment should be stopped if a clear beneficial effect is not obvious. Although only inhaled corticosteroids have been shown to be effective in long-term clinical studies with infants (Ilangovan et al. 1993; Gleeson and Price 1988; Bisgaard et al. 1990), cromolyn has demonstrated symptom control and reduced airway hyperresponsiveness in a number of pediatric studies (Geller-Bernstein and Sneh 1980; Hilman et al. 1987; Miraglia del Giudice et al. 1982; Shapiro and Konig 1985; Silverman et al. 1972; Bertelsen et al. 1986; Glass et al. 1981). Fewer studies are available on nedocromil, but benefit has been demonstrated (Brogden and Sorkin 1993). Sustained-release theophylline, an alternative long-term-control medication for older children, may have particular risks of adverse side effects in infants, who frequently have febrile illnesses which increase theophylline concentrations. Theophylline should be considered only if serum concentration levels will be carefully monitored.

In deciding when to initiate daily long-term-control therapy, the clinician must weigh the possible long-term effects of inadequately controlled asthma vs. the possible adverse effects of medications given over prolonged periods. A preliminary study suggests that appropriate control of childhood asthma may prevent more serious asthma or irreversible obstruction in later years (Agertoft and Pedersen 1994). There is evidence that anti-inflammatory treatment can reduce morbidity from wheezing in early childhood (Connett et al. 1993). Studies in older children suggest that the potential but small risk of delayed growth from the use of inhaled corticosteroids is balanced by their efficacy (see component 3-Medications). Furthermore, there are options (cromolyn and nedocromil) for initiating anti-inflammatory therapy.

Recommendations for treating infants and young children at different steps of care include:

- The patient's response to therapy should be monitored carefully. When benefits are sustained, a step down in therapy should be attempted. If there are no clear benefits, treatment should be stopped and alternative therapies or diagnoses should be considered.

- Daily long-term-control therapy often begins with cromolyn or nedocromil.

- When inhaled corticosteroids are introduced in step 2 care, doses may range from 100 to 400 mcg/day; this generally translates to a dose of 15 mcg/kg up to 400 mcg/day beclomethasone (Allen and Lemanske 1993). See figures 3-5b and 3-5c for discussion of equivalency among preparations.

FIGURE 3-6. STEPWISE APPROACH FOR MANAGING INFANTS AND YOUNG CHILDREN (5 YEARS OF AGE AND YOUNGER) WITH ACUTE OR CHRONIC ASTHMA SYMPTOMS

	Long-Term Control	Quick Relief
STEP 4 Severe Persistent	■ Daily anti-inflammatory medicine — High-dose inhaled corticosteroid with spacer/holding chamber and face mask — If needed, add systemic corticosteroids 2 mg/kg/day and reduce to lowest daily or alternate-day dose that stabilizes symptoms	■ Bronchodilator as needed for symptoms (see step 1) up to 3 times a day
STEP 3 Moderate Persistent	■ Daily anti-inflammatory medication. Either: — Medium-dose inhaled corticosteroid with spacer/holding chamber and face mask OR, once control is established: — Medium-dose inhaled corticosteroid and nedocromil OR — Medium-dose inhaled corticosteroid and long-acting bronchodilator (theophylline)	■ Bronchodilator as needed for symptoms (see step 1) up to 3 times a day
STEP 2 Mild Persistent	■ Daily anti-inflammatory medication. Either: — Cromolyn (nebulizer is preferred; or MDI) or nedocromil (MDI only) — Infants and young children usually begin with a trial of cromolyn or nedocromil OR — Low-dose inhaled corticosteroid with spacer/holding chamber and face mask	■ Bronchodilator as needed for symptoms (see step 1)
STEP 1 Mild Intermittent	■ No daily medication needed.	■ Bronchodilator as needed for symptoms ≤2 times a week. Intensity of treatment will depend upon severity of exacerbation (see component 3-Managing Exacerbations). Either: — Inhaled short-acting beta$_2$-agonist by nebulizer or face mask and spacer/holding chamber OR — Oral beta$_2$-agonist for symptoms ■ With viral respiratory infection — Bronchodilator q 4-6 hours up to 24 hours (longer with physician consult) but, in general, repeat no more than once every 6 weeks — Consider systemic corticosteroid if • Current exacerbation is severe OR • Patient has history of previous severe exacerbations

Step down
Review treatment every 1 to 6 months. If control is sustained for at least 3 months, a gradual stepwise reduction in treatment may be possible.

Step up
If control is not achieved, consider step up. But first: review patient medication technique, adherence, and environmental control (avoidance of allergens or other precipitant factors).

NOTE:

- The stepwise approach presents guidelines to assist clinical decisionmaking. Asthma is highly variable; clinicians should tailor specific medication plans to the needs and circumstances of individual patients.
- Gain control as quickly as possible; then decrease treatment to the least medication necessary to maintain control. Gaining control may be accomplished by either starting treatment at the step most appropriate to the initial severity of their condition or by starting at a higher level of therapy (e.g., a course of systemic corticosteroids or higher dose of inhaled corticosteroids).
- A rescue course of systemic corticosteroid (prednisolone) may be needed at any time and step.
- In general, use of short-acting beta$_2$-agonist on a daily basis indicates the need for additional long-term-control therapy.
- It is important to remember that there are very few studies on asthma therapy for infants.
- Consultation with an asthma specialist is *recommended* for patients with moderate or severe persistent asthma in this age group. Consultation should be *considered* for all patients with mild persistent asthma.

- When step 3 care is required, it is the opinion of the Expert Panel that control should be established promptly with higher doses of inhaled corticosteroid and then therapy should be stepped down after 2 to 3 months to maintain control (Pedersen and Hansen 1995). For some patients, control of asthma may be maintained by using a lower dose of inhaled corticosteroid (e.g., the minimum dose in the medium-dose range) along with the addition of either nedocromil or theophylline. Some, but not all, studies with nedocromil in adults have demonstrated its potential corticosteroid-sparing effect. There are no studies demonstrating this effect with cromolyn. Studies in infants and young children are necessary. Some clinicians prefer gradually increasing medication to establish control—for example, adding nedocromil or theophylline before increasing the dose of inhaled corticosteroid beyond low-dose therapy.

- Exacerbations caused by viral respiratory infections may be intermittent yet severe. Consider systemic corticosteroids if the exacerbation is moderate to severe or at the onset of a viral respiratory infection if the patient has a history of severe exacerbations.

- Consultation with an asthma specialist should be *considered* for infants and young children requiring step 2 care; consultation is *recommended* for those requiring step 3 or step 4 care.

- Several delivery devices are available for infants and young children. The dose received may vary considerably among devices and age groups. (See figure 3-3 for a summary of therapeutic issues regarding aerosol delivery devices.) The child's caregivers must be instructed in the proper use of appropriately sized face masks, spacers/holding chambers with face masks, and spacers/holding chambers for medication delivery to be effective and efficient. For children younger than 2 years of age, nebulizer therapy may be preferred for administering cromolyn and for high doses of beta$_2$-agonists during exacerbations. Children between 3 and 5 years may begin therapy with MDI and spacer/holding chamber alone, but if the desired therapeutic effects are not achieved, they may require a nebulizer or an MDI plus spacer/holding chamber and face mask.

School-Age Children (Older Than 5 Years of Age) and Adolescents

KEY RECOMMENDATIONS FOR MANAGING ASTHMA IN SCHOOL-AGE CHILDREN AND ADOLESCENTS

- Pulmonary function testing should use appropriate reference populations. Adolescents compare better to childhood than to adult predicted norms.
- When initiating daily anti-inflammatory therapy for mild-to-moderate persistent asthma, a trial of cromolyn or nedocromil is often given.
- Adolescents (and younger children as appropriate) should be directly involved in establishing goals for therapy and developing their asthma management plans.
- Active participation in physical activities, exercise, and sports should be promoted.
- A written asthma management plan should be prepared for the student's school, including plans to ensure reliable, prompt access to medications.

The pharmacologic management of school-age children and adolescents follows the same basic principles as those for adults, but the special circumstances of growth, school, and social development require special consideration.

Assessment

Pulmonary function testing should be performed using comparison data from an appropriate reference population (American Thoracic Society 1991). Adolescents generally compare better to childhood than to adult predicted norms. Testing in a laboratory or clinic specializing in children can result in higher pulmonary function values and more consistent data. Technicians who conduct pulmonary function testing for children should have special training in achieving the best possible effort from young patients.

Treatment

For children with mild or moderate persistent asthma, cromolyn or nedocromil are often effective anti-inflammatory therapies and have no known long-term systemic effects. However, for

children with severe persistent asthma, and for many children with moderate persistent asthma, cromolyn and nedocromil do not provide adequate control and thus inhaled corticosteroids are necessary for long-term therapy (see figure 3-4b).

The Expert Panel recommends that adolescents (and younger children as appropriate) be directly involved in developing their asthma management plans. Adolescents may experience more difficulties than younger children in adhering to a medication plan because they may fail to recognize the danger of poorly controlled asthma (Strunk et al. 1985), they may not accept having a chronic illness, or they may view the plan as infringing upon their emerging independence and adulthood. In teaching adolescents the same asthma self-management techniques expected of adults, the clinician should address adolescent developmental issues such as building a positive self-image and confidence, increasing personal responsibility, and gaining problem-solving skills. To accomplish this, it is often helpful to see the adolescent initially without parents present and to involve the adolescent directly in setting goals for therapy, developing an appropriate treatment plan, and reviewing the effectiveness of the plan at repeated visits. The parents can be brought in at the end of the visit to review the plan together and emphasize the parents' important role in supporting the adolescent's efforts.

School Issues

The clinician should prepare a written asthma management plan for the student's school (see figure 4-7) that includes the following information: an action plan for handling exacerbations (including the clinician's recommendation regarding self-administration of medication and plans to ensure prompt, reliable access to medications); recommendations for long-term-control medications and prevention of exercise-induced bronchospasm (EIB), if appropriate; and identification of those factors that make the student's asthma worse so the school may help the student avoid exposure.

It is preferable to schedule daily, long-term medications so that they are not taken at school, even if this results in unequal dosing intervals throughout the day. However, in school districts that have more comprehensive school nurse coverage, children who would benefit from close supervision to promote adherence may be given medications at school. In this way, daily medication can be administered and patient education can be supplemented most days of the week.

Students with asthma often require medication during school to treat acute symptoms or to prevent EIB that may develop during physical education class, school recess, or organized sports. Reliable, prompt access to medication is essential, but it may be difficult because of school rules that preclude the child from carrying medications. The National Asthma Education and Prevention Program and several member organizations have adopted resolutions that endorse allowing students to carry and self-administer medications when the physician and parent consider this appropriate. It may be helpful for some children to have a compressor-driven nebulizer available at the school.

Sports

Physical activity at play or in organized sports is an essential part of a child's life, and full participation in physical activities should be encouraged. Many children with asthma experience cough, wheeze, or excessive fatigue when they exercise. Treatment immediately prior to vigorous activity or exercise usually prevents EIB. If symptoms occur during usual play activities, a step up in long-term therapy is warranted. Poor endurance or EIB can be an indication of poorly controlled persistent asthma; appropriate use of long-term-control medication can reduce EIB (see Exercise-Induced Bronchospasm, page 100). Activity should be limited or curtailed only as a last resort.

Older Adults

KEY RECOMMENDATIONS FOR MANAGING ASTHMA IN OLDER ADULTS

- Chronic bronchitis/emphysema may coexist with asthma. A trial of systemic corticosteroids will determine the presence of reversibility and the extent of therapeutic benefit.
- Asthma medications may aggravate coexisting medical conditions (e.g., cardiac disease, osteoporosis); adjustments in the medication plan may need to be made.
- Be aware of increased potential for adverse drug/disease interaction (e.g., aspirin, beta-blockers).
- Review of patient technique in using medications and devices is essential.

Because of the high prevalence of other obstructive lung disease (e.g., chronic bronchitis, emphysema) among the elderly, it is important to determine the extent of reversible airflow obstruction. Careful evaluation is required because the precise cause of severe airflow obstruction can be difficult to identify in older patients with asthma. A 2- to 3-week trial of therapy with systemic corticosteroids can help detect the presence of significant reversibility of the airway disease. Long-term-control asthma medication can then be offered.

Asthma medications may have increased adverse effects in the elderly patient; adjustments in the medication plan may be necessary.

- Airway response to *bronchodilators* may change with age, although this is not clearly established. Older patients, especially those with preexisting ischemic heart disease, may also be more sensitive to beta$_2$-agonist side effects, including tremor and tachycardia. Concomitant use of anticholinergics and beta$_2$-agonists may be beneficial to the older patient (Ullah et al. 1981; Barros and Rees 1990; Gross et al. 1989).

- *Theophylline* clearance is reduced in the elderly patient (Nielsen-Kudsk et al. 1988), causing increased blood levels of theophylline. In addition, age is an independent risk factor for developing life-threatening events from iatrogenic chronic theophylline overdose (patients 75 years of age or older have a 16-fold greater risk of death from theophylline overdose than do 25-year-olds) (Shannon and Lovejoy 1990). The potential for drug interaction—especially with antibiotics and H_2-histamine antagonists such as cimetidine—is greater because of the increased use of medications in this age group. Theophylline and epinephrine may exacerbate underlying heart conditions.

- *Systemic corticosteroids* can provoke confusion, agitation, and changes in glucose metabolism.

- A dose-dependent reduction in bone mineral content may be associated with *inhaled corticosteroid* use, although low or medium doses appear to have no major adverse effect. Elderly patients may be more at risk due to preexisting osteoporosis, changes in estrogen levels that affect calcium utilization, and a sedentary lifestyle. However, the risk of not adequately controlling asthma may unnecessarily limit the patient's mobility and activities. Concurrent treatment with calcium supplements and vitamin D, and estrogen replacement when appropriate, are recommended. At the present time, the optimal approach for identifying patients at risk for accelerated bone loss from high-dose corticosteroid therapy is to conduct bone densitometry when treatment begins and again 6 months later (NHLBI 1996), although the benefits of this approach have not yet been evaluated in clinical trials.

Medications employed for other diseases may exacerbate asthma; adjustments may need to be made. Nonsteroidal anti-inflammatory agents for treating arthritis, nonselective beta-blockers for treating hypertension, or beta-blockers found in some eye drops used to treat glaucoma may exacerbate asthma. See component 2 for more details on drugs that can complicate asthma management.

For more information on asthma in older patients, see *NAEPP Working Group Report: Considerations for Diagnosing and Managing Asthma in the Elderly* (NHLBI 1996).

MANAGING SPECIAL SITUATIONS IN ASTHMA

Seasonal Asthma

Some patients experience asthma symptoms only in relationship to certain pollens and molds. Such seasonal asthma should be treated according to the stepwise approach to long-term management of asthma. If the patient has seasonal asthma on a predictable basis, daily, long-term anti-inflammatory therapy (inhaled corticosteroids, cromolyn, or nedocromil) should be initiated prior to the anticipated onset of symptoms and continued through the season.

Cough Variant Asthma

Cough variant asthma is seen especially in young children. Cough is the principal symptom; because this frequently occurs at night, examinations during the day may be normal. Monitoring of morning and afternoon PEF variability and/or therapeutic trials with anti-inflammatory or bronchodilator medication may be helpful in diagnosis. Once the diagnosis is established, treat according to the stepwise approach to long-term management of asthma.

Exercise-Induced Bronchospasm

Exercise-induced bronchospasm—which untreated can limit and disrupt otherwise normal lives—should be anticipated in all asthma patients. EIB is a bronchospastic event that is caused by a loss of heat, water, or both from the lung during exercise because of hyperventilation of air that is cooler and dryer than that of the respiratory tree (Anderson 1985; Godfrey 1986; McFadden and Gilbert 1994). EIB usually occurs during or minutes after vigorous activity, reaches its peak 5 to 10 minutes after stopping the activity, and usually resolves in another 20 to 30 minutes.

Exercise may be the only precipitant of asthma symptoms for some patients. These patients should be monitored regularly to ensure that they have no symptoms of asthma or reductions in PEF in the absence of exercise, because EIB is often a marker of inadequate asthma management and responds well to regular anti-inflammatory therapy.

Diagnosis

A history of cough, shortness of breath, chest pain or tightness, wheezing, or endurance problems during exercise suggests EIB. An exercise challenge can be used to establish the diagnosis. This can be performed in a formal laboratory setting or as a free-run challenge sufficiently strenuous to increase the baseline heart rate to 80 percent of maximum for 4 to 6 minutes. Alternatively, the patient may simply undertake the task that previously caused the symptoms. A 15 percent decrease in PEF or FEV_1 (measurements taken before and after exercise at 5-minute intervals for 20 to 30 minutes) is compatible with EIB.

Management Strategies

One goal of management is to enable patients to participate in any activity they choose without experiencing asthma symptoms. EIB should not limit either participation or success in vigorous activities. Recommended treatments include:

- $Beta_2$-agonists will prevent EIB in more than 80 percent of patients.
  - — Short-acting inhaled $beta_2$-agonists used shortly before exercise (or as close to exercise as possible) may be helpful for 2 to 3 hours.
  - — Salmeterol has been shown to prevent EIB for 10 to 12 hours (Kemp et al. 1994).
- Cromolyn and nedocromil, taken shortly before exercise, are also acceptable for preventing EIB (Tullett et al. 1985; Woolley et al. 1990; Albazzaz et al. 1989; de Benedictis et al. 1995).
- A lengthy warmup period before exercise may benefit patients who can tolerate continuous exercise with minimal symptoms. The warmup may preclude a need for repeated medications.
- Long-term-control therapy, if appropriate. There is evidence that appropriate long-term control of asthma with anti-inflammatory medication will reduce airway responsiveness, and this is associated with a reduction in the frequency and severity of EIB (Vathenen et al. 1991).

Teachers and coaches need to be notified that a child has EIB, should be able to participate in activities, and may need inhaled medication before activity. Individuals involved in competitive athletics need to be aware that their medication use should be disclosed and should adhere to standards set by the U.S. Olympic Committee (Nastasi et al. 1995). The U.S. Olympic Committee's Drug Control Hotline is 1-800-233-0393.

Surgery and Asthma

Asthma patients are at risk for specific complications during and after surgery: acute bronchoconstriction triggered by intubation, hypoxemia and possible hypercapnia, impaired effectiveness of cough, atelectasis and respiratory infection (Kingston and Hirshman 1984), and latex exposure (Slater 1994; Sussman and Beezhold 1995). The likelihood of these complications depends on the severity of the patient's airway hyperresponsiveness, airflow obstruction, mucus hypersecretions, and latex sensitivity.

Recommended actions include:

- Patients with asthma should have an evaluation before surgery that includes a review of symptoms, medication use (particularly the use of systemic corticosteroids for longer than 2 weeks in the past 6 months), and measurement of pulmonary function.

- If possible, attempts should be made to improve lung function (FEV_1 or PEF) to their predicted values or their personal best level. A short course of systemic corticosteroids may be necessary to optimize pulmonary function.

- For patients who have received systemic corticosteroids during the past 6 months, give 100 mg hydrocortisone every 8 hours intravenously during the surgical period and reduce dose rapidly within 24 hours following surgery.

Pregnancy and Asthma

Maintaining sufficient lung function and blood oxygenation to ensure adequate oxygen supply to the fetus is essential. Poorly controlled asthma during pregnancy can result in increased perinatal mortality, increased prematurity, and low birth weight (Nelson and Weber 1988). For most drugs used to treat asthma and rhinitis, with the exception of brompheniramine, epinephrine, and alpha-adrenergic compounds (other than pseudoephedrine), there is little to suggest an increased risk to the fetus (Schatz et al. 1988; *Federal Register* 1979; Briggs et al. 1986). Other classes of drugs with some possibility of risk to the fetus include decongestants (other than pseudoephedrine), antibiotics (tetracycline, sulfonamides, and ciprofloxacin), live virus vaccines, immunotherapy (if doses are increased), and iodides.

For more information on asthma and pregnancy, see *Executive Summary: Management of Asthma During Pregnancy* (NHLBI 1992).

Stress and Asthma

The role of stress and psychological factors in asthma is important but not fully defined. There is emerging evidence that stress can play an important role in precipitating exacerbations of asthma and possibly act as a risk factor for an increase in prevalence of asthma (Busse et al. 1995). The mechanisms involved in this process have yet to be fully established and may involve enhanced generation of proinflammatory cytokines (Friedman et al. 1994). Equally important are psychosocial factors that are associated with poor outcome (e.g., conflict between patients and family and the medical staff, inappropriate asthma self-care, depressive symptoms, behavioral problems, emotional problems, and disregard of perceived asthma symptoms) (Strunk et al. 1985; Strunk 1993; Brush and Mathé 1993).

REFERENCES

Agertoft L, Pedersen S. Importance of the inhalation device on the effect of budesonide. *Arch Dis Child* 1993;69:130-3.

Agertoft L, Pedersen S. Effects of long-term treatment with an inhaled corticosteroid on growth and pulmonary function in asthmatic children. *Respir Med* 1994;88:373-81.

Albazzaz MK, Neale MG, Patel KR. Dose-response study of nebulized nedocromil sodium in exercise induced asthma. *Thorax* 1989;44:816-9.

Allen DB, Lemanske RF Jr. The safety of chronic asthma treatments: continuous beta agonist therapy and prolonged inhaled corticosteroids in childhood asthma. In: Middleton E Jr, Reed CE, Ellis EF, Adkinson NF Jr, Yunginger JW, Busse WW, eds. *Allergy: Principles and Practice*. 4th ed. St. Louis, MO: Mosby Yearbook, 1993. pp. 1-16.

American Thoracic Society. Lung function testing: selection of reference values and interpretive strategies. *Am Rev Respir Dis* 1991;144:1202-18.

Anderson SD. Issues in exercise-induced asthma. *J Allergy Clin Immunol* 1985;76:763-72.

Ayres JG, Bateman ED, Lundback E, Harris TAJ. High dose fluticasone propionate, 1 mg daily, versus fluticasone propionate, 2 mg daily, or budesonide, 1.6 mg daily, in patients with chronic severe asthma. *Eur Respir J* 1995;8(4):579-86.

Barnes NC, Marone G, Di Maria GU, Visser S, Utama I, Payne SL. A comparison of fluticasone propionate, 1 mg daily, with beclomethasone dipropionate, 2 mg daily, in the treatment of severe asthma. *Eur Respir J* 1993;6:877-85.

Barnes PJ. Inhaled glucocorticoids for asthma. *N Engl J Med* 1995;332:868-75.

Barnes PJ, Pedersen S. Efficacy and safety of inhaled corticosteroids in asthma. *Am Rev Respir Dis* 1993;148:S1-S26.

Barros MJ, Rees PJ. Bronchodilator responses to salbutamol followed by ipratropium bromide in partially reversible airflow obstruction. *Respir Med* 1990;84:371-5.

Beam WR, Weiner DE, Martin RJ. Timing of prednisone and alterations of airways inflammation in nocturnal asthma. *Am Rev Respir Dis* 1992;146(6):1524-30.

Bertelsen A, Andersen JB, Busch P, et al. Nebulised sodium cromoglycate in the treatment of wheezy bronchitis: a multicentre double-blind placebo controlled study. *Allergy* 1986;41:266-70.

Bisgaard H, Munck SL, Nielsen JP, Petersen W, Ohlsson SV. Inhaled budesonide for treatment of recurrent wheezing in early childhood. *Lancet* 1990;336:649-51.

Bisgaard H, Nielsen MD, Anderson B, et al. Adrenal function in children with bronchial asthma treated with beclomethasone dipropionate or budesonide. *J Allergy Clin Immunol* 1988;81:1088-95.

Bjorkander J, Formgren N, Johansson SA, Millqvist E. Methodological aspects on clinical trials with inhaled corticosteroids: results of two comparisons between two steroid aerosols in patients with asthma. *Eur J Respir Dis* 1982;63(suppl 122):108-17.

Briggs GG, Freeman RK, Yaffe SJ. *Drugs in Pregnancy and Lactation: A Reference Guide to Fetal and Neonatal Risk.* 2nd ed. Baltimore, MD: Williams & Wilkins, 1986.

Brogden RN, Sorkin EM. Nedocromil sodium. An updated review of its pharmacological properties and therapeutic efficacy in asthma. *Drugs* 1993;45:693-715.

Brush J, Mathé A. Psychiatric aspects. In: Weiss EB, Stein M, eds. *Bronchial Asthma*. Boston: Little, Brown and Company, 1993. pp. 1121-31.

Busse WW, Kiecolt-Glaser JK, Coe C, Martin RJ, Weiss ST, Parker SR. NHLBI workshop summary. Stress and asthma. *Am J Respir Crit Care Med* 1995;151:249-52.

Chaplin MD, Rooks II W, Swenson EW, Cooper WC, Nerenberg C, Chu NI. Flunisolide metabolism and dynamics of a metabolite. *Clin Pharmacol Ther* 1980;27:402-13.

Check WA, Kaliner MA. Pharmacology and pharmacokinetics of topical corticosteroid derivatives used for asthma therapy. *Am Rev Respir Dis* 1990;141(suppl):S44-S51.

Clark DJ, Grove A, Cargill RI, Lipworth BJ. Comparative adrenal suppression with inhaled budesonide and fluticasone propionate in adult asthmatic patients. *Thorax* 1996;51:262-6.

Clissold SP, Heel RC. Budesonide: a preliminary review of its pharmacodynamic properties and therapeutic efficacy in asthma and rhinitis. *Drugs* 1984;28:485-518.

Cockcroft DW, Murdock KY. Comparative effects of inhaled salbutamol, sodium cromoglycate, and beclomethasone dipropionate on allergen-induced early asthmatic responses, late asthmatic responses, and increased bronchial responsiveness to histamine. *J Allergy Clin Immunol* 1987;79:734-40.

Connett GJ, Warde C, Wooler E, Lenney W. Use of budesonide in severe asthmatics aged 1-3 years. *Arch Dis Child* 1993;69:351-5.

Dahl R, Lundback E, Malo JL, et al. A dose-ranging study of fluticasone propionate in adult patients with moderate asthma. *Chest* 1993;104:1352-8.

Dahlberg E, Thalen A, Brattsand R, et al. Correlation between chemical structure, receptor binding, and biological activity of some novel, highly active, 16 alpha, 17 alpha-acetal-substituted glucocorticoids. *Mol Pharmacol* 1984;25:70-8.

Davies B. A comparison of beclomethasone dipropionate and budesonide in the treatment of asthma. *Br J Clin Prac* 1993;47:87-93.

de Benedictis FM, Tuteri G, Pazzelli P, Bertotto A, Bruni L. Vaccaro R. Cromolyn versus nedocromil: duration of action in exercise-induced asthma in children. *J Allergy Clin Immunol* 1995;96:510-4.

Ebden P, Jenkins A, Houston G, Davies BH. Comparison of two high dose corticosteroid aerosol treatments, beclomethasone dipropionate (1500 mcg/day) and budesonide (1600 mcg/day), for chronic asthma. *Thorax* 1986;41:869-74.

Fabbri L, Burge PS, Croonenborgh L, et al. on behalf of an International Study Group. Comparison of fluticasone propionate with beclomethasone dipropionate in moderate to severe asthma treated for one year. *Thorax* 1993;48:817-23.

Federal Register. 21 CFR Parts 201 and 202. 1979;44(124):37434-67.

Friedman EM, Coe CL, Ershler WB. Bidirectional effects of interleukin-1 on immune responses in rhesus monkeys. *Brain Behav Immun* 1994;8:87-99.

Geller-Bernstein C, Sneh N. The management of bronchial asthma in children under the age of $3^1/_2$ years using Intal (sodium cromoglycate) administered by Spinhaler. *Clin Allergy* 1980;10:503-8.

Glass J, Archer LN, Adams W, Simpson H. Nebulised cromoglycate, theophylline, and placebo in preschool asthmatic children. *Arch Dis Child* 1981;56:648-51.

Gleeson JG, Price JF. Controlled trial of budesonide given by the nebuhaler in preschool children with asthma. *BMJ* 1988;297:163-6.

Godfrey S. Controversies in the pathogenesis of exercise-induced asthma. *Eur J Respir Dis* 1986;68:81-8.

Greening AP, Ind P, Northfield M, Shaw G. Added salmeterol versus higher-dose corticosteroid in asthma patients with symptoms on existing inhaled corticosteroid. *Lancet* 1994;344:219-24.

Gross NJ, Petty TL, Friedman M, Skorodin MS, Silvers GW, Donohue JF. Dose response to ipratropium as a nebulized solution in patients with chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1989;139:1188-91.

Gustafsson P, Tsanakas J, Gold M, Primhak R, Radford M, Gillies E. Comparison of the efficacy and safety of inhaled fluticasone 200 mcg/day in mild and moderate asthma. *Arch Dis Child* 1993;69:206-11.

Haahtela T, Jarvinen M, Kava T, et al. Comparison of a beta$_2$-agonist, terbutaline, with an inhaled corticosteroid, budesonide, in newly detected asthma. *N Engl J Med* 1991;325:388-92.

Haahtela T, Jarvinen M, Kava T, et al. Effects of reducing or discontinuing inhaled budesonide in patients with mild asthma. *N Engl J Med* 1994;331:700-5.

Harding SM. The human pharmacology of fluticasone propionate. *Respir Med* 1990;84(suppl A):25-9.

Heald D, Argenti D, Jensen B, Vaccaro S. The disposition of 14C triamcinolone acetonide administrated as single oral dose of 100 mci (800mg) to healthy volunteers. Presented at Asthma Theory to Treatment, Chicago, IL, July 15-17, 1995. (data on file Rhône-Poulenc Rorer)

Hilman BC, Bairnsfather L, Washburne W, Vekovius AL. Nebulized cromolyn sodium: safety, efficacy, and role in the management of childhood asthma. *Pediatr Allergy Immunol* 1987;1:43-52.

Högger P, Rohdewald P. Binding kinetics of fluticasone propionate to the human glucocorticoid receptor. *Steroids* 1994;59:597-602.

Ilangovan P, Pedersen S, Godfrey S, Nikander K, Noviski N, Warner JO. Treatment of severe steroid dependent preschool asthma with nebulised budesonide suspension. *Arch Dis Child* 1993;68:356-9.

Johnson M. Pharmacodynamics and pharmacokinetics of inhaled glucocorticoids. *J Allergy Clin Immunol* 1996;97(1 Pt 2):169-76.

Kamada A, Szefler SJ, Martin RJ, et al. and the Asthma Clinical Research Network. Issues in the use of inhaled glucocorticoids. *Am J Respir Crit Care Med* 1996;153:1739-48.

Kemp JP, Dockhorn RJ, Busse WW, Bleecker ER, Van As A. Prolonged effect of inhaled salmeterol against exercise-induced bronchospasm. *Am J Respir Crit Care Med* 1994;150:1612-5.

Kerstjens HAM, Brand PLP, Hughes MD, et al. A comparison of bronchodilator therapy with or without inhaled corticosteroid therapy for obstructive airways disease. *N Engl J Med* 1992;327:1413-9.

Kingston HG, Hirshman CA. Perioperative management of the patient with asthma. *Anesth Analg* 1984;63:844-55.

Lal S, Dorow PD, Venho KK, Chatterjee SS. Nedocromil sodium is more effective than cromolyn sodium for the treatment of chronic reversible obstructive airway disease. *Chest* 1993;104:438-47.

Langdon CG, Capsey LJ. Fluticasone propionate and budesonide in adult asthmatics: a comparison using dry powder inhaler devices *Br J Clin Res* 1994;5:85-91.

Leblanc P, Mink S, Keistinen T, Saarelainen PA, Ringdal N, Payne SL. A comparison of fluticasone propionate 200 mcg/day with beclomethasone dipropionate 400 mcg/day in adult asthma. *Allergy* 1994;49:380-5.

Lipworth BJ. New perspectives on inhaled drug delivery and systemic bioactivity. *Thorax* 1995;50:105-10.

Lundback B, Alexander M, Day J, et al. Evaluation of fluticasone propionate (500 mcg day-1) administered either as dry power inhaler via a Diskhaler inhaler or pressurized inhaler and compared with beclomethasone dipropionate (1000 mcg day-1) administered by pressurized inhaler. *Respir Med* 1993;87:609-20.

Martin LE, Tanner RJN, Clark THJ, Cochrane GM. Absorption and metabolism of orally administered beclomethasone dipropionate. *Clin Pharmacol Ther* 1974;15:267-75.

Martinez FD. Viral infections and the development of asthma. *Am J Respir Crit Care Med* 1995;151:1644-7.

Martinez FD, Wright AL, Taussig LM, Holberg CJ, Halonen M, Morgan WJ, Group Health Medical Associates. Asthma and wheezing in the first six years of life. *N Engl J Med* 1995;332:133-8.

McCubbin MM, Milavetz G, Grandgeorge S, et al. A bioassay for topical and systemic effect of three inhaled corticosteroids. *Clin Pharmacol Ther* 1995;57:455-60.

McFadden ER Jr, Gilbert IA. Exercise-induced asthma. *N Engl J Med* 1994;330:1362-7.

Miraglia del Giudice, Capristo A, Maiello, Apuzzo G. Nebulized sodium cromoglycate for the treatment of asthma in children under five years of age. *Mod Probl Paediat* 1982;21:122-7.

Mollman H, Rohdewald P, Schmidt EW, Salomon V, Derendorf H. Pharmacokinetics of triamcinolone acetonide and its phosphate ester. *Eur J Clin Pharmacol* 1985;29:85-9.

Nassif EG, Weinberger M, Thompson R, Huntley W. The value of maintenance theophylline in steroid-dependent asthma. *N Engl J Med* 1981;304:71-5.

Nastasi KJ, Heinly TL, Blaiss MS. Exercise-induced asthma and the athlete. *J Asthma* 1995;32:249-57.

National Heart, Lung, and Blood Institute. *NAEPP Working Group Report: Considerations for Diagnosing and Managing Asthma in the Elderly*. National Institutes of Health pub no 96-3662. Bethesda, MD, 1996.

National Heart, Lung, and Blood Institute. *Executive Summary: Management of Asthma During Pregnancy*. National Institutes of Health pub no 92-3279a. Bethesda, MD, 1992.

Nelson HS, Weber RW. Endocrine aspects of allergic diseases. In: Bierman CW, Pearlman DS, eds. *Allergic Diseases From Infancy to Adulthood*. Philadelphia: WB Saunders, 1988, ch. 15.

Nielsen-Kudsk JE, Mellemkjaer S, Siggaard C, Nielsen CB. Effects of pinacidil on guinea-pig airway smooth muscle contracted by asthma mediators. *Eur J Pharmacol* 1988;157:221-6.

O'Hickey SP, Rees PJ. High-dose nedocromil sodium as an addition to inhaled corticosteroids in the treatment of asthma. *Respir Med* 1994;88:499-502.

Pedersen S, Fuglsang G. Urine cortisol excretion in children treated with high doses of inhaled corticosteroids: a comparison of budesonide and beclomethasone. *Eur Respir J* 1988;1:433-5.

Pedersen S, Hansen OR. Budesonide treatment of moderate and severe asthma in children: a dose-response study. *J Allergy Clin Immunol* 1995;95:29-33.

Prahl P. Adrenocortical suppression following treatment with beclomethasone and budesonide. *Clin Exp Allergy* 1991;21:145-6.

Prahl P, Jensen T, Bjerregaard-Andersen H. Adrenocortical function in children on high-dose steroid aerosol therapy. *Allergy* 1987;42:541-4.

Pullan CR, Hey EN. Wheezing, asthma, and pulmonary dysfunction 10 years after infection with respiratory syncytial virus in infancy. *BMJ* 1982;284:1665-9.

Rafferty P, Tucker LG, Frame MH, Fergusson RJ, Biggs BA, Crompton GK. Comparison of budesonide and beclomethasone dipropionate in patients with severe chronic asthma: assessment of relative prednisolone-sparing effects. *Br J Dis Chest* 1985;79:244-50.

Schatz M, Zeiger RS, Harden KM, et al. The safety of inhaled beta-agonist bronchodilators during pregnancy. *J Allergy Clin Immunol* 1988;82:686-95.

Shannon M, Lovejoy FH. The influence of age vs peak serum concentration on life-threatening events after chronic theophylline intoxication. *Arch Intern Med* 1990;150:2045-8.

Shapiro GG, Konig P. Cromolyn sodium: a review. *Pharmacotherapy* 1985;5:156-70.

Silverman M, Connolly NM, Balfour-Lynn L, Godfrey S. Long-term trial of disodium cromoglycate and isoprenaline in children with asthma. *BMJ* 1972;3:378-81.

Slater JE. Latex allergy. *J Allergy Clin Immunol* 1994;94:139-49.

Sporik R, Holgate ST, Cogswell JJ. Natural history of asthma in childhood—a birth cohort study. *Arch Dis Child* 1991;66:1050-3.

Stiksa G, Glennow C, Johannesson N. An open crossover trial with budesonide and beclomethasone dipropionate in patients with bronchial asthma. *Eur J Respir Dis* 1982;63(suppl 122):266-7.

Strunk RC. Death due to asthma. *Am Rev Respir Dis* 1993;148:550-2.

Strunk RC, Mrazek DA, Wolfson-Fuhrman GS, LaBrecque JF. Physiological and psychological characteristics associated with deaths due to asthma in childhood. A case-controlled study. *JAMA* 1985;254:1193-8.

Sussman GL, Beezhold DH. Allergy to latex rubber. *Ann Intern Med* 1995;122:43-6.

Svendsen UG, Jorgensen H. Inhaled nedocromil sodium as additional treatment to high dose inhaled corticosteroids in the management of bronchial asthma. *Eur Respir J* 1991;4:992-9.

Szefler SJ. Glucocorticoid therapy for asthma: clinical pharmacology. *J Allergy Clin Immunol* 1991;88:147-65.

Thorsson L, Edsbacker S, Conradson TB. Lung deposition of budesonide from Turbuhaler is twice that from a pressurized metered-dose inhaler P-MDI. *Eur Respir J* 1994;7:1839-44.

Tullett WM, Tan KM, Wall RT, Patel KR. Dose-response effect of sodium cromoglycate pressurized aerosol in exercise induced asthma. *Thorax* 1985;40:41-4.

Ullah MI, Newman GB, Saunders KB. Influence of age on response to ipratropium and salbutamol in asthma. *Thorax* 1981;36:523-9.

van Essen-Zandvliet EE, Hughes MD, Waalkens HJ, Duiverman EJ, Pocock SJ, Kerrebijn KF. Effects of 22 months of treatment with inhaled corticosteroids and/or beta$_2$-agonists on lung function, airway responsiveness, and symptoms in children with asthma. *Am Rev Respir Dis* 1992;146:547-54.

Vathenen AS, Knox AJ, Wisniewski A, Tattersfield AE. Effect of inhaled budesonide on bronchial reactivity to histamine, exercise, and eucapnic dry air hyperventilation in patients with asthma. *Thorax* 1991;46:811-6.

Waalkens HJ, van Essen-Zandvliet EE, Hughes MD, et al. Cessation of long-term treatment with inhaled corticosteroid (budesonide) in children with asthma results in deterioration. *Am Rev Respir Dis* 1993;148:1252-7.

Willey RF, Godden DJ, Carmichael J, Preston P, Frame M, Crompton GK. Comparison of twice daily administration of a new corticosteroid budesonide with beclomethasone dipropionate four times daily in the treatment of chronic asthma. *Br J Dis Chest* 1982;76:61-8.

Woolcock A, Lundback B, Ringdal N, Jacques LA. Comparison of addition of salmeterol to inhaled steroids with doubling of the dose of inhaled steroid. *Am J Respir Crit Care Med* 1996;153:1481-8.

Wong CS, Cooper S, Britton JR, Tattersfield AE. Steroid sparing effect of nedocromil sodium in asthmatic patients on high doses of inhaled steroids. *Clin Exp Allergy* 1993;23:370-6.

Woolley M, Anderson SD, Quigley BM. Duration of terbutaline sulfate and cromolyn sodium alone and in combination on exercise-induced asthma. *Chest* 1990;97:39-45.

Wurthwein G, Rohdewald P. Activation of beclomethasone dipropionate by hydrolysis to beclomethasone-17-monopropionate. *Biopharm Drug Dispos* 1990;11:381-94.

Pharmacologic Therapy: Managing Exacerbations of Asthma

KEY POINTS

- Early treatment of asthma exacerbations is the best strategy for management. Important elements of early treatment include:
  - A written action plan to guide patient self-management of exacerbations at home, especially for patients with moderate-to-severe persistent asthma and any patient with a history of severe exacerbations
  - Recognition of early signs of worsening asthma
  - Appropriate intensification of therapy
  - Prompt communication between patient and clinician about any serious deterioration in symptoms or peak flow, decreased responsiveness to inhaled beta$_2$-agonists, or decreased duration of effect
- Management of asthma exacerbations includes:
  - Inhaled beta$_2$-agonist to provide prompt relief of airflow obstruction
  - Systemic corticosteroids, for moderate-to-severe exacerbations or for patients who fail to respond promptly and completely to an inhaled beta$_2$-agonist, to suppress and reverse airway inflammation
  - Oxygen to relieve hypoxemia for moderate-to-severe exacerbations
  - Monitoring response to therapy with serial measurements of lung function

Asthma exacerbations are acute or subacute episodes of progressively worsening shortness of breath, cough, wheezing, and chest tightness or some combination of these symptoms. Exacerbations are characterized by decreases in expiratory airflow that can be documented and quantified by simple measurement of lung function (spirometry or peak expiratory flow [PEF]). These objective measures more reliably indicate the severity of an exacerbation than does the severity of symptoms.

GENERAL CONSIDERATIONS

The Expert Panel recommends that clinicians consider the following general principles and goals for managing asthma exacerbations, based on the scientific literature and the opinion of the Panel.

- Early treatment is the best strategy for management of asthma exacerbations. Important elements of early treatment include:
  - A written action plan (see figure 4-5) to guide patient self-management, especially for patients with moderate-to-severe persistent asthma and any patient with a history of severe exacerbations
  - Recognition of early indicators of an exacerbation, including worsening FEV_1 or PEF
  - Prompt communication between patient and clinician about any serious deterioration in symptoms or peak flow, decreased responsiveness to inhaled beta$_2$-agonist, or decreased duration of effect
  - Appropriate intensification of therapy, often including a short course of systemic corticosteroids
  - Removal of or withdrawal from allergic or irritant precipitants in the environment that may be contributing to the exacerbation
- Patients at high risk of asthma-related death require special attention—particularly intensive education, monitoring, and care. They should be counseled to seek medical care early during an exacerbation and instructed about the availability of ambulance services. Such patients include those with identifiable risk factors (see figure 3-7a).

- Infants require special attention, especially due to their greater risk for respiratory failure (see figure 3-7b).

TREATMENT GOALS

The principal goals for treating asthma exacerbations are:

- Correction of significant hypoxemia by administering supplemental oxygen. In rare instances, alveolar hypoventilation requires mechanically assisted ventilation.
- Rapid reversal of airflow obstruction. This is best achieved by
  - —Repetitive or continuous administration of an inhaled beta$_2$-agonist (Brenner 1983b; Lipworth et al. 1988; McFadden 1989; Lin et al. 1993; Rudnitsky et al. 1993; Papo et al. 1993)

AND

  - —Early in the course of treatment, administration of systemic corticosteroids to patients with moderate-to-severe exacerbations or to patients who fail to respond promptly and completely to an inhaled beta$_2$-agonist (Fanta et al. 1983; Littenberg and Gluck 1986; Rowe et al. 1992; Scarfone et al. 1993; Connett et al. 1994).
- Reduction of the likelihood of recurrence of severe airflow obstruction by intensifying therapy. Often, a short course of systemic corticosteroids is useful (Fanta et al. 1983; Littenberg and Gluck 1986; Rowe et al. 1992; Scarfone et al. 1993; Connett et al. 1994).

Achieving these goals requires close monitoring by serial measurements of lung function to quantify the severity of airflow obstruction and its response to treatment. The improvement in FEV_1

FIGURE 3-7a. RISK FACTORS FOR DEATH FROM ASTHMA

- Past history of sudden severe exacerbations
- Prior intubation for asthma
- Prior admission for asthma to an intensive care unit
- Two or more hospitalizations for asthma in the past year
- Three or more emergency care visits for asthma in the past year
- Hospitalization or an emergency care visit for asthma within the past month
- Use of >2 canisters per month of inhaled short-acting beta$_2$-agonist
- Current use of systemic corticosteroids or recent withdrawal from systemic corticosteroids
- Difficulty perceiving airflow obstruction or its severity
- Comorbidity, as from cardiovascular diseases or chronic obstructive pulmonary disease
- Serious psychiatric disease or psychosocial problems
- Low socioeconomic status and urban residence
- Illicit drug use
- Sensitivity to *Alternaria*

Sources: Kallenbach et al. 1993; Rodrigo and Rodrigo 1993; Suissa et al. 1994; Greenberger et al. 1993; O'Hollaren et al. 1991

FIGURE 3-7b. SPECIAL CONSIDERATIONS FOR INFANTS

- Assessment depends on physical examination rather than objective measurements. Use of accessory muscles, paradoxical breathing, cyanosis, and a respiratory rate >60 are key signs of serious distress.
- Objective measurements such as oxygen saturation of <91 percent also indicate serious distress.
- Response to beta$_2$-agonist therapy can be variable and may not be a reliable predictor of satisfactory outcome. However, because infants are at greater risk for respiratory failure, a *lack* of response noted by either physical examination or objective measurements should be an indication for hospitalization.
- 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 may be accompanied by fever. Antibiotics are generally not required.

after 30 minutes of treatment correlates significantly with a broad range of indices of the severity of asthma exacerbations (Rodrigo and Rodrigo 1993), and repeated measurement of airflow in the emergency department can help reduce unnecessary admissions (Taylor 1994). Use PEF or FEV_1 values to guide treatment decisions, along with the patient's history, current symptoms, and physical findings. In using PEF expressed as a percentage of personal best, it is important to consider the impact of irreversible airflow obstruction. For a patient whose best PEF is 160 L/min, for example, a fall of 40 percent represents severe, potentially life-threatening obstruction.

HOME MANAGEMENT OF ASTHMA EXACERBATIONS

Beginning treatment at home avoids treatment delays, prevents exacerbations from becoming severe, and also adds to patients' sense of control over their asthma. The degree of care provided in the home depends on the patients' (or parents') abilities and experience and on the availability of emergency care. General guidelines for managing exacerbations at home are presented in figure 3-8.

The Expert Panel recommends the following actions to prepare patients for home management of asthma exacerbations, based on scientific literature (see component 1-Periodic Assessment and Monitoring and component 4) and the opinion of the Panel.

- Teach all patients how to monitor symptoms to recognize early signs of deterioration (see component 1-Periodic Assessment and Monitoring and component 4) and how to adjust their medications accordingly.

- Teach patients with moderate-to-severe persistent asthma and those with a history of severe exacerbations how to monitor their peak flow to assess the severity of an exacerbation and the response to therapy (see component 1-Periodic Assessment and Monitoring). In the absence of PEF measurement, severity can be judged only from the presence and intensity of signs and symptoms (see figure 3-9), which correlate imperfectly with the severity of airflow obstruction. This is especially true in a subgroup of patients ("poor perceivers") who do not sense airway narrowing until it is far advanced (Kikuchi et al. 1994).

- Give a *written* asthma action plan to be followed in the event of an exacerbation (see figure 4-5), especially to patients with moderate-to-severe persistent asthma and any patient with a history of severe exacerbations. Children should also receive a plan appropriate to the school setting (see figure 4-7). The plan should direct the patient to adjust medications in response to particular signs, symptoms, and peak flow measurements and should state when to seek medical help. Review the plan with the patient and family. The clinician should tailor the plan to the needs of individual patients. Patients at risk for asthma death (see figure 3-7a) require especially close monitoring.

- Teach patients to seek medical help early if (1) an asthma exacerbation is severe, (2) therapy does not give rapid, sustained improvement, or (3) there is further deterioration.

- Advise patients with moderate-to-severe persistent asthma or a history of severe exacerbations to have the medication (e.g., corticosteroid tablets or liquid) and equipment (e.g., peak flow meter, compressor-driven nebulizer for young children) for treating exacerbations at home.

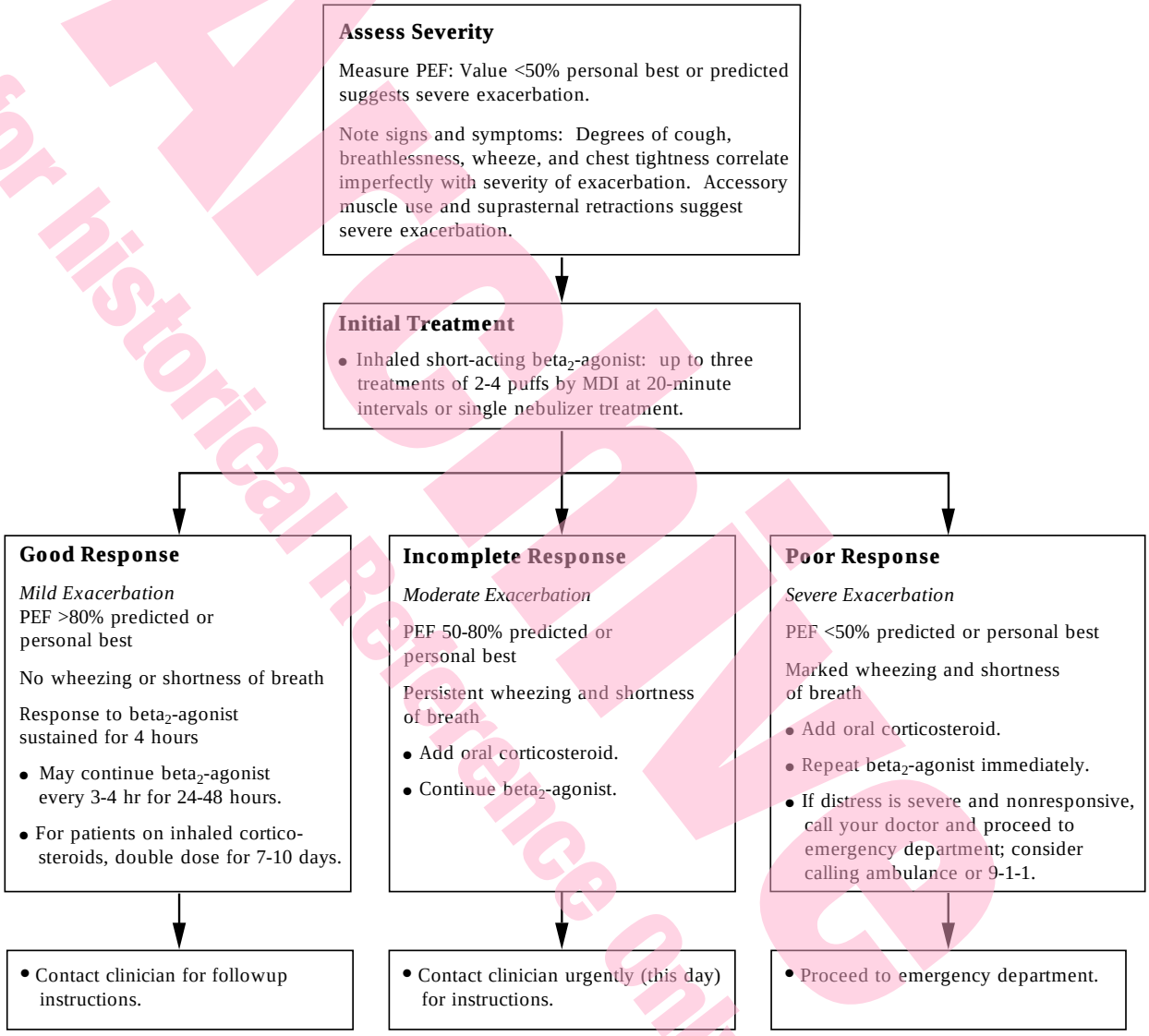
The Expert Panel recommends the following pharmacologic therapy, based on the scientific literature, for home management of exacerbations:

- Increase the frequency of inhaled $beta_2$-agonist.

- Initiate or increase corticosteroid treatment under certain circumstances. For mild exacerbations in patients already taking an inhaled corticosteroid, many experts prescribe doubling the dose until peak flow returns to predicted or personal best. Although this practice has not been proved in a clinical trial, a few studies suggest its benefit (Lahdensuo et al. 1996; Wilson and Silverman 1990). For moderate-to-severe exacerbations (see figure 3-9), and for mild exacerbations that persist despite an increased dose of inhaled corticosteroids, a course of oral corticosteroids is necessary (Chapman et al. 1991; Fiel et al. 1983; Harris et al. 1987; Deshpande and McKenzie 1986; Loren et al. 1980; Rowe et al. 1992).

- Continue more intensive treatment for several days. Recovery from an exacerbation is often gradual. Greater use of medication should be continued until symptoms and PEF are stable, but

FIGURE 3-8. MANAGEMENT OF ASTHMA EXACERBATIONS: HOME TREATMENT



Note:
Patients at high risk of asthma-related death (see figure 3-7a) should receive immediate attention clinical attention after initial treatment. Additional therapy may be required.

FIGURE 3-9. CLASSIFYING SEVERITY OF ASTHMA EXACERBATIONS

	Mild	Moderate	Severe	Respiratory Arrest Imminent
Symptoms				
Breathlessness	While walking	While talking (infant—softer, shorter cry; difficulty feeding)	While at rest (infant—stops feeding)	
	Can lie down	Prefers sitting	Sits upright	
Talks in	Sentences	Phrases	Words	
Alertness	May be agitated	Usually agitated	Usually agitated	Drowsy or confused
Signs				
Respiratory rate	Increased	Increased	Often >30/min	
		Guide to rates of breathing in awake children: *Age* — *Normal rate* <2 months — <60/minute 2-12 months — <50/minute 1-5 years — <40/minute 6-8 years — <30/minute		
Use of accessory muscles; suprasternal retractions	Usually not	Commonly	Usually	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	>120	Bradycardia
		Guide to normal pulse rates in children: *Age* — *Normal rate* 2-12 months — <160/minute 1-2 years — <120/minute 2-8 years — <110/minute		
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
Functional Assessment				
PEF % predicted or % personal best	>80%	Approx. 50-80% or response lasts <2 hrs	<50% predicted or personal best	
PaO_2 (on air)	Normal (test not usually necessary)	>60 mm Hg (test not usually necessary)	<60 mm Hg: possible cyanosis	
and/or				
PCO_2	<42 mm Hg (test not usually necessary)	<42 mm Hg (test not usually necessary)	≥42 mm Hg: possible respiratory failure (see text)	
SaO_2% (on air) at sea level	>95% (test not usually necessary)	91-95%	<91%	
	Hypercapnia (hypoventilation) develops more readily in young children than in adults and adolescents.			

Note:
- 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, so they serve only as general guides.

patients should seek medical care rather than rely on bronchodilator therapy in excessive doses or for prolonged periods.

The Expert Panel does *not* recommend the following home management techniques because there are no studies demonstrating effectiveness and it is the opinion of the Panel that these techniques may delay patients from obtaining necessary care.

- Drinking large volumes of liquids or breathing warm, moist air (e.g., the mist from a hot shower).
- Using over-the-counter products such as antihistamines, cold remedies, and bronchodilators. Over-the-counter metered-dose inhalers may provide transient bronchodilation, but their use should not be permitted to delay seeking medical care.

The Expert Panel also notes that although pursed-lip and other forms of controlled breathing may help to maintain calm during respiratory distress, they do *not* bring about improvement in lung function.

PREHOSPITAL EMERGENCY MEDICINE/AMBULANCE MANAGEMENT OF ASTHMA EXACERBATIONS

The Expert Panel recommends that prehospital providers administer supplemental oxygen and inhaled short-acting bronchodilators to patients who have signs or symptoms of asthma. Prehospital administration of inhaled bronchodilators reduces airflow obstruction and relieves symptoms (Fergusson et al. 1995). Thus, advanced life support units should have available an inhaler plus spacer/holding chamber and/or nebulizer for beta$_2$-agonist administration (see figure 3-10 for dosages). If these are not available, subcutaneous epinephrine or terbutaline should be given for severe exacerbations (see figure 3-10) (Sly et al. 1977; Smith et al. 1977).

Ambulance services should develop prehospital protocols for the treatment of acute asthma in children and adults. Prehospital providers should receive training in how to respond to the clinical signs and symptoms of severe airway obstruction and imminent respiratory failure.

EMERGENCY DEPARTMENT AND HOSPITAL MANAGEMENT OF ASTHMA EXACERBATIONS

Severe exacerbations of asthma are potentially life threatening. Care must be prompt. Effective initial therapies (i.e., a short-acting beta$_2$-agonist and the means of giving it by aerosol and a source of supplemental oxygen) should be available in a physician's office. However, serious exacerbations require close observation for deterioration, frequent treatment, and repetitive measurement of lung function. Therefore, most severe exacerbations of asthma require prompt transfer to an emergency department for a complete course of therapy (Brenner 1983a). An overview of the treatment strategies in emergency departments and hospitals is presented in figure 3-11 and detailed below.

Assessment

The Expert Panel recommends that all clinicians treating asthma exacerbations be familiar with the characteristics of patients at risk for life-threatening deterioration (see figures 3-7a and 3-7b). In the emergency department, treatment should be started as soon as an asthma exacerbation is recognized and an assessment of lung function is made.

While treatment is given, obtain a brief, focused history and physical examination pertinent to the exacerbation (see figure 3-9). Take a more detailed history and complete physical examination and perform laboratory studies only after initial therapy has been completed.

- The objectives of *functional assessment* are to:
  - Obtain objective information on the severity of airflow obstruction (FEV$_1$ or PEF) and the patient's response to treatment. *In the emergency department,* obtain FEV$_1$ or PEF on presentation, after initial treatment, and at frequent intervals thereafter, depending on the patient's response to therapy. Rarely, a patient's airflow obstruction may be so severe as to prevent performance of a maximal expiratory maneuver. *In the hospital,* measure FEV$_1$ or PEF before and 15 to 20 minutes after bronchodilator therapy during the acute phase of the exacerbation. Thereafter, measure FEV$_1$ or PEF at least daily until discharge. Values <30 percent of predicted that improve by <10 percent after

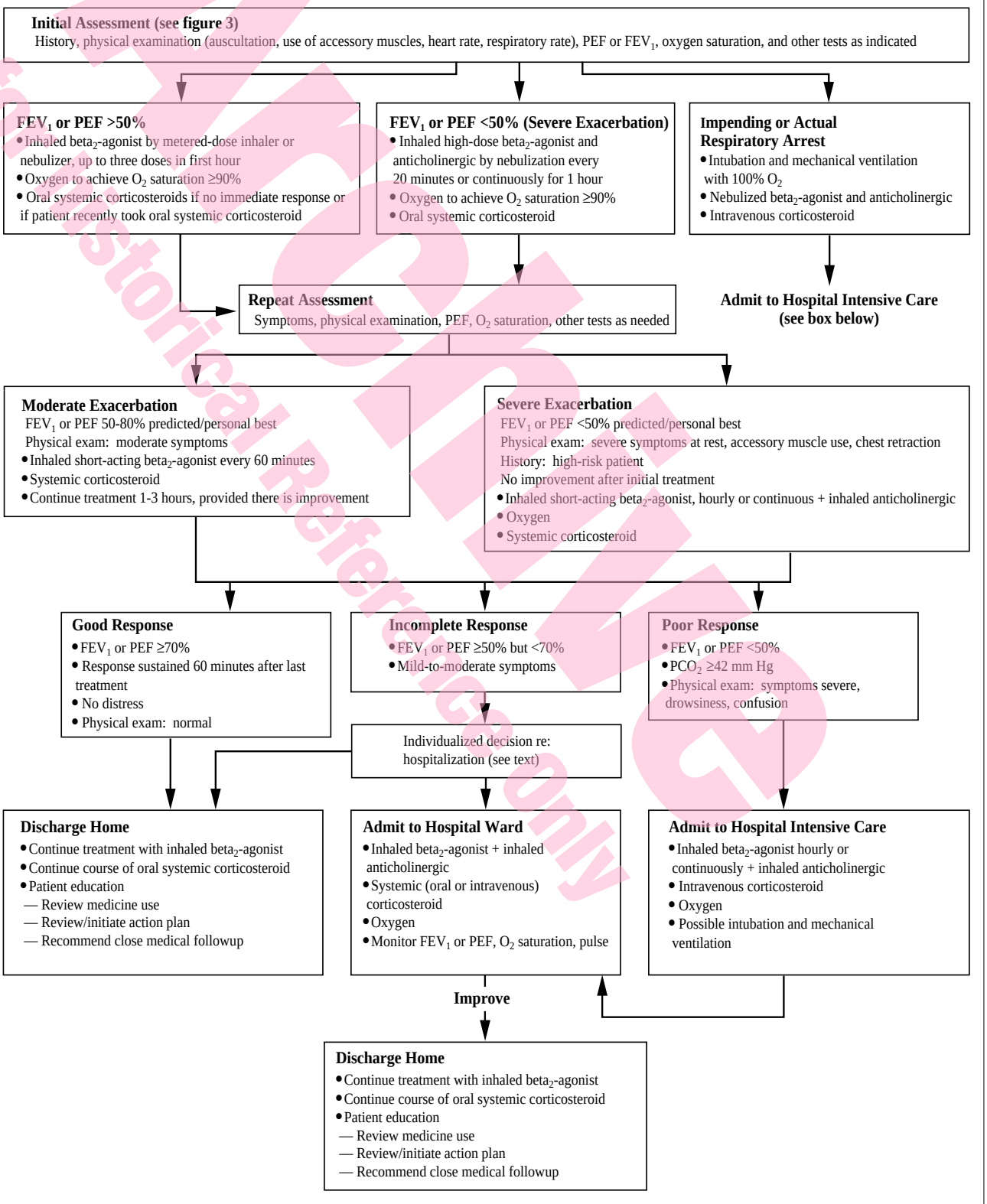
FIGURE 3-10. DOSAGES OF DRUGS FOR ASTHMA EXACERBATIONS IN EMERGENCY MEDICAL CARE OR HOSPITAL

Medications	Dosages: Adult Dose	Dosages: Child Dose	Comments
Inhaled Short-Acting Beta$_2$-Agonists			
Albuterol			
Nebulizer solution (5 mg/mL)	2.5-5 mg every 20 minutes for 3 doses, then 2.5-10 mg every 1-4 hours as needed, or 10-15 mg/hour continuously	0.15 mg/kg (minimum dose 2.5 mg) every 20 minutes for 3 doses, then 0.15-0.3 mg/kg up to 10 mg every 1-4 hours as needed, or 0.5 mg/kg/hour by continuous nebulization	Only selective beta$_2$-agonists are recommended. For optimal delivery, dilute aerosols to minimum of 4 mL at gas flow of 6-8 L/min.
MDI (90 mcg/puff)	4-8 puffs every 20 minutes up to 4 hours, then every 1-4 hours as needed as needed	4-8 puffs every 20 minutes for 3 doses, then every 1-4 hours inhalation maneuver. Use spacer/holding chamber.	As effective as nebulized therapy if patient is able to coordinate
Bitolterol			
Nebulizer solution (2 mg/mL)	See albuterol dose	See albuterol dose; thought to be half as potent as albuterol on a mg basis	Has not been studied in severe asthma exacerbations. Do not mix with other drugs.
MDI (370 mcg/puff)	See albuterol dose	See albuterol dose	Has not been studied in severe asthma exacerbations.
Pirbuterol			
MDI (200 mcg/puff)	See albuterol dose	See albuterol dose; thought to be half as potent as albuterol on a mg basis	Has not been studied in severe asthma exacerbations.
Systemic (Injected) Beta$_2$-Agonists			
Epinephrine 1:1000 (1 mg/mL)	0.3-0.5 mg every 20 minutes for 3 doses sq	0.01 mg/kg up to 0.3-0.5 mg every 20 minutes for 3 doses sq	No proven advantage of systemic therapy over aerosol.
Terbutaline (1 mg/mL)	0.25 mg every 20 minutes for 3 doses sq	0.01 mg/kg every 20 minutes for 3 doses then every 2-6 hours as needed sq	No proven advantage of systemic therapy over aerosol.
Anticholinergics			
Ipratropium bromide Nebulizer solution (.25 mg/mL)	0.5 mg every 30 minutes for 3 doses then every 2-4 hours as needed	.25 mg every 20 minutes for 3 doses, then every 2 to 4 hours	May mix in same nebulizer with albuterol. Should not be used as first-line therapy; should be added to beta$_2$-agonist therapy.
MDI (18 mcg/puff)	4-8 puffs as needed	4-8 puffs as needed	Dose delivered from MDI is low and has not been studied in asthma exacerbations.
Corticosteroids			
Prednisone Methylprednisolone Prednisolone	120-180 mg/day in 3 or 4 divided doses for 48 hours, then 60-80 mg/day until PEF reaches 70% of predicted or personal best	1 mg/kg every 6 hours for 48 hours then 1-2 mg/kg/day (maximum = 60 mg/day) in 2 divided doses until PEF 70% of predicted or personal best	For outpatient "burst" use 40-60 mg in single or 2 divided doses for adults (children: 1-2 mg/kg/day, maximum 60 mg/day) for 3-10 days

Note:

- No advantage has been found for higher dose 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 usual regimen is to continue the frequent multiple daily dosing until the patient achieves an FEV_1 or PEF of 50 percent of predicted or personal best and then lower the dose to twice daily. This usually occurs within 48 hours. Therapy following a hospitalization or emergency department visit may last from 3 to 10 days. If patients are then started on inhaled corticosteroids, studies indicate there is no need to taper the systemic corticosteroid dose. If the followup systemic corticosteroid therapy is to be given once daily, one study indicates that it may be more clinically effective to give the dose in the afternoon at 3:00 p.m., with no increase in adrenal suppression (Beam et al. 1992).

FIGURE 3-11. MANAGEMENT OF ASTHMA EXACERBATIONS: EMERGENCY DEPARTMENT AND HOSPITAL-BASED CARE



bronchodilator therapy or that fluctuate widely over 24 hours indicate a heightened risk of life-threatening deterioration.

—In patients with severe distress or with FEV_1 or PEF <50 percent of predicted, assess the adequacy of arterial oxygen saturation by pulse oximetry (Connett and Lenney 1993; Geelhoed et al. 1994).

- Objectives of the *brief history* are to determine:

—Time of onset and cause of current exacerbation

—Severity of symptoms, especially compared with previous exacerbations

—All current medications and time of last dose

—Prior hospitalizations and emergency department visits for asthma, particularly within the past year

—Prior episodes of respiratory insufficiency due to asthma (loss of consciousness or intubation and mechanical ventilation)

—Other potentially complicating illness, especially other pulmonary or cardiac disease or diseases that may be aggravated by systemic corticosteroid therapy such as diabetes, peptic ulcer, hypertension, and psychosis

- Objectives of the *physical examination* are to:

—Assess the severity of the exacerbation as indicated by the findings listed in figure 3-9.

—Assess overall patient status, including level of alertness, fluid status, and presence of cyanosis, respiratory distress, and wheezing. Wheezing can be an unreliable indicator of obstruction; in rare cases, extremely severe obstruction may be accompanied by a "silent chest" (Shim and Williams 1980).

—Identify complications (e.g., pneumonia, pneumothorax, or pneumomediastinum).

—Identify other diseases that may affect asthma (e.g., allergic rhinitis, rhinitis, sinusitis).

—Rule out upper airway obstruction. Both intrathoracic and extrathoracic central airway obstruction can cause severe dyspnea and may be diagnosed as asthma. Causes include epiglottitis, organic diseases of the larynx, vocal cord dysfunction, and extrinsic and intrinsic tracheal narrowing (see component 1-Initial Assessment and Diagnosis). Clues as to their presence include dysphonia, inspiratory stridor, monophonic wheezing loudest over the central airway, normal values for PO_2, and unexpectedly complete resolution of airflow obstruction with intubation. When upper airway obstruction is suspected, obtain further evaluation by flow-volume curves and by referral for laryngoscopy (see component 1-Initial Assessment and Diagnosis).

- The most important objective of *laboratory studies* is detection of actual or impending respiratory failure; other objectives include detection of theophylline toxicity and of conditions that complicate the treatment of asthma exacerbations. *Do not permit these studies to delay initiation of treatment.* For example,

—Consider *arterial blood gas* (ABG) measurement for evaluating arterial carbon dioxide tension (PCO_2) in patients with suspected hypoventilation, with severe distress, or with FEV_1 or PEF 30 percent of predicted after initial treatment. (NOTE: Respiratory drive is typically increased in asthma exacerbations, so a "normal" PCO_2 of 40 mm indicates severe airflow obstruction and a heightened risk of respiratory failure.)

—*Complete blood count* (CBC) may be appropriate in patients with fever or purulent sputum; keep in mind that modest leukocytosis is common in asthma exacerbations and that corticosteroid treatment causes a further outpouring of polymorphonuclear leukocytes within 1 to 2 hours of administration.

—Measure *serum theophylline concentration* in patients taking theophylline prior to presentation.

—It may be prudent to measure *serum electrolytes* in patients who have been taking diuretics regularly and in patients with coexistent cardiovascular disease, because frequent $beta_2$-agonist administration can cause transient decreases in serum potassium, magnesium, and phosphate.

— *Chest radiography* is not recommended for routine assessment but should be obtained in patients suspected of a complicating cardiopulmonary process, such as pneumothorax, pneumomediastinum, pneumonia, lobar atelectasis, or congestive heart failure.

— *Electrocardiograms* need not be routinely obtained, but a baseline electrocardiogram and continual monitoring of cardiac rhythm are appropriate in patients older than 50 years of age and in those with coexistent heart disease or chronic obstructive pulmonary disease. The electrocardiogram may show a pattern of right ventricular strain that reverses promptly with treatment of airflow obstruction.

■ *Assessment considerations unique to children and infants are as follows:*

— It is often difficult for physicians and parents to determine the severity of the airway obstruction in infants and small children with asthma. However, using a combination of the subjective and objective parameters in figure 3-9 permits a fairly accurate assessment to guide initial therapy. Many of these parameters have not been systematically studied, so they serve only as general guides.

— The differences in the anatomy and physiology of the lungs of infants place them at greater risk for respiratory failure. These differences include greater peripheral airway resistance, fewer collateral channels of ventilation, further extension of airway smooth muscle into the peripheral airways, less elastic recoil, and mechanical disadvantage of the diaphragm. Viral infections, particularly respiratory syncytial virus, are the most common cause of acute wheezing illness in infants. The edematous inflammatory response in the airways leads to air trapping and hyperinflation, atelectasis, increased respiratory rate, and wheezing. This sequence of changes can rapidly progress to respiratory failure. Close monitoring is critical.

— It is particularly important to monitor O_2 saturation by pulse oximetry in infants because their ventilation/perfusion characteristics lead them to become hypoxemic more readily than adults. SaO_2 should be normal for altitude (>95 percent at sea level). Decreased oxygen saturation is often an early sign of severe airway obstruction, and an SaO_2 <91 percent on room air is a good predictor of the need for hospitalization in small infants (Connett and Lenney 1993; Geelhoed et al. 1994).

— Capillary or ABG measurements should be performed in infants suspected of respiratory failure. PCO_2 is the best measurement of ventilation in infants, as it is in adults. Children with a normal PCO_2 but in obvious respiratory distress are at high risk for respiratory failure.

Treatment

In the emergency department and hospital, tailor the intensity of treatment and surveillance to the severity of the exacerbation. The primary therapies—the administration of oxygen, inhaled $beta_2$-agonist, and systemic corticosteroids—are constant, but the dose and frequency with which they are given and the frequency with which the patient's response is assessed may vary. Thus, for patients presenting with a severe exacerbation, give inhaled $beta_2$-agonist therapy at the higher dose (figure 3-10) either repeatedly (three treatments in the first hour) or continuously (by nebulization), give systemic corticosteroids immediately, and watch closely for signs of worsening airflow obstruction or fatigue. For patients with mild exacerbations, give inhaled $beta_2$-agonist therapy and assess the patient's response before deciding whether additional therapy is necessary. Give supplemental oxygen to patients with significant hypoxemia and to patients with FEV_1 or PEF <50 percent of predicted when arterial oxygen monitoring is not available.

The following recommendations are based on scientific evidence (key studies are cited) and the opinion of the Expert Panel:

■ Oxygen is recommended for most patients. Administer supplemental oxygen (by nasal cannulae or mask, whichever is best tolerated) to maintain an SaO_2 >90 percent (>95 percent in pregnant women and in patients with coexistent heart disease). Monitor oxygen saturation until a clear response to bronchodilator therapy has occurred.

■ Inhaled short-acting $beta_2$-agonists are recommended for all patients (for recommended doses, see figure 3-10).

— The repetitive or continuous administration of inhaled short-acting beta$_2$-agonists is the most effective means of reversing airflow obstruction (Lipworth et al. 1988; Lin et al. 1993; Rudnitsky et al. 1993).

— *In the emergency department,* three treatments of beta$_2$-agonists spaced every 20 to 30 minutes can be given safely as initial therapy. Thereafter, the frequency of administration varies according to the improvement in airflow obstruction and associated symptoms and the occurrence of side effects. Continuous administration of beta$_2$-agonists may be more effective in children and severely obstructed adults (Lin et al. 1993; Rudnitsky et al. 1993; Papo et al. 1993; Kelly and Murphy 1992).

— Because of the risk of cardiotoxicity, use only selective beta$_2$-agonists (albuterol, terbutaline, pirbuterol, bitolterol) in high doses.

— Studies show that equivalent bronchodilation can be achieved by either high doses (6 to 12 puffs) of a beta$_2$-agonist by MDI with a spacer/holding chamber under the supervision of trained personnel or by nebulizer therapy (Idris et al. 1993; Colacone et al. 1993; Kerem et al. 1993). However, nebulized therapy is more effective in patients who are unable to coordinate inhalation of medication from an MDI because of their age, agitation, or severity of the exacerbation.

— The onset of action for inhaled beta$_2$-agonist is less than 5 minutes; repetitive administration produces incremental bronchodilation (Lipworth et al. 1988).

— Duration of action of bronchodilation from beta$_2$-agonists in severe asthma exacerbations is not precisely known.

- Anticholinergics may be considered. Adding high doses of ipratropium bromide (0.5 mg in adults, 0.25 mg in children) to an aerosolized solution of a selective beta$_2$-agonist has been shown to cause additional bronchodilation, particularly in those with severe airflow obstruction (Schuh et al. 1995; Reisman et al. 1988; O'Driscoll et al. 1989; Kelly and Murphy 1991), although some studies did not demonstrate this effect (Karpel et al. 1996).

- Systemic corticosteroids are recommended for most patients (for recommended doses, see figure 3-10).

— *In the emergency department*: Give systemic corticosteroids to patients who have moderate-to-severe exacerbations and patients who do not respond completely to initial beta$_2$-agonist therapy. These medications appear to speed the resolution of airflow obstruction and reduce the rate of relapse (Fanta et al. 1983; Rowe et al. 1992; Scarfone et al. 1993; Connett et al. 1994; Chapman et al. 1991).

- Oral administration of prednisone has been shown to have effects equivalent to those of intravenous methylprednisolone (Harrison et al. 1986; Ratto et al. 1988) and, in the opinion of the Expert Panel, is usually preferred because it is less invasive.

- Give supplemental doses of oral corticosteroids to patients who take them regularly, even if the exacerbation is mild.

- In infants and children, it is especially important to give corticosteroids early in the course of an asthma exacerbation (Harris et al. 1987).

— *In the hospital*: Give systemic corticosteroids to patients admitted to the hospital, because they speed the resolution of asthma exacerbations (Connett et al. 1994; Rowe et al. 1992; Singh and Kumar 1993).

- Methylxanthines are *not* generally recommended.

— *In the emergency department*: Theophylline/aminophylline is not recommended because it appears to provide no additional benefit to optimal inhaled beta$_2$-agonist therapy and may increase adverse effects (Fanta et al. 1986; Rossing et al. 1980; Murphy et al. 1993; Rodrigo and Rodrigo 1994; Coleridge et al. 1993).

— In patients currently taking a theophylline-containing preparation, determine serum theophylline concentration to rule out theophylline toxicity.

— *In the hospital*: Therapy with oral or intravenous methylxanthines does not benefit children hospitalized with severe asthma (Strauss et al. 1994; Carter et al. 1993; DiGiulio et al. 1993). The addition of intravenous theophylline in hospitalized adults remains controversial (Huang et al. 1993; Self et al. 1990).

- Antibiotics are *not* recommended for asthma treatment but may be necessary for comorbid conditions. Bacterial, chlamydia, and mycoplasma respiratory tract infections are thought to contribute only infrequently to exacerbations of asthma. The use of antibiotics is generally reserved for those patients with fever and purulent sputum (discolored because of polymorphonuclear leukocytes, not eosinophils) and for patients with evidence of pneumonia. When the presence of bacterial sinusitis is suspected, treat with antibiotics.

- Aggressive hydration is *not* recommended for older children and adults but may be indicated for infants and young children. Intravenous or oral administration of large volumes of fluids does *not* play a role in the management of severe asthma exacerbations. However, infants and young children may become dehydrated as a result of increased respiratory rate and decreased oral intake. In these patients, make an assessment of fluid status (urine output, urine specific gravity, mucus membrane moisture, electrolytes) and provide appropriate corrections.

- Chest physical therapy is *not* generally recommended. In general, chest physiotherapy is not beneficial and is unnecessarily stressful for the breathless asthma patient.

- Mucolytics are *not* recommended. Avoid mucolytic agents (e.g., acetylcysteine, potassium iodide) because they may worsen cough or airflow obstruction.

- Sedation is *not* recommended. Anxiolytic and hypnotic drugs are contraindicated in severely ill asthma patients because of their respiratory depressant effect.

Repeat Assessment

The Expert Panel recommends that repeat assessment of patients with severe exacerbations be made after the initial dose of inhaled bronchodilator and that repeat assessment of all patients be made after three doses of inhaled bronchodilator (60 to 90 minutes after initiating treatment). The response to initial treatment in the emergency department is a better predictor of the need for hospitalization than is the severity of an exacerbation on presentation (Rodrigo and Rodrigo 1993). The elements to be evaluated include the patient's subjective response, physical findings, measurement of airflow, and measurement of ABG if the patient now meets the criteria described in the discussion of laboratory studies in the Assessment section, page 110.

Hospitalization

The decision to hospitalize a patient should be based on duration and severity of symptoms, severity of airflow obstruction, course and severity of prior exacerbations, medication use at the time of the exacerbation, access to medical care and medications, adequacy of support and home conditions, and presence of psychiatric illness. In general, the principles of care in the hospital resemble those for care in the emergency department and involve both treatment with oxygen, aerosolized bronchodilators, and systemic corticosteroids and frequent assessment, including clinical assessment of respiratory distress and fatigue and objective measurement of airflow (PEF or FEV_1) and oxygen saturation.

Impending Respiratory Failure

Most patients respond well to therapy. However, a small minority will show signs of worsening ventilation, whether from worsening airflow obstruction, worsening respiratory muscle fatigue, or a combination of the two. Signs of impending respiratory failure include a declining mental clarity, worsening fatigue, and a PCO_2 of ≥ 42 mm Hg. Exactly when to intubate is based on clinical judgment; however, the Expert Panel recommends that intubation not be delayed once it is deemed necessary. Because respiratory failure can progress rapidly and can be difficult to reverse, early recognition and treatment are critically important.

Because intubation of a severely ill asthma patient is difficult, additional treatments are sometimes attempted, such as intravenous administration of magnesium sulfate (Kuitert and Kletchko 1991; Skorodin et al. 1995; Tiffany et al. 1993; Green and Rothrock 1992) and substituting a mixture of helium and

oxygen ("heliox") for oxygen-enriched air (Manthous et al. 1995; Gluck et al. 1990). Although limited observations suggest that these therapies may be effective, possibly among certain subgroups (Bloch et al. 1995), they have not yet been proven consistently effective. Intravenous administration of a beta$_2$-agonist also falls into this category of unproven treatment. Recent studies suggest that albuterol is more effective and has fewer side effects when it is given by aerosol than when given intravenously (Salmeron et al. 1994), but the efficacy of adding an intravenous beta$_2$-agonist to high-dose nebulized therapy has not been studied. Do not use intravenous isoproterenol in the treatment of asthma because of the danger of myocardial toxicity (Maguire et al. 1991).

The Expert Panel recommends the following actions regarding intubation:

- Patients presenting with apnea or coma should be intubated immediately. There are no other absolute indications for endotracheal intubation, but persistent or increasing hypercapnia, exhaustion, and depression of mental status strongly suggest the need for ventilatory support.

- Consultation with or comanagement by physicians expert in ventilator management is appropriate because mechanical ventilation of patients with severe refractory asthma is complicated and fraught with risk.

- Because intubation is difficult in asthma patients, it is best done semi-electively, before the crisis of respiratory arrest.

- Intubation should be performed in a controlled setting by a physician with extensive experience in intubation and airway management.

  — It is preferable that patients with severe exacerbations who are slowly responsive to therapy be admitted to an intensive care unit where they can be monitored closely and intubated if it is indicated.

  — Because intubation should not be delayed once it is deemed necessary, it may be performed in the emergency department or inpatient ward and the patient transferred to an intensive care unit appropriate to the patient's age.

  — Children intubated for asthma should be admitted to a pediatric intensive care unit or transferred to a facility that has such a unit.

- Issues to consider at the time of intubation include the following:

  — Close attention should be given to maintaining or replacing intravascular volume, because hypotension commonly accompanies the initiation of positive pressure ventilation.

  — Once mechanical ventilation has been started, it is important to avoid high ventilator pressures and the associated risks of barotrauma.

- "Permissive hypercapnia" or "controlled hypoventilation" is the recommended ventilator strategy to provide adequate oxygenation and ventilation while minimizing high airway pressures and barotrauma (Tuxen 1994; Darioli and Perret 1984; Menitove and Goldring 1983). It involves administration of as high an FiO_2 as is necessary to maintain adequate arterial oxygenation, acceptance of hypercapnia, and treatment of respiratory acidosis with intravenous sodium bicarbonate. Adjustments are made to the tidal volume, ventilator rate, and I:E ratio to minimize airway pressures. Bronchodilators are continued, and even in ventilated patients, aerosol delivery is the route of choice (Dhand and Tobin 1996).

This ventilator strategy is not uniformly successful in critically ill asthma patients, and additional therapies are being evaluated. Their review is beyond the scope of this report.

Patient Discharge

Before discharge, provide patients with necessary medications and education in how to use them, instruction in self-assessment (e.g., by monitoring symptoms and peak flow), a followup appointment, and instruction in an action plan for managing recurrence of airflow obstruction. To ensure that these steps are taken, a discharge checklist may be useful (see example in figure 3-12).

From the Emergency Department

- Release of the patient from the emergency department depends on the patient's response to treatment.

FIGURE 3-12. HOSPITAL DISCHARGE CHECKLIST FOR PATIENTS WITH ASTHMA EXACERBATIONS

Intervention	Dose/Timing	Education/Advice	M.D./R.N. Initials
Inhaled medications (MDI + spacer/holding chamber)	Select agent, dose, and frequency (e.g., albuterol)	Teach purpose Teach technique	
Beta$_2$-agonist	2-6 puffs q 3-4 hr prn	Emphasize need for spacer/ holding chamber	
Corticosteroids	Medium dose	Check patient technique	
Oral medications	Select agent, dose, and frequency (e.g., prednisone 20 mg bid for 3-10 days)	Teach purpose Teach side effects	
Peak flow meter	Measure a.m. and p.m. PEF and record best of three tries each time	Teach purpose Teach technique Distribute peak flow diary	
Followup visit	Make appointment for followup care with primary clinician or asthma specialist	Advise patient (or caregiver) of date, time, and location of appointment within 7 days of hospital discharge	
Action plan	Before or at discharge	Instruct patient (or caregiver) on simple plan for actions to be taken when symptoms, signs, and PEF values suggest recurrent airflow obstruction	

— In general, discharge is appropriate if FEV_1 or PEF has returned to ≥70 percent of predicted or personal best and symptoms are minimal or absent. Patients with an incomplete response to therapy (FEV_1 or PEF ≥50 but <70 percent predicted or personal best) and with mild symptoms should be assessed individually for their suitability for discharge home, with consideration of factors listed in figure 3-7a.

— The Panel's opinion is that patients with a rapid response should be observed for 30 to 60 minutes after the most recent dose of bronchodilator to ensure stability of response before discharge to home.

— Extended treatment and observation in a holding area, clinical decision unit, or overnight unit to determine the need for hospitalization may be appropriate provided there is sufficient monitoring and nursing care.

- Prescribe sufficient medications for the patient to continue treatment after discharge. Patients given systemic corticosteroids should continue oral systemic corticosteroids for 3 to 10 days. The need for further corticosteroid therapy should be assessed at a followup visit. If the patient is receiving inhaled corticosteroids, it is not necessary to taper the dose gradually when the course is completed (O'Driscoll et al. 1993).

- Emphasize the need for continual, regular care in an outpatient setting. Refer the patient to a followup medical appointment. A visit to the emergency department is often an indication of inadequate long-term management of asthma or inadequate plans for handling exacerbations. Notify the patient's health care professional (or provide a referral to one if the patient does not name a source of asthma care), and instruct the patient to seek a followup medical appointment within 3 to 5 days. When possible, schedule such an appointment prior to the patient's discharge. The followup visit should include a detailed review of the patients' medications, inhaler and peak flow meter technique, and development of comprehensive daily management and action plans that will help prevent exacerbations and urgent care visits (see figures 4-4 and 4-5). Referral to an asthma specialist for consultation should be considered because this has been reported to reduce the rate of subsequent emergency department visits (Zeiger et al. 1991).

- Review written discharge medications and, whenever possible, provide patient education on avoidance of asthma triggers and correct use of an inhaler (see figure 4-3).

- Instruct the patient in a simple action plan for increasing medications or returning for care should asthma worsen.

- Consider issuing a peak flow meter and providing patient education on how to measure and record daily PEF rates.

From the Hospital

- Prior to discharge, adjust the patient's medication to an oral and/or inhaled regimen. The optimal timing of this transition is not precisely established, but the general approach is to wait until the patient is minimally symptomatic from asthma and has little wheezing on chest examination. Usually this clinical status corresponds to a PEF or FEV_1 of ≥70 percent of predicted or personal best. During the first 24 hours after this medication adjustment, observe the patient for possible deterioration.

- Discharge medications should include a short-acting inhaled $beta_2$-agonist and sufficient oral corticosteroid to complete the course of therapy or to continue therapy until the followup appointment. If the decision is made to start the patient on inhaled corticosteroids, they should be started before the course of oral corticosteroids is completed, because their onset of action is gradual (Kraan et al. 1988). Starting the inhaled corticosteroid therapy before discharge gives the patient additional time to learn and demonstrate appropriate technique.

- Provide patient education:

  — An exacerbation severe enough to require hospitalization may reflect a failure of the patient's self-management plan. Hospitalized patients may be particularly receptive to information and advice about their illness; take the opportunity to review patient understanding of the causes of asthma exacerbations, the purposes and correct uses of treatment, and the actions to be taken for worsening symptoms or peak flow values.

  — Educate patients about their discharge medications and the importance of a followup medical visit. Referral to an asthma specialist should be considered for patients with a history of life-threatening exacerbations or multiple hospitalizations (see component 1, page 23) (Mayo et al. 1990).

  — Educate patients older than 5 years of age in the use of peak flow meters to monitor their lung function at home.

  — *Review or develop an action plan for management of recurrent symptoms or exacerbations.* The plan should describe the signs, symptoms, and/or peak flow values that should prompt increases in self-medication, contact with a health care provider, or return for emergency care. The plan given at discharge from the emergency department may be quite simple (e.g., instructions for discharge medications and returning for care should asthma worsen). The plan developed for discharge from the hospital should be more complete (see figure 3-12). A detailed plan for comprehensive long-term management and handling exacerbations should be developed by the regular provider at a followup visit (see figure 4-5).

REFERENCES

Bloch H, Silverman R, Mancherje N, Grant S, Jagminas L, Scharf SM. Intravenous magnesium sulfate as an adjunct in the treatment of acute asthma. *Chest* 1995;107:1576-81.

Brenner BE. Bronchial asthma in adults: presentation to the emergency department. Part I: Pathogenesis, clinical manifestations, diagnostic evaluation, and differential diagnosis. *Am J Emerg Med* 1983a;1:50-70.

Brenner BE. Bronchial asthma in adults: presentation to the emergency department. Part II: Sympathomimetics, respiratory failure, recommendations for initial treatment, indications for admission, and summary. *Am J Emerg Med* 1983b;1:306-33.

Carter E, Cruz M, Chesrown S, Shieh G, Reilly K, Hendeles L. Efficacy of intravenously administered theophylline in children hospitalized with severe asthma. *J Pediatr* 1993;122:470-6.

Chapman KR, Verbeek PR, White JG, Rebuck AS. Effect of a short course of prednisone in the prevention of early relapse after the emergency room treatment of acute asthma. *N Engl J Med* 1991;324:788-94.

Colacone A, Afilalo M, Wolkove N, Kreisman H. A comparison of albuterol administered by metered dose inhaler (and holding chamber) or wet nebulizer in acute asthma. *Chest* 1993;104:835-41.

Coleridge J, Cameron P, Epstein J, Teichtahl H. Intravenous aminophylline confers no benefit in acute asthma treated with intravenous steroids and inhaled bronchodilators. *Aust N Z J Med* 1993;23:348-54.

Connett GJ, Lenney W. Use of pulse oximetry in the hospital management of acute asthma in childhood. *Pediatr Pulmonol* 1993;15(6):345-9.

Connett GJ, Warde C, Wooler E, Lenney W. Prednisolone and salbutamol in the hospital treatment of acute asthma. *Arch Dis Child* 1994;70:170-3.

Darioli R, Perret C. Mechanical controlled hypoventilation in status asthmaticus. *Am Rev Respir Dis* 1984;129:385-7.

Deshpande A, McKenzie SA. Short course of steroids in home treatment of children with acute asthma. *BMJ* 1986;293:169-71.

Dhand R, Tobin MJ. Bronchodilator delivery with metered-dose inhalers in mechanically-ventilated patients. *Eur Respir J* 1996;9:585-95.

DiGiulio GA, Kercsmar CM, Krug SE, Alpert SE, Marx CM. Hospital treatment of asthma: lack of benefit from theophylline given in addition to nebulized albuterol and intravenously administered corticosteroid. *J Pediatr* 1993;122:464-9.

Fanta CH, Rossing TH, McFadden ER Jr. Treatment of acute asthma: is combination therapy with sympathomimetics and methylxanthines indicated? *Am J Med* 1986;80:5-10.

Fanta CH, Rossing TH, McFadden ER Jr. Glucocorticoids in acute asthma. A critical controlled trial. *Am J Med* 1983;74:845-51.

Fergusson, RJ, Stewart CM, Wathen CG, Moffat R, Crompton GK. Effectiveness of nebulised salbutamol administered in ambulances to patents with acute severe asthma. *Thorax* 1995;50:81-2.

Fiel SB, Swartz MA, Glanz K, Francis ME. Efficacy of short-term corticosteroid therapy in outpatient treatment of acute bronchial asthma. *Am J Med* 1983;75:259-62.

Geelhoed GC, Landau LI, Le Souef PN. Evaluation of SaO_2 as a predictor of outcome in 280 children presenting with acute asthma. *Ann Emerg Med* 1994;23:1236-41.

Gluck EH, Onorato DJ, Castriotta R. Helium-oxygen mixtures in intubated patients with status asthmaticus and respiratory acidosis. *Chest* 1990;98:693-8.

Green SM, Rothrock SG. Intravenous magnesium for acute asthma: failure to decrease emergency treatment duration or need for hospitalization. *Ann Emerg Med* 1992;21:260-5.

Greenberger PA, Miller TP, Lifschultz B. Circumstances surrounding deaths from asthma in Cook County (Chicago) Illinois. *Allergy Proc* 1993;14:321-6.

Harris JB, Weinberger MM, Nassif E, Smith G, Milavetz G, Stillerman A. Early intervention with short courses of prednisone to prevent progression of asthma in ambulatory patients incompletely responsive to bronchodilators. *J Pediatr* 1987;110:627-33.

Harrison BD, Stokes TC, Hart GJ, Vaughan DA, Ali NJ, Robinson AA. Need for intravenous hydrocortisone in addition to oral prednisolone in patients admitted to hospital with severe asthma without ventilatory failure. *Lancet* 1986;1(8474):181-4.

Huang D, O'Brien RG, Harman E, et al. Does aminophylline benefit adults admitted to the hospital for an acute exacerbation of asthma? *Ann Intern Med* 1993;119:1155-60.

Idris AH, McDermott MF, Raucci JC, Morrabel A, McGorray S, Hendeles L. Emergency department treatment of severe asthma. Metered-dose inhaler plus holding chamber is equivalent in effectiveness to nebulizer. *Chest* 1993;103:665-72.

Kallenbach JM, Frankel AH, Lapinsky SE, et al. Determinants of near fatality in acute severe asthma. *Am J Med* 1993;95:265-72.

Karpel JP, Schacter EN, Fanta C, et al. A comparison of ipratropium and albuterol vs. albuterol alone for the treatment of acute asthma. *Chest* 1996;110:611-6.

Kelly HW, Murphy S. Beta-adrenergic agonists for acute, severe asthma. *Ann Pharmacother* 1992;26:81- 91.

Kelly HW, Murphy S. Corticosteroids for acute, severe asthma. *DICP* 1991;25:72-9.

Kerem E, Levison H, Schuh S, et al. Efficacy of albuterol administered by nebulizer versus spacer device in children with acute asthma. *J Pediatr* 1993;123:313-7.

Kikuchi Y, Okabe S, Tamura G, et al. Chemosensitivity and perception of dyspnea in patients with a history of near-fatal asthma. *N Engl J Med* 1994;330:1329-34

Kraan J, Koeter GH, van der Mark TW, et al. Dosage and time effects of inhaled budesonide on bronchial hyperreactivity. *Am Rev Respir Dis* 1988;137:44-8.

Kuitert L, Kletchko SL. Intravenous magnesium sulfate in acute, life-threatening asthma. *Ann Emerg Med* 1991;20:1243-5.

Lahdensuo A, Haahtela T, Herrala J, et al. Randomized comparison of guided self management and traditional treatment of asthma over one year. *BMJ* 1996;312:748-52.

Lin RY, Sauter D, Newman T, Sirleaf J, Walters J, Tavakol M. Continuous versus intermittent albuterol nebulization in the treatment of acute asthma. *Ann Emerg Med* 1993;22:1847-53.

Lipworth BJ, Clark RA, Dhillon DP, Brown RA, McDevitt DG. Beta-adrenoceptor responses to high doses of inhaled salbutamol in patients with bronchial asthma. *Br J Clin Pharmacol* 1988;26:527-33.

Littenberg B, Gluck EH. A controlled trial of methylprednisolone in the emergency treatment of acute asthma. *N Engl J Med* 1986;314:150-2.

Loren ML, Chai H, Leung P, Rohr C, Brenner AM. Corticosteroids in the treatment of acute exacerbations of asthma. *Ann Allergy* 1980;45:67-71.

Maguire JF, O'Rourke PP, Colan SD, Geha RS, Crone R. Cardiotoxicity during treatment of severe childhood asthma. *Pediatrics* 1991;88:1180-6.

Manthous CA, Hall JB, Caputo MA, et al. Heliox improves pulsus paradoxus and peak expiratory flow in nonintubated patients with severe asthma. *Am J Respir Crit Care Med* 1995;151:310-4.

Mayo PH, Richman J, Harris HW. Results of a program to reduce admissions for adult asthma. *Ann Intern Med* 1990;112:864-71.

McFadden ER Jr. Therapy of acute asthma. *J Allergy Clin Immunol* 1989;84:151-8.

Menitove SM, Goldring RM. Combined ventilator and bicarbonate strategy in the management of status asthmaticus. *Am J Med* 1983;74:898-901.

Murphy DG, McDermott MF, Rydman RJ, Sloan EP, Zalenski RJ. Aminophylline in the treatment of acute asthma when beta-2-adrenergics and steroids are provided. *Arch Intern Med* 1993;153:1784-88.

O'Driscoll BR, Kalra S, Wilson M, Pickering CA, Carroll KB, Woodcock AA. Double-blind trial of steroid tapering in acute asthma. *Lancet* 1993;341:324-7.

O'Driscoll BR, Taylor RJ, Horsley MG, Chambers DK, Bernstein A. Nebulised salbutamol with and without ipratropium bromide in acute airflow obstruction. *Lancet* 1989:1:1418-20.

O'Hollaren MT, Yunginger JW, Offord KP, et al. Exposure to an aeroallergen as a possible precipitating factor in respiratory arrest in young patients with asthma. *N Engl J Med* 1991;324:359-63.

Papo MC, Frank J, Thompson AE. A prospective, randomized study of continuous versus intermittent nebulized albuterol for severe status asthmaticus in children. *Crit Care Med* 1993;21:1479-86.

Ratto D, Alfaro C, Sipsey J, Glovsky MM, Sharma OP. Are intravenous corticosteroids required in status asthmaticus? *JAMA* 1988;260:527-9.

Reisman T, Galdes-Sebalt M, Kazim F, Canny G, Levison H. Frequent administration by inhalation of salbutamol and ipratropium bromide in the initial management of severe acute asthma in children. *J Allergy Clin Immunol* 1988:81:16-20.

Rodrigo C, Rodrigo G. Assessment of the patient with acute asthma in the emergency department. A factor analytic study *Chest* 1993;104:1325-8.

Rodrigo C, Rodrigo G. Treatment of acute asthma. Lack of therapeutic benefit and increase of the toxicity from aminophylline given in addition to high doses of salbutamol delivered by metered-dose inhaler with a spacer. *Chest* 1994;106:1071-6.

Rossing TH, Fanta CH, Goldstein DH, Snapper JR, McFadden ER Jr. Emergency therapy of asthma: comparison of the acute effects of parenteral and inhaled sympathomimetics and infused aminophylline. *Am Rev Respir Dis* 1980;122:365-71.

Rowe BH, Keller JL, Oxman AD. Effectiveness of steroid therapy in acute exacerbations of asthma: a meta-analysis. *Am J Emerg Med* 1992;10:301-10.

Rudnitsky GS, Eberlein RS, Schoffstall JM, Mazur JE, Spivey WH. Comparison of intermittent and continuously nebulized albuterol for treatment of asthma in an urban emergency department. *Ann Emerg Med* 1993;22:1842-6.

Salmeron S, Brochard L, Mal H, et al. Nebulized versus intravenous albuterol in hypercapnic acute asthma: a multicenter, double-blind, randomized study. *Am J Respir Crit Care Med* 1994;149:1466-70.

Scarfone RJ, Fuchs SM, Nager AL, Shane SA. Controlled trial of oral prednisone in the emergency department treatment of children with acute asthma. *Pediatrics* 1993;2:513-8.

Schuh S, Johnson DW, Callahan S, Canny G, Levison H. Efficacy of frequent nebulized ipratropium bromide added to frequent high-dose albuterol therapy in severe childhood asthma. *J Pediatr* 1995;126:639-45.

Self TH, Abou-Shala N, Burns R, et al. Inhaled albuterol and oral prednisone therapy in hospitalized adult asthmatics. Does aminophylline add any benefit? *Chest* 1990;98:1317-21.

Shim CS, Williams MH Jr. Evaluation of the severity of asthma: patients versus physicians. *Am J Med* 1980;68:11-3.

Singh M, Kumar L. Continuous nebulised salbutamol and oral once a day prednisolone in status asthmaticus. *Arch Dis Child* 1993;69:416-9.

Skorodin MS, Tenholder MF, Yetter B, et al. Magnesium sulfate in exacerbations of chronic obstructive pulmonary disease. *Arch Intern Med* 1995;155(5):496-500.

Sly RM, Badiei B, Faciane J. Comparison of subcutaneous terbutaline with epinephrine in the treatment of asthma in children. *J Allergy Clin Immunol* 1977;59:128-35.

Smith PR, Heurich AE, Leffler CT, Henis MM, Lyons HA. A comparative study of subcutaneously administered terbutaline and epinephrine in the treatment of acute bronchial asthma. *Chest* 1977;71:129- 34.

Strauss RE, Wertheim DL, Bonagura VR, Valacer DJ. Aminophylline therapy does not improve outcome and increases adverse effects in children hospitalized with acute asthmatic exacerbations. *Pediatrics* 1994;93:205-10.

Suissa S, Ernst P, Bolvin JF, et al. A cohort analysis of excess mortality in asthma and the use of inhaled beta$_2$-agonists. *Am J Respir Crit Care Med* 1994;149(3 Pt 1):604-10.

Taylor MR. Asthma: audit of peak flow rate guidelines for admission and discharge. *Arch Dis Child* 1994;70:432-4.

Tiffany BR, Berk WA, Todd IK, White SR. Magnesium bolus or infusion fails to improve expiratory flow in acute asthma exacerbations. *Chest* 1993;104:831-4.

Tuxen DV. Permissive hypercapnic ventilation. *Am J Respir Crit Care Med* 1994;150:870-4.

Wilson NM, Silverman M. Treatment of acute, episodic asthma in preschool children using intermittent high dose inhaled steroids at home. *Arch Dis Child* 1990;65:407-10.

Zeiger RS, Heller S, Mellon MH, Wald J, Falkoff R, Schatz M. Facilitated referral to asthma specialist reduces relapses in asthma emergency room visits. *J Allergy Clin Immunol* 1991;87:1160-8.

COMPONENT 4:
EDUCATION FOR A PARTNERSHIP IN ASTHMA CARE

KEY POINTS

- Patient education should begin at the time of diagnosis and be integrated into *every* step of clinical asthma care.
- It is essential that education be provided by *all* members of the health care team. The principal clinician should introduce the key educational messages and negotiate agreements with patients; these messages should be reinforced and expanded by all members of the health care team.
- Teach asthma self-management, tailoring the approach to the needs of each patient. Maintain a sensitivity to cultural beliefs and practices.
- Teach and reinforce at *every* opportunity:
  - Basic facts about asthma
  - Roles of medications
  - Skills: inhaler/spacer/holding chamber use, self-monitoring
  - Environmental control measures
  - When and how to take rescue actions
- Jointly develop treatment goals.
- To encourage an active partnership, provide all patients with a written daily self-management plan and an action plan for exacerbations. Action plans are especially important for patients with moderate-to-severe asthma and patients with a history of severe exacerbations. Provide appropriate patients with a daily asthma diary.
- Encourage adherence by promoting open communication; individualizing, reviewing, and adjusting plans as needed; emphasizing goals and outcomes; and encouraging family involvement.

DIFFERENCES FROM 1991 EXPERT PANEL REPORT

- Emphasis is on patient education by the principal clinician as well as other members of the health care team.
- To enhance the delivery of education, detailed questions to elicit information and educational messages for each visit are provided in chart form. Reinforcement of key messages is emphasized.
- Additional emphasis is placed on evaluating outcomes in terms of patient perceptions of improvement, especially quality of life and the ability to engage in desired activities.
- Roles of written materials and formal education programs are clarified with emphasis that they can supplement but not replace education by clinicians. A list of sources for asthma education programs and materials is provided.
- Renewed emphasis is placed on providing patients with *both* a written treatment plan for daily self-management and a written action plan for management of exacerbations. Examples are provided that are applicable to both children and adults.
- New section on assessing and responding to cultural and language differences was added.
- New section on patient education for non-chlorofluorocarbon inhalers was added.

FIGURE 4-1. KEY EDUCATIONAL MESSAGES FOR PATIENTS

Check off or document that the following key messages have been covered:

Basic Facts About Asthma

- ☐ The contrast between asthmatic and normal airways
- ☐ What happens to the airways in an asthma attack

Roles of Medications

- ☐ How medications work
  - – Long-term control: medications that prevent symptoms, often by reducing inflammation
  - – Quick relief: short-acting bronchodilator relaxes muscles around airways
- ☐ Stress the importance of long-term-control medications and not to expect quick relief from them.

Skills

- ☐ Inhaler use (patient demonstrate)
- ☐ Spacer/holding chamber use
- ☐ Symptom monitoring, peak flow monitoring, and recognizing early signs of deterioration

Environmental Control Measures

- ☐ Identifying and avoiding environmental precipitants or exposures

When and How To Take Rescue Actions

- ☐ Responding to changes in asthma severity (daily self-management plan and action plan)

Patient education is an essential component of successful asthma management. Current management approaches require patients and families to effectively carry out complex pharmacologic regimens, institute environmental control strategies, detect and self-treat most asthma exacerbations, and communicate appropriately with health care providers. Patient education is the mechanism through which patients learn to successfully accomplish those tasks. It is also a powerful tool for helping patients gain the motivation, skill, and confidence to control their asthma (Feldman et al. 1987; Mellins 1989). Research shows that asthma education can be cost-effective and can reduce morbidity for both adults and children, especially among high-risk patients (Trautner et al. 1993; Bolton et al. 1991; Fireman et al. 1981; Hindi-Alexander and Cropp 1984; Lewis et al. 1984; Clark et al. 1986).

This component covers strategies for enhancing the delivery of patient education and improving the likelihood that patients will follow clinical recommendations, as well as key messages to communicate to the patient. When references are not cited, recommendations are based on the opinion of the Expert Panel.

ESTABLISH A PARTNERSHIP

Patient education should begin at the time of diagnosis and be integrated into every step of medical care, in the context of medical appointments and other clinician-patient communication. When clinicians take the time to provide education, it sends a powerful message to patients and families about the importance of being knowledgeable self-management of asthma. Specific educational messages delivered in the context of a medical care appointment clearly communicate the importance of collaboration in the treatment of asthma (Mayo et al. 1990; Ignacio-Garcia and Gonzales-Santos 1995). From the time of diagnosis, the clinician and other members of the health care team should begin to build a partnership with the patient and family. Building the partnership requires that clinicians promote open communication and ensure that patients have a basic and accurate foundation of knowledge about asthma, understand the treatment approach, and have the self-management skills necessary to monitor the disease objectively and take medication effectively (Evans et al. 1997).

When nurses, pharmacists, respiratory therapists, and other health care professionals are available to support and expand patient education (NHLBI 1995a, 1995b), a team approach should be used. The principal clinician should introduce the key educational messages (see figure 4-1) and negotiate agreements with patients (Mayo et al. 1990; Kotses et al. 1996). Different members of the health care team should reinforce and expand these messages during office visits and telephone calls or in more formal educational sessions.

Communication and coordination within the team are critical. Team members should document in the patient's record the key educational points (see figure 4-1), patient concerns, and actions the

BOX 1. PATIENT EDUCATION FOR NON-CFC INHALERS

Clinicians need to be aware that metered-dose inhalers (MDIs) containing chlorofluorocarbons (CFCs) contribute to the depletion of stratospheric ozone. As a result of the consequent health hazards, CFCs have been internationally banned. Although a temporary medical exemption has been granted, MDIs with CFC propellants will eventually have to be replaced with alternative aerosol products, including MDIs with non-CFC propellants. Other non-CFC options include multidose dry powder inhalers and hand-held mini-nebulizers.

When first prescribing any of these new alternative products to patients accustomed to a CFC-containing MDI, the Expert Panel recommends that clinicians review with the patient the appropriate inhalation technique and care of the device to ensure proper use and optimum device performance. For alternative propellant MDIs, the patient may perceive differences in the aerosol delivery compared to their CFC-containing MDI. The patient should be given the following messages about these differences:

- All FDA-approved alternative propellant inhalers will have been demonstrated to be comparably safe and effective as their usual CFC-propelled medication in clinical trials. However, individual differences in tolerability may be observed.
- Clinicians should familiarize patients with any differences in the care and use of non-CFC devices.
- The alternative propelled MDIs may taste different or feel different due to differences in the propellant and formulations. However, patients should be assured that these differences should not lead to important differences in their use or benefit.

For alternate propellant MDIs that deliver a less forceful aerosol plume, patients may believe that this less forceful spray may not reach their lungs as effectively as their CFC product. Clinicians should reassure patients that medication delivery is assured by proper inhalation technique and that a less forceful spray does not equate with less efficacy. This is an opportunity to train patients in the use of non-CFC devices.

patient agrees to take. This will enable all members of the team to be consistent and to reinforce the educational points and the progress being made.

Teach Asthma Self-Management

The Expert Panel recommends that clinicians teach patients and families the essential information, medication skills, self-monitoring techniques, and environmental control measures outlined in figure 4-2 (Bailey et al. 1990; Ignacio-Garcia and Gonzales-Santos 1995; Kotses et al. 1995, 1996; Wilson et al. 1993). These key points should be adapted to meet the individual patient's needs. Clinicians should:

- Teach basic facts about asthma so that the patient and family understand the rationale for needed actions. Give a brief verbal description of what asthma is and the intended role of each medication. Do not overwhelm the patient with too much information all at once, but repeat the important messages at each visit. Ask the patient to bring all medications to each appointment for review.
- Teach the patient necessary medication skills, such as correct use of the inhaler (see figure 4-3) and spacer/holding chamber and knowing when and how to take quick- relief medications. (Also see box 1, Patient Education for Non-CFC Inhalers.)
- Teach self-monitoring skills: symptom monitoring, peak flow monitoring as appropriate (see component 1-Periodic Assessment and Monitoring), and recognizing early signs of deterioration.
- Teach relevant environmental control/avoidance strategies (see figure 2-4). Teach how environmental precipitants or exposures can make the patient's asthma worse (e.g., allergens and irritants) at home, school, and work and how to recognize both immediate and delayed reactions.

FIGURE 4-2. DELIVERY OF ASTHMA EDUCATION BY CLINICIANS DURING PATIENT CARE VISITS

Assessment Questions	Information	Skills
	Recommendations for Initial Visit	
Focus on: ■ Expectations of visit ■ Goals of treatment ■ Medications ■ Quality of life	Teach in simple language:	Teach or review and demonstrate:
"What worries you most about your asthma?" "What do you want to accomplish at this visit?" "What do you want to be able to do that you can't do now because of your asthma?" "What do you expect from treatment?" "What medicines have you tried?" "What other questions do you have for me today?"	What is asthma? A chronic lung disease. The airways are very sensitive. They become inflamed and narrow; breathing becomes difficult. Asthma treatments: two types of medicines are needed: ■ Long-term control: medications that prevent symptoms, often by reducing inflammation ■ Quick relief: short-acting bronchodilator relaxes muscles around airways Bring all medications to every appointment. When to seek medical advice. Provide appropriate telephone number.	Inhaler (see figure 4-3) and spacer/holding chamber use. Check performance. Self-monitoring skills that are tied to an action plan: ■ Recognize intensity and frequency of asthma symptoms ■ Review the signs of deterioration and the need to reevaluate therapy: • Waking at night with asthma • Increased medication use • Decreased activity tolerance Use of a simple, written self-management plan (see figure 4-4) and action plan (see figure 4-5)
	Recommendations for First Followup Visit (2 to 4 weeks or sooner as needed)	
Focus on: ■ Expectations of visit ■ Goals of treatment ■ Medications ■ Quality of life	Teach in simple language:	Teach or review and demonstrate:
Ask relevant questions from previous visit and also ask: "What medications are you taking?" "How and when are you taking them?" "What problems have you had using your medications?" "Please show me how you use your inhaled medications."	Use of two types of medications. Remind patient to bring all medications and the peak flow meter to every appointment for review. Self-evaluation of progress in asthma control using symptoms and peak flow as a guide.	Use of a daily self-management plan. Review and adjust as needed. Use of an action plan. Review and adjust as needed. Peak flow monitoring (see figure 1-7) and daily diary recording (see figure 1-9). Correct inhaler and spacer/holding chamber technique.

FIGURE 4-2. DELIVERY OF ASTHMA EDUCATION BY CLINICIANS DURING PATIENT CARE VISITS (CONTINUED)

Assessment Questions	Information	Skills
Recommendations for Second Followup Visit		
Focus on: ■ Expectations of visit ■ Goals of treatment ■ Medications ■ Quality of life	Teach in simple language:	Teach or review and demonstrate:
Ask relevant questions from previous visits and also ask: "Have you noticed anything in your home, work, or school that makes your asthma worse?" "Describe for me how you know when to call your doctor or go to the hospital for asthma care." "What questions do you have about the action plan?" "Can we make it easier?" "Are your medications causing you any problems?"	Relevant environmental control/avoidance strategies (see figure 2-4). ■ How to identify home, work, or school exposures that can cause or worsen asthma ■ How to control house-dust mites, animal exposures if applicable ■ How to avoid cigarette smoke (active and passive) Review all medications. Review and interpret from daily diary: ■ Peak flow measure ■ Symptom scores	Inhaler/spacer/holding chamber technique. Peak flow monitoring technique. Use of daily self-management plan. Review and adjust as needed. Review use of action plan. Confirm that patient knows what to do if asthma gets worse.
Recommendations for All Subsequent Visits		
Focus on: ■ Expectations of visit ■ Goals of treatment ■ Medications ■ Quality of life	Teach in simple language:	Teach or review and demonstrate:
Ask relevant questions from previous visits and also ask: "How have you tried to control things that make your asthma worse?" "Please show me how you use your inhaled medication."	Review and reinforce all: ■ Educational messages ■ Environmental control strategies at home, work, or school ■ Medications Review and interpret from daily diary: ■ Peak flow measures ■ Symptom scores	Inhaler/spacer/holding chamber technique. Peak flow monitoring technique. Use of daily self-management plan. Review and adjust as needed. Review use of action plan. Confirm that patient knows what to do if asthma gets worse. Periodically review and adjust written action plan.

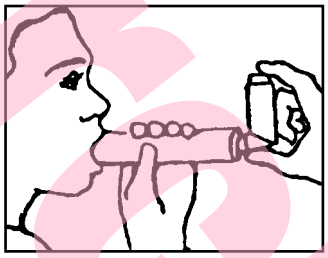
Figure 4-3.

STEPS FOR USING YOUR INHALER

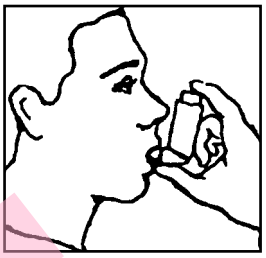
Please demonstrate your inhaler technique at every visit.

1. Remove the cap and hold inhaler upright.
2. Shake the inhaler.
3. Tilt your head back slightly and breathe out slowly.
4. Position the inhaler in one of the following ways (A or B is optimal, but C is acceptable for those who have difficulty with A or B. C is required for breath-activated inhalers):

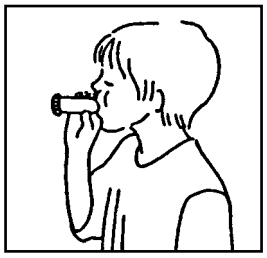
A. Open mouth with inhaler 1 to 2 inches away.



B. Use spacer/holding chamber (that is recommended especially for young children and for people using corticosteroids).



C. In the mouth. Do not use for corticosteroids.



D. NOTE: Inhaled dry powder capsules require a different inhalation technique. To use a dry powder inhaler, it is important to close the mouth tightly around the mouthpiece of the inhaler and to inhale rapidly.

5. Press down on the inhaler to release medication as you start to breathe in slowly.
6. Breathe in slowly (3 to 5 seconds).
7. Hold your breath for 10 seconds to allow the medicine to reach deeply into your lungs.
8. Repeat puff as directed. Waiting 1 minute between puffs may permit second puff to penetrate your lungs better.
9. Spacers/holding chambers are useful for all patients. They are particularly recommended for young children and older adults and for use with inhaled corticosteroids.

Avoid common inhaler mistakes. Follow these inhaler tips:

- Breathe out *before* pressing your inhaler.
- Inhale *slowly*.
- Breathe in through your mouth, not your nose.
- Press down on your inhaler at the *start* of inhalation (or within the first second of inhalation).
- Keep inhaling as you press down on inhaler.
- Press your inhaler only *once* while you are inhaling (one breath for each puff).
- Make sure you breathe in evenly and deeply.

NOTE: Other inhalers are becoming available in addition to those illustrated above. Different types of inhalers may require different techniques.

Source: *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma.* National Asthma Education and Prevention Program, National Heart, Lung, and Blood Institute, 1997.

Jointly Develop Treatment Goals

Fundamental to building a partnership is for clinicians and patients to jointly develop and agree on both short- and long-term treatment goals. Such agreements can encourage active participation, enhance the partnership, and improve asthma management (Schulman 1979; Clark 1989; Clark et al. 1995). It is the opinion of the Expert Panel that clinicians should:

- Determine the patient's personal treatment goals. Ask how asthma interferes with the patient's life (e.g., inability to sleep through the night, play a sport) and incorporate the responses into personal treatment goals. Asthma-specific quality-of-life instruments (Juniper et al. 1992; Marks et al. 1993) may be useful.

- Share the general goals of asthma treatment with the patient and family. Tell patients, "Our goals are to have you:

  — Be free from severe symptoms day and night, including sleeping through the night."
  — Have the best possible lung function."
  — Be able to participate fully in any activities of your choice."
  — Not miss work or school because of asthma symptoms."
  — Need fewer or no urgent care visits or hospitalizations for asthma."
  — Use medications to control asthma with as few side effects as possible."
  — Be satisfied with your asthma care."

- Agree on the goals of treatment. The clinicians, the patient, and when appropriate, the patient's family should agree on the goals of asthma management, which include both the patient's personal goals and the general goals (see list above) suggested by the clinicians.

Provide the Patient With Tools for Self-Management

It is the opinion of the Expert Panel that, at the first visit, clinicians should develop a written, individualized, daily self-management plan (see figure 4-4) in consultation with the patient. Include the recommended doses and frequencies of daily medications and the daily self-management activities needed to achieve the agreed-on goals. Review and refine the plan at subsequent followup visits. List the treatment goals in the plan and explain how following the plan will help the patient reach those goals. Emphasizing the patient's personal goals is essential to enhancing adherence. For example, ask, "Have you had any problems taking your bronchodilator immediately before playing basketball? Has it helped you stay in the game?"

Discuss the long-term benefits of following the written, daily self-management plan (Plaut 1996). For some patients, focusing on long-term treatment goals and discussing the "big picture" of asthma control and how medications can be adjusted over time may improve adherence (Mellins 1996).

Also at the first visit, jointly develop a written action plan to help the patient manage asthma exacerbations (see figure 4-5, pages 138-143) for examples). This is especially important for patients with moderate-to-severe persistent asthma and patients with a history of severe exacerbations. Review and refine the plan at followup visits. The action plan directs the patient to adjust medicines at home in response to particular signs, symptoms, and peak flow measurements. It should also list the PEF levels and symptoms indicating the need for acute care and emergency telephone numbers for the physician, emergency department, rapid transportation, and family/friend for aid and support. A number of action plans have been published (Woolcock et al. 1988; Beasley et al. 1989; D'Souza et al. 1994; Charlton et al. 1990; Mellins and Evans, in press; NHLBI 1995d; NHLBI 1995e). Those tested in randomized clinical trials were effective in decreasing asthma exacerbations (Woolcock et al. 1988; Charlton et al. 1990). Clinicians should choose an action plan that suits their practice, patients, and style. The examples in figure 4-5 are not endorsed by the Expert Panel; rather, they are provided to demonstrate a range of possibilities and should be modified as appropriate.

It is the opinion of the Expert Panel that clinicians should provide an asthma diary to appropriate patients for self-monitoring symptoms, peak flow measurements, frequency of daily quick-relief inhaler medication use, and activity restriction (see figure 1-9).

Figure 4-4.

ASTHMA DAILY SELF-MANAGEMENT PLAN (EXAMPLE 1)

ASTHMA SELF-MANAGEMENT PLAN FOR _____

(Name)

YOUR TREATMENT GOALS

- Be free from severe symptoms day and night, including sleeping through the night
- Have the best possible lung function
- Be able to participate fully in any activities of your choice
- Not miss work or school because of asthma symptoms
- Not need emergency visits or hospitalizations for asthma
- Use asthma medications to control asthma with as few side effects as possible

Add personal goals here:

_____

_____

_____

_____

YOUR DAILY MEDICATIONS

Daily Medication	How Much To Take	When To Take It

RECORD DAILY SELF-MONITORING ACTIONS in the asthma diary your doctor gives you.

Peak flow: At least every morning when you wake up, before taking your medication, measure your peak flow and record it in your diary. Bring these records to your next appointment with your doctor.

Symptoms: Note if you had asthma symptoms (shortness of breath, wheezing, chest tightness, or cough) and rate how severe they were during the day or night: mild, moderate, severe.

Use of your quick-relief inhaler (bronchodilator): Keep a record of the number of puffs you needed to use each day or night to control your symptoms.

Actual use of daily medications:

Activity restriction:

This plan is provided as an example to clinicians.

Figure 4-4.

ASTHMA DAILY SELF-MANAGEMENT PLAN (EXAMPLE 2)

LONG-TERM SELF-MANAGEMENT PLAN FOR PERSISTENT ASTHMA

Introduction: This long-term plan provides four benefits to the clinician and patient, who complete it together during an early visit and review it periodically. The chart (1) reflects the step-up/step-down concept of pharmacotherapy; (2) enables patient and clinician to negotiate which medicines will be used and how often; (3) combines symptoms and/or peak flow monitoring as the basis for patient's adding or deleting medicines at home and self-adjusting doses; and (4) gives the patient a view of what the clinician recommends over the long-term—under what future circumstances the clinician intends that the regimen be increased or decreased.

Directions: The clinician writes the patient's medicines in the first column. Based on the symptoms and peak flow specified in the top row, the clinician then writes the doses and frequency of administration for each medication. (Some clinicians may prefer to print standard recommendations on the form to save time.)

Medication	At the FIRST sign of a cold or exposure to known trigger	If cough or wheeze is present OR peak flow is between 50 and 80% of personal best	If cough or wheeze worsen OR peak flow is below 50% of personal best	As soon as cough and wheeze have stopped OR peak flow is above 80% of personal best	When there is no cough or wheeze for 2 weeks, even with activity OR peak flow is above 80% of personal best for 2 weeks	When there is no cough or wheeze for ___months OR peak flow is above 80% of personal best for ___ months	Before exercise or physical activity	For rapidly worsening asthma (severe exacerbation)
Times per day								

Source: Mellins 1996.

This plan is provided as an example to clinicians.

Please note that the following long-term plan is included only as an example of how to fill out the plan. The treatment regimen itself does not correspond to recommendations made in the *Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma*.

LONG-TERM SELF-MANAGEMENT PLAN FOR PERSISTENT ASTHMA (EXAMPLE ONLY)

Medication	At the FIRST sign of a cold or exposure to known trigger	If cough or wheeze is present OR peak flow is between 50 and 80% of personal best	If cough or wheeze worsen OR peak flow is below 50% of personal best	As soon as cough and wheeze have stopped OR peak flow is above 80% of personal best	When there is no cough or wheeze for 2 weeks, even with activity OR peak flow is above 80% of personal best for 2 weeks	When there is no cough or wheeze for ___ months OR peak flow is above 80% of personal best for___ months	Before exercise or physical activity	For rapidly worsening asthma (severe exacerbation)
Short-acting $beta_2$-agonist	2 puffs	2 puffs	2 puffs	2 puffs	0	0	2 puffs	2-4 puffs
Nonsteroidal anti-inflammatory	2 puffs	2 puffs	2 puffs	2 puffs	2 puffs	2 puffs	0	0
Inhaled corticosteroid	2 puffs	4 puffs	4 puffs	2 puffs	2 puffs	0	0	0
TIMES PER DAY	3	4 (every 4 hrs)	4 (every 4 hrs)	3	3	3	5-10 minutes before exercise	every 20 minutes for 3 doses*
Oral corticosteroid	0	0	2 mg/kg/day x 2 days then 1 mg/kg/day x 3 days	0	0	0	0	0

* If there is not a good response, seek emergency care immediately. If there is a good response, return to the third column.

Encourage Adherence

An important part of patient education is encouraging adherence.

- Use effective techniques to promote open communication. Research suggests that certain clinician behaviors are associated with patient adherence and/or satisfaction with care (Clark et al. 1995). Not all are appropriate for cultural subgroups, but the items listed in figure 4-6 are general guidelines.

- Early in each visit, elicit the patient's concerns, perceptions, and unresolved questions about his or her asthma (see figure 4-2). A question such as "What worries you most about your asthma?," which cannot be answered yes or no, encourages patients and families to voice issues, personal beliefs, or concerns they may be apprehensive about discussing or may not think are of interest to the clinician. These potential barriers to adherence can be dealt with only if they are identified. By asking about and discussing such concerns, clinicians build trust and a sense of partnership with the patient. Most nonadherence originates in personal beliefs or concerns about asthma that have not been discussed with the clinician (Korsch et al. 1968; Janz et al. 1984). Until such fears and worries are identified and addressed, patients will not be able to adhere to the clinician's recommendations (Korsch et al. 1968).

- Assess the patient's and family's perceptions of the severity level of the disease. Two questions may prove useful: "How severe do you think your asthma is?" and "How much danger do you believe you are in from your asthma?" When patients are identified who are overwhelmed by fear of death, put their fears in perspective by providing them with the results of objective assessments and expert opinion. A clearly written, detailed action plan that directs the patient how to respond to worsening asthma may be extremely helpful in reducing anxiety (figure 4-5). Patients' perceptions about their disease severity and its threat to their well-being influence self-management behavior and use of the health care system (Janson-Bjerklie et al. 1992; Janz et al. 1984).

- Assess the patient's and family's level of social support. Ask, "Who among your family or friends can you turn to for help if your asthma worsens?" Counsel patients to identify an asthma "partner" among their family or friends who is willing to be educated and provide support. Include at least one of these individuals in followup appointments with the patient so that he or she can hear what is expected of the patient in following the self-management and action plans (Graham et al. 1990).

- Encourage or enlist family involvement. Ask patients to identify ways their family members can help them follow the plans. Ask the patient to share the plans with family members, elicit their input, and agree on actions they can help with. It may be helpful for children and parents to discuss this with a clinician present.

- Consider referral to a psychologist, social worker, psychiatrist, or other licensed professional when stress seems to unduly interfere with daily asthma management. As with other chronic diseases, emotional and social stress may be a confounding factor for many patients struggling with asthma control. Although stress does not cause asthma, it can play a role in precipitating asthma exacerbations (Busse et al. 1995) and can complicate an individual's attempts at self-management. Referral to a local support group may be useful.

FIGURE 4-6. PROMOTING OPEN COMMUNICATION TO ENCOURAGE PATIENT ADHERENCE

Friendly Manner:

- Show attentiveness (eye contact, attentive listening, etc.)
- Give encouragements with nonverbal communication (nodding agreement, smiling, etc.)
- Give verbal praise for effective management strategies
- Use interactive conversation (e.g., asking open-ended questions)

Reassuring Communication:

- Elicit patient's underlying concerns about asthma
- Allay fears with specific reassuring information

Adapted with permission from Clark et al. 1995.

- Use methods to increase the chances that the patient will adhere to the written, daily self-management plan. For instance, adherence to the self-management plan is enhanced when the plan is simplified as much as possible, when the number of medications and frequency of daily doses are minimized, when the medication doses and frequency fit into the patient's and family's daily routine (Clark et al. 1995; Haynes et al. 1979; Eisen et al. 1990; Evans 1993; Meichenbaum and Turk 1987), and when the plan considers the patient's ability to afford the medications (Hindi-Alexander and Throm 1987). Because nonadherence is difficult for clinicians to detect (Haynes et al. 1979; Charney et al. 1967; Mushlin and Appel 1977), it is prudent to explore potential barriers to adherence with every patient by asking what concerns they have about medicines (e.g., safety) or other aspects of treatment.

Tailor Education to the Needs of the Individual Patient

Assess cultural or ethnic beliefs or practices that may influence self-management activities and modify educational approaches, as needed. Cultural variables may affect patient understanding of and adherence to medical regimens (Pachter and Weller 1993; Kleinman et al. 1978). Open-ended questions such as "In your community, what does having asthma mean?" can elicit informative responses. The culturally sensitive clinician should attempt to find ways to incorporate harmless or potentially beneficial remedies with the pharmacologic plan. For example, a prevalent belief among the Latino population is that illnesses are either "hot" or "cold" (Risser and Mazur 1995). Asthma is viewed as a "cold" illness amenable to "hot" treatment. Suggesting that asthma medications be taken with hot tea or hot water incorporates this belief into the therapeutic regimen and helps build the therapeutic partnership. When harmful home remedies are being used, clinicians should discourage their use by suggesting a culturally acceptable alternative as a replacement or recommending a safer route of administration (Pachter et al. 1995). These and other strategies may be useful in working with ethnic minorities (NHLBI 1995c).

Every effort should be made to discuss asthma care, especially the self-management plan, in the patient's native language so that educational messages are fully understood. Research suggests that lack of language concordance between the clinician and the patient affects adherence and appropriate use of health care services (Manson 1988). Language barriers also may complicate the assessment of cultural differences. If interpreters are used, they should be equally competent in both English and the patient's language and knowledgeable about medical terms (Woloshin et al. 1995).

MAINTAIN THE PARTNERSHIP

As part of ongoing care, the clinician should continue to build the partnership by being a sympathetic coach and by helping the patient follow the self-management plan and take other needed actions. Educational efforts should be continuous, because it may take up to 6 months for the impact of education to be evident (Toelle et al. 1993). Furthermore, it is necessary to periodically review information and skills covered previously because patient self-management behavior is likely to decline over time (Reis et al. 1995).

In particular, it is essential that clinicians demonstrate, review, evaluate, and correct inhaler/spacer/holding chamber technique at each visit because these skills deteriorate rapidly (Keston et al. 1993). Written instructions are helpful (see figure 4-3), but insufficient (Nimmo et al. 1993; Wilson et al. 1993). Research suggests that patients tend to make specific mistakes in using inhalers that need to be corrected (Larsen et al. 1994; Dolovich et al. 1981; Kesten et al. 1993; Hanania et al. 1994). Patients especially need to be reminded to inhale slowly and to activate the inhaler only *once* for each breath (Rau et al. 1996).

Clinicians should continue to promote open communication with the patient and family by addressing the following elements (see figure 4-2) in each followup visit:

- Continue asking patients early *in each visit* what concerns they have about their asthma and what they especially want addressed during the visit.

- Review the short-term goals agreed on in the initial visit. Assess how well they are being achieved (e.g., was the patient's wish to engage in physical activity achieved?). Revise the goals as needed. Achievement of short-term goals should be discussed as indicators that the patient is moving toward long-term goals. Give positive verbal reinforcement for achievement of a goal and recognize the patient's success in moving closer to full control of the disease.

- Review the daily self-management plan and the steps the patient was to take (Clark et al. 1995). Adjust the plan as needed (e.g., the recommendations of how to use medicines if the dose or type is not working). Identify other problems the patient has in following the agreed-on steps (e.g., disguising the bad taste of medicine); treat these as areas needing more work, not as adherence failures. Write a self-management plan to help school personnel manage a child's asthma (see figure 4-7, page 144, for an example).

- Periodically review the asthma action plan and revise as necessary. Confirm that the patient knows what to do if his or her asthma gets worse.

- Continue teaching and reinforcing key educational messages (see figure 4-1). Provide information and teach skills over several visits so as not to overwhelm the patient with too much information at one time. Repeat important points often.

- Give patients simple, brief written materials that reinforce the actions recommended and skills taught (Morris et al. 1986; Ley 1972; Davis et al. 1990; Estey et al. 1991). Figure 4-8 (page 146) lists organizations that distribute patient education materials; many of these organizations also have some Spanish-language materials.

SUPPLEMENT PATIENT EDUCATION DELIVERED BY CLINICIANS

All patients may benefit from a *formal asthma education program* that has been evaluated and reported in the literature to be effective. These programs should be taught by qualified asthma educators who are knowledgeable about asthma and experienced in patient education. Communication among the asthma educator, the clinicians providing direct care, and the patient/family is critical. When formal programs are available in local communities, they can *supplement, but not replace*, patient education provided in the office. Individual and group programs have been developed and tested for patients of all ages, including parents of very young children (birth to 4 years) (Clark et al. 1986; Creer et al. 1988; Evans et al. 1987; Lewis et al. 1984; NHLBI 1984a, 1984b, 1984c, 1985; Taggart et al. 1991; Wilson-Pessano et al. 1987; Wilson-Pessano and McNabb 1985; Bailey et al. 1990; Kotses et al. 1995; Wilson et al. 1996; Lahdensuo et al. 1996). A list of organizations distributing programs that have been validated in the literature can be found in figure 4-8.

These patient education programs should be delivered as designed. Some validity and effectiveness may be compromised when segments of various programs are pieced together or when programs are condensed. In the interest of saving time, educators should not delete educational strategies, such as using small groups or scheduling multiple sessions spaced with "homework" assignments, because these strategies have demonstrated effectiveness in motivating individuals to make significant behavior changes (Thapar 1994; Wilson et al. 1993; Kotses et al. 1995; Bailey et al. 1990).

A variety of *other educational formats*, such as videotapes (Yoon et al. 1993) and interactive computer software (Osman et al. 1994), also may *enhance, but not replace*, education delivered by clinicians.

PROVIDE PATIENT EDUCATION IN OTHER CLINICAL SETTINGS

Patient education also should be delivered in the context of emergency department visits and hospitalizations. Asthma exacerbations may represent teachable moments when patients are more receptive to educational messages. Research on adults with asthma who are referred by emergency department providers to an asthma education program shows that education can decrease utilization of emergency services (Bolton et al. 1991). Educational programs delivered to hospitalized children and adult asthma patients show increased knowledge and use of self-management behaviors (Taggart et al. 1991), reduced length of hospital stay, and overall reduction in asthma readmissions (Mayo et al. 1996).

REFERENCES

Bailey WC, Richards JM Jr, Brooks CM, Soong SJ, Windsor RA, Manzella BA. A randomized trial to improve self-management practices of adults with asthma. *Arch Intern Med* 1990;150:1664-8.

Beasley R, Cushley M, Holgate ST. A self management plan in the treatment of adult asthma. *Thorax* 1989;44:200-4.

Bolton MB, Tilley BC, Kuder J, Reeves T, Schultz LR. The cost and effectiveness of an education program for adults who have asthma. *J Gen Intern Med* 1991;6:401-7.

Busse WW, Kiecolt-Glaser JK, Coe CL, Martin RJ, Weiss RT, Parker SR. NHLBI workshop summary. Stress and asthma. *Am J Respir Crit Care Med* 1995;151:249-52.

Charlton I, Charlton G, Broomfield J, Mullee MA. Evaluation of peak flow and symptoms only self management plans for control of asthma in general practice. *BMJ* 1990;301:1355-9.

Charney E, Bynum R, Eldredge D, et al. How well do patients take oral penicillin? A collaborative study in private practice. *Pediatrics* 1967;40(2):188-95.

Clark NM. Asthma self-management education. Research and implications for clinical practice. *Chest* 1989;95(5):1110-3.

Clark NM, Feldman CH, Evans D, Levison MJ, Wasilewski Y, Mellins RB. The impact of health education on frequency and cost of health care use by low income children with asthma. *J Allergy Clin Immunol* 1986;78(1):108-15.

Clark NM, Nothwehr F, Gong M, et al. Physician-patient partnership in managing chronic illness. *Acad Med* 1995;70(11):957-9.

Creer TL, Backial MA, Burns KL, et al. Living with asthma. I. Genesis and development of a self-management program for childhood asthma. *J Asthma* 1988;25:335-62.

Davis TC, Crouch MA, Wills G, Miller S, Abdehou M. The gap between patient reading comprehension and the readability of patient education materials. *J Fam Pract* 1990;31:533-8.

Dolovich M, Ruffin RE, Roberts R, Newhouse MT. Optimal delivery of aerosols from metered dose inhalers. *Chest* 1981;80(6):911-5.

D'Souza W, Crane J, Burgess C, et al. Community-based asthma care: trial of a "credit card" asthma self-management plan. *Eur Respir J* 1994;7:1260-5.

Eisen SA, Miller DK, Woodward RS, Spitznagel E, Przybeck TR. The effect of prescribed daily dose frequency on patient medication compliance. *Arch Intern Med* 1990;150(9):1881-4.

Estey A, Musseau A, Keehn L. Comprehension levels of patients reading health information. *Patient Educ Couns* 1991;18:165-9.

Evans D. To help patients control asthma the clinician must be a good listener and teacher [editorial]. *Thorax* 1993;48:685-7.

Evans D, Clark NM, Feldman CH, et al. A school health education program for children with asthma aged 8-11 years. *Health Educ Q* 1987;14(3):267-79.

Evans D, Mellins R, Lobach K, et al. Improving care for minority children with asthma: professional education in public health clinics. *Pediatrics* 1997;99(2):157-64.

Feldman CH, Clark NM, Evans D. The role of health education in medical management of asthma. Some program applications. *Clin Rev Allergy* 1987;5:195-205.

Fireman P, Friday GA, Gira C, Vierthaler WA, Michaels L. Teaching self-management skills to asthmatic children and their parents in an ambulatory care setting. *Pediatrics* 1981;68:341-8.

Graham NM, Woodward AJ, Ryan P, Douglas RM. Acute respiratory illness in Adelaide children. II: The relationship of maternal stress, social supports and family functioning. *Int J Epidemiol* 1990;19(4):937-44.

Hanania NA, Wittman R, Kesten S, Chapman KR. Medical personnel's knowledge of and ability to use inhaling devices. Metered-dose inhalers, spacing chambers, and breath-actuated dry powder inhalers. *Chest* 1994;105(1):111-6.

Haynes RB, Taylor DW, Sackett DL, eds. *Compliance in Health Care*. Baltimore, MD: Johns Hopkins University Press, 1979.

Hindi-Alexander MC, Cropp GJA. Evaluation of a family asthma program. *J Allergy Clin Immunol* 1984;74:505-10.

Hindi-Alexander MC, Throm J. Compliance or noncompliance: that is the question! *Am J Health Promotion* 1987;1(4):5-11.

Ignacio-Garcia JM, Gonzales-Santos P. Asthma self-management education program by home monitoring of peak expiratory flow. *Am J Respir Crit Care Med* 1995;151:353-9.

Janson-Bjerklie S, Ferketich S, Benner P, Becker G. Clinical markers of asthma severity and risk: importance of subjective as well as objective factors. *Heart Lung* 1992;21:265-72.

Janz NK, Becker MH, Hartman PE. Contingency contracting to enhance patient compliance: a review. *Patient Educ Counsel* 1984:5(4):165-78.

Juniper EF, Guyatt GH, Epstein RS, Ferrie PJ, Jaeschke R, Hiller TK. Evaluation of impairment of health related quality of life in asthma: development of a questionnaire for use in clinical trials. *Thorax* 1992;47:76-83.

Kesten S, Zive K, Chapman KR. Pharmacist knowledge and ability to use inhaled medication delivery systems. *Chest* 1993;104(6):1737-42.

Kleinman A, Eisenberg L, Good B. Culture, illness, and care: clinical lessons from anthropologic and cross-cultural research. *Ann Intern Med* 1978;88:251-8.

Korsch BM, Gozzi EK, Francis V. Gaps in doctor-patient communication. I. Doctor-patient interaction and patient satisfaction. *Pediatrics* 1968;42(5):855-71.

Kotses H, Bernstein IL, Bernstein DI, et al. A self-management program for adult asthma. Part I: Development and evaluation. *J Allergy Clin Immunol* 1995;95(2):529-40.

Kotses H, Stout C, McConnaughy K, Winder JA, Creer TL. Evaluation of individualized asthma self-management programs. *J Asthma* 1996;33:113-8.

Lahdensuo A, Haahtela T, Herrala J, et al. Randomised comparison of guided self management and traditional treatment of asthma over one year. *BMJ* 1996;312:748-52.

Larsen JS, Hahn M, Ekholm B, Wick KA. Evaluation of conventional press-and-breathe metered-dose inhaler technique in 501 patients. *J Asthma* 1994;31(3):193-9.

Lewis CE, Rachelefsky G, Lewis MA, de la Sota A, Kaplan M. A randomized trial of A.C.T. (Asthma Care Training) for kids. *Pediatrics* 1984;74:478-86.

Ley H. Primacy, rated importance, and the recall of medical statements. *J Health Soc Behav* 1972;13:311-7.

Manson A. Language concordance as a determinant of patient compliance and emergency room use in patients with asthma. *Med Care* 1988;26(12):1119-28.

Marks GB, Dunn SM, Woolcock AJ. An evaluation of an asthma quality of life questionnaire as a measure of change in adults with asthma. *J Clin Epidemiol* 1993;46(10):1103-11.

Mayo PH, Richman J, Harris HW. Results of a program to reduce admissions for adult asthma. *Ann Intern Med* 1990;112:864-71.

Mayo PH, Weinberg BJ, Kramer B, Richman J, Seibert-Choi O-S, Rosen MJ. Results of a program to improve the process of inpatient care of adult asthmatics. *Chest* 1996;110:48-52.

McNabb WL, Wilson-Pessano SR, Hughes GW, Scamagas P. Self-management education of children with asthma: AIR WISE. *Am J Public Health* 1985;75:1219-20.

Meichenbaum D, Turk D. *Facilitating Treatment Adherence: A Practitioners Guidebook.* New York: Plenum Press, 1987.

Mellins RB. Patient education is key to successful management of asthma. *J Rev Respir Dis* 1989;(Suppl):S47-S52.

Mellins RB. Developing a therapeutic plan for asthma in a primary-care setting. *City Health Info* 1996:15:4-6.

Mellins RB, Evans D. The role of health education in the management of asthma. In: Taussig LM, Landau L, eds. *Pediatric Respiratory Medicine.* St. Louis, MO: Mosby, in press.

Morris LA, Grossman R, Barkdoll GL, Gordon E. *A National Survey of Prescription Drug Information Provided to Patients.* Food and Drug Administration, Rockville, MD 1986. OPE study 73, May 1986.

Mushlin AL, Appel FA. Diagnosing potential noncompliance. Physicians' ability in a behavioral dimension of medical care. *Arch Intern Med* 1977;137(3):318-21.

National Heart, Lung, and Blood Institute. *Asthma Management and Prevention: A Practical Guide for Public Health Officials and Health Care Professionals.* National Institutes of Health pub. no. 96-3659A. Bethesda, MD, 1995d.

National Heart, Lung, and Blood Institute. *Asthma Management in Minority Children: Practical Insights for Clinicians, Researchers, and Public Health Planners*. National Institutes of Health pub. no. 95-3675. Bethesda, MD, 1995c.

National Heart, Lung, and Blood Institute. *Air Power: Self-Management of Asthma Through Group Education.* National Institutes of Health pub no 85-2362. Bethesda, MD, 1984c.

National Heart, Lung, and Blood Institute. *Air Wise: Management of Asthma Through Individual Education.* National Institutes of Health pub no 84-2363. Bethesda, MD, 1984a.

National Heart, Lung, and Blood Institute. *Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention. NHLBI/WHO Workshop Report.* National Institutes of Health pub no 95-3659. Bethesda, MD, 1995e.

National Heart, Lung, and Blood Institute. *Living With Asthma: Manual for Teaching Families the Self-Management of Childhood Asthma*. National Institutes of Health pub no 85-2364. Bethesda, MD, 1985.

National Heart, Lung, and Blood Institute. *Nurses: Partners in Asthma Care*. National Institutes of Health pub no 95-3308. Bethesda, MD, 1995a.

National Heart, Lung, and Blood Institute. *Open Airways/Respiro Abierto: Asthma Self-Management Program.* National Institutes of Health pub no 84-2365. Bethesda, MD, 1984b.

National Heart, Lung, and Blood Institute. *The Role of the Pharmacist in Improving Asthma Care*. National Institutes of Health pub no 95-3280. Bethesda, MD, 1995b.

Nimmo CJR, Chen DNM, Martinusen SM, Ustad TL, Ostrow DN. Assessment of patient acceptance and inhalation technique of a pressurized aerosol inhaler and two breach-actuated devices. *Ann Pharmacother* 1993;27:922-7.

Osman LM, Abdalla MI, Beattie JAG, et al. Reducing hospital admission through computer supported education for asthma patients. *BMJ* 1994;308(6928):568-71.

Pachter LM, Cloutier MM, Bernstein BA. Ethnomedical (folk) remedies for childhood asthma in a mainland Puerto Rican community. *Arch Pediatr Adolesc Med* 1995;149:982-8.

Pachter LM, Weller SC. Acculturation and compliance with medical therapy. *Dev Behav Pediatr* 1993;14(3):163-8.

Plaut TF. Asthma peak flow diary improves care. *Ann Allergy Asthma Immunol* 1996;76:476-8.

Plaut TF, Brennan C. *Asthma Charts and Forms*. Amherst, MA: Pedipress, Inc., 1996.

Rau JL, Restrepo RD, Deshpand EV. Inhalation of single vs. multiple metered dose bronchodilator actuations from reservoir devices. An in vitro study. *Chest* 1996;109:969-74.

Ries AL, Kaplan RM, Limberg TE, Prewitt LM. Effects of pulmonary rehabilitation on physiologic and psychosocial outcomes in patients with chronic obstructive pulmonary disease. *Ann Intern Med* 1995;122(11):823-832.

Risser AL, Mazur LJ. Use of folk remedies in a Hispanic population. *Arch Pediatr Adolesc Med* 1995;149:978-81.

Schulman BA. Active patient orientation and outcomes in hypertensive treatment. Application of a socio-organizational perspective. *Med Care* 1979;17(3):267-80.

Taggart VS, Zuckerman AE, Sly RM, et al. You can control asthma: evaluation of an asthma education program for hospitalized inner-city children. *Patient Educ Counsel* 1991;17:35-47.

Thapar A. Educating asthmatic patients in primary care: a pilot study of small group education. *Fam Pract* 1994;11(1):39-43.

Toelle BG, Peat JK, Salome CM, Mellis CM, Bauman AE, Woodcock AJ. Evaluation of a community-based asthma management program in a population sample of school-children. *Med J Austr* 1993;158:742-6.

Trautner C, Richter B, Berger M. Cost-effectiveness of a structured treatment and teaching programme on asthma. *Eur Respir J* 1993;6:1485-91.

Wilson SR, Latini D, Starr NJ, et al. Education of parents of infants and very young children with asthma: a developmental evaluation of the Wee Wheezers program. *J Asthma* 1996;33(4):239-54.

Wilson SR, Scamagas P, German DF, et al. A controlled trial of two forms of self-management education for adults with asthma. *Am J Med* 1993;94:564-76.

Wilson-Pessano SR, McNabb WL. The role of patient education in the management of childhood asthma. *Prev Med* 1985;14:670-87.

Wilson-Pessano SR, Scamagas P, Arsham GM, et al. An evaluation of approaches to asthma self-management education for adults: the AIR/Kaiser-Permanente study. *Health Educ Q* 1987;14(3):333-43.

Woloshin S, Bickell NA, Schwartz LM, Gany F, Welch HG. Language barriers in medicine in the United States. *JAMA* 1995;273(9):724-8.

Woolcock AJ, Yan K, Salome CM. Effect of therapy on bronchial hyperresponsiveness in the long-term management of asthma. *Clin Allergy* 1988;18:165-76.

Yoon R, McKenzie DK, Bauman A, Miles DA. Controlled trial evaluation of an asthma education programme for adults. *Thorax* 1993;48:1110-6.

Figure 4-5.

ASTHMA ACTION PLAN (EXAMPLE 1)

Name _____ Date _____

It is important in managing asthma to keep track of your symptoms, medications, and peak expiratory flow (PEF).
You can use the colors of a traffic light to help learn your asthma medications:

A. **GREEN means Go** Use preventive (anti-inflammatory) medicine
B. **YELLOW means Caution** Use quick-relief (short-acting bronchodilator) medicine in addition to the preventive medicine.
C. **RED means STOP!** Get help from a doctor.

A. Your **GREEN ZONE** is _____ 80 to 100% of your personal best. GO!
Breathing is good with no cough, wheeze, or chest tightness during work, school, exercise, or play.

ACTION:

☐ Continue with medications listed in your daily treatment plan.

B. Your **YELLOW ZONE** is _____ 50 to less than 80% of your personal best. CAUTION!
Asthma symptoms are present (cough, wheeze, chest tightness).
Your peak flow number drops below _____ or you notice:

☐ Increased need for inhaled quick-relief medicine
☐ Increased asthma symptoms upon awakening
☐ Awakening at night with asthma symptoms
☐ _____

ACTIONS:

☐ Take _____ puffs of your quick-relief (bronchodilator) medicine _____.
Repeat _____ times.
☐ Take _____ puffs of _____ (anti-inflammatory) _____ times/day.
☐ Begin/increase treatment with oral steroids:
Take _____ mg of _____ every a.m. _____ p.m. _____ .
☐ Call your doctor (phone) _____ or emergency room _____.

C. Your **RED ZONE** is _____ 50% or less of your best. DANGER!!
Your peak flow number drops below _____ , or you continue to get worse after increasing treatment according to the directions above.

ACTIONS:

☐ Take _____ puffs of your quick-relief (bronchodilator) medicine _____. Repeat _____ times.
☐ Begin/increase treatment with oral steroids. Take _____ mg now.
☐ Call your doctor now (phone _____). If you cannot contact your doctor, go directly to the emergency room (phone _____).

Other important phone numbers for transportation _____.

AT ANY TIME, CALL YOUR DOCTOR IF:

☐ Asthma symptoms worsen while you are taking oral steroids, or
☐ Inhaled bronchodilator treatments are not lasting 4 hours, or
☐ Your peak flow number remains or falls below _____ in spite of following the plan.

Physician Signature _____ Patient's/Family Member's Signature _____

This plan is provided as an example to clinicians.

Figure 4-5.

ASTHMA ACTION PLAN (EXAMPLE 2)

Name: _____

Doctor's Name: _____

Doctor's Phone: _____

Baseline/Personal Best Peak Flow: _____

Medicines: _____

ZONE	ACTIONS
GREEN	
YELLOW	
RED	

Adapted with permission from Cecilia Vicuña-Kneady, R.N.
This plan is provided as an example to clinicians.

Figure 4-5.

ASTHMA ACTION PLAN (EXAMPLE 3)

ADULT SELF-MANAGEMENT INSTRUCTIONS FOR ASTHMA ACTION PLAN

DATE -_____.

When to Monitor Peak Flow Numbers

- ☐ In the morning soon after waking up.
- ☐ Before supper.
- ☐ Before bed.
- ☐ Before and 5-15 minutes after inhaled treatments.
- ☐ With increased respiratory symptoms.
- ☐ _____.

Important Peak Flow Numbers

Baseline _____.

_____ % baseline _____.

_____ % baseline _____.

If your peak flow number drops below_____ or you notice:

- Increased use of inhaled treatments to manage asthma
- Increased asthma symptoms upon awakening
- Awakening at night with asthma symptoms
- _____.

Follow these treatment steps:

- ☐ Increase inhaled steroids.
  Take_____ puffs of _____ _____times a day.
- ☐ Begin/increase treatment with oral steroids.
  Take_____ mg of _____.
  In the ☐ morning and /or ☐ before supper.
- ☐ _____.

If your peak flow number drops below_____ or you continue to get worse after increasing treatment according to the directions above, follow these treatment steps:

- ☐ Begin/increase treatment with oral steroids.
  Take_____mg of _____.
  In the ☐ morning and /or ☐ before supper.
- ☐ Contact your health care provider.

Contact your health care provider if:

- ☐ Asthma symptoms worsen while you are taking oral steroids or,
- ☐ Inhaled bronchodilator treatments are not lasting 4 hours or,
- ☐ Your peak flow number falls below_____.
- ☐ If you cannot contact your health care provider go directly to the Emergency Room.

Directions for Resuming Normal Treatment:

- ☐ Continue increased treatment until symptoms and peak flow number have returned to normal, then continue increased inhaled steroids or _____ mg of oral steroids for the same number of days it took to return to normal. If your peak flow number has not returned to normal in 5 days contact your health care provider.
- ☐ Call your health care provider for specific instructions.

If you have questions please call:

☐ ☐ Other_____ After hours

☐ Your home physician.

Physician Signature _____ Date _____

Patient/Family Signature_____ Staff Signature _____

T-101 1/95

Adapted with permission from National Jewish Medical and Research Center.
This plan is provided as an example to clinicians.

Figure 4-5.

ASTHMA ACTION PLAN (Peak Flow monitoring)

[1]

ZONE	LEVEL	STATUS	ACTION
Green Zone: All Clear My best peak Flow: _____ **Peak Flow:** _____ to _____ (100 - 80% of My Best Peak Flow) • No symptoms of an asthma episode • Able to do usual activities • Usual medications control asthma	1	DOING WELL	**TAKE:** Medicine / Dose / Max # times/day
Yellow Zone: Caution Peak Flow: _____ to _____ (80 - 50% of My Best Peak Flow) • Increased asthma symptoms (including wakening at night due to asthma) • Usual activities somewhat limited • Increased need for asthma medications	2	INCREASE IN SYMPTOMS	**ADD:** Medicine / Dose / Max # times/day Return to Level 1 when symptoms improve
Red Zone: Medical Alert Peak Flow: Less than _____ (50% of My Best Peak Flow) • Increased symptoms longer than 24 hrs • Very short of breath • Usual activities severely limited • Asthma medications haven't reduced symptoms	3	NO IMPROVEMENT AFTER ____ HRS or EVEN MORE SYMPTOMS	**ADD:** Medicine / Dose **AND CALL YOUR PROVIDER**

DANGER SIGNS:

- ***DIFFICULTY WALKING AND TALKING DUE TO SHORTNESS OF BREATH*** ☛ ***GO TO THE HOSPITAL NOW OR CALL 911 NOW***
- ***LIPS OR FINGERNAILS ARE BLUE***

ASTHMA ACTION PLAN (EXAMPLE 4)

Adapted with permission from Kaiser Permanente Center for Health Research, Portland, OR.
This plan is provided as an example to clinicians.

Figure 4-5.

ASTHMA ACTION PLAN (Symptom monitoring)

[3]

LEVEL		STATUS	ACTION
All Clear • No symptoms of an asthma episode • Able to do usual activities • Usual medications control asthma	1	DOING WELL	**TAKE:** Medicine / Dose / Max # times/day
Caution • Increased asthma symptoms (including wakening at night due to asthma) • Usual activities somewhat limited • Increased need for asthma medications	2	INCREASE IN SYMPTOMS	**ADD:** Medicine / Dose / Max # times/day Return to Level 1 when symptoms improve
Medical Alert • Increased symptoms longer than 24 hrs • Very short of breath • Usual activities severely limited • Asthma medications haven't reduced symptoms	3	NO IMPROVEMENT AFTER ___ HRS or EVEN MORE SYMPTOMS	**ADD:** Medicine / Dose **AND CALL YOUR PROVIDER**
DANGER SIGNS:		• *DIFFICULTY WALKING AND TALKING DUE TO SHORTNESS OF BREATH* ☛ *GO TO THE HOSPITAL NOW OR CALL 911 NOW* • *LIPS OR FINGERNAILS ARE BLUE*	

ASTHMA ACTION PLAN (EXAMPLE 5)

Adapted with permission from Kaiser Permanente Center for Health Research, Portland, OR.
This plan is provided as an example to clinicians.

Figure 4-5.

ASTHMA ACTION PLAN (EXAMPLE 6)

For adults, teens, and children age 5 and over

PEAK FLOW-BASED HOME TREATMENT PLAN

Name: Date: Best Peak Flow:

Green Zone

GREEN ZONE: Peak flow between _____ and _____.

Normal activity. (Insert brand name in blanks.)

- ❑ Adrenaline-like medicine: albuterol (_____), pirbuterol (_____), or terbutaline (_____): 1 or 2 puffs 15 minutes before exercise.
- ❑ Nedocromil (_____) or cromolyn (_____): 2 puffs before contact with cat or other allergen.

Medicine to be taken every day:

- ❑ Nedocromil (_____) or cromolyn (_____): ____ puffs____ times a day (a total of____ puffs daily).
- ❑ Inhaled steroid (_____): ____ puffs____ times a day (a total of____ puffs daily).
- ❑ Adrenaline-like medicine (see above): ____ puffs before each *nedocromil, cromolyn,* or *inhaled steroid* dose for the first month.
- ❑ Other:

Yellow Zone

HIGH YELLOW ZONE: Peak flow between _____ and _____.

Eliminate triggers and change medicines. No strenuous exercise.

Medicine to be taken:

- ❑ Adrenaline-like medicine: ____ puffs by holding chamber. Give three to six times in 24 hours. Continue until peak flow is in the *Green Zone* for 2 days.
- ❑ Double *inhaled steroid* to ____ puffs daily until peak flow is in the *Green Zone* for as long as it was in the *Yellow Zone*.
- ❑ Other:

LOW YELLOW ZONE: Peak flow between _____ and _____.

Follow this plan if peak flow does not reach *High Yellow Zone* within 10 minutes after taking inhaled adrenaline-like medicine, or drops back into *Low Yellow Zone* within 4 hours:

- ❑ Continue adrenaline-like medicine treatment as above.
- ❑ Add *oral steroid** ____ mg immediately. Continue each morning (8:00 a.m.) until peak flow is in the *Green Zone* for at least 24 hours.
- ❑ Please call the office before starting oral steroid.

* If your condition does not improve within 2 days after starting oral steroid, or if peak flow does not reach the *Green Zone* within 7 days of treatment, see your doctor.

Red Zone

RED ZONE: Peak flow less than _____.

Follow this plan if peak flow does not reach *Low Yellow Zone* within 10 minutes after taking inhaled adrenaline-like medicine, or drops back into *Red Zone* within 4 hours.

- ✔ Adrenaline-like medicine: ____ puffs by holding chamber.
- ✔ Give oral steroid____ mg.
- ✔ Visit your doctor or go to the emergency room.

Adapted with permission from Plaut and Brennan 1996.
This plan is provided as an example to clinicians.

Figure 4-7.

SCHOOL SELF-MANAGEMENT PLAN

Asthma and Allergy
Foundation of America
1125 15th St., N.W., Suite 502
Washington, DC 20005

STUDENT ASTHMA ACTION CARD

Endorsed by
National Asthma Education Program

ID Photo

Name: _____ Grade: _____ Age: _____

Teacher: _____ Room: _____

Parent/Guardian Name: _____ Ph: (H) _____

Address: _____ Ph: (W) _____

Parent/Guardian Name: _____ Ph: (H) _____

Address: _____ Ph: (W) _____

Emergency Phone Contact #1 _____ (Name) _____ (Relationship) _____ (Phone)

Emergency Phone Contact #2 _____ (Name) _____ (Relationship) _____ (Phone)

Physician Student Sees for Asthma: _____ Ph: _____

Other Physician: _____ Ph: _____

DAILY ASTHMA MANAGEMENT PLAN

- **Identify the things which start an asthma episode (Check each that applies to the student.)**

☐ Exercise
☐ Respiratory infections
☐ Change in temperature
☐ Animals
☐ Food _____
☐ Strong odors or fumes
☐ Chalk dust
☐ Carpets in the room
☐ Pollens
☐ Molds
☐ Other _____
_____

Comments _____

- **Control of School Environment**

(List any environmental control measures, pre-medications, and/or dietary restrictions that the student needs to prevent an asthma episode.)

_____
_____
_____

- **Peak Flow Monitoring**

Personal Best Peak Flow number: _____

Monitoring Times: _____ _____ _____

- **Daily Medication Plan**

	Name	Amount	When to Use
1.			
2.			
3.			
4.			

Figure 4-7.

SCHOOL SELF-MANAGEMENT PLAN (CONTINUED)

Emergency Plan

Emergency action is necessary when the student has symptoms such as _____, _____, _____, _____ or has a peak flow reading of _____.

- **Steps to take during an asthma episode:**
  1. Give medications as listed below.
  2. Have student return to classroom if _____
  3. Contact parent if _____
  4. Seek emergency medical care if the student has any of the following:
     - ✔ No improvement 15-20 minutes after initial treatment with medication and a relative cannot be reached.
     - ✔ Peak flow of _____
     - ✔ Hard time breathing with:
       - Chest and neck pulled in with breathing
       - Child is hunched over
       - Child is struggling to breathe
     - ✔ Trouble walking or talking
     - ✔ Stops playing and can't start activity again
     - ✔ Lips or fingernails are gray or blue

} ***If This Happens, Get Emergency Help Now!***

- **Emergency Asthma Medications**

	Name	Amount	When to Use
1.			
2.			
3.			
4.			

Comments / Special Instructions

_____

_____

_____

For Inhaled Medications

☐ I have instructed _____ in the proper way to use his/her medications. It is my professional opinion that _____ should be allowed to carry and use that medication by him/herself.

☐ It is my professional opinion that _____ should not carry his/her inhaled medication by him/herself.

_____ _____
Physician Signature Date

_____ _____
Parent Signature Date

FIGURE 4-8. SOURCES OF PATIENT EDUCATION PROGRAMS AND MATERIALS

Organization	Validated Program(s); Age Group	Other written and audiovisual patient education materials? (in other languages?)	Local support groups?
American Lung Association For the affiliate nearest you, call (800) LUNG-USA [800-586-4872]	Open Airways at School; 8-11 years (Evans et al. 1987)	Yes (Yes)	Yes
Asthma and Allergy Foundation of America 1125 15th Street, N.W., Suite 502 Washington, DC 20005 (800) 7-ASTHMA [800-727-8462]	Asthma Care Training for Kids (A.C.T.); 7-12 years (Lewis et al.1984) You Can Control Asthma; 8-12 years (Taggart et al. 1991)	Yes (Yes)	Yes
National Technical Information Service 5285 Port Royal Road Springfield, VA 22161 (703) 487-4650	Air Power; 9-13 years (Wilson-Pessano and McNabb 1985; NHLBI 1984c) Air Wise; 8-13 years (McNabb et al. 1985; NHLBI 1984a) Living With Asthma; 8-13 years (Creer et al. 1988; NHLBI 1985) Open Airways; 4-12 years (Clark et al. 1986; NHLBI 1984a)	Yes (Yes)	No
National Asthma Education and Prevention Program National Heart, Lung, and Blood Institute Information Center P.O. Box 30105 Bethesda, MD 20824-0105 (301) 251-1222	Breathe Easier; adult (Wilson et al. 1993)	Yes (Yes)	No
Allergy and Asthma Network/Mothers of Asthmatics, Inc. 3554 Chain Bridge Road, Suite 200 Fairfax, VA 22030-2709 (800) 878-4403	No validated programs	Yes (Yes)	No
American Academy of Allergy, Asthma, and Immunology 611 East Wells Street Milwaukee, WI 53202 (800) 822-ASTHMA [800-822-2762]	No validated programs	Yes (No)	No
American College of Allergy, Asthma, and Immunology 85 West Algonquin Road Arlington Heights, IL 60005 (800) 842-7777	No validated programs	Yes (No)	No
National Jewish Medical and Research Center 1400 Jackson Street Denver, CO 80206 (800) 423-8891	No validated programs	Yes (No)	No

Discrimination Prohibited: Under provisions of applicable public laws enacted by Congress since 1964, no person in the United States shall, on the grounds of race, color, national origin, handicap, or age, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity (or, on the basis of sex, with respect to any education program or activity) receiving Federal financial assistance. In addition, Executive Order 11141 prohibits discrimination on the basis of age by contractors and subcontractors in the performance of Federal contracts, and Executive Order 11246 states that no federally funded contractor may discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. Therefore, the National Heart, Lung, and Blood Institute must be operated in compliance with these laws and Executive Orders.

U.S. DEPARTMENT OF HEALTH AND
HUMAN SERVICES

Public Health Service
National Institutes of Health
National Heart, Lung, and Blood Institute

NIH Publication No. 97-4051
July 1997