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Contact Hours: 7

Asthma

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COURSE OBJECTIVE: The purpose of this course is to enable healthcare professionals to plan, deliver, and evaluate evidence-based preventative and therapeutic care for patients at risk for asthma and patients who have asthma.

LEARNING OBJECTIVES:
Upon completion of this course, you will be able to:

- Define asthma.
- Discuss the epidemiology of asthma.
- Review the pathophysiology, etiology, and contributing factors related to the development of asthma.
- List the signs and symptoms of asthma.
- Describe the diagnostic process and assessment of asthma severity.
- Review the pharmacologic treatments for asthma.
- Identify the elements of long-term asthma management.
- Discuss the roles of respiratory, physical, and occupational therapy in the long-term management of asthma.
- Outline self-management, emergency, and inpatient management of asthma exacerbations.
- Relate complications of asthma.
- Discuss asthma care for special populations.

Most people go through their days blissfully unaware of the approximately 25,000 breaths they take every 24 hours. This allows them to enjoy life and pursue their goals in relative comfort. They may experience some shortness of breath with exertion, but otherwise they breathe along nicely without concern.

For persons who have asthma, those 25,000 breaths may become the focus of their day. Depending on the severity of their symptoms, some may experience only occasional wheezing and shortness of breath, but for others each breath must be earned through great effort. Sometimes people know why an asthma attack has occurred, and other times they may be unaware of what triggered it, living with a sense of uneasiness even when they are doing well.

In those who must fight for each breath, fear and anxiety often aggravate the problem. Relief from this struggle becomes the only thing such people may think about, and they know they need help. Self-medication often works, but there are times when a trip to the emergency room is necessary to reverse the disease process and return the patient to maintenance status once again. Sometimes, the person is not so lucky and may need to be hospitalized. Regrettably, asthma may even lead to death.

ASTHMA DEFINED

Asthma is a chronic reactive airway disease characterized by reversible inflammation and constriction of bronchial smooth muscle, excessive secretion of mucus, and edema. Asthma causes recurring periods of wheezing, chest tightness, shortness of breath, and coughing. There are many factors that airways react to which can precipitate asthma, including allergens, physical and emotional stress, cold weather, exercise, chemicals, medications, and infections. There is no cure for asthma, but it can be controlled with effective treatment and management.

The clinical definitions of asthma stress four features of the condition:

- The patient has recurrent episodes of airway obstruction.
- Symptoms of these episodes can be reversed by medication.
- The patient's airways are chronically inflamed.
- The patient's airways are sensitive to a variety of stimuli to which a normal lung would not react.

Inflammation is the central problem in asthma.

The long-term management of the disease has two separate components:

1. "Cleaning" the patient's environment (i.e., reducing the patient's exposure to triggers of airway inflammation)
2. Giving the patient anti-inflammatory medicine (i.e., reducing the body's inflammatory response to those triggers)

Asthma causes lower quality of life and has large direct and indirect economic costs. It is the most common chronic health condition in childhood. Asthma affects individuals in many different ways—physically, psychologically, and socially.

Physical effects of asthma can range from an occasional bothersome cough all the way to the life-threatening inability to breathe. The frequency and seriousness of asthma symptoms depend greatly on how well a person's asthma is controlled as well as how severe the individual's asthma was to begin with.

Psychologically, an individual having difficulty breathing can experience fear during an acute episode and constant anxiety due to the unpredictability of the disease and possibility that another episode could happen at any time.

Socially, those with asthma may experience self-consciousness in employment, schooling, social interactions, and personal relationships related to the need to use an inhaler and to avoid triggers that can set off an asthma attack. Embarrassment and social stigma may be experienced especially by children and adolescents at a time when "fitting in" is so important.

EPIDEMIOLOGY

Asthma Worldwide

According to the World Allergy Organization, the prevalence of allergic diseases and asthma has been increasing worldwide, and the complexity and severity continue to increase especially among children and young adults (Pawankar, 2014).

The Global Asthma Network (GAN, 2014) has indicated that 334 million people worldwide have asthma, and the Global Initiative for Asthma (GINA, 2014a) estimates an additional 10 million are expected to have asthma by 2025. Asthma is a public health problem in all countries regardless of their level of development.

According to GAN, the burden of asthma is greatest for children ages 10 to 14 years and the older adult ages 75 to 79 years. It is the fourteenth most important disorder in the world in terms of the degree and length of disability.

Asthma accounts for 250,000 deaths per year. The prevalence is 8 to 10 times higher in developed countries than in developing countries; however, most asthma-related deaths (80%) occur in low- and lower-middle-income countries. The United Kingdom was reported to have one of the highest prevalence rates for childhood asthma. GINA notes that prevalence is higher in lower socioeconomic groups in urban areas.

Asthma in the United States

The Centers for Disease Control and Prevention (CDC, 2014a) reported that in 2012 9.3% of U.S. children and 8.0% of adults were affected by asthma. The rate for males was 7.0% and females 9.5%. The percentage of the U.S. population with asthma increased from 3.1% in 1980 to 8.4% in 2010. The American Lung Association (ALA, 2012) reported that in 2011 there were an estimated 25.9 million Americans diagnosed with asthma, 7.1 million of these being children.

GENDER

In 2012, the overall prevalence rate in females was 35% greater than in males, and among adults 18 and older, females were 62% more likely than males to have asthma.

This is reversed in childhood, however, when the prevalence rate for boys under 18 was 16% higher than among girls. Boys are affected more before puberty (three times greater), but prevalence becomes equal in adolescence. Among children, prevalence was higher among males ages 0 to 4 years (7.7%) and 5 to 14 years (12.4%) compared with female children in the same age groups (CDC, 2014a).

RACE/ETHNICITY

The American Lung Association report indicates the current asthma prevalence rate was a significant 47% higher in blacks than whites. The highest prevalence rates for both whites and blacks were among those aged 5 to 17 years.

Among Hispanics, 5.8 million have been diagnosed with asthma in their lifetime, and 1.7 million experienced an asthma attack in the past year. Lifetime current rates in Hispanics were significantly lower than non-Hispanic blacks and non-Hispanic whites in 2011. The CDC reports that among Hispanics, 16.1% of Puerto Ricans have asthma compared to 6.5% of the total Hispanic population.

GEOGRAPHY

The CDC finds that people in the United States living in the Northeast and Midwest have higher prevalence than those living in the South or West, with a prevalence range from 11.1% in Vermont to 6.0% in Tennessee. There is no significant difference between living in a metropolitan or nonmetropolitan area on the chances of having asthma.

ASTHMA ATTACK PREVALANCE

In 2011, an estimated 13.2 million Americans, including 4.1 million children, had an asthma attack. This is 51% of the total number in the United States who currently have asthma. In the past several years, those aged 5 to 17 years had the highest asthma attack prevalence rate, while those over 65 had the lowest every year. Females tend to consistently have higher attack prevalence rates.

The attack prevalence rate in blacks is 48% higher than the rate in whites. In 2011 the attack prevalence rate in whites and blacks was highest among those aged 5 to 17 years and lowest in those 65 years and older.

PATHOPHYSIOLOGY

The exact underlying cause of asthma is still unknown, but the pathophysiology of the disease is largely related to:

- Chronic airway inflammation
- Airway hyperresponsiveness
- Bronchoconstriction
- Airway remodeling

Fundamentally, asthma is an inflammatory disease of the airways. Asthmatic inflammation is distributed throughout the respiratory airways (i.e., the trachea, bronchi, and bronchioles), with the bronchioles being the most heavily involved. Although asthma causes a variety of clinical syndromes—such as intermittent asthma, persistent asthma, and exercise-induced asthma—all forms of asthma are characterized by similar chronic airway inflammation.

Inflammation resulting in hyperresponsiveness of the airways is the major pathological feature of all types of asthma. Some of the most important inflammatory mediators released during an asthma attack are histamine, prostaglandins, and leukotrienes. In addition, chemotactic factors are produced that result in bronchial infiltration by neutrophils, eosinophils, and lymphocytes. The resulting inflammatory process produces:

- Bronchial smooth muscle spasm
- Vascular congestion
- Increased blood vessel permeability
- Edema formation
- Production of thick, tenacious mucus
- Impaired mucociliary clearance
- Thickening of airway walls
- Increased contractile response of bronchial smooth muscle

These changes, combined with the damage to epithelial cells caused by eosinophil infiltration, produce airway hyperresponsiveness and obstruction. If untreated, these changes can lead to long-term airway damage that is irreversible. Permanent changes in the airways result from repeated bouts of inflammation, which leads to scarring of the airways (fibrosis) and permanent narrowing of the airways (remodeling). These changes usually occur slowly over a long period of time (Dunsky et al., 2015).

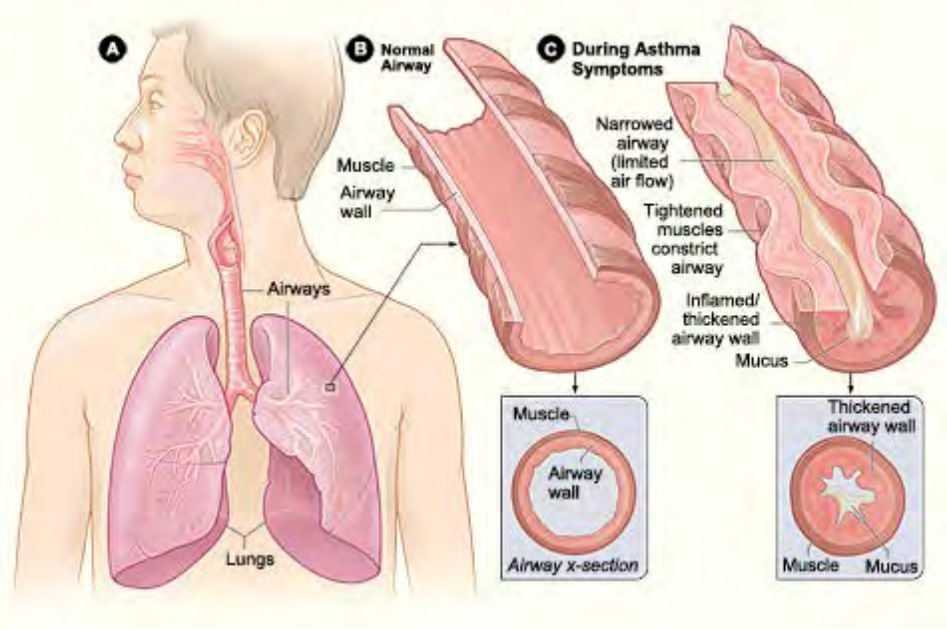
Airway obstruction resulting from the disease process increases resistance to airflow and decreases flow rates, mainly expiratory flow. Impaired expiration causes hyperinflation distal to the obstructions and increases the work of breathing. Because of differences in airway resistance in different areas of the lungs, the distribution of inspired air is uneven, with more air flowing to the less resistant portions.

Hyperventilation is eventually triggered by lung receptors responding to increased lung volume from air trapping and obstruction. Intrapleural and alveolar gas pressures rise and cause decreased perfusion of the alveoli.

Increased alveolar gas pressure, decreased ventilation, and decreased perfusion lead to erratic and uneven ventilation-perfusion relationships within different segments of the lungs. The result is early hypoxemia. Hypoxemia further increases hyperventilation by stimulating the respiratory center so that carbon dioxide arterial levels decrease and pH increases (respiratory alkalosis).

As the obstruction becomes more severe, the number of alveoli being inadequately ventilated and perfused increases, and carbon dioxide retention (hypercapnia) and respiratory acidosis develop. The development of respiratory acidosis signals impending respiratory failure (Huether & McCance, 2011).

There appear to be two distinct onset patterns to asthma: sudden onset and the more common slow onset. It has been observed that patients with sudden-onset fatal asthma had higher numbers of neutrophils and fewer eosinophils in the airway mucosa, raising the possibility that the mechanisms of inflammation and airway narrowing are completely different from those seen with slow-onset asthma (Hess et al., 2012).



During an asthma attack, the airways of the lung narrow and the movement of air is obstructed. This narrowing is caused by three processes: muscles in the airway walls contract, the airway walls become edematous and swollen, and excess mucus fills the airways. (Source: NHLBI, 2014a).

Asthma Progression by Age Groups

Asthma symptoms can vary over the lifetime of each person. Nonetheless, there are some generalities and commonalities that characterize the progression of the disease in various age groups.

CHILDREN

Asthma progression in childhood can go in many different directions. Some children with asthma continue to have the disease for their entire lives. Other children find that their symptoms decrease or even disappear during adolescence. Of those patients whose disease is in remission, some will remain symptom-free for the rest of their lives, while others will develop symptomatic asthma again later in life (Eberle et al., 2015).

As for general trends, clinicians often discuss asthma in three age ranges: infants, preschoolers, and school-age children.

Infants: Years 0 to 2

Many infants wheeze with respiratory diseases, and half of them have at least one episode of wheezing before the age of 3 years. However, infants who repeatedly develop wheezing should be evaluated.

Infants with intermittent wheezing are more likely to have or to develop asthma if:

- They wheeze when they have no respiratory illness
- They develop wheezing with allergies or after inhaling common triggers, such as dust or smoke
- They are prone to developing nasal, conjunctival, or skin signs of allergy, food allergies, or eczema
- A parent has a history of asthma
- Blood tests of the infant show eosinophilia (i.e., higher than usual concentrations of eosinophils)

  (Tran et al., 2014)

Some infants can have persistent wheezing or cough. When these infants have atopy (tendency to have allergic reactions) or a family history of atopic diseases, asthma is likely, although it is important for them to have an open-minded medical evaluation (Eberle, 2015).

Preschool: Years 3 to 5

In the preschool years, asthma phenotypes become distinct, and children with wheezing often fall into one of three categories:

- Asthma symptoms that come episodically with colds and other respiratory infections
- Asthma symptoms that are brought on by exercise
- Asthma symptoms that persist throughout the year

An important caveat for clinicians and parents is that episodes of wheezing in early childhood do not necessarily mean that the child will have a lifetime of asthma. Fifty-five percent of all children who have episodes of wheezing before the age of 7 years will be symptom-free by the time they are 21 years old.

School-Age Children: Years 6 to 12

In the pre-adolescent school years, allergen-induced asthma is more common than before, and viral-induced asthma remains a prevalent phenotype in school-age children (Guilbert et al., 2014).

Asthma is a progressive disease that gradually diminishes lung function. All people lose lung function as they age, but people with asthma lose lung function faster. In children, there is an additional risk. The lungs of young children are growing, and childhood asthma can interfere with this growth. A study has shown that children who develop asthma by age 7 years had a lung function deficit and increased airway responsiveness as newborns. This lung function deficit progressed to age 7. The study raised an important question as to whether the loss of function associated with asthma is a cause or a consequence of the disease (Bisgaard et al., 2012).

ADOLESCENTS

Asthma can first appear in a person at any age, and new cases of asthma develop throughout the adolescent years. Asthma symptoms can also become less frequent or even disappear altogether at any age, and overall about 50% of asthmatic children go into remission during their first 18 years of life (Javed et al., 2013).

Children with infrequent wheezing or with wheezing only during viral infections are most likely to lose their symptoms in adolescence.

Adolescents have more remissions of symptomatic asthma than any other age group. During their teen years, between a quarter and a half of all children with asthma symptoms go into remission, which may be explained by the increased growth of the airways during and after puberty. The more severe the asthma past the age of 5, however, the more likely symptoms will continue (Edgar, 2015).

Adolescence also brings new difficulties in asthma management. Adolescent cigarette smoking is one of the factors, involving taking health risks, being pressured by peers, and parental role modeling. In a recent study, asthmatic adolescents had greater odds of smoking than

nonasthmatics, with 79% having tried cigarette smoking. The study found that those adolescents with asthma reported experiencing feelings of moderate or intense physical relaxation when they smoke. As a result, they were less likely to try to quit smoking (Dowdell et al., 2011).

ADULTS

When people are diagnosed with asthma when they are older than age 20, it is known as **adult-onset asthma**. The thirties is the typical decade for symptoms to appear. Adult-onset asthma is most common in females during the childbearing years, when body and hormonal changes are occurring. Asthma may develop during or immediately after pregnancy.
Adult-onset asthma is different than childhood asthma because adults have a lower lung capacity and changes in muscles and stiffening of chest walls after middle age. Asthma is common among persons over age 65, and most deaths caused by asthma occur in this age group.

When asthma develops in advanced age, symptoms are much like those in young adults. Unlike asthma in younger persons, though, asthma in older adults rarely goes into remission. It is likely to remain a severe and disabling disorder, and daily medications may be required to keep the disease under control (UMMC, 2013).

About half of adults who have asthma also have allergies. Many persons with adult-onset asthma have had a history of long-standing nasal allergies or frequent sinus infections. Allergies often begin with nasal symptoms and progress to breathing symptoms over a period of years. Adult-onset asthma also may be the result of commonplace irritants in the workplace or home, and the asthma symptoms come on suddenly (Buddiga, 2013a).

Types of Asthma

Asthma generally is categorized into two types that partially explain the most common exposures: extrinsic and intrinsic.

Extrinsic (allergic) asthma is the most common variety and develops with exposure to specific allergenic substances such as dusts, mites, animal dander, molds, yeasts, and fungi. Extrinsic asthma is most commonly seen in children.

In this form of asthma, hypersensitivity to an allergen mediates an immunoglobulin E (IgE) antibody reaction in the airway. IgE binds to allergens and then to mast cells, causing mast cell degranulation. Degranulation is a cellular process that releases antimicrobial cytotoxic molecules from secretory vesicles called granules found inside some cells involved in the immune system. This results in the release of histamine and other inflammatory substances, and the allergic cascade begins.

Intrinsic (idiosyncratic or nonallergenic) asthma is a result of neurological imbalances in the autonomic nervous system in which the alpha and beta adrenergic as well as the cholinergic sites of the system are not properly coordinated. This form of asthma is associated with respiratory tract infections, emotions, exercise, or airway cooling. Inflammation of the airway follows

similar pathologic pathways as in allergic asthma, but there is no evidence of an IgE-mediated reaction (Eberle et al., 2015).

EXERCISE-INDUCED ASTHMA

Exercise-induced asthma (EIA) is an intrinsic type of asthma that affects people of all ages. It is characterized by transient airway obstruction that typically occurs 5 to 15 minutes after strenuous exertion, peaks at 8 to 15 minutes after exercise, and eventually spontaneously resolves in about 20 to 30 minutes. EIA is prevalent in 90% of people with asthma, and among athletes it is estimated to range between 3% and 11%.
The exact cause of EIA is unclear. Theories include:

- Respiratory heat and/or water loss from the bronchial mucosa
- Mucosal drying and increased osmolarity, stimulating mast cell degranulation
- Rapid airway rewarming after exercise, causing vascular congestion, increased permeability, and edema leading to obstruction
- Hyperventilation, causing discharge of bronchospastic chemical mediators
  (Hess et al., 2012)

OCCUPATIONAL ASTHMA

Occupational asthma, an intrinsic type, is caused by inhaling fumes, gases, dust, or other potentially harmful substances while on the job. Persons with a family history of allergies are more likely to develop occupational asthma, particularly to some substances such as flour, animals, and latex. Occupational asthma has become the most common work-related lung disease in developed countries and accounts for up to 15% of adult-onset asthma cases in the United States (Malo et al., 2014).

There are two types of occupational asthma:

- **Immunologic** asthma develops only after months or years of exposure to an agent present in the workplace during which time sensitization develops.
- **Nonimmunologic** (irritant-induced) asthma occurs without a latency period after an intense exposure to an irritating dust, mist, vapor, or fume. The pathophysiologic mechanism underlying nonimmunologic asthma is not well understood, and it is not known why the asthmatic response persists in certain people. Mechanisms believed to be involved include genetic predisposition, immunologically mediated responses, and nonspecific airway inflammation (Hess et al., 2012).

NOCTURNAL ASTHMA

Nocturnal asthma can be either intrinsic or extrinsic and refers to asthma that worsens during the night, most often between 2 A.M. and 4 A.M. There are several explanations for this.

- **Reclining position**. During sleep, airways tend to narrow, which may cause increased resistance to airflow, increased blood volume in the lungs, and decreased lung volume. Drainage from sinus infections or postnasal drips may trigger nighttime coughing, which can cause more tightening of the airways.

- **Hormones and circadian rhythms**. Circadian changes in epinephrine, histamine, and other inflammatory mediators, cortisol, vagal tone, body temperature, and lower airway secretions are mechanisms believed to be involved in nocturnal asthma. Epinephrine helps keep the bronchial muscles relaxed and suppresses the release of other substances, such as histamines, that cause mucus secretion and bronchospasm. Cortisol also protects against asthma, and the levels of these two substances are lowest between midnight and 4 A.M. Histamine levels, however, tend to peak at this time, all of which increases the potential for symptoms. It is important to recognize that individuals who have reversed sleep patterns (i.e., sleeping during the day and working at night) have the same circadian changes that increase potential for asthma.

- **Allergen exposure**. House dust, dust mites, animal dander, and/or other allergens are concentrated in bedding. After inhaling these allergens for a few hours, asthma symptoms develop.

- **Air conditioning or colder night air**. Breathing cooler air may cause loss of heat and moisture from the airway.

- **GERD** (gastroesophageal reflux disorder). Reflux of stomach acid up through the esophagus and into the larynx may stimulate a bronchial spasm. This worsens when lying down or if asthma medications (theophylline or albuterol) have been taken that relax the sphincter between the stomach and the esophagus.
  (ALA, 2015a; Karriem-Norwood, 2014a)

COUGH-VARIANT ASTHMA

Cough-variant asthma can be either intrinsic or extrinsic and accounts for about 25% to 35% of cases of chronic cough. The main symptom is a chronic, nonproductive cough. Anyone can get cough-variant asthma at any time, but it is common in young children with childhood asthma. Cough-variant asthma may lead to the development of other asthma symptoms such as wheezing and dyspnea.

Causes may include exposure to allergens, breathing in cold air, post–upper respiratory infection, and the use of beta blocker medications for various conditions, including eye drops for treatment of glaucoma. Aspirin intolerance is the cause in up to 30% of patients with severe cough-variant asthma and in <10% of all patients with cough-variant asthma (Merck Manual, 2014).

ETIOLOGY

Although the fundamental causes of asthma are not completely understood, there is strong evidence that the development of asthma includes a combination of genetic predisposition and environmental exposure to ingested or inhaled substances that could provoke allergic reactions or irritate the airways as well as to infectious agents.

Genetic Contributions

Asthma runs in families, and if one identical twin has asthma, the other twin is likely to have it. Observations such as these demonstrate that the tendency to develop asthma is inherited. The specific genes that are responsible for inheriting asthma, however, have as yet not been identified. Asthma is thought to be transmitted most likely by multiple genes, some of which may influence the development of asthma, while others modify asthma severity or the patient's response to treatment (Barnes, 2014).

OXIDATIVE STRESS AND ENZYME ANTIOXIDANTS

There is strong evidence that oxidative stress plays a major role in airway inflammation and is a determinant of asthma severity.

Oxidative stress is an imbalance between the production of free radicals and the ability of the body to counteract or detoxify their harmful effects through neutralization by antioxidants. Free radicals are oxygen-containing molecules that have one or more unpaired electrons, making them highly reactive with other molecules.

Free radicals can chemically interact with various cell components—including DNA, protein, or lipid molecules—and "steal" electrons from them in order to become stabilized. This destabilizes the molecules of the cell components, which then seek out and "steal" an electron from other molecules, thereby triggering a large chain of free radical reactions. Free radicals cause cellular damage and/or cellular death.

Enzymatic and nonenzymatic antioxidants protect the body against such harmful effects. A genetic deficiency in the plasma antioxidant platelet-activating factor-acetylhydrolase (PAF-AH) has been shown to play a role in inflammatory diseases including asthma. When PAF-AH levels are low, platelet-activating-factor (PAF), which has potent inflammatory actions, is produced in larger quantities by cells in response to specific stimuli. It is likely that PAF plays an extremely important, perhaps a pivotal, role in the etiology of acute and chronic inflammatory processes such as asthma.

Source: Larkin et al., 2015.

Environmental Contributions

In a person with asthma, substances in the environment can trigger an episode of bronchoconstriction, and it appears that exposure to some of the same substances can also initiate the disease.

INHALED SUBSTANCES

Inhaling can bring foreign substances into direct contact with airway walls, where these irritants can provoke inflammation. Because asthma is caused by the chronic inflammation of airway walls, inhaled substances are high on the list of probable initiating causes of asthma.

Most studies have shown that exposure to biological allergens such as cockroaches, dust mites, pets, or mold spores increases a child's risk of developing asthma, and these substances may have a role in causing asthma. The push toward more energy-efficient homes has led to an increase in exposure to these substances as well as to fumes from household cleaners, air fresheners, and paints (MNT, 2013). In homes that do not "breathe" adequately, stale air becomes trapped indoors, and allergens and nonmold microorganisms may accumulate. If a sufficient amount of new air does not circulate into a home, the people inside will be breathing this trapped air constantly (Mize, 2015).

In a pregnant woman who smokes, some of the toxic chemicals in tobacco smoke pass through the placenta to her fetus. Children born to mothers who smoked have a higher asthma prevalence risk. The increased risk of negative respiratory outcomes might be caused by an adverse effect prenatally on both the immune system and the structural and functional development of the lung (Ferrante et al., 2014).

AIR POLLUTION

Air pollutants are related to the development of asthma. Components of air pollution include nitrogen dioxide (which can enhance the allergic response to inhaled allergens) and ozone (which induces epithelial damage and inflammatory responses in the upper and lower airways). Ozone impairs respiratory function and causes or exacerbates airway inflammation in healthy subjects and in those with atopy (D'Amato et al., 2013).

Evidence collected over the past 20 years shows an association between climate change and adverse health outcomes. Due to climate change, air pollution patterns are changing around the world.

VITAMIN E AND ASTHMA

Vitamin E is a nonenzymatic antioxidant that protects the body from free radicals and maintains the immune system. Vitamin E is not produced by the body and must be ingested. There are two forms of vitamin E: gamma-tocopherol and alpha-tocopherol.

Recent studies have shown that gamma-tocopherol has been linked to diminished lung function. Gamma-tocopherol is found in canola, soybean, and corn oils, which over the years have become the "healthier" replacements for butter and lard. It has been shown that higher concentrations of gamma-tocopherol in the blood plasma indicated a 10% to 17% reduction in lung function as measured by spirometry.

In contrast, alpha-tocopherol—found in olive oil, wheat germ, and almond and sunflower oils—has been found to have beneficial effects on lung function. Adult-onset asthma patients in the study were found to have significantly lower levels of alpha-tocopherol.

Source: Larkin et al, 2015.

RESPIRATORY INFECTIONS

Studies have suggested respiratory viral (respiratory syncytial virus, rhinovirus) and bacterial (chlamydia, Mycoplasma) infections are linked to the development of asthma.
Respiratory virus-induced wheezing illnesses in early childhood are a significant factor in the subsequent development of asthma, and viral infections are also believed to play an important role in the development and progression of airway remodeling in asthma. It is known that upper respiratory tract viral infections can spread to the lower respiratory tract and trigger acute asthma attacks (Leigh & Proud, 2014).

Respiratory syncytial virus (RSV) infects all children early in life and is the most common cause of infant lower respiratory tract infections. Episodes of lower respiratory tract infection in early life are associated with asthma development. RSV results in wheezing, either by causing bronchiolitis or by bringing about acute exacerbations of asthma. Epidemiological studies have shown that a link exists and that instead of being the cause for asthma, RSV infection may be a marker of predisposing factors for it (Lotz et al., 2013).

The rhinovirus has been linked to a genetic predisposition to developing allergic reactions (Turunen et al., 2014). It has been shown to cause DNA changes in airway epithelial cells that differ between asthmatic and healthy individuals (McErlean et al., 2014).

Early-life exposure to respiratory chlamydia infections modulate immune response, alter lung function and structure, and enhance the severity of allergic airways disease in later life (Patel & Ebley, 2013).

A history of *Mycoplasma pneumonia* has been found more often in children with acute episodes of wheezing than in controls, and infection is significantly associated with a history of recurrent wheezing. Although *Mycoplasma pneumonia* infection is known to exacerbate asthma, the role in the cause of the initial onset remains unclear. It appears that acute infection can initiate asthma in some previously asymptomatic patients and in some individuals with atopy (Hong, 2012).

CESAREAN SECTION

Babies born by Cesarean section have a 20% increase in asthma prevalence compared to babies born vaginally. This is thought to be due to immune system modifying infection from bacterial exposure. In children born by Cesarean section, the "good" maternal bacteria that are found in the birth canal are lacking, while the "bad" bacteria that may endanger the child's immune system are frequently present. In children born by vaginal delivery, the good maternal bacteria stimulate the newborn's white blood cells and other components of the immune system (Kulas et al., 2013; Huang et al., 2015).

Comorbid Factors

There is mounting evidence that **obesity** is associated with asthma. It is a risk factor for the development of asthma and is also associated with poor asthma control. Obesity causes a variety of mechanical, metabolic, and immunological changes that can affect the airways.

Mechanically, obesity lowers resting lung volume, and breathing at low lung volumes can induce airway hyperresponsiveness. Metabolically, adipose tissue regulates systemic inflammation via mediators such as cytokines and adipokines that can have direct effects on the airways. Immunological changes occurring with obesity include alterations in macrophage and lymphocyte function (Pradeepan et al., 2014).

Chronic obstructive pulmonary disease (COPD) has been found in a significant proportion of patients who present with symptoms of chronic airway disease. These patients have features of both asthma and COPD. Prevalence rates between 15% and 55% have been reported, with variation by age and gender. Concurrent physician-diagnosed asthma and COPD has been reported in 15% to 20% of patients and is known as asthma-COPD overlap syndrome (ACOS) (GINA, 2014b).

Other comorbid factors include hyperthyroidism, which is believed to aggravate asthma symptoms by enhancing airway smooth muscle remodeling in asthmatics (Dekkers et al., 2014); allergic rhinitis; gastroesophageal reflux disease (GERD); and acetylsalicylic acid (aspirin) sensitivity.

CASE

JONAH, AGE 11

Jonah Bachman is an 11-year-old boy whose identical twin brother, Adam, was diagnosed with asthma at age 8. Jonah is brought to the pediatrician's office by his mother, Laura, who tells the office nurse that Jonah has been experiencing episodes of wheezing and shortness of breath over the last two weeks, during which time there have been several days of high humidity and poor air quality.

When asked about Jonah's medical history as part of the nursing assessment, Laura cannot recall any early respiratory infections, though she notes that he seems to have become more

susceptible to colds in recent years. When asked about her own history, Laura recalls periodic episodes of wheezing and coughing when she was a young girl, but she was never screened for asthma.

Because Jonah's twin brother has asthma, Laura possibly having had asthma as a young girl, and Jonah's reactivity to temperature and air pollution, it is decided to screen and test Jonah for asthma. These tests are completed in the office, and a diagnosis of asthma is confirmed.

(*continues*)

SIGNS AND SYMPTOMS

The classic signs and symptoms of asthma are coughing, wheezing, and dyspnea. Asthma symptoms vary from patient to patient. The symptoms can also change as the patient ages. The type of asthma symptoms a patient has, how often they occur, and how severe they are may vary over time. Sometimes symptoms might be just irritating, and at other times they may limit activities of daily living. Severe symptoms can be fatal, and it is important they be treated as soon as they appear so they do not become severe (NHLBI, 2014b).

Coughing

Cough may be the only symptom of asthma. Coughing is a sign of airway irritation, and asthma attacks often include coughing. In some persons with asthma the cough is dry, while in others the cough can be mucus-filled.

Asthma should be considered in anyone who has a chronic cough, a seasonal cough, or a cough repeatedly brought on by exposure to chemical vapors, cold air, or exercise. Lung function tests and computed tomography (CT) scans can help distinguish cough-variant asthma from other causes of cough.

There is a debate as to whether people with cough-variant asthma will go on to develop other asthma symptoms later in life. People with cough-variant asthma tend to maintain better control of their disease by using anti-inflammatory medications than by using bronchodilators.

Wheezing

Wheezing is produced by air being forced through narrowed airways, and in asthma the affected airways are mainly the small bronchioles of the lung. When wheezing is heard with a stethoscope on a routine exam of an asymptomatic person, the chances are 80% to 90% that the individual has asthma. If wheezing is not heard, however, the patient may still have asthma.

During an asthma attack, most people with asthma wheeze, but other problems can also bring on wheezing. For example, congestive heart failure can lead to wheezing accompanied by difficult breathing and sometimes a cough. A vocal cord spasm or a foreign body trapped in the airways can also cause wheezing, difficulty breathing, and a choking feeling.

Wheezing occurs at some time in more than half of all children younger than 6 years. This wheezing is most often caused by a viral respiratory infection and not by asthma. When wheezing is caused by asthma, it is often accompanied by difficulty breathing or by effects on the child's sleep or normal daily activities.

A diagnosis of asthma in young children with a history of a wheezing is more likely if they have wheezing or coughing that occurs with exercise, laughing, or crying in the absence of an obvious respiratory infection, if they have a history of other allergic disease, or if there is asthma in a first-degree relative (GINA, 2014b).

Dyspnea

Dyspnea is a subjective feeling of breathlessness, and it comes from a mix of three sensations, all of which contribute to the dyspnea of asthma:

- **The urge to breathe.** This urge is triggered by exercise or by the metabolic results of exercise.
- **Difficulty breathing.** This feeling is produced by excess amounts of chest movement and by unusual amounts of effort of the muscles of respiration during breathing.
- **Anxiety.** This sensation can be caused by a fear of suffocating or by a memory of past uncomfortable experiences with breathlessness. Anxiety can also come from other sources of stress.

During an asthma attack, a patient feels the bronchoconstriction—the chest feels tight. The difficulty of breathing, chest tightness, and need for more air makes patients feel anxious and panicky, and this heightens their sensation of breathlessness.

Each person experiences dyspnea differently, and the reported degree of severity can vary widely. Therefore, clinicians cannot always judge the severity by questioning the patient.

Normally, we use our diaphragm muscles to pull air into our lungs, but we empty our lungs without muscular effort, relying instead on the elastic recoil of our lungs and our chest wall to push the air out. This changes during an asthma attack.

During an asthma attack, the narrowed airways resist the movement of air and a patient must use chest muscles to force air out of the lungs. The increased pressure this generates pushes on all parts of the lung tissue and collapses some of the airways, leaving air trapped in the lung. The leftover air then takes up space that cannot be filled during the next breath. The result is that during an asthma attack a patient does considerably more work but gets less air exchange.

Dyspnea is not specific to asthma. Other heart and lung problems also present with a chief complaint of dyspnea. These might include congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), as well as other obstructive or inflammatory lung conditions.

Excess Airway Mucus

Patients with severe asthma or with asthma that is not well controlled produce enough extra mucus to worsen the obstruction in their airways. The mucus produced in asthma is thicker and stickier than normal. Asthmatic mucus is more likely to form plugs in the airways, and patients find it more difficult to clear their lungs by coughing.

Sleep Disturbances

People with asthma often suffer from sleep disturbances that affect their ability to function during the day. There is also evidence that people with asthma are at greater risk of developing sleep apnea, a condition in which breathing is briefly and repeatedly interrupted during sleep (NSF, 2014).

Signs and Symptoms Unique to Children

For children younger than 2 years of age, signs and symptoms related to asthma can also produce:

- Noisy breathing
- Vomiting with cough
- Chest retractions when breathing
- Difficulty feeding
- Changes in the rate of breathing

For children older than 2 years, asthma can cause:

- Shortness of breath
- Easy fatigability
- Complaints of feeling ill
- Poor school performance
- Avoidance of normal activities such as playing outside or visiting friends

DIAGNOSING ASTHMA

Difficulty breathing is the symptom that brings a person with asthma to the doctor. This problem shows up in flares called “exacerbations” or “attacks” that include a spasm of wheezing, coughing, chest tightness, and increased mucus production. Asthma attacks are often brought on by contact with identifiable triggers such as smoke, cold air, or chemical fumes. Such attacks can be infrequent or almost continuous, and they can be mild or severe enough to require hospitalization.

When a person presents with such intermittent attacks of wheezing, coughing, or difficulty breathing, asthma is high on the list of probable diagnoses. These symptoms can, however, be caused by other lung problems, heart problems, or systemic disorders. In children, wheezing is a common symptom with colds, and the pediatric possibilities of similar breathing symptoms include respiratory infections, foreign body aspiration, congenital malformations, and genetic diseases (Hess, 2012).

History

The pathologic process in asthma is chronic inflammation of hypersensitive airways. The consequences of the common underlying problem can play out somewhat differently in different people, and the clinical appearance of the disease varies. For instance, some asthma sufferers find that their attacks are so easily triggered that the patient is almost continually ill and must spend an inordinate amount of time in the hospital or emergency department. Other patients will have only rare asthmatic attacks, and the episodes will be quickly and completely reversed by inhalation of a bronchodilator.

Given the wide variation in presentation, a detailed history is needed to understand each individual's particular asthma variant.

GUIDELINES FOR OBTAINING THE HISTORY OF AN ASTHMA PATIENT

In the "Guidelines for the Diagnosis and Management of Asthma," the National Heart Lung and Blood Institute's (NHLBI) Expert Panel recommended that the history of a patient with asthma include:

- Symptoms
- Typical pattern of occurrence of symptoms
- Triggers and aggravating factors
- Chronological history of the patient's asthma
- Family history of related medical problems
- Patient's social history
    - Current living environments
    - Current lifestyle and habits
    - Impact of asthma on patient and family
    - Perception of the disease by patient and family

Source: NHLBI, 2012a.

SYMPTOMS

The NHLBI Expert Panel report offers a set of questions regarding symptoms as a screening for people who might have 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), chest tightness, 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?
- Upon awakening?
- After running, moderate exercise, or other physical activity?

TYPICAL SYMPTOM PATTERNS

Although asthma is described as a disease with episodic attacks, the pattern of clinical symptoms varies from person to person. In the medical history, the symptom pattern of the individual should be described, noting these features:

- Whether the symptoms occur in separate episodes or continuously
- How often the symptoms occur each week or each month
- Whether the symptoms occur with a daily or seasonal pattern
- Whether the symptoms occur more often during a certain part of the day or night
- For women, whether the symptoms occur during a particular part of their menstrual cycle

TRIGGERS AND AGGRAVATING FACTORS

Once asthma is acquired, it is a disease of episodic bouts of wheezing, coughing, and difficulty breathing. Regardless of the factors that entered into the initial development of asthma, there are multiple triggers and aggravators that can bring about exacerbations in a patient with an established diagnosis of asthma.

Many of the factors that are implicated in the development of asthma can also trigger an exacerbation. For asthma patients, it is necessary to learn what those triggers and aggravators are. For some, the triggers are hard to identify, and their asthma symptoms seem to appear spontaneously.

POTENTIAL ASTHMA TRIGGERS AND AGGRAVATORS	
Type	**Examples**
Infections and comorbid conditions	• Respiratory infections (respiratory syncytial virus, rhinovirus) • Sinusitis (most common factor associated with more severe and harder-to-control asthma) • Hyperthyroidism • GERD (heartburn and acid reflux)
Inhaled substances	• Biological allergens: mold, fungal spores, pollen (weeds, grasses, trees), pets, dust mites • Chemical vapors: perfumes, cleaning products, aerosol sprays, chlorine (e.g., in indoor pools), industrial solvents (e.g., paint thinner) • Air pollutants: particulates, sulfur dioxide, ozone, nitrogen oxide, tobacco smoke • Specific items: old books, pieces of furniture, mattresses
Ingested substances	• Foods or drinks (e.g., homemade wine or beer) • Sulfites (preservatives) and tartarzine dyes • Medicines: aspirin, NSAIDs (e.g., ibuprofen), beta-adrenergic blockers
Physical factors	• Temperature extremes: heat, cold • Weather: storms, wind, humidity
Exercise	• Hyperventilation • Winter sports more commonly than summer sports
Emotional situations	• Stress, anger, frustration, laughter, crying • Anxiety • Depression
Hormonal changes	• Premenstrual days, pregnancies • Estrogen and progesterone

CHRONOLOGY OF THE PATIENT'S ASTHMA

The chronology section of a patient's asthma history includes major disease events and treatments:

- First appearance of symptoms
- Date of diagnosis
- Dates of ED visits and hospitalizations (noting any ICU admissions or intubations)
- Dates of related medical and health problems

- Treatment history
- Treatment routine currently in effect

It is particularly important to note any **intubations**, because a history of asthma attacks of that severity is the most accurate predictor of fatal asthma attacks.

CASE: Asthma History

James, age 61, recently moved to another town and paid his first visit to a new primary care physician. As part of his intake assessment, the nurse in the office took the following asthma history:

- Born 1950
- 1952–1955, some wheezing with colds
- 1958, mild hay fever began yearly
- 1964, started smoking (infrequently)
- 1968, smoking regularly with occasional coughing spells
- 1972, choking/coughing episode, possible asthma diagnosed in ED
- 1972, given inhaler for asthma attacks, stopped smoking
- 1973–1979, used inhaler occasionally
- 1979, divorced, moved to new city, began smoking again
- 1980, two visits to ED for asthma attacks
- 1981–1985, physician changed prn bronchodilator to Isoprel; slowly stopped smoking completely
- Current regimen, Proventil prn, which is effective at reversing the four to five asthma episodes each year, most often in the early summer (hay fever season), and on occasion, in cold wintery weather; weight at pre-1995 levels; no ED visits in more than 20 years

FAMILY HISTORY

The family history section of the medical history lists those close relatives with atopic illnesses such as asthma, allergies, sinusitis, rhinitis, eczema, or nasal polyps (a condition associated with asthma).

SOCIAL HISTORY

A key part of asthma management is discovering and avoiding triggers and other aggravating factors. In addition to the usual items, such as a brief biography and a review of social and financial support, the social history section of the medical history records features of the patient's environment and lifestyle that have the potential to induce asthma symptoms.

Current Living Environments

The places in which the patient spends most of his or her time are noted. These include:

- Home (age, type of heating and cooling systems, type and age of floor coverings, areas of mold or mildew, and presence of any smokers)
- School or daycare
- Workplace (exposure to chemicals, tobacco smoke, air pollutants)
- Vacation places
- Locations of other activities

Asthma symptoms can begin hours after exposure to certain triggers. Therefore, descriptions of the workplace environment can sometimes point to triggers previously unrecognized by the patient.

Current Lifestyle

The features and habits of the patient's daily life are listed, including:

- Smoking
- Diet and dietary supplements
- Recreational drugs
- Exercise routines
- Pets
- Hobbies

Impact of Asthma on Patient and Family

It is always important to deal with diseases in a way that solves practical problems in patients' lives. The goal of this section of the medical history is to elicit the practical difficulties that are posed by the patient's asthma. It includes:

- Ways asthma symptoms disrupt the patient's normal routine, such as the number of unplanned health visits (urgent care, ED, or hospitalization) and the number of days missed from school or work
- Limitations imposed by asthma, such as activities that cannot be undertaken and frequency of sleep disturbances
- Issues related to impact on the family's finances

Perception of the Disease by Patient and Family

As with all those who have chronic diseases, asthma patients must be the day-to-day managers of their medical care. This section of the history describes the patient's and the family's understanding of the disease process and the current management plan. It includes whether the patient and the family can realistically carry out their current management plan, whether they can afford the current plan, and whether they believe that the current plan is worth the cost and effort required.

CASE: Patient History

Deborah Hartley is a 24-year-old teacher's aide who works in a public elementary school. She has come to her healthcare provider's office complaining of a chest cold that she has had for two weeks and that does not seem to be getting better. She complains of frequent bouts of coughing and bringing up thick, sticky mucus. She also says she has had some occasional wheezing and difficulty breathing. Her sleep has been disturbed at least three nights a week since this all started.

Following a physical examination she is referred to the office nurse for a complete asthma assessment. The nurse has Deborah fill out an asthma screening questionnaire. Her responses indicate a family history of asthma, a personal history of allergies, worsening of coughing and wheezing during periods of humid weather and poor air quality, more frequent episodes of sleep disturbances over the past two months, and a cigarette smoking habit (though she indicates that she is trying to quit).

When asked about her work situation, Deborah notes that in addition to using a blackboard and chalk during the school day and "magic markers" to grade students' papers, she is regularly exposed to first- and second-graders who come to school with coughs and colds. She adds that the school is located in an urban neighborhood not far from a factory with smokestacks that spew out thick, black smoke.

Following review of the assessment with her healthcare provider, Deborah is referred for lung function testing, and the results confirm a diagnosis of asthma.

Physical Examination

During an asthma attack, a patient's clinical signs differ from those seen between attacks, and the associated physical examinations therefore differ.

EXAMINATION DURING AN ASTHMA ATTACK

In the course of a typical asthma attack, the patient begins to cough and becomes breathless. If lying down, the patient sits up and leans forward, sometimes over a table or the back of a chair. The patient becomes worried, looks anxious, and may begin to sweat.

Breathing becomes labored, and shoulder and neck muscles (accessory muscles of respiration) are used. The chest remains expanded in an inspiratory position. It takes longer and longer for the patient to empty the lungs. Meanwhile, the patient begins to wheeze. Later, after the attack has subsided, the patient often clears the throat of thick sputum.

Examining a patient during an attack, the clinician finds a person who is breathing laboriously, sweating, and tachycardic. If respiratory failure is nearing, the patient will be cyanotic, dulled, and less responsive.

On auscultation of the chest, each breath will have a short inspiration and a prolonged expiration. During most attacks, musical wheezing (high-pitched whistling sounds) will be heard throughout the lung fields. In a severe attack, however, the airflow may be so reduced that no wheezes are produced. Instead, the chest will be hyper-resonant with diminished breath sounds everywhere.

EXAMINATION BETWEEN ASTHMA ATTACKS

Between symptomatic attacks, an asthma patient may have no abnormal lung findings and no signs related to asthma. Sometimes, however, there are clues.

People with asthma frequently have atopy and signs of allergies. Their skin may be dry and exhibit atopic dermatitis (eczema) or other allergic rashes. They may have dark rings under their eyes (“allergic shiners”), or their conjunctivae (the mucous membranes lining the inner surface of the eyelids) may be red and irritated. In the nasal cavities, allergic rhinitis and sinusitis produce inflamed and edematous mucosa, and asthma is associated with nasal polyps.

Even when not symptomatic, some asthma patients have a hyper-resonant chest on percussion. Hyper-resonant sounds are louder and lower pitched than normal sounds. Wheezes can sometimes be heard on auscultation, and there may be an abnormal breathing pattern in which breathing out takes more than twice as long as breathing in (Kaneshiro, 2014).

Diagnostic Testing

PULMONARY FUNCTION TESTS

The best objective measures of asthma are pulmonary (lung) function tests, which can quantify the degree of a patient’s airflow obstruction.

Spirometry is the most common pulmonary function test, employing a spirometer to measure the amount of air a patient can inhale completely and exhale completely as well as the rate of airflow through the airways. It is used for diagnosis and monitoring a patient with asthma. Spirometry may be done before and after taking a medication to determine how helpful the medication is and may be done during exercise to see how the airways react.

A patient breathes into a spirometer. (Source: NHLBI, 2012b).

For asthma, two basic lung characteristics are of clinical value:

- **Forced vital capacity (FVC)** is the total amount of air that can be forced quickly from the lungs after a complete inhalation.
- **Forced expiratory volume in 1 second (FEV1)** is the amount of air expired in the first second of forced exhalation.
  (Hess, 2012)

The ratio of FEV1 to FVC is used to assess for airflow obstruction. For people with airway obstruction, it takes longer than normal to empty their lungs. Therefore, the fraction of air expelled in one second is reduced. This fraction is FEV1/FVC, and the value of FEV1/FVC goes down when a patient's airways are narrowed.

Nevertheless, the improvement (i.e., increase) in FEV1/FVC in any particular asthma patient is an objective measure of the level of control achieved through therapy. On the other side of the coin, the decrease in FEV1/FVC during an asthma attack is an objective measure of the severity of the symptoms.

These measurements are expressed in percentages of predicted values for the individual based on age, gender, and body structure. Spirometric reference value calculators are available for the clinician to use to determine the appropriate predicted value. Spirometric reference values have been set for the following groups: Caucasians, African Americans, Mexican Americans, North Africans and Iranians, South East Asians, and North East Asians (Quanjer et al., 2012).

Peak expiratory flow (PEF) meters are recommended for monitoring asthma in the home. PEF meters are inexpensive hand-held devices that record the maximum flow of air while a patient is forcefully emptying his or her lungs. Normal PEF values can vary according to a person's sex, age, height, and race.

USING A PEAK FLOW METER

When using a peak flow meter, the patient:

- Measures peak flow close to the same time each day
- Makes certain the sliding marker or arrow on the meter is at the bottom of the numbered scale
- Stands straight, takes in a complete breath, closes the lips tightly around the mouthpiece, and blows out as hard and as fast as possible until all air is emptied from the lungs
- Writes down the number the marker or arrow has reached along the numbered scale
- Repeats the steps above two more times
- Records the highest reading of the three, which is called the patient's predicted normal value, or "personal best"

PEAK FLOW RATE INTERPRETATION

Zone	Measurement	Finding
Green	80%–100% of patient's normal	Asthma is under control
Yellow	50%–80% of patient's normal	• Rescue medicines should be used • A medical visit may be needed
Red	<50% of patient's normal	• Signals a medical alert • Emergency care is needed

Source: ALA, 2015b.

CHILDREN AND LUNG FUNCTION TESTING

Most children who have asthma develop their first symptoms before 5 years of age. Asthma in children ages 0 to 5 years, however, can be hard to diagnose. Most children who wheeze when they get colds or respiratory infections do not go on to develop asthma after they are 6 years old. The most certain way to diagnose asthma is with a lung function test, a medical history, and a physical exam. However, it is hard to do lung function tests in children younger than 5 years, and clinicians depend on a child's medical history, signs and symptoms, and physical exams to make a diagnosis (NHLBI, 2012b).

BRONCHIAL PROVOCATION AND BRONCHODILATOR TESTING

Among the features of asthma that vary from individual to individual is the innate degree of hypersensitivity of the patient's airways. In some patients, a small amount of irritation triggers a severe reaction. Other patients, however, are less sensitive and get much less bronchoconstriction with the same amount of irritation. The degree of hyper-reactivity of each person's airways can be assessed by bronchial provocation testing.

Two classes of trigger are commonly used for provocation tests: chemicals and exercise.

Direct challenge tests assess airway reactivity with histamine or methacholine (a synthetic version of histamine). This test is used mostly in adults when screening spirometry and symptoms do not clearly establish the diagnosis of asthma. The test requires the patient to inhale histamine or methacholine, which are cholinergic agonists and airway constrictors that cause airway smooth muscle contraction and narrowing if asthma is present. The inhalation of the mist is done both before and after spirometry and is considered positive for asthma if the patient's lung function drops by at least 20%. Following the test, the patient is given a bronchodilator to reverse the effects of the histamine (Benaroch, 2014).

Indirect challenge tests include exercise challenge, hypertonic saline, adenosine, or mannitol testing.

For patients who develop symptoms of asthma after exercise (i.e., exercise-induced asthma), spirometry can measure the increase in airway obstruction. In these tests, baseline spirometric values are measured, and patients then exercise on a treadmill or other stationary exercise equipment to 85% to 90% of their maximal heart rate. Afterward, spirometric measurements are taken for 15 to 30 minutes. In exercise-induced asthma, exercise will reduce the patient's FEV1 by ≥15% (Benaroch, 2014).

Indirect mannitol challenge involves inhaling increasing doses of mannitol, a dry powder that can trigger water loss from the surface of the airways and turn on molecular activity that controls inflammation. These conditions cause bronchoconstriction in people with oversensitive airways.

Bronchodilator reversibility testing uses a bronchodilator and spirometry to document the reversibility of a patient's airway obstruction and assess the asthma's responsiveness to medication. Demonstrating reversibility will sometimes clarify the diagnosis. For example, in older people who have been smokers, asthma and COPD can be difficult to distinguish.

Before-and-after tests can also be used to monitor the effectiveness of various medications on a particular patient. Spirometric measurements before and 2 to 4 weeks after the patient begins a new drug can document the degree of improvement.

CASE: Bronchial Provocation Testing

Calvin Thompson is a 46-year-old African American male who is overweight and smokes a pack of cigarettes daily. He is suspected of having asthma or COPD and is referred to the clinic for spirometry testing. The nurse measures his baseline FEV1/FVC. Bronchial provocation testing with histamine lowers his FEV1 value by 25%. Calvin then undergoes before-and-after inhalation therapy with a short-acting bronchodilator; the second test shows an improvement in his FEV1. Together, the findings suggest a diagnosis of asthma.

ALLERGY TESTING

Many persons with asthma have atopy. In these people, allergic reactions from inhaled biologic substances will increase their sensitivity to asthmatic triggers. The best protection from this increased sensitization is for the patient to avoid inhaling the allergens, and to do this, patients need to identify the allergens that cause them trouble.

As a first step in building a list of probable offending allergens, the patient should keep a diary of exposures and symptoms. The second step is allergy testing to verify or reject at least some of the suspected allergens. Ridding a patient's environment of offending allergens can be time-consuming and expensive, and allergy testing will indicate which specific types of cleaning and avoidance should be worth the effort.

Allergy testing can be done in vivo and in vitro. **In vivo tests** (skin tests) use skin pricks, intradermal injection, or skin patches to introduce a small quantity of a known allergen into the dermis. This challenges the allergic reactivity of the skin to the antigen.

In vivo allergy testing is not without risk. Common side effects include swollen, red, itchy bumps (wheals) that may develop during the test. In some people an area of swelling, redness, and itching may develop hours after the test and persist for as long as a couple of days. Other side effects might be pain or bleeding at the injection site, dizziness, or lightheadedness during testing.

In vivo allergy testing can also trigger an exacerbation of asthma. In rare instances a patient can have a severe, immediate allergic reaction (anaphylaxis) requiring emergency management. Intradermal testing carries a slightly higher risk of provoking significant allergic reactions than other methods.

Allergy skin tests are not always accurate, especially in people who are taking antihistamine medications, those who are being tested for food allergens rather than inhaled allergens, and people with eczema or other skin conditions that make the results difficult to read (Mayo Clinic, 2014a).

In vitro tests use a blood sample from the patient to detect circulating IgE antibodies to specific allergens. Types of in vitro allergy tests are immunoassay tests (which include the enzymes-linked immunosorbent assay [ELISA or EIA]) and the radioallergosorbent tests (RAST). These tests are more complicated, more expensive, less sensitive, and slower than skin tests.

Nonetheless, they are sometimes the best option because they pose no risk to the patient, are not affected by medications, and are more convenient to administer.

People's responses to allergens can change, so allergy testing of atopic asthma patients should be repeated, usually at intervals measured in years.

LABORATORY DATA

Laboratory studies are not usually a major part of diagnosing or following asthma, but a few tests can give supportive evidence and may be used to exclude other diagnoses.

- CBC (complete blood count), to evaluate blood cells and provide information on infection and inflammation
- Comprehensive metabolic panel, to evaluate overall body organ function, including kidney, liver, and lungs
- Cystic fibrosis tests, to rule out cystic fibrosis in both children and adults
- AFB (acid-fast bacilli) smear and culture, to diagnose or rule out tuberculosis and nontuberculous mycobacteria

Other laboratory tests related to asthma may include:

- Blood gases, during severe asthma attacks, to predict respiratory failure and the consequent need for mechanical ventilation (Morris, 2014)
- Sputum cultures, to diagnose lung infections caused by bacteria
- Sputum cytology, to assess for the increased concentration of eosinophils and neutrophils that occurs in patients with asthma
- Nitric oxide in exhaled breath, as a means to assess asthma-related airway inflammation, to monitor how well a patient's asthma is controlled, and to predict the onset of asthma symptoms or loss of control (Morris, 2014).

KIT-ON-A-LID-ASSAY (KOALA)

A new diagnostic tool has been developed that can diagnose asthma even in patients experiencing no symptoms at the time of examination and testing. The test requires only a single drop of blood.

This test takes advantage of a previously unknown correlation between asthmatic patients and neutrophils, the most abundant type of white blood cells in the blood. These white cells are the first cells to migrate toward inflammation. Neutrophils detect chemical signals in response to inflammation and migrate to the site to assist with the healing process.

KOALA can track the speed at which the neutrophils migrate (chemotaxis velocity) to differentiate nonasthmatic samples from the significantly reduced speed of asthma patients. In the case of an asthmatic patient, the speed of neutrophils movement is slower as compared to a normal patient.

Source: Sackmann et al., 2014.

PULSE OXIMETRY

Pulse oximetry is used to determine hypoxemia in patients with acute asthma. In children it is often used to grade the severity of acute asthma. Pulse oximetry measures the percentage of hemoglobin that is carrying oxygen.

HYPOXEMIA AND ASTHMA SEVERITY

Severity	Oxygen Saturation
Mild asthma	≥97% oxygen saturation
Moderate asthma	92%–97% oxygen saturation
Severe asthma	<92% oxygen saturation

Source: Morris, 2014.

IMAGING STUDIES

A routine **chest X-ray** of a patient with asthma may show hyperinflation, but the film can also be normal. In long-standing asthma, permanent bronchial wall thickening can sometimes be seen in chest films.

For diagnostic purposes, atypical presentations, and hospital admissions, chest X-rays should be taken. In asthma, radiographs can show the presence of superimposed infections, atelectasis (collapse of an expanded lung), or pneumothorax (abnormal presence of air in the pleural cavity, leading to collapse of the lung). Chest films may also help to distinguish asthma from allergic bronchopulmonary aspergillosis, sarcoidosis, congestive heart failure, pulmonary emboli, and foreign body aspiration.

High-resolution CT (HRCT) is a second-line examination useful for patients with chronic or recurring symptoms to rule out possible complications. Between attacks, HRCT of an asthmatic lung can show in finer detail widened bronchi with thickened walls, air trapping, and mucus plugs. Scans of the patient's head can reveal acute and chronic sinus diseases. In cough-variant asthma, HRCT scans can show bronchial wall thickening, which will not be present in certain other causes of cough (Morris, 2014).

ECG

Patients with severely symptomatic asthma should undergo ECG monitoring. Acute asthma patients commonly have sinus tachycardia and ECG evidence of right heart strain (Morris, 2014).

An exercise ECG stress test helps in assessing the degree of pulmonary dysfunction present, evaluating effectiveness of bronchodilator therapy, and planning or evaluating an exercise program.

Classifying Asthma Severity

Asthma attacks can range from minor to life threatening. The severity of an attack is classified as intermittent, mild persistent, moderate persistent, and severe persistent. These levels of asthma severity are used to make treatment and management decisions.

INTERMITTENT

Intermittent asthma is the most common and least severe form of asthma. Asthma is classified as intermittent if **any** of the following are present:

- Asthma symptoms are present 2 days a week or less.
- Sleep is interrupted by asthma symptoms 2 nights per month or less.
- A rescue inhaler must be used 2 or fewer days per week.
- Symptoms do not interfere with activities of daily living.
- Spirometry shows the FEV1 is normal.
- Peak expiratory flow varies less than 20% from morning to afternoon.

MILD PERSISTENT

Mild persistent asthma is present if **any** of the following occur:

- Symptoms are present more than 3 to 6 times a week.
- Exacerbations may affect activity levels.
- Nighttime symptoms occur 3 to 4 times a month.
- Lung function tests are normal, with FEV1 equal to or above 80%.
- PEF varies 20% to 30% from morning to afternoon.

MODERATE PERSISTENT

Moderate persistent asthma is present if **any** of the following occur:

- Symptoms occur daily.
- Symptoms interfere with daily activities.
- Control of symptoms is with two medications.
- Rescue inhaler is used daily.
- Nighttime symptoms occur more than once a week.
- Lung function tests are abnormal (more than 60% to less than 80% of the expected value).
- PEF varies more than 30% from morning to afternoon.

SEVERE PERSISTENT

Severe persistent asthma is present when **any** of the following occur:

- Symptoms occur throughout each day and severely limit physical activities.
- Nighttime symptoms occur often, sometimes every night.
- A rescue inhaler is used multiple times per day.
- Lung function tests are abnormal (60% or less).
- PEF varies more than 30% from morning to afternoon.
  (NCI, 2013; Basso 2014)

TREATMENT: PHARMACOLOGY

Drugs are the cornerstones of asthma therapy, and patients with asthma typically take at least one medication daily. Asthma therapy with medications has two modes:

- Short-term treatment of asthma attacks with quick-relievers (rescue medications)
- Long-term treatment of the disease to minimize attacks and to moderate symptoms with daily controllers

The main routes of delivery for asthma medications are systemic (oral or injectable) and inhaled. The inhaled route is more convenient and is used most commonly because of fewer side effects and quicker onset of action

Drug Administration: Inhalers

Many asthma drugs are administered by inhaler to send the medication directly to the target tissue, the inner linings of the airways of the lung. Higher concentrations of medicine can be delivered this way with fewer systemic side effects.

TYPES OF AEROSOL DEVICES

A variety of devices are available for delivering drugs directly into the lungs. The common aerosol devices include:

- **Nebulizer:** A drug delivery device used to change medication from a liquid to a mist so that it can be more easily inhaled into the lungs through a mouthpiece or mask worn over the nose and mouth. A nebulizer is the most common device used to deliver medications to infants, small children, and patients requiring hospitalization.
- **Metered-dose inhaler (MDI):** A pressurized canister containing medication that fits into a boot-shaped mouthpiece. The canister is activated by compressing it into the boot, which delivers a metered dose of the drug to be inhaled. This is the most common device used to deliver medications in an ambulatory setting.

  Spacers, or valved holding chambers (VHCs), are often used with non-breath-activated MDIs to minimize local side effects and enhance drug delivery. A spacer is a simple tube added to the mouthpiece of an MDI to move the inhaler farther from the patient's mouth. A VHC is a spacer with a one-way valve that keeps the patient from exhaling into the MDI.
- **Dry powder inhaler (DPI):** A device that does not use a chemical propellant to push the medication out of the inhaler. Instead, the medication is released through the mouthpiece by deep and fast inspiration. This device is not indicated for use in children younger than 12 years because of the requirement of a high inspiratory flow.

Asthma spacer for an adult. (Source: © 2011 Tradimus, reprinted under the terms of the GNU Free Documentation License.)

Asthma spacer for a child. (Source: © 2011 Tradimus, reprinted under the terms of the GNU Free Documentation License.)

PROPER USE OF INHALERS

Most asthma patients use MDIs for their quick-relief medications. It is easiest to learn the proper use of an MDI through an in-person demonstration. These are the essential steps whether or not a spacer or VHC is used:

Preparation

1. Take off the cap and shake the inhaler for 5 seconds.
2. Breathe out all the way.
3. Hold the inhaler as instructed.

Administer the Medicine

1. Close your lips around the mouthpiece (closed-mouth technique) or hold the mouthpiece 1 to 2 inches in front of your open mouth (optimal technique when not using a spacer or VHC).
2. As you start to slowly inhale, press down on the inhaler one time. (**If the inhaler has a spacer or holding chamber, press down on the inhaler and wait 5 seconds before beginning to inhale.**)
3. Keep inhaling slowly and as deeply as possible.
4. Hold your breath and slowly count to 10 (if possible).
5. Let your breath out.

When inhaling quick-relief medicine, wait 30 to 60 seconds between puffs. For other medicines it is not necessary to wait before taking the prescribed number of puffs. Always make certain to shake an inhaler before taking another puff (Buddiga, 2013b; Bonds et al, 2015).

When using a dry powder inhaler, the steps are the same, however, the inhaler is activated when the person inhales, not by pressing down on a tube.

It is important to keep the inhaler clean. Look at the hole where the medicine sprays out of the inhaler. If there is powder in or around the hole, it should be cleaned.

1. Remove the metal canister from the L-shaped plastic mouthpiece.
2. Rinse only the mouthpiece and cap in warm water.
3. Let them air dry overnight.
4. In the morning, put the canister back inside. Put the cap on.
5. Do not rinse any other parts.
6. Follow the manufacturer's instructions for cleaning a dry powder inhaler.

CASE: Inhaler Education

Kamiko is a 35-year-old woman who has recently been diagnosed with asthma. She has an appointment with the office nurse to receive additional education on controlling her disease. During the visit her medications are discussed and reviewed, as well as the new asthma action plan developed between herself and her primary physician.

Before Kamiko leaves the office, the nurse asks her to demonstrate the use of her inhaler. A dummy inhaler is provided, and as the nurse watches, Kamiko proceeds through the steps.

Following her demonstration, the nurse points out three problems with her technique. First, she did not fully exhale all the air in her lungs before inhaling the medication. Secondly, she did not shake the inhaler again before administering a second dose. And lastly, she did not begin to inhale until she had sprayed the medicine into her mouth.

The nurse next demonstrates the proper technique for Kamiko, who then returns the demonstration. She is given a pamphlet to refer to at home that visually guides her through the technique.

INHALER MISUSE

A study of patients from adult and pediatric clinics has shown that up to 92% of asthmatic patients do not use inhalers correctly, and problems are not limited to only one type of device. This study showed that even among medical personnel, rates of correct use are suboptimal. It is obvious that improving techniques will improve clinical outcomes.

The study showed that only 7% of MDI users demonstrated perfect technique, and of the remaining 93%, 63% missed three or more steps. The most commonly missed step was exhaling to functional residual capacity or residual volume before actuating the canister. The least common error was failure to insert the spacer mouthpiece between the lips.

It was typical that multiple steps were performed improperly. However, most participants were able to complete more than half the steps properly. The common errors that MDI users demonstrated result in diminished drug delivery rather than no delivery at all (Bonds et al., 2015).

MDIs are the preferred delivery method for those patients hospitalized with asthma. MDI with spacer devices are often left at the patient's bedside with minimal monitoring of proper MDI technique. Risk factors for improper use have been identified as poor grip strength, insufficient vision, and unrecognized cognitive dysfunction (Nadaraja et al., 2012).

Age, race, gender, and vision do not predict rates of inhaler misuse. Older patients, however, may be at risk for misuse due to higher rate of low health literacy. A disparity has been shown between older and younger patients in their ability to learn proper inhaler techniques (Trela, 2014).

A study done among registered nurses, medicine residents, respiratory therapists, staff physicians, and pharmacists showed that only 71% of participants demonstrated correct technique. All respiratory therapists and staff physicians, 68% of registered nurses, and 60% of medicine residents demonstrated correct technique. Participants reported feeling "comfortable" or "very comfortable" administering and teaching MDI technique, but the study showed a discrepancy between proficiency and perception of knowledge among nurses in particular (Nadaraja et al., 2012).

Quick-Relief Medications

Bronchodilators are used to reverse the bronchoconstriction of asthma attacks and in this way to relieve cough, wheezing, dyspnea, and chest tightness. Bronchodilators are also the primary medicine for preventing exercise-induced asthma. There are two classes of bronchodilators used as quick-relief asthma medications:

- Beta-2 agonists (short-acting)
- Anticholinergics

SHORT-ACTING BETA-2 AGONISTS (SABA)

Short-acting beta-2 agonists (sympathomimetics) are the recommended initial treatment for relief of acute asthma symptoms. The smooth muscle in bronchioles (small airways) is relaxed by beta-2 adrenergic agonist drugs, which reverse and prevent further contraction of muscle cells. Beta-2 agonists come in aerosol, pill, liquid, and injectable forms.

Because beta-2 agonists have a wide array of effects throughout the body, they are preferably administered by inhalation directly to the inner lining of the airways. When inhaled, they produce an effect in less than 5 minutes, which is as fast as could be achieved by IV or subcutaneous injections. The effect then lasts for 3 to 6 hours.

SHORT-ACTING BETA-2 AGONISTS (INHALED AND ORAL)	
Generic Name	**Brand Name**
Albuterol	Proventil HFA Ventolin HFA AccuNeb Proair HFA Proair Respiclick Vospire ER
Levalbuterol	Xopenex
Terbutaline	None

ANTICHOLINERGICS

Another group of bronchodilators, anticholinergics, are muscarinic receptor antagonists (parasympatholytics). Whereas beta-2 agonists affect the bronchioles, anticholinergics affect the muscles around the bronchi (large airways). Anticholinergics do not affect airway narrowing caused by histamine but will reverse constriction of airways that is initiated by the autonomic nervous system (i.e., bronchospasm). Anticholinergics may reduce the excess mucus secreted during asthma attacks.

Anticholinergics begin to work within 15 minutes, work best after 1 to 2 hours, and usually last from 3 to 4 hours or up to 6 hours in some people. They are used for severe asthma attacks and are always given along with short-acting inhaled beta-2 agonists to treat severe asthma attacks, especially in children.

ANTICHOLINERGICS	
Generic Name	**Brand Name**
Ipratropium bromide	Atrovent HFA
Oxitropium bromide	Oxivent (Canada/EU)
Long-acting tiotropium	Spiriva

ANTICHOLINERGIC AND BETA-2 AGONIST COMBINATION	
Generic Name	**Brand Name**
Ipratropium and albuterol	Combivent DuoNeb

Controller Medications

Various classes of medications are used as long-term treatment to minimize attacks and to moderate symptoms of asthma.

LONG-ACTING BETA-2 AGONISTS (LABA)

Long-acting beta-2 agonists are bronchodilators used for persistent asthma that is difficult to control. They are always used along with an anti-inflammatory medication. These medications are not rescue inhalers and should not be used as treatment for sudden asthma symptoms. When taken with inhaled corticosteroids, long-acting beta-2 agonists allow better asthma control at lower corticosteroid doses. Long-acting beta-2 agonists are administered via a metered-dose inhaler or dry powder inhaler.

LONG-ACTING BETA-2 AGONISTS COMBINED WITH INHALED CORTICOSTEROID	
Generic Name	**Brand Name**
Formoterol and budesonide	Symbicort
Formoterol and mometasone	Dulera
Salmeterol and fluticasone	Advair Advair HFA
Fluticasone furoate and vilanterol	Breo Ellipta

Salmeterol takes about 30 minutes to start working, reaches peak effectiveness after 3 to 4 hours, and lasts for more than 12 hours. Formoterol starts to work within a few minutes and lasts for more than 12 hours.

METHYLXANTHINES

Methylxanthines (phosphodiesterase inhibitors) is the class of drugs that includes caffeine. **Theophylline** is structurally classified as a methylxanthine whose mechanism of action is uncertain. It has two distinct effects in the airways: smooth muscle relaxation and suppression of the response of airways to stimuli. It also has an effect on mucus clearance.

Theophylline is an alternative, but not preferred, therapy in mild to moderate persistent asthma. It is usually reserved as a third-line therapy, most often in combination with inhaled therapy, and its use requires monitoring of plasma concentrations so that therapeutic, but not toxic, levels are achieved. Theophylline is a pharmacologicly active molecule but is only slightly soluble in water, making it difficult to administer.

Aminophylline is a combination of theophylline and ethylenediamine with ethylenediamine in a 2:1 ratio. This medication is used as a second- or third-line adjunct treatment for asthma.

These medications can be given intravenously and orally as tablets, capsules, liquid preparations, or sprinkles for the tongue or soft food. Some oral preparations are available in long-acting doses, allowing the dose to be taken once or twice a day.

METHYLXANTHINES	
Generic Name	**Brand Name**
Theophylline (short-acting)	Elixophyllin Theochron Uniphyl
Theophyllin (long-acting)	Theo-24
Aminophyllin (suppository)	Truphylline
Aminophylline (injectable)	None

CORTICOSTEROIDS

Corticosteroids are variants of the natural hormone cortisol. Corticosteroids dampen inflammation at the level of cell nuclei, switching off genes for inflammatory molecules such as cytokines, chemokines, and inflammatory enzymes and activating genes that have anti-inflammatory effects.

Inhaled Corticosteroids

Corticosteroids are considered the most potent and consistent anti-inflammatory agents currently available by inhaled therapy in the long-term management of the inflammatory component of asthma. Because chronic use of corticosteroids can cause serious systemic complications, they are administered to patients with asthma by inhalation, which enables delivery of a high concentration of medicine directly to the inflamed tissue with only a small amount leaking into the systemic circulation.

The exact dose and treatment regimen varies with the patient and the specific corticosteroid. However, most patients take two inhaler treatments daily. Using MDI inhalers, patients typically take 2 puffs twice a day; using DPI inhalers, patients typically take 1 actuation twice a day. Patients should rinse their mouths of any excess medicine after each treatment.

INHALED CORTICOSTEROIDS	
Generic Name	**Brand Name**
Beclomethasone dipropionate	QVAR
Budesonide	Pulmicort
Fluticasone propionate	Flovent Flovent HFA Flovent Rotadisk
Mometasone	Asmanex HFA
Ciclesonide	Alvlesco

Systemic Corticosteroids

Systemic corticosteroids are used as a short-term treatment for an asthma attack or when asthma has not been under control, and may continue for 3 to 14 days or longer. Side effects from a short course of systemic corticosteroids include:

- Sleep disturbance
- Increased appetite
- Weight gain

Taking systemic corticosteroids at high doses or for an extended period (weeks, months, or years) can cause more serious side effects (see "Complications Related to Asthma Medication Use" later in this course).

Systemic corticosteroids, whether administered intravenously or orally, are a key treatment for moderate or severe episodes of asthma. For patients whose asthma attacks do not resolve promptly after inhalation of their rescue medicines, systemic corticosteroids will speed the widening of airways and make a near-term recurrence less likely.

Corticosteroids are given orally (short term) during asthma exacerbations or given intravenously during severe acute attacks.

A small number—perhaps 1%—of asthma patients need long-term systemic corticosteroids to control their asthma. The clinician works to find the minimum necessary dose and institutes protective measures to reduce side effects; for example, calcium supplements and vitamin D are used to slow mineral loss from bones (Hess et al., 2012).

SYSTEMIC CORTICOSTEROIDS	
Generic Name	**Brand Name**
Oral prednisone	Prednisone Intensol Rayos
Oral prednisolone	Orapred Pediapred Prelone
Injectable methylprednisolone	A-Methapred Solu-Medrol
Oral methylprednisolone	Medrol
Injectable triamcinolone	Kenalog

LEUKOTRIENE MODIFIERS

Leukotriene modifiers act on cells that produce leukotrienes, which are lipid compounds released from mast cells, eosinophils, and basophils and that are responsible for airway bronchoconstriction, inflammatory cell recruitment, increased vascular permeability, and secretion production.

Drugs that specifically reduce the effect of leukotrienes are relatively recent additions to the arsenal of asthma medications. Leukotriene modifiers work in two ways:

1. Leukotriene receptor antagonists work by binding to cysteinyl leukotriene receptors and blocking their activation and subsequent inflammatory cascade.

2. 5-lipoxygenase inhibitors work by stopping or inhibiting the production of the enzyme 5-lipoxygenase, which is a precursor to the production of leukotrienes.

Leukotriene modifiers appear to work best in patients with mild to moderate persistent asthma. They are an alternative, but not preferred, therapy to low- to medium-dose inhaled corticosteroids. These drugs decrease the need for short-acting beta-2 agonists, particularly in patients with allergies.

LEUKOTRIENE MODIFIERS (granules, tablets, chewable tablets)	
Generic Name	**Brand Name**
Leukotriene receptor agonists	
Montelukast	Singulair
Zafirlukast	Accolate
5-lipoxygenase inhibitor	
Zileuton	Zyflo Zyflo CR

IMMUNOMODULATORS

There is currently one immunomodulator drug used for asthma: omalizumab (Xolair). It is a recombinant DNA-derived monoclonal antibody that inhibits the binding of IgE to the receptors on the surface of mast cells and basophils. This decreases the activation of these immune cells and reduces the release of inflammatory molecules such as histamine, prostaglandins, and leukotrienes.

Omalizumab is an alternate, but not preferred, drug in the treatment of moderate to severe persistent asthma in patients who have positive skin tests to aeroallergens and whose symptoms are inadequately controlled with inhaled corticosteroids. It is approved only for patients 12 years of age and older.

Omalizumab is given as a subcutaneous injection. It has the potential to induce anaphylaxis, so it must be administered only in a closely observed clinic (Hess et al., 2012).

MAST CELL STABILIZERS

Mast cell stabilizers are inhaled medications that prevent the release of histamine and other inflammatory substances from mast cells. Cromolyn sodium (Intal) is currently the only mast cell stabilizer available and comes as a nebulizer solution. It prevents asthma symptoms especially in children with allergies and asthma and in people with exercise-induced asthma. It is used in long-term management of asthma, taking 3 to 4 weeks to begin working, and needs to be taken 2 to 4 times a day. For exercise-induced asthma, Cromolyn can be taken 30 minutes before an activity to prevent symptoms. This drug is very safe and has few, if any, side effects.

Pharmacology Step Therapy

The step treatment of asthma is based on severity of symptoms and the patient's age. Asthma medications are added or deleted according to the frequency and severity of the patient's symptoms.

The Global Initiative for Asthma (2015) recommends the steps described in the following table:

STEP THERAPY		
Step	**Description**	**Alternatives**
1	As needed short-acting beta-2 agonist (SABA) with no controller	Regular low-dose inhaled corticosteroid (ICS) for patients with exacerbation risks
2	Regular low-dose ICS plus as-needed SABA	Leukotriene receptor agonist (LTRA) ICS + long-acting beta-2 agonist (LABA)
3	Low-dose ICS + LABA or medium-dose ICS plus as-needed SABA	• Medium-dose ICS • For children 6–11 years: medium-dose ICS or low-dose ICS + LABA
4	Low-dose ICS + formoterol maintenance and reliever therapy, or medium dose ICS + LABA as maintenance plus as-needed SABA	• Add-on tiotropium by soft-mist inhaler for adults 18 and over with a history of exacerbations • High-dose ICS + LABA, LTRA, or slow-release theophylline for adults • Children 6–11 years: refer for expert assessment and advice
5	Refer for expert investigation and add-on treatment with omalizumab	Add-on tiotropium by soft-mist inhaler for adults with history of exacerbations

Once control of asthma is achieved and maintained for at least three months, a gradual reduction of the maintenance therapy should be tried in order to identify the minimum therapy required to maintain control.

LONG-TERM ASTHMA MANAGEMENT

Asthma is a chronic illness, and good asthma therapy is built on a long-term plan. The ultimate goal for a patient with asthma is the prevention of functional and psychological morbidity to provide as healthy a lifestyle as possible for the individual's age. Because the goal of asthma treatment and control is for each patient to live a near-normal life, asthma control should minimize the symptoms that interfere with work, school, sleep, exercise, and leisure activities. Asthma attacks should be prevented or reduced, and ED visits should be rare.

Control of symptoms and risk reduction are the main features of long-term asthma management.

Control of Symptoms

Symptom control relies on medication that is adjusted in a continuous cycle of assessment, fine-tuning, and review of response. Medications are prescribed at the minimum necessary to maintain control of symptoms.

MEDICATION MANAGEMENT

Medication management for a patient diagnosed with asthma should be based on the patient's severity of symptoms and should follow step-therapy guidelines (see "Pharmacology Step Therapy" above). Medication effectiveness should be assessed at two- to six-week intervals, and if the patient is doing well, medications should be reduced according to step therapy until the lowest level has been reached that maintains satisfactory asthma control (GINA, 2015).

ASSESSING CONTROL

Once a minimum level has been reached, the patient should be seen every one to six months for symptom and lung function assessments. Women who are pregnant should be assessed every four to six weeks.

Assessment of control can be done using a validated asthma questionnaire. These include:

- Asthma Control Test (ACT)
- Asthma Control Questionnaire (ACQ)
- Asthma Therapy Assessment Questionnaire (ATAQ)

Each questionnaire may address different issues, but they all include the basic questions:

In the past four weeks, have you had . . .

- Daytime symptoms more than twice a week?
- Night wakening due to asthma symptoms?
- To use quick-relief medication more than twice a week?
- Any activity limitation due to asthma?

If the patient has experienced none of these, symptoms are considered **well controlled.** If the patient has experienced one or two of these, symptoms are **partially controlled.** If the patient has experienced three or four, symptoms are **uncontrolled.**

Lung function testing is done using spirometry after treatment has begun and again when symptoms have stabilized. This should be done at least every one to two years.

Ongoing home monitoring can be done using a peak flow meter to monitor changes in lung function, or patients can monitor symptoms by keeping a diary or journal for communication with their healthcare provider (GINA, 2015).

REMOTE MONITORING

A trial has been conducted to determine the effectiveness of remote monitoring of asthma inhaler use. The device senses each inhaler actuation and uploads details to a mobile phone application. It also sends reports and change of status alerts to their providers. It is expected that over time it will become more standard and will be used routinely in medication management to control asthma symptoms.

Source: Phend, 2013.

QUALITY OF LIFE ASSESSMENT

The Asthma Quality of Life Questionnaire (AQLQ) can be used to measure functional problems (physical, social, occupational) that are most bothersome to adults aged 17 to 70 with asthma. There are also several questionnaires available that are appropriate for the different ages of pediatric patients with asthma. (*See "Resources" at the end of this course.*)

Developing an Asthma Action Plan

A successful asthma management plan requires the continued attention of a disease manager, and the patient or a child's caregiver should take that role. With their primary care provider, asthma patients should design a plan that is realistic, and the patients and caregivers must then ensure that the plan is carried out. To these ends, providers and patients should design an action plan together.

The better patients understand the reason for their healthcare providers' recommendations, the more likely it is that those recommendations will be carried out. Providers must shape their recommendations to be realistic for and understandable to the particular patient; they should also listen to be certain that they are working on their patients' goals.

PATIENT EDUCATION

The plan of action should include patient education, which begins with an initial assessment of what the asthma patient understands about the disease and what the patient is imagining that the healthcare system can do for him or her. When talking with a patient, the clinician can then begin at the patient's level of understanding when making comments or giving advice.

The NHLBI guidelines (2012a) emphasize these features of asthma education:

- Begin at the time of diagnosis and continue through all the follow-up visits.
- Explain basic facts about asthma, including: what is good control, how the medications

work, how to use an inhaler (including practice sessions), what triggers to avoid, what triggers to remove and how to remove them, and how the patient can get help and advice.

- Ensure that all members of a healthcare team—nurses, physicians, technicians, social workers, therapists, and pharmacists—add some educational information to their patient interactions.
- Explain the disease principles and let the patient help to decide the care details.
- Consider using at-home, in-school, and Internet-based education programs.
- Give all patients a written asthma action plan that includes details of daily management and a list of threatening symptoms and how to deal with them.

CASE: Patient Education

JONAH, AGE 11 *(continued)*
Jonah Bachman, the 11-year-old identical twin who was brought to the pediatrician's office by his mother (as described in the case above), returned to the office to meet with the nurse after being diagnosed with asthma and given a prescription for quick-relief inhaler. The following patient education was accomplished at this visit.

1. The nurse gave Jonah the inhaler, described how it is used, and told him he is to use it when he experiences an asthma attack while at home or at school. The nurse then explained how the inhaler works, demonstrated the technique, and had Jonah return the demonstration using a dummy inhaler. She also gave him a pamphlet that pictorially describes the use of the inhaler and instructions on the prescribed dosage and frequency of inhaler use.
2. The nurse gave Jonah tips to help him assess the severity of an attack, noting that when he starts to wheeze, cough, and have difficulty breathing or talking during normal activities, those symptoms signal a need for the use of the inhaler.
3. The nurse reviewed the use of the peak flow meter with Jonah and his mother. Jonah practiced using it to arrive at his "personal best." This and detailed instructions on how to assess Jonah's values were discussed.
4. The nurse helped prepare a written set of instructions for Jonah and a separate, more detailed set of instructions for his mother. The mother's instructions focused more specifically on when to repeat bronchodilator treatment, call the doctor, or take Jonah to the emergency department based on his response to the quick-relief bronchodilator (as determined by peak flow values and the severity and/or persistence of symptoms).
5. The nurse made a separate copy of the mother's instructions for the school nurse, which Jonah's mother promised to deliver herself.

ELEMENTS OF THE ACTION PLAN

The most effective way to ensure that patients understand how to manage their asthma is by developing an individualized action plan between the patient and his or her healthcare provider. An action plan is a written worksheet that gives specific instructions for early treatment of asthma symptoms, what steps should be taken to prevent asthma from worsening, and guidance on when to call a healthcare provider or when to seek emergency treatment.

A good asthma plan can:

- Determine asthma control by tracking asthma symptoms or by monitoring peak flow ratings
- Provide a list of all medications and how much and how often they should be administered
- Track use of a quick-relief inhaler
- Describe how to adjust medications
- Outline how to recognize and treat an asthma attack
- Tell when to seek emergency care
- Teach how to avoid asthma triggers

  (Mayo Clinic, 2014b)

The asthma action plan can be based on peak flow monitoring or on symptom tracking. Peak flow monitoring is recommended for those with moderate to severe asthma. Most action plans refer to **zones,** which help the person determine medication need and when to contact a healthcare provider.

- **Green** means the person is doing well, has no symptoms, or has a peak flow rate of 80% to 100% of personal best.
- **Yellow** means the person is getting worse. Asthma symptoms are present or peak flow rate is between 50% to 80% of the person's personal best.
- **Red** means Medical Alert. The person's symptoms have worsened or peak flow rate is less than 50% of personal best and medication is not helping. Emergency treatment is required.

  (ALA, 2015b)

Patients can track their symptoms and maintain a **journal or diary,** which can be an important communication tool to share with their healthcare provider. Monitoring four key symptoms will help determine asthma control.

- Daytime symptoms
- Nighttime symptoms
- Rescue inhaler use
- Activity level

CASE: Asthma Action Plan

Sixteen-year-old Nadia Marquez, recently diagnosed with asthma, is meeting with the office nurse, who is assessing Nadia's current status so she can report her findings to Nadia's physician. The nurse judges Nadia's asthma severity to be moderate and notes her baseline FEV1 and PEF values. She also notes that Nadia's asthma appears to be triggered by exercise, dust mites, and fragrances, and that Nadia's knowledge of the disease appears to be minimal.

The nurse then counsels Nadia on the basics of asthma management, focusing on issues such as carrying an inhaler (particularly during exercise), avoiding asthma triggers, using a peak flow meter, and anticipating and handling an attack. These matters are incorporated into the written plan, which includes a diary for Nadia to record the following information:

- The state or level of Nadia's asthma on a daily basis (including assessment of her symptoms, lung function, and ability to perform routine activities)
- Nadia's response to asthma attacks
- Phone numbers and website addresses for Nadia's physician, the local hospital, and organizations providing asthma-related educational information and counseling

The medication portion of the written plan outlines step therapy for asthma management, starting with short-acting beta-agonist inhalers and progressing to corticosteroids (at increasing doses) and other medications as appropriate. These instructions emphasize the need to administer the minimal amount of medication to control Nadia's symptoms, as well as the importance of assessing her asthma severity level at each step of the protocol.

Once Nadia has reviewed and accepted the written plan, she schedules a follow-up appointment in two weeks, at which time her degree of asthma control will be assessed and her medications will be adjusted as necessary.

Nonpharmacologic Asthma Treatment and Therapies

As outpatients, persons with asthma may be referred for special procedures or to specialized therapists for education and training in ways to better manage the disease.

RESPIRATORY THERAPY

Respiratory therapists may work in inpatient and outpatient departments providing patients with asthma trigger management, asthma education, and working as part of the care team, implementation of the patient's asthma action plan.

Respiratory therapists may assist with routine monitoring of patient respiratory symptoms and lung function, controlling trigger factors, controlling comorbid respiratory conditions, and teaching proper administration of inhaled drugs. (See also "Interdisciplinary Inpatient Management: Respiratory Therapy" later in this course.)

PHYSICAL THERAPY

Physical therapy has been shown to improve asthma symptom control, exercise capacity, and sense of well-being. Physical therapists may provide:

- Exercise training
- Self-management
- Breathing control
- Sputum clearing techniques
- Education concerning monitoring symptoms and correct inhaled medication delivery technique
- Assistance with written asthma management plan

Breathing Retraining

Breathing retraining exercises are among the most frequently used adjunct treatments for asthma. One such type is the **Buteyko technique**, which is based on the theory that hyperventilation leads to decreased carbon dioxide (CO_2) levels in the blood, which leads to airway constriction in an attempt to conserve it. This technique increases the CO_2 level through controlled shallow breathing through the nose only, with breath-holding at the end of exhalation. Patients are taught that sighs, yawns, and gasps should be eliminated, as these are considered over-breathing. Patients using this technique are instructed to use the method for 5 to 10 minutes before using a bronchodilator for symptom relief (O'Connor et al., 2012; Hassan et al., 2012).

Another retraining method is called the **Papworth**, which involves teaching the patient to breathe slowly and steadily through the nose using diaphragmatic breathing and pausing after each breath. Breathing from the diaphragm allows the lungs to expand fully and inhale more oxygen (Frea, 2014).

Inspiratory Muscle Training

Physical therapists may use techniques such as inspiratory muscle training that strengthen both inspiratory and/or expiratory muscles in an effort to reduce the patient's perception of dyspnea, aid in overcoming airway resistance, and avoid hyperinflation due to insufficient expiratory strength (O'Connor et al., 2012).

Relaxation Techniques

Relaxation and anxiety reduction techniques are also taught by physical therapists, such as yoga-based approaches that involve slow and regular breathing and prolongation of expiration, which is meant to promote mental and physical relaxation. These techniques improve abdominal/diaphragmatic breathing and force resistance to both inspiration and exhalation (O'Connor et al., 2012).

Biofeedback

Biofeedback techniques can indirectly target airway resistance. Electronic devices may be used to show the patient a physiologic level to teach him or her to control body functions that normally occur without conscious input (O'Connor et al., 2012).

Exercise

A physical therapist may also design individualized exercise programs for improving strength, posture, and endurance as well as strategies to help avoid exercise-induced asthma attacks (AHRQ, 2012).

OCCUPATIONAL THERAPY

Occupational therapists (OTs) work with patients with pulmonary diseases such as asthma to increase their potential for independence. OT plays a major role in pulmonary rehabilitation and combines exercise training, education, and counseling to teach patients how to live a fuller life with a chronic lung condition.

Occupational therapy may include education about the anatomy and physiology of the lungs, various medications and their purpose, and medication management. OTs may teach relaxation techniques, energy conservation, and stress management techniques and preventative actions the patient can use to manage asthma.

Stress Management

Occupational therapy strategies that assist with stress management can include panic control, progressive relaxation techniques, and breath support exercises to help the patient with asthma better adapt to daily life and to decrease the effects of stress. OTs offer strategies to decrease shortness of breath and improve quality of life and continued participation in meaningful occupations by introducing adaptive, compensatory, and restorative techniques and interventions.

Learning to relax is an essential tool in the arsenal for management of the disease. OTs teach techniques such as deep breathing, progressive muscle relaxation, autogenic therapy, and guided imagery.

Progressive muscle relaxation and controlled breathing are taught to help relieve tension and stress. Guided imagery encourages people to experience internal accord, to increase body awareness, and to enhance relaxation. Autogenic therapy is a technique in which a patient is taught to connect mind and body so that the body responds to the mind's commands. For patients with asthma, it enables the mind to tell the body to relax and control breathing (CAOTA, 2015).

Biofeedback techniques are also utilized by occupational therapists to improve self-awareness of the effects of stress. One such technique is pneumograph feedback, which measures breathing patterns (LUHS, 2014).

Energy Conservation

OTs are also knowledgeable in addressing energy conservation techniques to promote independence and participation in activities of daily living (IU Health, 2015). Energy conservation techniques can include:

- Prioritizing activities so that there is an even mix between heavy and light tasks during the day and carrying out strenuous activities during the time of day when the person has the most energy
- Modification of the environment to avoid excessive bending, carrying, and reaching
- Sitting during activities as much as possible
- Taking frequent rest breaks between activities rather than one long break at the end
- Using labor-saving tools
- Elimination of unnecessary steps whenever possible
- Gathering tools and materials before starting an activity
- Using proper body mechanics
  (UVA Health System, 2012)

Family Support

Family support is also provided by occupational therapists, especially for parents of children, helping to discover efficient ways to adjust habits and routines to conserve energy and to take part in physical activity. Parents are provided with instruction in coping, positioning, breathing techniques, counseling, and medication management (IU Health, 2015).

BRONCHIAL THERMOPLASTY (ABLATION)

One of the pathologic features of asthma is hypertrophy of the airway smooth muscle. Bronchial thermoplasty (BT) is a method of delivering controlled heat to airway mucosa with the aim of reducing airway smooth muscle mass and consequently bronchoconstriction, thereby reducing the risk of exacerbation recurrence.

Ablations are performed starting in the distal airways and working proximally in a contiguous fashion. Treatments are done in three sessions approximately three weeks apart. BT has been

shown to be safe, to improve symptoms in patients who cannot achieve control with standard medical care, and to have long-lasting benefits (Miller & Murgu, 2014).

Asthma Triggers and Exposure Reduction

Patients will usually know many of the things that trigger or worsen their asthma symptoms. As the patient and doctor work to identify all the environmental factors that are asthma aggravators, it is helpful to give the patient a list showing the wide range of common triggers and how to avoid them. (See also "Triggers and Aggravating Factors" earlier in this course.)

STRATEGIES TO AVOID COMMON ASTHMA TRIGGERS

Trigger	Exposure Reduction Strategies
Animals (dander, urine, or saliva from animals and birds)	• Keep pets with fur or feathers out of the home. • If pets cannot be kept outdoors, keep them out of the bedroom and keep the door closed. • Install a HEPA air cleaner in the bedroom. • Keep pets off upholstered furniture and away from stuffed toys.
Dust mites (arachnids that live on human skin cells that have been shed and that colonize beds, upholstered furniture, and carpets)	• Reduce indoor humidity and do not use humidifiers. • Wash mattress covers and bedding in hot water each week. • Wash stuffed animals frequently and dry completely. • Steam clean bedding, mattresses, and furniture that cannot be washed. • Use dust-proof pillow and mattress covers. • Remove carpeting from the home. • Vacuum weekly with a HEPA vacuum cleaner. • Avoid lying on upholstered furniture.
Cockroaches	• Do not leave food or garbage uncovered. • Clean up spills and food crumbs right away. • Store food in airtight containers. • Use traps, poison baits, powders, gels, or pastes to kill cockroaches (asthma patients should avoid sprays). • Keep food out of the bedroom. • Store cooking oils in the refrigerator.

Outdoor pollens and molds (from trees, grasses, weeds, etc.; often seasonal)	• If possible, stay indoors with air conditioning on and windows closed, especially during the midday and the afternoon. • Wash clothes and shower after gardening or playing outdoors. • When traveling by car, keep windows closed and air conditioning on in the recirculation mode. • Avoid hanging sheets or clothes outside to dry. • Do not mow the lawn. • Wash pets after long outdoor play. • Do not rake leaves or compost without wearing a dust mask. • Get daily air-quality forecasts of pollen counts.
Molds (fungi) (common in humid climates and in homes with continual areas of dampness; usually black in color)	• Look for and repair leaks in household plumbing. • Look for moisture under sinks, inside showers, around windows and doors; check the basement floor and walls for moisture infiltration. • Clean moldy surfaces with a diluted bleach solution (one cup per gallon of water). If that doesn't work, have surfaces cleaned by professionals. • Lower the humidity in the home and do not use vaporizers or humidifiers. • Measure moisture in the home, especially in bathrooms, basement, and kitchen, using an inexpensive hygrometer. • Wear a mask when sweeping, vacuuming, or doing yard work; use a vacuum with a HEPA filter. • Remove carpet from basements, bathrooms, and bedrooms. • Clean bathrooms with mold-killing products. • Disinfect cleaned surfaces with a penetrating fungicide. • Add mold inhibitors to paints before application and repaint disinfected surfaces with a paint-fungicide mixture. • Equip the furnace with a high-efficiency filter; replace the filter every three months and have the furnace serviced every six months (CDC, 2014b).
Cigarette smoke	• Do not allow smoking in the home, car, or anywhere nearby. • Quit smoking. Ask a healthcare provider for help to quit and perhaps a referral to a smoking program. • If family members smoke, ask them to quit.

Wood smoke, strong odors and sprays, chemical vapors	• Avoid strong odors and sprays such as perfume, powder, hair spray, paints, incense, cleaning products, candles, and new carpeting. • Avoid inhaling smoke from burning wood. • Avoid air fresheners. • When in a workplace with chemical vapors, limit or avoid exposure altogether by using respiratory protective gear (ALA, 2015c).
Outdoor air pollution	• When the level of outdoor pollution is high, stay indoors as much as possible and avoid exertion when being outdoors. • Check the Environmental Protection Agency's website or other sources for daily updates on air quality. • Choose routes for walking or exercising that avoid major streets or highways. • Instruct children with asthma to play in playgrounds that are not near major highways (NRDC, 2014).
Viruses, colds, influenza, bronchitis	• Wash hands often. • Avoid touching eyes, nose, or mouth. • Avoid contact with people who have colds. • Get a flu shot every year, preferably in the fall if over 6 months old. (Although not contraindicated, nasal spray vaccine (e.g., FluMist) may increase risk for wheezing) (CDC, 2015a).
Nonselective beta blockers (can cause bronchoconstriction and make airway constriction difficult to reverse with quick-relief medicines)	Avoid taking any of the following drugs: o Carteolol o Levobunolol o Metipranolol o Nadolol o Pindolol o Propranolol o Sotalol o Timolol
Aspirin and NSAIDs*	Avoid aspirin and NSAIDS if sensitive to them. (*Aspirin and NSAIDs can trigger severe or fatal attacks; most common in those with Samter's triad, a combination of asthma, aspirin sensitivity, and nasal polyps [Karriem-Norwood, 2014b].)
Sulfite preservatives (food and drink rarely cause asthma symptoms)	Eliminate suspected problem foods and note effect on asthma symptoms.

Exercise and activity	• Take rescue medicines before sports or exercise to prevent symptoms, if directed by a healthcare provider. • Warm up/cool down for 5 to 10 minutes before and after sports or exercise. • Cover nose and mouth with a scarf when exercising in the cold. • Use controller medications (corticosteroids) as prescribed.
Emotions (fear, stress, laughter, crying, anger, anxiety)	• Become aware of things, events, or people that cause stress. • Avoid unnecessary stress; leave stress-provoking situations if possible. • Find constructive and positive ways to reduce anger, anxiety, or fear. • Get adequate sleep to help reduce emotional instability. • Eat a healthy diet. • Accept things that cannot be changed. • Exercise regularly.

MANAGEMENT OF ASTHMA EXACERBATIONS (ATTACKS)

The most effective strategy for dealing with an **asthma attack** is early treatment.

Four Principles of Management

There are four principles to consider in the management of asthma exacerbations:

- Correcting hypoxemia
- Reversing airflow obstruction
- Assessing treatment progress
- Avoiding exacerbations

CORRECTING HYPOXEMIA

Therapy for an asthma attack begins with correcting any hypoxemia and maintaining sufficient blood oxygenation. Hypoxemia is a blood oxygen concentration (an arterial blood oxygen partial pressure [PaO_2]) of less than 60 mm Hg. Clinical signs of hypoxemia are restlessness, tachycardia, and cardiac irritability (i.e., a tendency to develop irregularities in rate and rhythm). Prolonged or significant hypoxemia will lead to bradycardia, hypotension, and cardiac arrest.

An asthma attack will produce hypoxemia, and this must be corrected. In a mild attack, short-acting bronchodilators can usually relieve the bronchoconstriction sufficiently for the patient's

breathing to maintain appropriate blood oxygen levels. In a severe attack, supplemental oxygen is needed.

REVERSING AIRFLOW OBSTRUCTION

The hallmark of an asthma attack is a significant increase in the difficulty of moving air through the bronchi and bronchioles of the lungs. For the patient to maintain a healthy level of oxygen in the blood, the airway obstruction must be reduced, so one goal when treating an asthma attack is to widen the airways and lessen the obstruction. Airflow obstruction is most quickly reversed by inhaling short-acting bronchodilators and then taking systemic corticosteroids.

ASSESSING TREATMENT PROGRESS

The extent and the time course of medical treatment for an asthma attack must be tailored to each specific situation, and often the initial treatment is modified as events progress. For moderate and severe attacks, patients should be evaluated clinically, their blood oxygen saturation (measured via pulse oximetry) followed, and their FEV1 measured at regular intervals. Acutely ill patients must be treated immediately; for them, initial lung function tests are distressing and unnecessary.

AVOIDING EXACERBATIONS

At the end of acute treatment, the final goal is to reduce the likelihood that the patient will have additional attacks. To this end, a course of systemic corticosteroids is often prescribed. Asthma attacks can be a sign that the patient's disease is not being managed optimally. Therefore, regardless of the severity of the current attack, at the end of their treatment, all patients seen by a primary care provider should be counseled, given any necessary medications, provided with a telephone number for questions, and scheduled for a follow-up visit.

Relief from an asthma attack requires proper treatment, and it is the patient or the patient's family who have the responsibility for initiating that treatment. For this reason, when a patient is diagnosed with asthma, the patient or the family should be given a written plan that explains how to deal with an asthma attack.

Self-Management of an Asthma Attack

Asthma patients should have a **quick-relief inhaler** that they can carry with them to school, work, or any place outside the home. At home, patients with moderate or severe asthma should have additional medications (e.g., oral corticosteroids) and a peak flow meter, and children should have a compressor-driven nebulizer.

All asthma patients need a **written plan of action**—an instruction manual on how to handle an attack. This plan should be written clearly enough for a family member or friend to follow. The plan should be tailored to the individual patient.

An emergency action plan sets out four steps for treating attacks:

1. Assess the severity of symptoms
2. Take quick-relief medications
3. Get medical advice
4. Follow the after-the-attack instructions

STEP 1: ASSESSING SEVERITY

The first step of the typical action plan for asthma attacks is deciding the severity of the attack.

Mild

- The patient starts to experience wheezing, coughing, or difficulty breathing.
- The patient becomes breathless doing exercise.
- The patient has no problem speaking.
- The patient's peak expiratory flow rate (PEF) is 70% to 80% of his or her personal-best value.

Moderate

- The patient starts to experience wheezing, coughing, or difficulty breathing.
- The patient becomes breathless doing normal activities.
- The patient can finish a sentence.
- The patient's PEF is 50% to 70% of his or her personal-best value.

Severe

- The patient starts to experience wheezing, coughing, or difficulty breathing.
- The patient is breathless while sitting.
- The patient cannot finish a sentence.
- The patient's PEF is less than 40% of his or her personal-best value.

Extremely Severe

- The patient starts to experience wheezing, coughing, or difficulty breathing.
- The patient cannot catch his or her breath when sitting.
- The patient is choking, wheezing, or coughing continuously.
- The patient cannot speak a full sentence.
- The patient is sweaty and perhaps confused or sleepy.
- The patient's PEF is less than 25% of his or her personal-best value.

Extremely severe asthma attacks require immediate attention. For patients likely to have an extremely severe attack, step 1 of their asthma attack plan should be, “Take quick-relief medications and call 911.”

STEP 2: TAKE QUICK-RELIEF MEDICINES ACCORDING TO SEVERITY

Pharmacologic self-management should always begin with the inhalation of a short-acting bronchodilator such as albuterol. Although each self-management plan must be individualized, here are some common protocols.

Mild

Begin with 2 to 6 puffs of the quick-relief bronchodilator. Repeat the same dose in 20 minutes. A complete response includes significantly decreased symptoms and a PEF 80% or higher of one’s personal-best value within 30 minutes.

If the response is incomplete, the bronchodilator treatment can be repeated once every 3 to 4 hours for 24 to 48 hours. For an incomplete response, a short course of oral corticosteroids should be considered, in which case the patient should consult his or her primary care provider.

Moderate

Begin with 2 to 6 puffs of the quick-relief bronchodilator. Repeat the same dose in 20 minutes. A complete response includes significantly decreased symptoms and a PEF 80% or higher of one’s personal-best value within 30 minutes. For a complete response, repeat the bronchodilator treatment once every 3 to 4 hours for 24 to 48 hours.

If the response is incomplete, the bronchodilator treatment should be repeated every 3 to 4 hours for 24 to 48 hours. In addition, a short course of oral corticosteroids should be started, in which case the patient should consult his or her primary care provider.

Severe

Begin with 2 to 6 puffs of the quick-relief bronchodilator. Repeat the same dose in 20 minutes. A complete response includes significantly decreased symptoms and a PEF of 80% or higher of one’s personal-best value within 30 minutes. For a complete response, repeat the bronchodilator treatment once every 3 to 4 hours for 24 to 48 hours. Begin taking oral corticosteroids, and contact one’s primary care provider within 24 hours.

If the response is incomplete (persistent wheezing, difficulty breathing, or a PEF of 50% to 80%), begin taking corticosteroids and contact one’s primary care provider within the hour.

If the response is poor (marked wheezing or coughing, difficulty breathing at rest, PEF less than 50%), repeat the bronchodilator treatment immediately, begin taking oral corticosteroids, call one’s primary care provider, and call 911 rather than driving oneself to the emergency department.

Extremely Severe

Immediately take 2 to 6 puffs of the quick-relief bronchodilator and call 911. Oral corticosteroids should be started. For increasing symptoms, inject oneself with epinephrine (Epipen) if this is a part of one's asthma attack plan.

RESPONDING TO AN ATTACK WHEN NO INHALER IS AVAILABLE

An individual experiencing an asthma attack but who does not have a quick-relief inhaler at hand can be instructed to follow these steps:

- Get away from the asthma trigger as soon as possible and go to an air-conditioned environment or other place with clean air.
- Sit upright; stooping over or lying down constricts breathing.
- Take long, deep breaths to help slow down breathing and prevent hyperventilation, breathing in through the nose to the count of four and then out through the mouth to the count of six. Purse the lips during exhalation to slow exhalation and keep airways open longer.
- Stay calm to prevent further tightening of chest muscles and make breathing easier.
- Press on acupressure points in the front parts of the inner shoulders just above the armpits and the outer edges of the creases of the bent elbows. Pressing on one area at a time for a few consecutive minutes may relax muscles.
- Drink a cup or two of a hot caffeinated beverage (coffee or nonherbal tea), which can help open up the airways slightly and help loosen mucus, providing some relief. (Caffeine is mobilized into theophylline, which is a drug used to prevent and treat asthma by relaxing airways and decreasing the lungs' response to irritants.)
- Take magnesium and vitamin C during the attack (for adults). (Magnesium is a bronchodilator that relaxes the airways, and vitamin C has a slight antihistamine effect.)
- Take pseudoephedrine (e.g., Sudafed), a nasal decongestant.
- Seek emergency medical help if wheezing, coughing, and breathing difficulty do not subside after a period of rest.

Source: SGH, 2015; Firshein, 2013.

STEP 3: GET APPROPRIATE MEDICAL ADVICE

Severe or Extremely Severe Initial Symptoms

Regardless of the usual severity of their asthma, all patients need a list of symptoms—such as extreme breathlessness, insufficient breath to speak more than a few words at a time, or

drowsiness—that suggest the onset of an extremely severe attack. These symptoms should prompt patients to call 911 immediately while taking their quick-relief medicine.

Poor Response to Quick-Relief Medicines

If symptoms are worsening, or if after 30 minutes marked wheezing and difficulty breathing persist, or if the PEF is less than 50% of the patient's predicted or personal-best value, the patient should follow the above medication regimen (Step 2), contact his or her primary care provider immediately, and proceed to an emergency department, calling 911 rather than driving oneself. If the patient is drowsy, confused, sweating, or turning blue, call 911 immediately.

Incomplete Response to Quick-Relief Medicines

If after 30 minutes wheezing or difficulty breathing or if the PEF is between 50% and 80% of the patient's personal-best value, the patient should follow the above medication regimen (Step 2) and contact his or her primary care provider within 24 hours for further instructions.

Complete Response to Quick-Relief Medicines

If after 30 minutes the patient no longer has wheezing or difficulty breathing and the PEF is at least 80% of the patient's personal-best value, the patient should follow the above medication regimen (Step 2) and contact his or her primary care provider later for follow-up instructions.

STEP 4: FOLLOW AFTER-THE-ATTACK INSTRUCTIONS

After an asthma attack, the patient should continue stepped-up treatments for several days. A full recovery will take 1 to 2 days for moderate symptoms and more than 3 days for severe symptoms. Improvement can be gradual. The underlying disease flare-up will last for 2 to 3 weeks. Always contact the primary care provider within a day of the attack for specific after-the-attack instructions.

EMS Management of an Attack

Quick treatment with oxygen and bronchodilators is the optimal treatment for a severe asthma attack, and EMS transport is the preferred way for a patient with a severe asthma attack to get to an emergency department.

EMS teams should be trained in the recognition of and response to asthma attacks, and they should be trained to recognize imminent respiratory failure and asphyxiation. They should also have written protocols for the prehospital treatment of asthma attacks in children and adults. The type of prehospital care that is provided will depend on the level of training of the EMS personnel called to the scene (e.g., first responder, EMT-basic, EMT-advanced, or paramedic).

The basic protocol should begin with evaluation of the patient while in the transport vehicle.

EMS responders should:

- Check vital signs and level of consciousness
- Listen for breath sounds
- Record oxygen saturation (SaO_2)
- Administer oxygen

It is ideal for EMS technicians to have standing orders to provide inhaled albuterol for patients experiencing asthma symptoms. This may be administered by nebulizer, either hand-held, small-volume nebulizer or in conjunction with a continuous positive airway pressure (CPAP) device or bag valve mask.

For patients who do not respond to this medication, parenteral beta-agonist therapy may be given, the most common of which is epinephrine administered subcutaneously or intramuscularly. Magnesium sulfate (Epsom salt) intravenously may also be administered for its effect as a smooth muscle relaxant.

Heliox, a mixture of helium and oxygen, may also be given, which can help distribute oxygen and nebulized medications and decrease the work of breathing.

In addition, many EMS systems are recommending the use of CPAP systems to reduce the work of breathing, hold airway structures open, and improve oxygenation (Ogilvie, 2012; El-Khatib et al., 2014; Kew et al., 2014).

CASE: EMS Response to an Asthma Attack

MR. WILSON
Howard Wilson is a 54-year-old patient with asthma who calls 911 while experiencing a severe attack at his workplace. The EMS team arrives within 10 minutes and immediately administers oxygen and inhaled albuterol treatment as specified in their protocol.

After placing Mr. Wilson on a stretcher, the team loads him into their ambulance to transport him to the emergency department. While en route to the ED, the team checks the patient's vital signs, which, aside from an elevated heart rate, are normal. The patient remains conscious during the 30-minute trip to the ED, though his breathing is labored and his SaO_2 level is only 70%.

The team continues to follow their protocol by administering oxygen using CPAP, along with a repeat dose of inhaled albuterol 20 minutes after the first dose, while also giving Mr. Wilson subcutaneous epinephrine. By the time he arrives at the ED, the patient is breathing more easily and his wheezing and coughing are less severe.

After the patient is admitted to the ED, one of the EMTs calls the team's medical director, who confirms that their actions in this case were appropriate.
(continues)

Emergency Department Management of an Asthma Attack

STEP 1: TRIAGE BY ASSESSING SEVERITY

The ED team makes a judgment of the severity of the attack by assessing:

- Intensity of symptoms, including both the interviewer's observations and the patient's report of the extent of wheezing, coughing, and dyspnea
- Signs, including heart rate, respiratory rate, use of accessory muscles, sounds heard on chest auscultation, cyanosis, and state of consciousness
- Peak flow or FEV1 values, unless the patient is too dyspneic to perform them or the symptoms are becoming life-threatening
- Blood oxygen saturation by pulse oximetry

STEP 2: TREAT ACCORDING TO SEVERITY

The team begins treatment according to the severity level of the attack. Even if the patient has taken rescue medicines, treatment is given immediately for attacks that are of moderate severity or worse or when the patient has dyspnea at rest, a PEF or FEV1 value less than 70% of predicted, or an SaO_2 less than 95%.

ED BASIC TREATMENT PROTOCOLS

For mild to moderate symptoms with a PEF greater than 40% of the predicted value:

- Initially give:
  - O_2, with a minimum goal of SaO_2 greater than 90%
  - Inhaled short-acting bronchodilator (nebulizer or MDI), 4 to 8 puffs, repeatable every 20 minutes during the first hour (short-acting bronchodilators begin to have an effect in less than 5 minutes)
- If no improvement within 5 to 10 minutes, oral corticosteroids (prednisone)

For severe symptoms or a PEF less than 40% of the predicted value:

- O_2, with a minimum goal of SaO_2 greater than 90%
- Inhaled high-dose short-acting bronchodilator plus ipratropium via nebulizer either every 20 minutes or continuously for one hour
- Oral or IV corticosteroids (prednisone or methylprednisolone)

Source: OAC 4723-4-01.

STEP 3: TAKE HISTORY AND DO PHYSICAL EXAM

The **history** should include:

- Time of onset of current attack
- Possible causes
- Severity of symptoms compared to previous attacks
- Medications taken before ED admission and any change in symptoms as a result
- All current medications and times of last doses
- Approximate number of attacks during the past year
- Any previous attacks that were serious enough to cause loss of consciousness, intubation and mechanical ventilation, or ICU admission
- Other concurrent illnesses, including lung diseases (e.g., COPD), heart diseases (e.g., heart failure), endocrine diseases, bleeding problems (e.g., gastrointestinal ulcers), hypertension, kidney diseases, or psychotic illnesses
- Recent surgeries, prolonged inactivity, or propensity for deep venous thromboses

The **physical exam** should note especially:

- Severity of asthma signs and symptoms
- State of alertness
- Degree of hydration
- Lung complications, such as respiratory infections, chest trauma, chest deformity, or uncommonly, possible pneumothorax
- Signs of heart failure
- Evidence of upper airway obstruction

STEP 4: ASSESS RESPONSE TO INITIAL TREATMENT

The ED team will record pulse oximetry values regularly and reassess the severity of the asthma symptoms after one hour. In addition, they will monitor for signs of increasing fatigue from the work of breathing. Next is an assessment for discharge, additional therapy, or hospitalization:

- If on reassessment the symptoms are minimal and the PEF greater than 70% of predicted value, the patient is watched for another hour. A continued remission after 60 minutes means the patient can be discharged. In two thirds of ED asthma patients, the initial 3 doses of bronchodilator will be sufficient to reverse their symptoms and allow them to be discharged. The patient should be sent home with brief counseling, oral corticosteroids, and a scheduled outpatient follow-up visit.

- If the patient is not improving after an hour, additional therapy (e.g., IV magnesium sulfate or heliox) is considered.

If at any time the patient is worsening or if the SaO_2 is dropping, an arterial blood gas should be checked for indications of impending respiratory failure. At that point, intubation, mechanical ventilation, and hospitalization must be considered (Moses, 2015).

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MONITORING INFANTS AND YOUNG CHILDREN

The severity of airway obstruction is harder to determine in young children, but an increasing respiratory rate (i.e., tachypnea) can be the equivalent of dyspnea. Close monitoring is critical for young children because infants have less of a safety margin than older children and can descend rapidly into respiratory failure.

Continuous pulse oximetry is an easy way to monitor an infant's respiratory status. A decreasing SaO_2 or a SaO_2 less than 92% on room air one hour after the initial treatment signals that an infant will probably need hospitalization. As in adults, blood gas measurements of carbon dioxide partial pressure ($PaCO_2$) are the best measures of respiratory status, and a child who is in respiratory distress but who has a normal $PaCO_2$ is at high risk for respiratory failure.

WHEN TO HOSPITALIZE

Even with good treatment, 10% to 25% of patients seen in the ED for asthma attacks will need to be hospitalized. Patients should be admitted to an ICU if they need continued careful monitoring, are candidates for intubation, or are already intubated.

When PEF or FEV1 values begin very low and then increase only minimally after treatment, the patient is a candidate for admission to an ICU. Widely fluctuating lung function values also suggest that respiratory function is unstable, and the patient may need to be watched in an ICU. In addition, if serial pulse oximetry values remain low or begin to decrease, there is some form of respiratory compromise, and it is probable that the patient will need to be hospitalized.

Intubation is a difficult procedure in patients with asthma, and it should be done before a crisis develops. In general, increasing levels of carbon dioxide in the blood, patient exhaustion, and a reduced level of alertness suggest that an asthma patient will need intubation. Asthma patients who come to the ED unable to breathe or in a coma should be intubated immediately.

Adjunct treatments, such as IV magnesium sulfate or heliox-driven albuterol nebulizers, are sometimes used in an attempt to avoid intubation of a patient with severe asthma symptoms.

HOSPITALIZATION OF CHILDREN HAVING ASTHMA ATTACKS

In children, lung function measures are hard to obtain during an asthma attack. Spirometry frequently is not feasible, so a severity assessment tool can be used to help predict the need for admission to the hospital.

One such tool is the Pediatric Respiratory Assessment Measure (PRAM). PRAM assesses chest and neck muscle retractions, air entry, wheezing, and oxygen saturation, scoring 0 to 3 in each area. The range is 0 to 12 points, with 12 being the greatest severity. Moderate-to-severe acute asthma is defined as a PRAM of 4 or higher (Alnaji et al., 2014; Arnold et al., 2013).

DISCHARGE FROM THE ED

Before being discharged, asthma patients must have their:

- Symptoms largely alleviated
- Lung function values (PEF or FEV1) returned to greater than 70% of the predicted or personal-best levels

Even with a rapid improvement, patients should be watched for 30 to 60 minutes to be certain they are stable before being released.

When asthma patients are discharged, they should be given all necessary medications with written instructions on their use. Patients who have been given systemic corticosteroids should continue the drugs for 3 to 10 days. Some patients should also be put on an inhaled corticosteroid regimen at discharge, because adding inhaled corticosteroids to systemic corticosteroids can reduce relapse rates.

Studies have shown that a brief, focused session of asthma education at the time of discharge can reduce recurrence rates. Educational information should include a list of symptoms that signal the need for retreatment and phone numbers at which advice is available 24 hours a day. Finally,

an ED visit can be a sign of poor asthma control, and patients should have a follow-up visit either with their own primary care provider or with an asthma clinic.

CASE: ED Care for an Asthma Attack

MR. WILSON *(continued)*
Upon arrival at the ED, the EMS technicians tell the ED nurse that Mr. Wilson's wheezing, coughing, and dyspnea have improved within the last 10 minutes and that his vital signs are normal, except for an elevated heart rate.

The patient is admitted and assessed for the severity of his symptoms. Following the routine protocol, the ED nurse conducts spirometry testing, which reveals a PEF of 60% of the predicted value, and pulse oximetry, which shows SaO_2 level of 80%. The nurse relays these results to the other members of the ED team, whereupon they initiate the mild-to-moderate asthma emergency protocol, which involves administration of oxygen and a short-acting bronchodilator.

Ten minutes later, not satisfied with Mr. Wilson's response to treatment thus far, the team (which includes the physician) initiates a short course of oral prednisone, followed by a repeat bronchodilator dose 10 minutes after that. The nurse also takes the patient's history, noting the time of onset of his asthma attack; his self-reported severity of symptoms compared to previous attacks; his current medications, including those taken before his ED admission (and the resulting change in symptoms); and the patient's report of six attacks during the past year, as well as his admission of habitual inactivity.

After conducting a physical exam, the nurse notes that Mr. Wilson's asthma symptoms are moderate, though he has remained alert throughout the admission process as well as during the exam, and he appears to be adequately hydrated, with no signs of lung complications, heart failure, or upper airway obstruction. The nurse continues to conduct pulse oximetry and to assess the patient's asthma symptoms for the next hour, after which the team judges his symptoms to be minimal, while his PEF has reached 70% of the predicted value.

After watching Mr. Wilson for another hour, during which time his symptoms appear to stabilize, the team discharges him with a prescription for oral prednisone, but not before the nurse briefly counsels him on anticipating and responding to future attacks, as well as scheduling a follow-up appointment with his healthcare provider.

INTERDISCIPLINARY INPATIENT MANAGEMENT

When patients are admitted to the hospital following an acute asthma exacerbation, a multidisciplinary team will manage their care, including medicine, nursing, and respiratory therapy.

Patients usually will have received bronchodilator treatments, systemic corticosteroids, other medications, and oxygen in the emergency department. Inpatient treatment is often a continuation of those therapies and monitoring progress.

Inpatient Medical Management

Medication and treatment modalities will be ordered by the admitting provider, who determines initial pharmacologic treatment depending on the severity of the patient's exacerbation.

During the patient's inpatient stay, medical management includes:

- Monitoring and responding to changes in vital signs, peak expiratory flow rate, and oxygen saturation
- Oxygen administration
- Telemetry monitoring
- Monitoring arterial blood gases
- Evaluating pulmonary function tests
- Monitoring for and treating electrolyte imbalances
- Evaluating for signs of improvement
- Determining the need for more intensive treatment options (ICU)
- Preparing the patient for discharge
    - Asthma education
    - Completing an asthma action plan
    - Follow-up appointments

Nursing Diagnoses and Interventions

Upon arrival to a nursing unit, the admitting nurse will perform a complete nursing assessment and will develop a plan of care that addresses issues according the patient's individual needs. In the creation of a care plan, specific problems are identified, related factors are acknowledged, defining characteristics are taken into account, and a nursing diagnosis is made. Common nursing diagnoses for an asthma patient may include, but are not limited to:

- Ineffective airway clearance
- Ineffective breathing pattern
- Impaired gas exchange

For each nursing diagnosis, short- and long-range measurable and achievable goals are set, followed by nursing interventions that will assist the patient to meet those goals. The plan will be implemented, and each intervention and outcome will be assessed for effectiveness.

INEFFECTIVE AIRWAY CLEARANCE

Ineffective airway clearance is related to bronchoconstriction, increased mucus production, decreased ciliary action, and decreased energy or fatigue and is evidenced by wheezing, dyspnea, and cough. The goal of intervention is to have the patient maintain or improve airway clearance as evidenced by the improved lung sounds and absence of signs of respiratory distress.

Nursing interventions specific to meeting this goal most often consist of:

- Keeping the patient well-hydrated to make secretions thinner and easier to expectorate (warm liquids can help decrease bronchial spasms)
- Administering nebulizer treatments and medications followed by assessment of their effectiveness
- Assisting with coughing and deep breathing techniques (e.g., incentive spirometry) to improve the productivity of the cough and mobilize secretions

INEFFECTIVE BREATHING PATTERN

Ineffective breathing pattern exists when the patient's inhalations and exhalations do not allow for adequate ventilation. Asthma patients are prone to dysfunctional breathing patterns most often related to hypoxia, the underlying inflammatory process, tracheobronchial constriction, decreased energy, fatigue, or anxiety.

Assessment of breathing patterns includes rate, depth, airflow velocity, timing and duration, ratio of inhalation to exhalation, pauses, rhythm, and primary region of the body used in the mechanics of breathing. Evidence that an ineffective breathing pattern is present includes dyspnea, tachypnea, respiratory depth changes, use of accessory muscles, nasal flaring, and prolonged expiratory phase.

The goal of intervention is to restore and maintain an effective breathing pattern with rate and depth appropriate for age, normal skin color, regular respiratory rhythm, and absence of accessory muscle use.

Nursing interventions specific to meeting this goal include:

- Positioning the patient for optimal comfort with head of the bed elevated at 45 degrees, if tolerated, allowing for good lung expansion and chest excursion
- Maintaining oxygen flow as ordered to reach an oxygen saturation of 90% or higher using pulse oximeter
- Encouraging deep breathing and coughing or use of incentive spirometer to mobilize secretions (inability to clear secretions may add to a change in breathing pattern)
- Asking the patient to yawn to promote deep inspiration

- Demonstrating and encouraging diaphragmatic and pursed-lip breathing to decrease air trapping and to make breathing more efficient

IMPAIRED GAS EXCHANGE

Impaired gas exchange is present when there is an imbalance between ventilation and perfusion. Asthma patients have reduced airway diameter due to bronchospasm, mucosal edema, and mucus plug formation. There is a rise in airway resistance, which leads to a decrease in the amount of air entering on inspiration and exiting on expiration. Ventilation is impaired, but perfusion is not directly affected.

The balance between ventilation and perfusion, however, is lost because, despite adequate blood flow to the lungs, not much oxygen is available to diffuse from the alveoli to the capillaries. The carbon dioxide in the capillaries is able to diffuse into the alveoli, but because expiration is impaired, it is not ventilated out.

Patients with impaired gas exchange have the same manifestations as patients with both impaired airway clearance and impaired breathing pattern, but they may also have tachycardia, restlessness, irritability, anxiety, cyanosis, decreased oxygen saturation readings, abnormal blood gases, and altered level of consciousness.

Expected goals for a patient with impaired gas exchange include improved ventilation and adequate oxygenation of tissues evidenced by the absence of respiratory distress, oxygen saturation persisting at greater than 90%, arterial blood gases remaining within the patient's normal limits, and normal mentation.

Nursing assessments and interventions for a patient experiencing impaired gas exchange include:

- Elevating the head of the bed to minimize difficulty breathing and promote maximum lung expansion, using High Fowler's position or over-the-table positioning whenever possible
- Assessing for signs of hypoxemia: tachycardia, restlessness, diaphoresis, headache, lethargy, confusion, and somnolence
- Monitoring oxygen saturation utilizing continuous pulse oximetry
- Suctioning patient as needed to optimize air exchange
- Pacing activities and scheduling rest periods to prevent fatigue
- Monitoring arterial blood gases for signs of respiratory failure
- Encouraging deep breathing using incentive spirometry as indicated
- Observing for cyanosis, especially the color of the tongue and oral mucosa (central cyanosis of tongue and oral mucosa is an indication of serious hypoxia and is a medical emergency)

- Anticipating the need for intubation and mechanical ventilation
- Administering medications as prescribed and monitoring effectiveness

PATIENT TEACHING

The nursing team also has a large role to play in patient teaching, providing education to patients and families throughout the inpatient stay. The topics addressed include:

- Asthma disease process
- Symptom recognition
- Development or updating of the asthma action plan
- Differentiating between rescue and controller medications, their uses and effects
- Environmental control of triggers and aggravators
- Demonstration and verification of correct inhaler use
- Demonstration and verification of correct nebulizer use
- Demonstration and verification of correct peak flow meter use
- Review of written home instructions before discharge, including medication use, timing, and dosing with both patient and family
- Importance of post-hospitalization follow-up with one's primary care provider

Respiratory Therapy

Respiratory therapists play an important role in the inpatient management of asthma patients. Their top priority is protecting the patient's airway. Respiratory therapists make quick assessments, adjust medications, and initiate specialty therapies according to protocol to immediately treat an exacerbation. Because of their in-depth knowledge of the respiratory system, its diseases, and treatments, they are often consulted and deferred to in treatment decision making.

Respiratory therapists follow and assess patients throughout their hospital stay, adjusting their treatment and educating them according to guidelines. Respiratory therapists:

- Deliver inhaled medications via nebulizer and inhalers
- Provide emergency management including resuscitation, airway management, and mechanical/ventilation assistance
- Provide treatments for lung expansion or to help clear secretions, such as chest physiotherapy and incentive spirometry
- Perform pulmonary function testing, arterial blood gases, EKG, and pulse oximetry
- Administer and titrate oxygen therapy

Most respiratory therapy treatments are provided at the bedside, but pulmonary function testing is performed in the respiratory therapy department (Kacmarek et al., 2012).

Respiratory therapists often perform chest physical therapy (CPT) that helps remove secretions from the lungs. CPT consists of two parts: postural drainage and percussion or vibration. During postural drainage, the patient is positioned so that drainage of mucus from the lungs is accomplished utilizing gravity. The goal is to help mucus drain to the bigger airways, where it can be coughed out.

Percussion or vibration is performed by clapping with a cupped hand over the rib cage, which causes vibrations that loosen secretions, making them easier to drain. Oscillating devices are often used in place of manual clapping (UW Health, 2014).

ASTHMA COMPLICATIONS

Asthma is a serious chronic inflammatory disease and, as such, places persons with asthma at risk for multiple complications.

Disrupted Quality of Life

Quality of life can be negatively impacted due to chronic sleep deprivation affecting a person's ability to function to varying degrees at work or school. Asthma can affect a person's productivity as a result of frequent absences from school or work (Krucik, 2014). It is also dangerous for one who is driving or working with machinery.

Physical activity is affected due to a decreased ability to exercise. This places the person at an increased risk for developing other health problems and for weight gain. Decreased activity can also contribute to depression and other psychological distress. Children with asthma are at greater risk for obesity due to inactivity.

Persistent coughing is a major quality of life issue. When cough persists, it can become a disabling problem leading to loss of sleep, muscle pain, fractured ribs, syncope, stress, vomiting, urinary incontinence in women, and fecal incontinence in both men and women. Persistent coughing can also create difficulties in social situations as well as at work or school (The Asthma Center, 2015).

Respiratory Complications

Persons with asthma have a high risk for developing other respiratory problems. They are at increased risk for severe disease and complications from **influenza**. Asthma is the most common medical condition among children hospitalized with the flu and one of the more common medical conditions among hospitalized adults with the flu (CDC, 2015b).

A very serious complication is status asthmaticus, severe asthma that does not respond to treatment. Status asthmaticus can range from mild to severe and can cause difficulty breathing, carbon dioxide retention, hypoxemia, respiratory failure, and ultimately death (Saadeh, 2014).

Those with asthma also have a higher risk for developing **bronchitis** and **pneumonia**, and those with asthma who smoke have an increased risk for the development of **COPD** (Meyers, 2015).

Another serious respiratory complication that can occur is a secondary spontaneous **pneumothorax**. This results from the rupture of overstretched alveoli, which allows air to enter the pleural space and can lead to atelectasis (collapsed lung or portion of a lung) causing hypoxemia by impairing oxygenation and/or ventilation depending upon the degree of collapse. If the pneumothorax is significant, it can cause mediastinal shift enough to compromise hemodynamic stability (Daley, 2014).

A rare complication of an acute exacerbation of asthma is **pneumomediastinum**. This is a condition where air enters the central compartment of the thoracic cavity. It is considered a self-limiting condition that usually resolves with successful management of asthma. However, morbidity and mortality is high when it is associated with pneumothorax. During a serious attack, the combination can prove fatal (Porpodis et al., 2014).

Other Systemic Complications

Persons with asthma or with a family history of asthma are at risk for developing **nummular eczema**, a long-term chronic, pruritic, and inflammatory dermatitis occurring in the form of coin-shaped plaques on the arms and legs that may also spread to the middle of the body. The skin is inflamed, and lesions may ooze and become crusty, carrying the risk of secondary infection. This is relatively uncommon; it occurs most often in elderly males (Berman, 2013).

Complications Related to Asthma Medication Use

With prolonged exposure to elevated levels of exogenous corticosteroids, the person may develop **Cushing syndrome,** sometimes called hypercortisolism. Signs and symptoms of this condition include:

- Fatty deposits under the skin, especially of the face, upper back, torso, and supraclavicular region
- Skin changes, including pink or purple stretch marks, easy bruising, thinning, and fragility
- Hirsutism in women
- Progressive proximal muscle weakness
- Menstrual irregularities/amenorrhea
- Infertility, decreased libido, and impotence in men
- Psychological problems, including depression, emotional lability, and cognitive problems

- Osteopenia, osteoporotic fractures
- Cataracts
- Immunosupression with slow wound healing and increased infections
- New-onset or worsening of hypertension or diabetes mellitus
- Growth retardation in children
  (Adler, 2014)

Complications related to inhaled corticosteroids include **thrush** (candidiasis), oral or esophageal, which can be prevented by using a spacer and rinsing, gargling, and spitting after use. **Dysphonia** (hoarse voice) is common with the use of inhaled corticosteroids and may be due to myopathy and spasm of laryngeal muscle, mucosal irritation, or laryngeal candidiasis. It is reversible when treatment is withdrawn (Saag et al., 2015).

SPECIAL POPULATIONS AND SITUATIONS

Healthcare must be individualized, but there are some useful general guidelines for working with patients with asthma who belong to certain populations or in specific situations.

Older Adults

Asthma in older adults is more dangerous, as they are more likely to develop respiratory failure, even during mild attacks. Most asthma deaths occur among persons over the age of 65, and although symptoms are very much the same as those in younger adults, greater amounts of medication are needed to maintain normal breathing in these patients. Unlike younger persons, asthma in the older adult rarely goes into remission.

An asthma diagnosis in an older person may be missed because other health problems can mask the disease. Heart disease and emphysema are more common in this age group, and the symptoms of these illnesses can be similar to those of asthma. Asthma symptoms are more likely to take the form of coughing and excess sputum production, which is very often interpreted as being due to other illnesses, such as chronic bronchitis or congestive heart failure.

Treatment of the older person can be complicated, since many take multiple medications for other problems. Asthma medications can react with these other medications and can cause unwanted side effects. Some medications, such as beta blockers, aspirin, some other pain relievers, and anti-inflammatory medicines, can prevent asthma medications from working and may worsen asthma symptoms.

Older adults using inhaled corticosteroids, especially at high doses, may develop weakened bones and require calcium and vitamin D pills to maintain bone strength. Older patients are more likely than their younger counterparts to have mental confusion and memory problems, which can make it difficult to follow treatment instructions.

In addition, many asthma medications come in the form of some type of inhaler. Using an inhaler requires a certain amount of coordination, dexterity, and strength. Older adults are more likely to have conditions such as arthritis, which can affect physical movement and coordination. As a result, they may find it more difficult to use an inhaler properly and to receive a correct dose.

Treatment with oral medications may be chosen, such as oral steroids in short courses to treat asthma exacerbations. Long-term use of steroids, however, is normally avoided in older patients, as over time they can develop weakening of bones, ulcers, and high blood pressure (AAFA, 2015).

Pregnant Women

Most women with mild asthma will have no problems during pregnancy; however, patients with severe asthma are at greater risk for deterioration that may require Cesarean section (AAAAI, 2013). This is especially true during the last portion of the pregnancy, when the effect of pregnancy on respiratory physiology can create a state of hyperventilation as well as to the possible influence of progesterone.

Negative effects for the woman may include:

- Preeclampsia
- Pregnancy-induced hypertension
- Uterine hemorrhage
- Respiratory failure and need for mechanical ventilation
- Complications of parenteral steroid use
  (Little, 2014)

PERINATAL EFFECTS

Asthma needs to be controlled to ensure a good supply of oxygen to the fetus. Severe and poorly controlled asthma has been found to be associated with many poor fetal outcomes, including:

- Preterm labor and premature delivery
- Increased risk for postnatal jaundice
- Respiratory distress syndrome
- Transient tachypnea
- Asphyxia
- Congenital anomalies
- Fetal growth restriction
- Low birth weight
- Postnatal hypoglycemia

- Seizures
- Increased risk for neonatal intensive care unit admission
- Risk for intracerebral hemorrhage and anemia in infants born at term
  (Rejnö et al., 2014; AAAAI, 2013; Little, 2014)

Infants and Children

Diagnosis of asthma in infants is less clear-cut, and treatment recommendations are still in flux for children ages 0 to 2 years. Asthma spontaneously goes into remission in many children during adolescence.

After puberty (approximately 12 years of age), children with asthma are treated much like adults, with inhaled corticosteroids the drug of choice for long-term management. However, the use of high-dose inhaled corticosteroids or systemic (oral) corticosteroids can suppress growth or cause eye problems in children. All children with asthma, regardless of the drugs they are taking, should have their height and weight measured at each office visit.

With children, it is important to find an inhaler that they will use, and use correctly. It is helpful to offer a number of varieties and let the child pick his or her favorite.

Children have a poor rate of adhering to treatment plans, and extra effort is needed to encourage their compliance. For children, the reports from their home use of peak flow meters are not always accurate, so regular office testing (spirometry) should be done at least once a year.

Surgical Patients

All surgical patients with asthma should have an asthma assessment and evaluation before surgery. As a rule, a patient with well-controlled asthma can be given general anesthesia with intubation, although asthma patients are more likely to develop respiratory complications during and after surgery. Those who have been taking systemic or high-dose inhaled corticosteroids may be at risk for adrenal insufficiency from the stress of surgery.

Dental Patients

Asthma patients should schedule dental procedures for late morning, when asthma attacks are less likely. They should bring their quick-relief medicines, and some dentists recommend taking a prophylactic inhalation at the beginning of the appointment. Patients can be asked to bring their peak flow meters so that it can be ascertained that their PEF is greater than 80% of their personal-best value.

During dental procedures, pulse oximetry can be used to identify a drop in oxygen saturation that would warrant oxygen supplementation or other interventions. Dental offices should be equipped with oximeters, positive-flow oxygen, and epinephrine.

Travel

Asthma often worsens during patient travel. Patients most likely to have problems are those who were using their rescue medicines at least three times a week before traveling or those whose travels involve significant exercise, such a long hikes. Other factors associated with increased asthma symptoms are exposure to smoke or air pollution and travel to very high altitudes.

Asthma patients planning extensive travel should be medically evaluated before leaving to ensure their asthma is under the best control possible. Adequate controller and quick-relief medications should be obtained, and the patient should have the necessary tools (asthma action plan and peak flow meter) to monitor their control.

During evaluation, a review of simple measures to reduce the risk of acquiring a respiratory infection should be done, such as frequent handwashing or the use of alcohol-based hand sanitizers. Immunizations should be updated.

If possible, those with asthma are advised to request a nonsmoking hotel room, or better yet, choose a facility that does not permit smoking at all.

Asthma in School

Children with asthma are dependent on a team made up of parents, healthcare providers, and school staff. It is important that parents connect with the school nurse and other health services staff to inform them about a child's asthma. The law requires parental permission to communicate any student health information to a child's healthcare provider, and it is important for parents to ask about the school's requirements for such communication.

A child with asthma should have an asthma action plan on file at the school and have immediate access to quick-relief medication in case of an exacerbation. All 50 states have laws in place allowing students with asthma to carry and self-administer asthma quick-relief inhalers. Laws vary by state and school district, so it is important for parents to know their child's school's policies and requirements.

Parents should include a discussion about their child's asthma management during any parent/teacher meetings or conferences (ALA, 2015d).

The American Lung Association encourages schools to make a safe environment for children with asthma and provides a toolkit for implementation that includes the following recommendations:

- Know which students are at risk for an asthma emergency.
- Have an asthma action plan on file for each student diagnosed with asthma.
- Ensure students have access to quick-relief medication.
- Ensure good indoor air quality.

- Adopt a tobacco-free policy for both indoor and outdoor environments.
- Offer education to teachers, school staff, parents, and children about asthma.
- Reduce student exposure on high pollution days.
- Provide a full-time registered school nurse all day, every day for each school.
- Assure access to asthma students' primary care providers.
- Encourage physical education and activity for students whose asthma is well managed.
- Provide options for modified activities.
  (ALA, 2015e)

Asthma in the Workplace

In the workplace, asthma patients need to avoid exposure to known environmental allergens or irritants and should report respiratory symptoms immediately. Employees should also report breakdowns in ventilation and other protective equipment to their employer.

Asthma patients at work should have an action plan, see a healthcare provider regularly, and take medications as directed. They should avoid tobacco smoke, and if they smoke, they should get help to quit.

The Occupational Safety and Health Act requires employers to provide workplaces free from recognized hazards. Programs should be introduced to reduce exposure to allergens and irritants through elimination or substitution. Employers must provide protective equipment to reduce the occurrence of asthma exacerbations and establish a surveillance program to identify workers who become affected early.

Employers need to train workers on potential workplace hazards and what precautions to take, as well as mechanisms for reporting hazards or problems.

Workplace smoking should be eliminated, and employers should offer benefits and smoking cessation programs for those employees who smoke (NHLBI, 2011).

CONCLUSION

Asthma is a chronic respiratory disease in which patients have repeated episodes of coughing, wheezing, and difficulty breathing. In a patient with asthma, the airways of the lungs are excessively reactive to irritants (called triggers) and respond by narrowing, swelling, and filling with mucus. This disabling response can usually be reversed by inhaling a short-acting bronchodilator medication.

Asthma is a common problem that often first shows up in childhood, although it can appear at any age. Currently, there is no cure, but the symptoms disappear on their own in a significant number of patients, especially during their teenage years.

Asthma varies in its severity, but a common feature of the disease is the lungs' sensitivity to stimuli that do not produce similar symptoms in people with normal lungs. The irritants that trigger asthma can include dust, chemical vapors, exercise, sudden changes in air temperature or humidity, allergens, psychological stress, or certain medicines, such as aspirin.

Between exacerbations, an asthma patient may have no noticeable breathing difficulties, although measurements of lung function will show an increase in the time that it takes the patient to forcefully empty his or her lungs. However, during an exacerbation or attack, the patient develops a marked airflow obstruction that makes breathing difficult and which, in extremely severe cases, can be fatal.

Mild and intermittent asthma attacks can usually be treated with a pocket inhaler of a beta-2 agonist bronchodilator. Severe attacks need medical attention, and they are treated with bronchodilators, oxygen, and oral corticosteroids.

The best prevention of asthma attacks is a long-term management plan that includes inhaled corticosteroids plus careful avoidance of contact with the patient's triggers. The specific regimen of controller medications (such as inhaled corticosteroids) must be tailored to the severity of the patient's underlying disease.

At one time, the focus of asthma treatment was on avoiding or quickly treating attacks. Recently, with the realization that asthma is a chronic inflammatory condition, the goal has also been to manage and damp down the inflammation so that the daily life of an asthma patient can include as wide a variety of activities as possible.

QUESTIONS PATIENTS MAY ASK ABOUT ASTHMA

Advice Questions

Q: I think I'm having an asthma attack; what should I do?

A: If you aren't sure whether you have asthma and you are having sudden trouble breathing, call 911 or have someone call for you. Don't try to drive to the hospital yourself.

- If you know you have asthma, take your rescue medicines and call your doctor.
- If you have asthma and your symptoms are unusual or especially bad, call 911.

Q: I have asthma and I use an inhaler once or twice a week for my symptoms. I just started breastfeeding my new baby. Is she going to be hurt by my medicines? Should I stop breastfeeding?

A: No. Only small amounts of inhaled asthma medicines get into breast milk, so your baby should be safe.

Q: We have a pet dog, and my 6-year-old child has asthma. Do we have to get rid of our dog?

A: Not everyone gets asthma symptoms from a pet. If you have seen instances where contact with your dog causes your child to wheeze, cough, or have difficulty breathing, then you should ask your doctor or an allergist for advice. The allergist can test your child to see if dogs are likely to be a problem. It is always possible that the dog is not directly the problem but is, instead, getting some asthma-producing substance on its fur, such as pollen or mold.

Once you are convinced that your dog does trigger asthma symptoms in your child, you and your primary care provider should decide how seriously these symptoms affect your child's life. For mild symptoms, you can reduce the contact that your child has with your dog. The animal should be kept out of your child's bedroom and off upholstered furniture. Bedrooms are the most important areas to keep clean, and you can buy a HEPA cleaner for your child's bedroom.

If you decide to give the dog away, be patient. It can take up to 6 months for all the dog "dust" (i.e., dander) to be cleaned out of a household.

Q: Should I be taking any special vitamins for my asthma?

A: Some people have found that vitamin C supplements reduce asthma symptoms. Vitamin B_6 supplements have also been reported to decrease episodes of wheezing; however, check with your doctor before taking this vitamin because high doses or prolonged use of vitamin B_6 may cause nerve problems.

Q: Are there any good herbal remedies that I should try for my asthma?

A: There still aren't many scientifically sound studies on herbal remedies for asthma, so asthma experts do not yet recommend any herbal treatments.

The medical community is always hesitant about recommending herbal products because they are not standardized and they can have a variety of ingredients. Moreover, some components in herbal products can be dangerous or can interact with your regular medicines.

On the other hand, some of the herbal treatments contain chemicals that are available as medicines. If you check with your doctor, you can find whether a purified and exactly measured dose of this medicine might be helpful for you.

General Information Questions

Q: What is asthma?

A: Asthma is a disease that causes episodes of difficult breathing. In most people, asthma is not noticeable until something triggers an attack. Then, the person's airways tighten, the patient begins to wheeze and cough, and the patient finds it hard to get enough air.

People differ in what things trigger these flares in their asthma. Common triggers include colds and other respiratory infections, cigarette smoke, exercise, cold air, and allergens such as pollen and mold.

Most asthma attacks can be relieved by inhaling a few puffs of a bronchodilator that asthma patients carry as a "rescue medicine." Some asthma attacks, however, are so severe that the patient must go to an emergency department to get oxygen and additional medicines.

Q: What's the difference between allergies and asthma?

A: Allergies are over-reactions of the immune system. They occur when susceptible people come in contact with particular things called allergens, such as pollen, insect stings, peanuts, or latex. Hay fever, for example, is an allergy to pollens. Allergic reactions vary, ranging from itchy eyes to skin rashes to swelling (hives). The most severe allergic reaction, which is called anaphylaxis, can put a person into life-threatening shock, with low blood pressure, poor blood circulation, and difficulty breathing.

Asthma is also an over-reaction of the immune system, but in asthma, the reaction occurs in the airways of the lungs. Asthma's symptoms are always breathing problems, such as wheezing, coughing, chest tightness, and difficulty getting enough air. Many people with asthma are especially prone to allergies, and for them, allergens that get into their lungs (pollen, animal dander, mold spores) will trigger lung symptoms. On the other hand, people with asthma may not have allergies and may not have their symptoms set off by allergens. Similarly, people with allergies need not have asthma.

Q: How serious is asthma?

A: For some people, asthma can be a serious and continuing health problem, and without proper medicines, an asthma attack can even be fatal. On the other hand, with the appropriate medical care, people with asthma can live normal, active lives.

Q: What causes an asthma attack?

A: Asthma is a chronic disease. This means that airways in the lungs of a person with asthma are always inflamed and unusually sensitive. Sometimes, however, the disease is triggered and the person's airways over-react and constrict. At this point, the person gets symptoms, such as

wheezing, coughing, chest-tightness, and difficulty breathing. These sudden over-reactions are called attacks.

Asthma attacks can happen for no apparent reason, but there are also certain triggers that will usually set off a patient's disease. The triggers vary from person to person, but some common triggers include pollen, mold, chemical vapors, dust, smoke, sudden cold air, exercise, and stress.

Q: Can older people get asthma?

A: Yes. A person's asthma can last one's whole life, and sometimes asthma first shows up when a person is elderly. Middle-aged and older people who have been long-time smokers sometimes develop COPD (chronic obstructive pulmonary disease). Asthma and COPD can have similar symptoms and may even overlap. At times, it can be difficult to distinguish between the two diseases, but both need medical care.

Q: Is asthma contagious?

A: No. However, asthma runs in families, so it wouldn't be surprising to find that more than one person living in the same house has asthma.

Q: Can asthma be cured?

A: At the moment, there is no way to make asthma symptoms go away permanently, although many children lose their asthma symptoms spontaneously as teenagers, and some of these children never have symptoms again. Today's asthma treatments don't cure the disease. Instead, they keep the disease under control so the asthma patient can live a normal life with as few restrictions as possible.

Q: How is asthma treated?

A: Some people's asthma produces symptoms only occasionally, and these symptoms can be relieved by inhaling a bronchodilator medicine. Other people keep their asthma symptoms under control by taking daily medicines, which are usually inhaled so that the drugs can get directly into the lungs.

People's asthma symptoms are often triggered by particular things, such as dust, smoke, or sudden cold wind. Therefore, asthma patients learn to avoid the triggers, to remove the triggers from their environment, or to protect themselves with medicine before coming in contact with the triggers.

Q: I've heard that people with asthma can't exercise. Is that true?

A: Regular exercise is important for everyone's health, even people with asthma. Some asthma patients get symptoms during or after hard exercise. By inhaling a protective bronchodilator before exercising, and gradually warming up and cooling down, these people prevent the

symptoms from developing. In addition, physical training reduces the asthmatic response to exercise, and well-conditioned asthma patients can become top competitive athletes.

Q: Does acupuncture treatment reduce asthma symptoms?

A: The medical studies that are currently available haven't found any evidence that acupuncture is helpful for asthma.

Q: Are there any medicines that are bad for asthma?

A: Some medicines may cause problems for people with asthma. If you are taking any of the following medications, check with your primary care provider to see if they could cause problems in your particular case:

- Blood pressure and heart medicines, especially certain beta-blockers
- Aspirin and NSAIDs (i.e., pain relievers such as ibuprofen)
- Sleeping pills and tranquilizers, especially in older people

Q: I heard that a kind of insect called a dust mite can make asthma symptoms worse. What's a dust mite?

A: Dust mites are microscopic relatives of spiders. They live in most houses and prefer warm, damp climates. Dust mites eat bits of leftover skin, which are always falling off our bodies, especially into things that we rub against, such as beds and furniture.

You probably can't get rid of all your dust mites, but you can keep their numbers down by regular cleaning. Wash your bedding weekly in water hotter than 130 °F. Put special allergen-impermeable dust covers on your pillows and mattresses. Don't lie or sleep on upholstered furniture. Remove the carpets in your bedroom and take up any carpets in your house that are laid on concrete. Then, dehumidify your house, ideally to below 50% humidity.

RESOURCES

Asthma (American Lung Association)
http://www.lung.org/lung-disease/asthma/

Asthma (CDC)
http://www.cdc.gov/asthma/

Asthma Action Plan (NHLBI)
http://www.nhlbi.nih.gov/health/public/lung/asthma/actionplan_text.htm

Asthma and Allergy Foundation of America
http://aafa.org

Asthma Control Test
http://www.asthma.com/additional-resources/asthma-control-test.html

Asthma Data, Statistics, and Surveillance (CDC)
http://www.cdc.gov/asthma/asthmadata.htm

Asthma Quality of Life Questionnaires (Measurement of Health-Related Quality of Life & Asthma Control)
http://www.qoltech.co.uk/questionnaires.htm

My Asthma Wallet Card (NHLBI)
http://www.nhlbi.nih.gov/health/public/lung/asthma/walletcard_text.htm

National Asthma Control Program (CDC)
http://www.cdc.gov/asthma/NACP.htm

What Is Asthma? (NHLBI)
http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html

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TEST

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1. Asthma is a chronic airway disease characterized by:
- a. Decreased mucus secretion.
- b. Irreversible airway obstruction.
- c. Constriction of bronchial smooth muscle.
- d. Hyposensitivity to various stimuli.

2. According to the Global Asthma Network, the burden of asthma worldwide is greatest for:
- a. Children ages 1 to 3 and adults ages 30 to 50 years.
- b. Adults ages 50 to 65 and older adults over age 85 years.
- c. Children ages 3 to 5 and adolescents ages 15 to 19 years.
- d. Children ages 10 to 14 and older adults ages 75 to 79 years.

3. Which is a **true** statement concerning asthma prevalence rates in the United States?
- a. Females are more likely to have asthma than males.
- b. Girls are more affected than boys by asthma before puberty.
- c. Hispanics have significantly higher rates than non-Hispanic blacks and non-Hispanic whites.
- d. People living in the South have higher rates than people living in the Northeast.

4. The primary pathophysiological process underlying the effects of asthma is:
- a. A neuromuscular disorder of the airways.
- b. A genetically induced thickening of airway secretions.
- c. Chronic inflammation of the airways.
- d. Increased elasticity of the airways.

5. Changes in the airways as a result of repeated bouts of inflammation include:
- a. Irreversible swelling and blood vessel permeability.
- b. Permanent narrowing and scarring.
- c. Irreversible bronchial smooth muscle spasm.
- d. Decreased contractile response of bronchial smooth muscle.

6. One concern in young children with asthma is that the disease may:
a. Decrease the immune response.
b. Damage the vocal cords.
c. Interfere with lung growth.
d. Decrease airway responsiveness.

7. Adult-onset asthma is different than childhood asthma because adults:
a. Have higher lung capacity.
b. Have more blood flow to the lungs.
c. Rarely go into remission.
d. Rarely require daily medications.

8. Which statement best describes intrinsic asthma?
a. It is caused by an autonomic nervous system imbalance.
b. It is not associated with respiratory tract infections.
c. It involves degranulation of mast cells that release cytotoxic molecules.
d. It develops following exposure to specific allergenic substances.

9. Circadian and hormone changes are consistent with which type of asthma?
a. Exercise-induced
b. Occupational
c. Nocturnal
d. Cough-variant

10. The tendency to develop asthma is:
a. Due to a bacterial antigen passed from mother to fetus.
b. Genetically inherited.
c. Limited to certain ethnic groups.
d. Acquired from inborn errors of metabolism.

11. A comorbid condition associated with asthma is:
a. Endogenous Cushing syndrome.
b. Congestive heart failure.
c. Obesity.
d. Hypothyroidism.

12. Coughing from asthma is a symptom of airway irritation and:

a. Is always productive in a patient with asthma.
b. Indicates a patient's likelihood of having asthma later in life.
c. Is best controlled by the use of bronchodilators.
d. Can be a patient's only symptom of asthma.

13. Wheezing in children younger than age 6 who do **not** have asthma is most often caused by:

a. Laughing or crying.
b. A foreign body aspiration.
c. A viral respiratory infection.
d. Croup.

14. The most accurate predictor of a fatal asthma attack is having a history of:

a. Administration of beta-agonist inhalers.
b. Hospitalizations or an ED visit for asthma.
c. The frequent need for quick-relief asthma medication.
d. Intubations for asthma.

15. Which atopic illness should be noted in the family history section of the medical history for a patient with asthma?

a. Viral respiratory infections
b. Eczema
c. Laryngitis
d. Gastroenteritis

16. During most asthma attacks, when the patient's chest is auscultated, wheezing:

a. Will always be heard.
b. Is typically heard at only one spot.
c. Sounds are musical and high-pitched.
d. Sounds are rough, wet, and rumbling or snoring.

17. When examining a patient, which may be a clue that the patient has asthma?

a. Hypo-resonant chest on percussion
b. Soft, high-pitched sounds upon percussion
c. Breathing in takes twice as long as breathing out
d. "Allergic shiners" or nasal polyps

18. As measured by a spirometer, FEV1 is the measurement of the:

a. Rate at which one cubic liter of air can be forcefully expelled from the lungs.
b. Force with which all air can be expelled from the lungs.
c. Average force with which air is expelled from the lungs over a one-second interval.
d. Amount of air that can be forcefully expelled from the lungs in one second.

19. The percent of the vital capacity that can be exhaled in one second usually:

a. Increases when a person has asthma.
b. Increases in all people as they age.
c. Decreases when a person has asthma.
d. Stays the same in all people as they age.

20. A peak expiratory flow (PEF) meter measures the patient's:

a. Volume of air exhaled during a cough.
b. Maximum speed of air forcibly exhaled.
c. Reaction to maximum exercise capacity.
d. Vital capacity expelled from the lungs.

21. The bronchial provocation test that triggers water loss from the surface of the airways and turns on molecular activity that controls inflammation is called the:

a. Exercise challenge test.
b. Bronchodilator reversibility test.
c. Indirect mannitol challenge.
d. Direct histamine challenge.

22. Skin and blood allergy testing is conducted to determine:

a. How easily the patient's lymphocytes convert IgE to new substances (allergens).
b. Which specific substances (allergens) trigger an allergic reaction in the patient.
c. Whether certain viruses will mimic an allergic reaction in the patient.
d. Whether exercise will mimic an allergic reaction in the patient.

23. The KOALA test is conducted for patients with asthma to:

a. Track the speed of neutrophils in migration.
b. Determine the concentration of eosinophils and neutrophils.
c. Measure the amount of nitric oxide exhaled.
d. Predict the possible need for mechanical ventilation.

24. A patient with severe persistent asthma is someone who:

a. Requires use of a rescue inhaler 2 or fewer days per week.
b. Has normal peak expiratory flow (PEF) rates.
c. Uses a rescue inhaler multiple times per day.
d. Experiences nighttime symptoms more than once a week.

25. Which drug delivery device changes a medication from a liquid to a mist?

a. Metered-dose inhaler
b. Dry powder inhaler
c. Valved holding chamber
d. Nebulizer

26. Which is a correct step when using an inhaler with a spacer?

a. Breathe in and out 5 times with the spacer away from the mouth.
b. Press down on the output tube after starting to slowly inhale.
c. Press down on the inhaler and wait 5 seconds before starting to inhale.
d. Shake the inhaler 15 times before beginning use.

27. Quick-relief medications used to reverse bronchoconstriction include:

a. Corticosteroids.
b. Beta-2 agonists.
c. Methylxanthines.
d. Leukotriene modifiers.

28. Which is a breathing retraining exercise that increases the carbon dioxide (CO_2) content in the blood in order to reduce bronchoconstriction?

a. Papworth technique
b. Chest percussion
c. Buteyko technique
d. Biofeedback

29. Occupational therapy's role in asthma management is to:

a. Measure a patient's forced vital capacity.
b. Teach patients how to use a pulse oximeter.
c. Educate patients on adaptive strategies.
d. Develop an asthma action plan.

30. For asthma relief, dust mite populations can be effectively reduced by:

a. Using chemical pesticides.
b. Adding protective rugs and carpets over concrete floors.
c. Regular washing of bedding in hot water.
d. Using humidifiers and keeping the house warmer than usual.

31. For patients with asthma who are older than 6 months, yearly flu shots are:

a. Potentially dangerous and not recommended.
b. Recommended.
c. Discouraged due to higher risk of side effects.
d. Optional because they are ineffective in most asthma patients.

32. Which medications can trigger bronchoconstriction and should be avoided by patients with asthma?

a. Anticholinergic drugs such as ipratropium (Atrovent)
b. Beta-2 agonists
c. Nonselective beta-blockers
d. Acetaminophen (Tylenol)

33. Which is a **true** statement regarding exercise as a trigger to asthma?

a. Asthma is a life-threatening condition that requires avoiding all exercise.
b. Asthma can usually be prevented by limiting exercise to once a month.
c. Asthma can usually be prevented by using a bronchodilator inhaler before exercising.
d. Asthma is a good reason to stop participating in competitive sports.

34. One reason for giving patients a course of corticosteroids after an asthma attack is to:

a. Protect against respiratory infections.
b. Prevent the occurrence of clinical depression.
c. Reduce the chance of a recurrence.
d. Keep blood sugar levels low during a period of stress.

35. The first step of a typical emergency action plan for an asthma attack is for the patient to quickly:

a. Take oral corticosteroids.
b. Assess the severity of the attack.
c. Breathe warm humidified air from a steamer or a hot shower.
d. Calculate the time since his or her last attack.

36. An asthma symptom that should prompt a patient to call 911 immediately is:

a. Becoming breathless doing normal activities.
b. Becoming breathless doing exercise.
c. Having a PEF less than 40% of his or her personal-best value.
d. Being unable to catch one's breath when sitting.

37. For any level of severity of an asthma attack, patients are instructed to:

a. Call 911 immediately.
b. Drive themselves to the ED immediately.
c. Take their quick-relief medicines.
d. Immediately lie down and rest.

38. In the absence of a quick-relief inhaler, a patient experiencing an asthma attack may gain relief by:

a. Using a corticosteroid inhaler.
b. Drinking a cold soda.
c. Lying down to try to relax.
d. Drinking a hot cup of coffee.

39. Which intervention used by EMS personnel reduces the work of breathing by holding airway structures open?

a. Heliox administration
b. CPAP device use
c. Epsom salt administration
d. Small-volume nebulizer use

40. For **all** patients with asthma attacks presenting to the ED, the healthcare team should administer:

a. Intramuscular epinephrine.
b. A short-acting bronchodilator.
c. A nonspecific beta-blocker.
d. Oral theophylline (a methylxanthine).

41. One sign suggesting that intubation may be needed for a patient experiencing an asthma attack is a:

a. Continually rising arterial oxygen saturation (SaO_2).
b. Continually falling arterial oxygen saturation (SaO_2).
c. Continually rising peak expiratory flow (PEF).
d. Stable peak expiratory flow (PEF) greater than 70% of the patient's predicted value.

42. When patients are discharged from the ED after an asthma attack, they:

a. Will still have significant asthma symptoms.
b. Should receive a brief, focused session of asthma education.
c. Will still be on supplemental oxygen.
d. Should receive a prescription for epinephrine (Epipen).

43. A nursing intervention specific to the diagnosis of ineffective airway clearance is:

a. Maintaining the oxygen flow rate.
b. Keeping the patient well hydrated.
c. Monitoring arterial blood gases.
d. Auscultating the patient's breath sounds.

44. A sign of impaired gas exchange indicating a medical emergency is:

a. The need for suctioning.
b. Abnormal arterial blood gases.
c. Central cyanosis.
d. A decline in activity tolerance.

45. Which is a rare complication of asthma that is described as a self-limiting condition that usually resolves with successful management of asthma?

a. Nummular eczema
b. Pneumomediastinum
c. Status asthmaticus
d. Pneumothorax

46. A serious complication that can be caused by long-term use of oral corticosteroids is:

a. Preeclampsia.
b. Cushing syndrome.
c. Dysphonia.
d. Intracerebral hemorrhage.

47. Asthma in older adults can be more difficult to diagnose and treat because:

a. Other health problems can mask the disease.

b. Inhaled asthma medications are not tolerated in this population.

c. The disease often goes into remission.

d. The majority of older adults have only cough-variant asthma.

48. Women who are pregnant and have asthma are more likely to have deterioration of their illness during the last portion of the pregnancy because:

a. The fetus is making greater demands for oxygen.

b. Asthma medications cannot be used during pregnancy.

c. They experience respiratory physiologic changes.

d. They begin to hypoventilate.

49. For most patients with asthma, surgery:

a. Should be avoided because intubation and general anesthesia are too dangerous.

b. Is safe when preceded by a preoperative asthma assessment and evaluation.

c. Must only be performed with local or regional anesthesia.

d. Poses no higher risk of respiratory complications than for patients without asthma.

50. Which is an American Lung Association safe environment recommendation for students with asthma?

a. Keeping quick-relief asthma inhalers in the school nurse's office

b. Submitting an asthma action plan to the school nurse

c. Encouraging no physical activity for students with exercise-induced asthma

d. Inviting the school nurse to attend all parent-teacher meetings