LEARNING OUTCOME AND OBJECTIVES: Upon completion of this course, you will have increased your knowledge of how to plan, deliver, and evaluate evidence-based preventative and therapeutic care for patients at risk for asthma and patients who have asthma. Specific learning objectives include:

- Discuss the epidemiology of asthma.
- Review the pathophysiology, etiology, and contributing factors related to the development of asthma.
- List asthma signs and symptoms.
- Describe the diagnostic process and assessment of asthma severity.
- Review the pharmacologic and nonpharmacologic treatments for asthma.
- Describe the management of acute asthma attacks.
- Identify the elements of long-term asthma management.
- Discuss the roles of respiratory, physical, and occupational therapy in the long-term management of asthma.
- Describe complications of asthma.
- Discuss asthma care for special populations.
INTRODUCTION

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 with asthma 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 is a chronic reactive airway disease characterized by:

- Reversible inflammation
- Constriction of bronchial smooth muscle
- Excessive secretion of mucus
- 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**

Recent decades have seen both asthma prevalence and incidence increasing around the world. In 2015, asthma was the most prevalent chronic respiratory disease worldwide and was ranked globally among the top 20 conditions causing disability (GBD, 2017). There are varying estimates of the exact numbers, however, because assessment of the prevalence of asthma has been hindered by varying definitions of asthma and methods of data collection (Litonjua & Weiss, 2018).

As of 2018, the World Health Organization estimates there are 235 million people around the world with asthma (WHO, 2018). By 2025 this number is estimated to increase by another 100 million. This may be an underestimate because it is well known that asthma is underdiagnosed. Globally, asthma is associated with a high disease burden, the highest being among children 14 years old and younger. The overall impact of asthma, however, increases with age, particularly for the older adult, especially women (Nunes et al., 2017).
Asthma symptoms have been common in high-income countries. Currently, however, increases in prevalence in low- and middle-income countries with large populations have been occurring, while the prevalence rate in high-income countries remains the same or decreased. Overall, this indicates that the world asthma burden is increasing and global disparities decreasing.

Worldwide estimated asthma deaths total 180,000 per year. Over the decades with the spread of preventive anti-inflammatory drugs to control the disease, mortality has declined in most high-income areas. This is not true in the United States, however, where there has been no reduction, especially among people with low income (Nunes et al., 2017).

**Asthma in the United States**

National Health Interview Survey 2016 data indicate there were 26.5 million people in the United States diagnosed with asthma. Of this number, 6.1 million were children under the age of 18.

<table>
<thead>
<tr>
<th>ASTHMA PREVALENCE BY AGE</th>
<th></th>
<th>Percentage of U.S. Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Individuals with Asthma (millions)</td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>0.76</td>
<td>3.8</td>
</tr>
<tr>
<td>5–14</td>
<td>4.14</td>
<td>10.1</td>
</tr>
<tr>
<td>15–19</td>
<td>2.08</td>
<td>10.0</td>
</tr>
<tr>
<td>20–24</td>
<td>1.99</td>
<td>9.5</td>
</tr>
<tr>
<td>25–34</td>
<td>3.08</td>
<td>7.1</td>
</tr>
<tr>
<td>35–64</td>
<td>10.91</td>
<td>8.8</td>
</tr>
<tr>
<td>65+</td>
<td>3.53</td>
<td>7.4</td>
</tr>
</tbody>
</table>

Source: CDC, 2018a.

**GENDER**

The strongest nonmodifiable factor associated with asthma is gender. As adults, women have an increased asthma prevalence compared to men. Further, women are more likely to have severe asthma, a later onset of asthma, a higher rate of hospitalizations, and higher mortality compared to men (Zein & Erzurum, 2015).

<table>
<thead>
<tr>
<th>ASTHMA PREVALENCE BY GENDER</th>
<th></th>
<th>Percent of U.S. Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Individuals with Asthma (millions)</td>
<td></td>
</tr>
<tr>
<td>Males (total)</td>
<td>10.73</td>
<td>6.9</td>
</tr>
<tr>
<td>&lt;18 years</td>
<td>3.46</td>
<td>9.2</td>
</tr>
<tr>
<td>18+ years</td>
<td>7.27</td>
<td>6.2</td>
</tr>
</tbody>
</table>
In childhood, asthma-related office visits, emergency room visits, and hospitalizations are higher among boys than girls aged 0 to 14 years. But after puberty (11–18 years) asthma in males begins to improve and asthma in females becomes more prevalent and severe. The exact reason is unknown but may be linked to immunologic and hormonal factors and/or to differences in gender-specific responses to environmental or occupational exposure.

What is known, however, is that during puberty, changes occur in the growth of airways and parenchyma. Boys have larger lungs but smaller airways as compared to girls. In puberty, this is reversed. Sex hormones affect the function of epithelial cells. Progesterone affects airway epithelium and inhibits the beat frequency of cilia, while testosterone decreases airway inflammation, but the mechanism for this remains unclear. Animal studies have shown that females have increased protein interleukin-17A-mediated airway inflammation and increased immune response compared to males (Fuseini & Newcomb, 2017).

There is a risk of increased asthma severity by as much as twofold in girls with early menarche, and an increase in women who have had multiple gestations. The longer exposure to higher estrogen levels is thought to be a contributing factor in the higher prevalence and severity among women (Zein & Erzurum, 2015).

In pregnant women with chronic asthma, there is reduced growth of the female fetus and normal growth of the male fetus. The exact mechanisms for this effect are not known, but it is thought that placental function may play a role. It has been found that there are 65 genes altered in the placenta of pregnancies complicated by asthma. Of these, only 6 genes were altered in male placentae, but 59 gene alterations occurred in female placentae. Some of these changes were associated with growth, inflammation, and immune pathways (Zein & Erzurum, 2015).

As people age, men and women once again differ in the prevalence of asthma. The risk of severe asthma continues to rise in men after the age of 45 years, but not so in women, as there are protective physiological events in the female lung that are associated with menopause and the resultant drop in female sex hormones (Zein & Erzurum, 2015).

**RACE/ETHNICITY**

The CDC reports that asthma prevalence in 2016 among respondents diagnosed with asthma is distributed by race and ethnicity as shown in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Females (total)</th>
<th>Males (total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18 years</td>
<td>2.67</td>
<td>7.4</td>
</tr>
<tr>
<td>18+ years</td>
<td>13.11</td>
<td>10.4</td>
</tr>
</tbody>
</table>

Source: CDC, 2018a.
## ASTHMA PREVALENCE BY RACE/ETHNICITY

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Individuals with Asthma (millions)</th>
<th>Percentage of U.S. Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Non-Hispanic</td>
<td>16.11</td>
<td>8.3</td>
</tr>
<tr>
<td>Black Non-Hispanic</td>
<td>4.48</td>
<td>11.6</td>
</tr>
<tr>
<td>Other Non-Hispanic</td>
<td>2.19</td>
<td>8.0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3.74</td>
<td>6.6</td>
</tr>
<tr>
<td>Puerto Rican*</td>
<td>0.85</td>
<td>14.3</td>
</tr>
<tr>
<td>Mexican/Mexican American*</td>
<td>1.98</td>
<td>5.7</td>
</tr>
</tbody>
</table>

*As a subset of Hispanic

Source: CDC, 2018a.

A study published in 2015 found that disparities in asthma prevalence by racial/ethnic groups have increased over the last decade, with non-Hispanic Blacks and Puerto Rican Hispanics at greater risk than whites. Hispanics, studies show, have lower odds than whites of having an asthma diagnosis, but the difference varies by region. In states with large Puerto Rican and Dominican Republican populations, Hispanics reported higher rates than Hispanics living in other states. Such disparities may represent differences in access to quality healthcare and exposure to pollutants and environmental stressors (Bhan et al., 2015).

### GEOGRAPHY

According to the National Health Interview Survey, 2014–2016 (CDC, 2018b), the prevalence of asthma was highest in five states: New Hampshire (12.7%), Vermont (12.3%), Arizona (11.0%), Kentucky (10.8%), and Maine (10.8%). The five states with the lowest prevalence were Hawaii (4.9%), North Dakota (5.7), Arkansas (5.9%), South Carolina (6.2%), and North Carolina (6.2%).
ASTHMA ATTACK PREVALENCE

There were a total of 12.4 million people who experienced one or more asthma attacks in 2016. Of these, 3.3 million (53.7%) were under the age of 18, and 9.14 million (44.9%) were age 18 and over (CDC, 2018a).

The asthma attack incidence has gone down in children of all races and ethnicities from 2001 through 2016. A little over 6 million children in the United States ages 0 to 17 years have asthma, and more than half of all children with asthma had one or more attacks in 2016. Asthma attacks occurred most frequently among children younger than 5 years of age in 2016. Emergency department and urgent care center visits related to asthma attacks were highest among children ages 0 to 4 years and among non-Hispanic black children.

Among all age groups the number of emergency department visits for the diagnosis of asthma in 2016 was 1.7 million, the number of physician office visits for the diagnosis of asthma was 11.0 million, and the number of hospital outpatient visits was 1.3 million (CDC, 2018a).

ASTHMA MORTALITY

The CDC (2018a) reports that in 2016 there were 3,518 deaths with the underlying cause of asthma. Of these, 209 (2.8 per million) were among children under the age of 18, and 3,309 (13.3 per million) were among adults ages 18 and over.
ASTHMA 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.

There are many cells and cellular elements that contribute to the chronic inflammation of bronchial mucosa and the hyperresponsiveness of airways. When the epithelium of a sensitized individual’s airways is exposed to environmental stimuli such as antigens, irritants, infections, or exercise, both innate and adaptive immune responses are initiated. This exposure activates antibody production, and together, the stimuli and antibodies cause mast cell degeneration. When mast cells degenerate, they release inflammatory mediators that cause vasodilation, resulting in:

- Increased capillary permeability
- Mucosal edema
- Bronchoconstriction (bronchospasm)
- Thick tenacious mucus secretion
- Hyperresponsiveness of bronchial smooth muscle
This causes narrowing of airways (bronchoconstriction) and obstruction to airflow. The eosinophils released directly cause injury to tissues and release toxins, which add to the increased hyperresponsiveness of the bronchi. Damage to the ciliated epithelial cells contributes to impairment of ciliary function that results in an accumulation of mucus and cellular debris that forms plugs in the airways. With repeated bouts of untreated inflammation, it can result in irreversible long-term airway damage referred to as airway remodeling (Huether & McCance, 2017).

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 (overbreathing or breathing too quickly) 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, perfusion increases, and carbon dioxide retention (hypercapnia) and respiratory acidosis develop. The development of respiratory acidosis signals impending respiratory failure, a life-threatening condition requiring emergency care (Huether & McCance, 2017).

There appear to be two distinct onset patterns to asthma: sudden onset and the more common slow onset.

- **Sudden-onset asthma** symptoms occur in less than one hour and are most often triggered by nonsteroidal anti-inflammatory drugs (NSAIDs) and fume inhalation.

- **Slow-onset asthma** symptoms develop over more than 2.5 hours and are triggered most often by suspected respiratory infections. (Burgel et al., 2017)

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, 2018.)
Asthma Development in Children and Adolescents

Asthma symptoms can vary over the lifetime of each person. Nonetheless, there are some generalities and commonalities that characterize the progression of the disease throughout development.

Many infants wheeze with respiratory illnesses, and half of them have at least one episode of wheezing before the age of 3 years. No single respiratory infection with wheezing before the age of 1 year, however, is predictive of a diagnosis of asthma at a later age.

For most children, wheezing before the age of 6 years is most likely to be a benign condition reflecting smaller airways that will improve or resolve in a few years. Sixty percent of children with wheezing in the first 3 years of life have no wheezing at 6 years of age. However, the majority of chronic asthma begins in the first 6 years of life.

A subgroup with wheezing before age 6 will have persistent symptoms and will eventually develop clinical asthma. Asthma in early childhood results in decrements in pulmonary function that persist and are detectable throughout childhood, adolescence, and even adulthood. Studies of children who develop asthma before 6 years of age demonstrate persistent lung function abnormalities that may be associated with reduced lung growth and/or an early decline in lung function in adulthood.

Children with more severe symptoms often have lower lung function than those whose symptoms are less severe. These deficits in lung function that develop by 6 to 7 years often persist into adulthood.

Wheezing and asthma in adolescence is associated with a high rate of persistence into adulthood. Adolescents and adults are not likely to experience progressive worsening of asthma in the absence of other comorbidities. It is estimated that between 30% and 70% of children with asthma are markedly improved or asymptomatic by early adulthood (Litonjua & Weiss, 2017).

Adolescents have more remissions of symptomatic asthma than any other age group, which may be explained by the increased growth of the airways during and after puberty. Only 3% of patients diagnosed at age 15 or older with mild disease require treatment for severe disease five years later.

Asthma Development in Adults

When people are diagnosed with asthma when they are older than age 20, it is known as adult-onset asthma. New-onset asthma in adults is often the result of undiagnosed childhood asthma.

Unlike children, adults rarely experience a complete remission from asthma symptoms. The risk of progressive clinical deterioration, however, is small, and in the absence of comorbidities, asthma does not decrease life expectancy.
Asthma severity seems to remain stable over several years, and those patients who receive asthma treatment for mild asthma are not likely to progress clinically over the next five years. The rate of lung function loss is greater in adults with more severe symptoms and in those with newly diagnosed asthma when compared to persons without asthma.

Severe and difficult-to-treat asthma comprises only a small portion of the asthma population but accounts for a large portion of asthma morbidity (Litonjua & Weiss, 2017).

**Asthma Development in Older Adults**

It is not uncommon for adults over the age of 65 to develop asthma symptoms for the first time. There are two categories of asthma in this age group:

- Those who developed asthma in childhood or early adulthood that persisted through later life interspersed with periods of normal lung function. Childhood asthma usually remits in adolescence but can often reappear later in adulthood.
- Those who first develop new asthma symptoms as older adults.

When asthma does occur at a later age, symptoms are similar to those experienced by other age groups. Asthma creates a much greater risk in older adults because they are more likely to develop respiratory failure as a result, even during mild episodes of symptoms. Older patients with “mild” asthma symptoms can have the same degree of breathing difficulty as younger patients who are experiencing “severe” asthma symptoms.

The diagnosis of asthma in older adults may be missed because of similar symptoms related to other health conditions. Asthma symptoms are more likely to take the form of coughing with sputum production in the older adult. Such symptoms can be interpreted as due to chronic bronchitis or congestive heart failure. Heart disease and emphysema are more common in older adults, especially smokers.

Up to half of older people with an asthma diagnosis are current or former smokers. Tobacco smoke contributes to worsened control of symptoms (AAFA, 2015).

**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 neurologic 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 BRONCHOCONSTRICTION**

Exercise-induced bronchoconstriction (EIB), an intrinsic type of asthma, was formerly known as exercise-induced asthma, wrongly suggesting that exercise causes asthma. Approximately 90% of individuals with asthma experience EIB during exercise, and for adolescents and young adults, this might be the most common cause of asthma symptoms.

Although symptoms include wheezing, chest tightness, and shortness of breath, coughing is often the most common symptom of EIB, and it may be the only symptom a person has.

Symptoms of EIB begin during exercise, usually worsen 5 to 10 minutes after discontinuing exercise, and peak at 15 minutes. Symptoms can range from mild to severe. Symptoms often resolve in another 20 to 30 minutes. At times, some people experience a second or late phase of symptoms that begins 4 to 12 hours after exercise cessation. The symptoms during this phase are frequently less severe and may take up to 24 hours to resolve.

EIB occurs due to the faster and deeper breathing required to meet oxygen demand during exercise. Inhalation usually occurs through the mouth, and this causes the air to be dryer and cooler than the air inhaled through the nose. This dry and/or cold air is the trigger for airway bronchoconstriction. Exercising in cold, dry air is more likely to cause symptoms than exercising in warm, humid air. Other factors that can make EIB symptoms worse include:

- Levels of air pollution
- High pollen counts
- Exposure to other irritants (e.g., fumes, smoke)
- Having had a recent upper respiratory viral infection (common cold)
- Having had a recent asthma attack

(AAFA, 2018a)
OCCUPATIONAL ASTHMA

Occupational asthma, an intrinsic type caused by inhaling fumes, gases, dust, or other potentially harmful substances while on the job, accounts for an estimated 10% to 20% of adult-onset asthma. There are several terms used to define the different types of work-related asthma.

- **Occupational asthma (OA)** begins during adulthood and is induced by exposure to immunologic or nonimmunologic stimuli found in the workplace.

- **Work-exacerbated asthma** or work-aggravated asthma is preexisting or concurrent asthma that becomes worse in the workplace.

- **Irritant-induced asthma** results from single or multiple exposures to a nonimmunologic irritant substance at a high level of intensity.

- **Reactive airways dysfunction syndrome (RADS)** is a form of irritant-induced asthma triggered by a single acute high-level exposure to a nonimmunologic stimulus. The symptoms of this syndrome begin within minutes of exposure and are followed by ongoing asthma-like symptoms and bronchial hyperresponsiveness that can last for a prolonged period of time.

- **Occupational nonasthmatic eosinophilic bronchitis** is a type of asthma that develops in the workplace and causes symptoms that mimic asthma but is not associated with bronchial hyperresponsiveness.

The intensity of the workplace exposure is the most important factor in the development of the disease. There are a wide variety (over 350) of airborne agents in the workplace that have been reported to cause occupational asthma, and the specific agent to which a worker is exposed influences the frequency of developing occupational asthma. Most workers exposed to occupational sensitizing agents do not develop occupation asthma. The chance of developing the disease is influenced by a variety of host factors such as atopy (genetic tendency to develop allergic diseases), cigarette smoking, and genetic predisposition (Cartier & Bernstein, 2018).

NOCTURNAL ASTHMA

Nocturnal asthma can be either intrinsic or extrinsic and is a characteristic feature of asthma that is not well-controlled in a patient with daytime asthma symptoms. It is associated with a circadian pattern in which the best lung function occurs at around 4 p.m. and the worst at around 4 a.m. and is associated with more severe disease and increased mortality. Mortality statistics show that over a one-year period, 53% of asthma deaths occurred at night. Of this number, 73% complained of asthma affecting their sleep, and 42% reported that asthma symptoms occurred every night (Martin, 2017).

Airway resistance increases throughout the night whether or not a person sleeps, although the increase is much greater if the person does sleep. Airway function is best just before the onset of sleep and decreases as sleep progresses. The more a person with asthma sleeps, the greater the impairment of his or her lungs. These airway changes do not disturb sleep in the healthy person;
however, in those with asthma, worsening of symptoms is a characteristic feature of asthma that is not well-controlled.

There are several hormones secreted in a circadian pattern that can contribute to nocturnal airway inflammation and asthma symptoms.

- **Corticotrophin** levels are increased but are not accompanied by commensurate increases in cortisol levels, resulting in less suppression of airway inflammation.

- **Melatonin** is a sleep-inducing hormone that has a proinflammatory effect in those with nocturnal asthma. Peak melatonin levels occur at approximately 2 a.m. and these levels are significantly greater in nocturnal asthmatics. Melatonin is associated with a greater overnight fall in lung function.

- Nocturnal asthma may be caused by a circadian fall in plasma **epinephrine**, which affects sensitized mast cells in the lung, causing the release of histamine and other mediators and resulting in bronchoconstriction.

Other factors that contribute to nocturnal asthma include:

- **Mast cell mediator** levels may be elevated, causing inflammation predominately affecting the distal, smaller airways, with the greatest inflammation occurring in the alveolar tissues at 4 a.m. compared to 4 p.m.

- **Cholinergic** or vagal tone is increased at night and may contribute to the circadian changes in airway function.

- **Pulmonary capillary volume** significantly increases during sleep, which may contribute to the recruitment of additional inflammatory cells, thus producing more edema in the airways.

- **Allergen exposure** in the bedroom—such as house dust, animal dander, and especially dust mites concentrated in the bedding—may be a contributor.

- **Delayed response** to an allergen may occur 3 to 8 hours following exposure.

- **Airway cooling** due to the normal drop in body temperature at night, air conditioning, or colder night air results in loss of heat and moisture from the airways.

- **Asthma control medication effects** may diminish during early morning hours.

- **Chronic sinus disease** may cause throat irritation due to a constant drip of inflammatory and infectious secretions from the back of the nose to the back of the throat, resulting in bronchial constriction by a reflex transmitted to the nervous system.

- **GERD** (gastroesophageal reflux disorder) may result in stomach acid entering the larynx, triggering a bronchial spasm.

(Covar, 2017; Jazwinski et al., 2017)
COUGH-VARIANT ASTHMA

Cough-variant asthma can be either intrinsic or extrinsic and accounts for about 24% of cases of chronic cough. Chronic cough is defined by the presence of persistent cough symptoms for a minimum of 8 weeks in adults and 4 weeks in children. People with asthma experience wheezing, shortness of breath, chest tightness, and coughing, but in some people the only symptom is a chronic nonproductive cough, often nocturnal. The cough can occur for many years as an extremely annoying symptom interfering with work, sleep, and quality of life.

Anyone can get cough-variant asthma at any time, but it is common in young children with childhood asthma. About 30% to 40% of adults with cough-variant asthma go on to develop classic asthma (Mehta et al., 2016).

Cough-variant asthma can often be missed as the cause of chronic cough because other conditions may mimic this form of asthma, including postviral infection cough and eosinophilic bronchitis.

Although the typical symptoms of asthma are not present, cough-variant asthma affects the body in the same manner, increasing sensitivity of the airways, narrowing and swelling the airways, and disrupting air flow. It is characterized by bronchial hyperresponsiveness and eosinophilic inflammation. Although patients with classic asthma do not usually have an enhanced cough reflex, patients with cough-variant asthma might.

Causes may include exposure to allergens, breathing in cold air, post–upper respiratory infection, aspirin intolerance, and the use of beta-blocker medications for various conditions, including eye drops for treatment of glaucoma (Ortega & Pennington, 2017).

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.

Five asthma genes or gene complexes have been identified:

- ADAM33
- PHF11
- DPP10
- GRPA
- SPINK5
The functions of these genes are as yet not fully understood, but some may deal with threat or damage from the external environment or exert effects within cells that make up mucosa. These include genes that modify mucus production, the allergic trigger on mast cells, and microbial pattern recognition receptors of the innate immune system (WHO, 2016).

In 2017, the National Institutes of Health reported the discovery of BPIFB1, a gene that is a regulator of a protein critical in mucus production during life-threatening asthma attacks (Guidry, 2017).

**Lung Microbiome**

Several studies have been done that are pointing toward the role of altered lung microbiome in the development of asthma. These studies show there is an association between bacterial colonization of the hypopharynx in asymptomatic newborns and the later development of recurrent wheezing, asthma, and allergies during the first five years of life. Other studies show that airway microbiotic composition and diversity are significantly connected with bronchial hyperresponsiveness (Vedanthan et al., 2016).

**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 (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 (body parts, saliva, and waste), dust mites (body parts and waste), 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, 2016).

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) (see also “Indoor Air Pollution” below).

In a pregnant woman who smokes, some of the nicotine, carbon monoxide, and numerous other toxic chemicals in tobacco smoke pass through the placenta to her fetus. Cigarettes contain more than 4,000 substances, 250 of which are known to be toxic. Children born to mothers who smoked have a higher asthma prevalence risk. One important effect of nicotine is its effect on the structural development of the lung. The alveoli are bigger and there is a reduction in the number of alveolar-bronchiolar attachment points, resulting in reduced lung function. Lower lung function in infancy is a recognized risk factor for air-flow obstruction in young adults. Another effect of maternal smoking while pregnant, documented in animal models, is the premature aging of the lungs (Zacharasiewicz, 2016).

AIR POLLUTION

According to multiple sources, including worldwide and U.S. government agencies, the scientific consensus is that the earth’s climate is changing and getting warmer. Climate change is a huge threat to respiratory health by directly causing or aggravating preexisting respiratory diseases and increasing exposure to risk factors for respiratory diseases (NASA, 2018).

Increasing temperatures lead to increasing ground-level ozone, which causes airway inflammation and damages lung tissue. Ozone, a gas, is a common air pollutant that contributes to smog or haze. It is most commonly found in cities where there are more automobiles and is also more common in the summer when there is more sunlight and low winds. Ground-level ozone is found in the lowest layer of the atmosphere and is generated by chemical reactions between other air pollutants in the presence of sunlight. Breathing in ground-level ozone can lead
to chest pain, coughing, and inflammation of the airways even in those who do not have asthma (Blount, 2017).

The populations most vulnerable to ground-level ozone are children, the elderly, people with lung disease, or people who are active outdoors. Children are at the greatest risk and are more likely than adults to have asthma. Unhealthy rises in ground-level ozone pollution correspond with increases in emergency room visits and hospitalizations for people with asthma (AAFA, 2018b).

**INDOOR AIR POLLUTION**

In addition to the air pollution outdoors, indoor air pollutants also contribute to the development of asthma and worsening of asthma symptoms. Indoor air pollutants include:

- Household cleaners and air-freshening sprays or devices
- Fuel-burning heat sources such as a wood-burning stoves
- Smoke from cooking, candles, fireplaces, or tobacco
- Toxic fumes emitted from new products such as furniture and carpet
- Fumes from attached garages that store cars, motorcycles, or lawnmowers
- Building and paint products (e.g., adhesives, solvents)
- Pesticides
- Radon (a gas that comes from the ground)
- Humidity that facilitates the growth of molds
- Cosmetics, perfumes, and hair sprays (AAFA, 2015)

**WEATHER**

Thunderstorm asthma is an uncommon event, but it can be life-threatening. Asthma epidemics have occurred under such circumstances and have affected people who have never had asthmatic symptoms before. The first reported epidemic was in the United Kingdom in 1983, and since then they have occurred in Australia, Canada, the United States, and Italy. The most recent severe episode occurred in Australia in 2016, with 8,500 emergency asthma visits and nine deaths.

Pollen grains are large and normally cannot enter the bronchial tree. During a thunderstorm, however, these grains are carried up by a dry updraft, ruptured by high humidity at the cloud base, and then forced down by colder air. These smaller grains contain allergens of the right size to reach the bronchial tree, resulting in asthma symptoms. People who are sensitized to the allergens are at risk as well as those who have poorly controlled asthma or more bronchial
hyperresponsiveness. Although thunderstorm asthma is rare, these events are expected to occur more often with anticipated climate change (Stadtmauer, 2017).

VITAMIN E AND ASTHMA

Recent research has uncovered a link between maternal vitamin E levels and childhood asthma. Children born to mothers with low vitamin E levels are more likely to suffer from wheezing and to require asthma medications.

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.

- **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 blood plasma indicated a 10% to 17% reduction in lung function as measured by spirometry.

- **Alpha-tocopherol** is found in olive oil, wheat germ, and almond and sunflower oils and has been found to have beneficial effects on lung function. Adult-onset asthma patients have been found to have significantly lower levels of alpha-tocopherol. (Larkin et al., 2015)

Children with wheezing were found to more likely be born to mothers with significantly lower concentrations of the vitamin E isoform known as alpha-tocopherol. Women with the highest levels of this form of vitamin E were less likely to have a child with symptoms. High levels of the other vitamin E isoform (gamma-tocopherol) in the mother’s system did not have the same protective effect against wheezing and modified the protective effect of alpha-tocopherol (AAAAI, 2017).

Women should be counseled to eat a healthy diet during pregnancy, which includes plenty of fruits and vegetables as well as whole grains, low-fat dairy, a variety of proteins, and oils and foods containing alpha-tocopherol. Vitamin E should be obtained through diet, as there is some evidence that vitamin E supplements increase self-reported abdominal pain and prelabor rupture of membranes at term. Any vitamin supplementation during pregnancy should be taken only after discussion with one’s healthcare provider (Garner, 2018).

RESPIRATORY INFECTIONS

Studies have suggested that viral and bacterial respiratory infections are linked to the development or worsening of asthma.

**Viral Infections**

Viral respiratory infections are the most common causes of wheezing in infants and young children. They are also common triggers of asthma exacerbations in both adult and
pediatric patients with preexisting asthma. Viral infections trigger up to 85% of asthma exacerbations in school-aged children and up to 50% of exacerbations in adults (Kakumanu, 2016).

Symptoms most likely are the result of viral-induced damage to the epithelium of the airways, followed by inflammation of the airways in a predisposed individual. The immune responses involved include amplified allergic inflammation, increased granulocyte recruitment, promotion of cytokine production, and up-regulation of the parasympathetic response. All of these are proinflammatory factors that have an effect on the person’s response to microbial infections, allergens, stress, and pollutants.

- **Respiratory syncytial virus (RSV)** in children under 2 years of age is the most common cause of wheezing.

- **Rhinovirus** is also a common cause but is more significant in adults and children older than 2 years. Viral infections, especially with rhinovirus, are the most common causes of wheezing or increased symptomatology in patients with preexisting asthma (Kakumanu, 2016).

- **Parainfluenza** can cause lower respiratory tract infections and are most likely to affect infants, young children, the older adult, those with chronic diseases such as asthma, and those with compromised immune systems, causing new onset asthma and also acting as an asthma trigger.

- **Metapneumovirus** presents similar to RSV and is the second most common cause of lower respiratory tract infections in children. It also affects adults, particularly older adults. Lower airway infections have been shown to trigger asthma attacks in those with existing asthma.

- **Coronavirus**, a cause of the common cold, has been implicated as an asthma trigger.

- **Adenovirus** has been found to initiate chronic, more persistent, and severe asthma. (Bottrell, 2017)

**Bacterial Infections**

- **Chlamydia pneumonia** is a bacterium known for causing bronchitis and pneumonia. These bacteria worsen airway inflammation in such a manner as to make asthma chronic, more persistent, and severe.

- **Mycoplasma pneumonia** is another bacterium found to be associated with chronic, more persistent, and severe asthma. (Bottrell, 2017)
CESAREAN SECTION

Babies born by cesarean section, especially before membranes have ruptured, have approximately a 20% increase in risk of asthma compared to babies born vaginally (Huang et al., 2015). It is speculated that the effect of cesarean delivery is mediated by changes in the microbiome of the newborn. During normal vaginal delivery the infant is exposed to a microbiome different from the one encountered during a cesarean section in an operating room. The microbiome of the newborn is also likely affected by the standard procedure of giving prophylactic antibiotics to women delivering by cesarean section for reduction of postpartum infections in the mother.

Other factors that may potentially affect the early environment of the newborn include a reduction in the cord blood of cells involved in the immune cells’ response. In addition, stress hormone induction in the fetus is dependent on mode of delivery, with lower production found in children born by cesarean section (Sevelsted et al., 2016).

Pilot studies are underway in which infants delivered by cesarean section are exposed to maternal vaginal fluids at birth in an effort to determine whether it will decrease the risk for immune and metabolic disorders, including asthma (Domínguez-Bello et al., 2016).

Comorbid Factors

OBESITY

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 is defined as having a body mass index (BMI) of 30 or more. The normal range is 18.5 to 24.9, and overweight is 25 to 29.9. People with a BMI of 30 or more have a much higher risk of having asthma. Seven percent of adults with a BMI in the normal range have asthma, but 11% of adults with a BMI classified as obese have asthma. The reasons for this are not yet understood, but it has been shown that this is a problem particularly for women. Nearly 15% of women who are obese have asthma (Dixon, 2018).

It is speculated that extra weight around the chest and abdomen might constrict the lungs, making it more difficult to breath, but it is most likely more complicated than this. It is known that fat tissue produces inflammatory substances, and a number of studies have suggested these substances contribute to asthma.

It is known, however, that obese patients often use more asthma medications, have worse symptoms, and are less able to control their asthma than those in a healthy weight range. Studies have also shown that people with asthma and a BMI over 30 do not respond to medications in the same way that those with lower BMI. People who are obese and have asthma have worse asthma control when they are treated with theophylline, and the effectiveness of medications such as inhaled corticosteroids is reduced.
People with asthma and obesity are also more likely to have medical problems that can affect asthma. This includes depression and obstructive sleep apnea. Both are associated with worse asthma symptoms.

Another theory is that there may be a common gene set that increases the chances of developing both conditions, and recent research has shown that genes linked to chronic inflammation in asthma may be more active in people who are obese (Dixon, 2018; Kushner & Kushner, 2018).

**CHRONIC OBSTRUCTIVE PULMONARY DISEASE**

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, which is referred to as asthma-COPD overlap syndrome (ACOS). It is generally thought to involve persistent airflow limitation in a patient older than 40 years with a history of asthma.

ACOS affects approximately 25% of COPD patients and almost 33% of patients who previously had asthma. These individuals have significantly worse respiratory symptoms, poorer quality of life, and an increased risk of exacerbations and hospital admissions. It is not known if this condition occurs following airway remodeling and inflammation in a patient who has COPD, if it is the result of exposures to substances in patients with asthma, or if it is a new disease with its own pathophysiology (Leung & Sin, 2017).

**GASTROESOPHAGEAL REFLUX DISORDER**

Studies have shown that gastroesophageal reflux disorder (GERD) can trigger asthma symptoms. In addition, GERD is more common in people with asthma than in the general population. Individuals with asthma that is especially difficult to treat appear more susceptible to GERD than other affected persons. GERD is thought to cause asthma symptoms in one of two ways.

1. Stomach acid that enters the esophagus irritates nerve endings and the brain responds with impulses to the lungs stimulating muscle and mucus production in the airways, which then constrict, resulting in asthma symptoms.

2. Refluxed stomach contents are aspirated into the lungs, irritating the airways and causing the symptoms of asthma to occur.

It is also believed by some that asthma may trigger GERD. Either breathing difficulties or certain asthma medications cause the esophageal sphincter muscle to relax and allow stomach contents to reflux, which then causes asthma symptoms, completing a cycle (AAFA, 2018c).

**HYPOTHYROIDISM AND HYPERTHYROIDISM**

Hypothyroidism and hyperthyroidism are both known to cause respiratory muscle weakness and decrease pulmonary function. Hyperthyroidism increases respiratory drive and can cause
dyspnea on exertion. Hypothyroidism reduces respiratory drive, increases bronchial reactivity, and can cause sleep apnea (Johnson, 2018).

CASE

JONAH, AGE 11
Jonah 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 reported that the twins had been delivered by cesarean section. She 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, the twins were born by cesarean section, 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 later in this course under "Asthma Patient Education")

ASTHMA 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 a patient ages. The type of asthma symptoms a patient has, how often they occur, and how severe they are may vary over time. Some people with asthma may have extended symptom-free periods interrupted by periodic asthma episodes, while others have some symptoms every day. 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 occur so they do not become severe (Cleveland Clinic Foundation, 2018a).

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.

Coughing is common during childhood and is a nonspecific symptom of various diseases. The most frequent underlying causes for cough are asthma; bacterial bronchitis; chronic ear, nose, and throat diseases; GERD; and prolonged bronchial responsiveness following infections (Jurca et al., 2017).
Asthma should be considered in anyone who has a chronic cough, seasonal cough, or 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.

**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. A wheeze is a continuous high-pitched sound, and in the mildest form of asthma, wheezing is heard only at the end of expiration. As severity increases, the wheeze lasts throughout expiration. In a more severe asthmatic attack, wheezing is also present during inspiration. In most severe attacks, wheezing may be absent because of the severe limitation of airflow associated with airway narrowing and respiratory muscle fatigue. Asthma can occur without wheezing, however, when the obstruction predominately involves the small airways (Morris, 2017).

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 foreign body trapped in the airways can also cause wheezing, difficulty breathing, and a choking feeling.

A diagnosis of asthma in young children with a history of a wheezing is more likely if they have:

- Recurrent and long episodes of wheezing
- Wheezing or coughing that occurs with exercise, laughing, or crying in the absence of an obvious respiratory infection
- A history of other allergic disease
  (Tenero et al., 2016)

**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 unusual amounts of effort of the muscles of respiration during breathing.
- **Anxiety.** This sensation can be caused by a fear of suffocating or a memory of past uncomfortable experiences with breathlessness. Anxiety can also come from other sources of stress.
During an asthma attack, patients feel the bronchoconstriction—the chest feels tight. The difficulty of breathing, chest tightness, and a 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, diaphragm muscles are used to pull air into the lungs. The lungs empty without muscular effort, relying instead on the elastic recoil of the lungs and 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 heart failure, COPD, mitral stenosis, diffuse interstitial lung disease, pneumonia, spontaneous pneumothorax, acute pulmonary embolism, and hyperventilation (Jurca et al., 2017).

**Excess Airway Mucus**

Mucus is the normal secretory product of the epithelial lining and contains secreted water, sugar, proteins, lipids, minerals, and mucins. Under normal conditions, mucus protects the airways and moistens the air. 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 (more viscous) than normal. Additionally, in persons with asthma the specialized cells called *cilia* that cleanse the airways of inhaled particles and mucus are dysfunctional. Asthmatic mucus is more likely to remain in the airways and form plugs that make it more difficult for patients to clear their lungs by coughing (Shen et al., 2017).

**Sleep Disturbances**

People with asthma often experience sleep disturbances that affect their ability to function during the day. Coughing is a frequent cause for such disturbances. Sleep apnea occurs more often in people with asthma, causing increased inflammation in the airways, which can worsen asthma symptoms throughout the day. Sleep apnea results in the stoppage of breathing from a few seconds up to one minute and ends with an audible snore or grunt. This can occur more than 30 times in a typical night, and the person may be unaware of it. Such disturbances result in daytime sleepiness. Asthma is associated with a 40% greater risk of new-onset obstructive sleep apnea (Lebowitz, 2016).
Signs and Symptoms Unique to Children

Various forms of noisy breathing, including wheezing, are common among babies and preschoolers. Noisy breathing is particularly common among infants under 6 months old, but only a small proportion wheeze.

Wheezing occurs at some time in about one third of children during the first five years of life. The most common causes of wheezing in preschool children are viral infections and asthma. A child with two or three episodes of wheezing in a year that last less than 10 days and without symptoms between episodes probably has viral bronchospasm with a low probability of developing asthma. A child with recurrent and longer episodes and a history of atopy associated with exercise-induced wheezing has a higher probability of developing asthma (Morris, 2017; NACA, 2018).

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

- 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

There is no “gold standard” or standardized diagnostic criteria for asthma. Diagnosis is based on the patient’s history, physical examination, consideration of other diagnoses, and documentation of variable expiratory airflow limitation as determined by spirometry. In some instances, observing a response to treatment may confirm an asthma diagnosis, but lack of a response to treatment does not rule out asthma (NACA, 2018).
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 patients find that their attacks are so easily triggered that they are 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.

Information necessary for assistance in making a diagnosis of asthma requires asking the patient about:

- **Current symptoms.** Are they occurring mostly in the daytime, at night, or both?
- **Pattern of symptoms.** What is their course over a day, week, or year?
- **Chronology.** What is the chronological history of the symptoms over the person’s lifetime?
- **Smoking history.** Does or did the patient smoke (tobacco, cannabis)? Has the person been exposed to secondhand smoke?
- **Precipitating or aggravating factors.** What brings the symptoms on or what makes them worse, e.g., do they occur with exercise or with viral infections?
- **Relieving factors.** Is there anything that relieves the symptoms, e.g., medications?
- **Home or work exposure.** What types of environmental exposures are present in the home or workplace?
- **Impact of symptoms.** How do the symptoms affect the person’s occupation, lifestyle, and activities of daily living?
- **Past history.** Is there a history of allergies, including atopic dermatitis (eczema) or allergic rhinitis (hay fever)? Is there a history of other pertinent medical conditions such as COPD?
- **Family history.** Is there is history of asthma and/or allergies among family members? (NACA, 2018)
HISTORY OF SYMPTOMS IN CHILDREN

When taking a history of a child with wheezing or asthma-like symptoms:

- Confirm that the breathing sounds described by the parents (caregivers) as wheezing are actually “wheeze.”
- If possible, see the child during a bout of wheezing.
- Ask the parents (caregivers) to make an audio or video recording of noisy breathing.
- Ask the parents (caregivers) to describe exactly what they see or hear, and then show them a video of true wheezing and ask whether the signs match those of the child.
- Ask about the appearance of the child’s chest during episodes of noisy breathing (use of accessory muscles to breathe, retractions of the chest wall adjacent to the ribs).
  (NACA, 2018)

TYPICAL ASTHMA 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, recognition of the pattern of symptoms is pivotal to raising the possibility of a diagnosis of asthma. The symptom pattern of the individual should be described, noting these features:

- Whether the symptoms occur continually, episodically, or both
- Onset of symptoms, duration, and frequency
- Whether the symptoms occur perennially, seasonally, or both
- Diurnal variations, especially nocturnal and upon awakening early in the morning
- For women, whether the symptoms occur during a particular part of the menstrual cycle

Children with chronic asthma may have one of several distinct patterns of symptoms, and the asthma pattern can change over time. These may include:

- Intermittent asthma attacks with no symptoms between them
- Chronic symptoms with intermittent worsening
- Attacks that become more severe or frequent over time
- Morning “dipping” (when the symptoms get worse in the morning and get better as the day goes on)
  (Sawicki & Haver, 2017)
ASTHMA 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Infections and comorbid conditions</td>
<td>• Respiratory infections (respiratory syncytial virus, rhinovirus)</td>
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<tr>
<td></td>
<td>• Sinusitis (most common factor associated with more severe and harder-to-control asthma)</td>
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<td></td>
<td>• Hyperthyroidism</td>
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<td></td>
<td>• Hypothyroidism</td>
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<td>• GERD (heartburn and acid reflux)</td>
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<td>Hormonal changes</td>
<td>• Premenstrual days, pregnancies</td>
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<td></td>
<td>• Estrogen and progesterone</td>
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<td>Inhaled substances</td>
<td>• Biological allergens: mold, fungal spores, pollen (weeds, grasses, trees), pets with fur or hair, dust mites</td>
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<td></td>
<td>• Chemical vapors: perfumes, cleaning products, aerosol sprays, chlorine (e.g., in indoor pools), industrial solvents (e.g., paint thinner)</td>
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<td>• Air pollutants: particulates, sulfur dioxide, ozone, nitrogen oxide, tobacco smoke</td>
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<td></td>
<td>• Specific items: old books, pieces of stuffed furniture, mattresses</td>
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<tr>
<td>Ingested substances</td>
<td>• Foods or drinks (e.g., homemade wine or beer)</td>
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<td></td>
<td>• Sulfites (preservatives) and tartrazine dyes</td>
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<td>• Foods high in nitrites</td>
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<td>• Monosodium glutamate (MSG)</td>
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<td>• Medicines: aspirin, NSAIDs (e.g., ibuprofen), beta-adrenergic blockers</td>
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<tr>
<td>Physical factors</td>
<td>• Temperature extremes: heat, cold</td>
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<td></td>
<td>• Weather: storms, wind, humidity</td>
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</tbody>
</table>
CHARACTERISTICS OF THE HOME
Age, location, cooling/heating system, wood burning stove, humidifier, carpeting over concrete, presence of mold or mildew

ENVIRONMENTAL CHANGES
Moved to new home, gone on vacation, altered workplace, altered workplace processes or materials used

EXERCISE
- Hyperventilation
- Winter sports more commonly than summer sports

EMOTIONAL SITUATIONS
- Stress, anger, frustration, laughter, crying
- Anxiety
- Depression

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 due to asthma**, because a history of asthma attacks of that severity is the most accurate predictor of fatal asthma attacks (Madison & Irwin, 2017).

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 to parents who smoked
- 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
- Nasal polyps (a condition associated with asthma)

Atopic illnesses share an underlying problem with the immune system, predisposing persons toward the development of allergic hypersensitivity reactions.

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, presence of any smokers)
• School or daycare
• Workplace (exposure to chemicals, tobacco smoke, air pollutants)
• Vacation or other travel 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
• Effect on growth, development, behavior, school or work performance
• Issues related to impact on the family’s finances
• School characteristics that may interfere with adherence to treatment
**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 asks about:

- Patient’s, parents’, and spouse/partner’s knowledge of the disease process, belief in the chronicity of asthma and efficacy of treatment
- Patient’s perception and beliefs regarding the use and long-term effects of medications
- Ability of the patient, parents, spouse/partner to cope with the disease
- Level of family support and the patient’s, parents’, spouse/partner’s capacity to recognize the severity of exacerbation
- Whether the patient and family can realistically carry out the current management plan
- Whether the current plan is economically affordable

(NACA, 2018)

**CASE: Patient History**

Deborah 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 (which 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 inner city, low-income 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

The physical examination of a patient with suspected asthma includes looking for specific evidence of atopy or allergic rhinitis:

- **Eye exam**
  - Conjunctival congestion (redness, swelling, inflammation) or discharge
  - Skin around the eyes, looking for signs of atopy or allergy:
    - “Allergic” or “ocular shiners” (dark circles under the eyes caused by congestion of the nose and sinuses)
    - Dennie’s lines (folds of skin below the lower eyelid caused by edema in atopic dermatitis)

- **Nose interior and exterior**
  - Swelling of normal structures (turbinates)
  - Color and consistency of nasal lining
  - Amount, color, and consistency of any nasal discharge
  - Abnormal structures such as a nasal polyps
  - Foreign bodies (e.g., button, bead)
  - Transverse nasal crease (“allergic salute”) across the lower third of the nose caused by constant upward wiping of the nose due to allergic rhinitis

- **Oral cavity**
  - Postnasal drip (amount, color, consistency)
  - Signs of inflammation of the throat

- **Chest**
  - Shape and movement
  - Use of accessory muscles to breathe
  - Prolonged expirations, inhalation period shorter than exhalation

- **Lungs**
  - High-pitched musical wheezes most commonly heard during auscultation on expiration, crackles (rales), congestion, or any other abnormal sounds
  - Hyperresonance found during percussion, related to trapped air in the lungs (Morris, 2017)
During an asthma attack, a patient’s clinical presentation differs from that seen between attacks, and the associated physical examinations therefore differ.

**EXAMINATION DURING A MILD ASTHMA ATTACK**

During a mild attack, patients may:

- Be breathless after physical activity such as walking into the office
- Still be able to speak in sentences and lie flat
- Be agitated
- Have increased respiratory rate, but accessory muscles are not required to breathe
- Have a pulse rate below 100 beats per minute (bpm)
- Have moderate wheezing detectible upon auscultation of the chest but otherwise inaudible
- Have an oxygen saturation on room air higher than 95%

**EXAMINATION DURING A MODERATELY SEVERE ASTHMA ATTACK**

During a moderately severe asthma attack, patients may:

- Be breathless and assume a sitting position while talking
- Have an increased respiratory rate
- Require accessory muscles to breathe
- Have a pulse rate between 100 and 120 bpm
- Exhibit plainly audible expiratory wheezing
- Exhibit pulsus paradoxus (an exaggerated fall in systolic blood pressure during inspiration) of 10 to 20 mmHg
- Have an oxygen saturation on room air between 91% and 95%

**EXAMINATION DURING A SEVERE ASTHMA ATTACK**

During a severe asthma attack, patients may:

- Be breathless during rest, sit upright, talk in words rather than sentences, and usually be agitated
- Have a respiratory rate often greater than 30 per minute
- Require accessory muscles to breathe
- Commonly exhibit suprasternal retractions
- Have a pulse greater than 120 bpm
- Exhibit pulsat paradoxus (an exaggerated fall in systolic blood pressure during inspiration) of 20 to 40 mmHg
- Exhibit loud expiratory and inspiratory wheezing
- Have an oxygen saturation on room air below 91%
- Assume a tripod position (sitting hunched over with hands supporting the torso) as severity increases

When a patient is experiencing status asthmaticus with imminent respiratory arrest, paradoxical thoracoabdominal movements in which the abdomen moves out with expirations occur. Wheezing may be absent due to severe airway obstruction, and severe hypoxemia presents with bradycardia. Pulsus paradoxus previously noted may now be absent, and this indicates respiratory muscle fatigue.

As the attack becomes more severe, there may be profuse diaphoresis along with a rise in pCO₂ and hypoventilation. During such a severe episode, patients may struggle to breathe and become confused and agitated. They may try to remove their oxygen mask, complaining that they cannot breathe. These are all indications of life-threatening hypoxia (decreased oxygen reaching the tissues). As the CO₂ level increases, breathing slows, the patient becomes somnolent, and there may be profuse diaphoresis. At this point almost no breath sounds may be heard and the patient is now willing to lie flat (Morris, 2017).

**PHYSICAL EXAMINATION OF CHILDREN**

The physical examination of children is identical to that of the adolescent and adult, however, one of the most important goals is to identify signs and symptoms that suggest an alternative diagnosis requiring further investigation.

- Persistent cough not associated with wheeze/breathlessness or systemic disease is unlikely to be due to asthma.

- Bluish discoloration of the skin around the lips and nails due to low oxygen in the blood suggests bronchopulmonary dysplasia, a chronic lung disease of prematurity.

- A “wet” cough from birth or infancy with or without mucus production that lasts for a long time may indicate primary ciliary dyskinesia.

- Noisy breathing and difficulty with feeding with no response to bronchodilators and steroids could indicate a congenital vascular abnormality.

- Crepitations on chest auscultation that do not clear with coughing suggest a serious lower respiratory tract condition such as pneumonia.
• Unilateral wheeze suggests the presence of an inhaled foreign body.

• Systemic symptoms (fever, weight loss, failure to thrive) could indicate an alternative systemic disorder.

• Inspiratory upper airway noises (e.g., stridor, snoring) suggests tracheobronchitis (croup).

• Persistent voice abnormality indicates a possible upper airway disorder.

• Salty skin and clubbing of the fingers suggests cystic fibrosis or bronchiectasis. (Morris, 2017)

![Clubbing of the fingers.](image)

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. Spirometry assesses the unified mechanical function of the lung, the chest wall, and respiratory muscles by measuring the total volume of air exhaled from a full lung, called the *total lung capacity* (TLC).

Spirometry is used for diagnosing and monitoring a patient with asthma. During the process, the technician applies a clamp to the patient’s nose to keep it shut, and the patient is encouraged to inhale deeply and blow out as hard and as quickly as possible into the mouthpiece. The patient should exhale for at least six seconds, and at the end of the forced exhalation, the patient should
again inhale as fully and as rapidly as possible. The results are recorded by the spirometry machine.

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

For asthma, three 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. Airway obstruction is the most common cause of reduction in FEV1.

- **FEV1:FVC ratio** assesses airflow obstruction. When people with airway obstruction exhale, it takes longer than normal to empty the lungs. The amount of air expelled in one second, therefore, is reduced. The value of FEV1:FVC ratio goes down when a patient’s airways are narrowed.

Nevertheless, the improvement (i.e., increase) in FEV1:FVC ratio in any 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 ratio during an asthma attack is an objective measure of the severity of the symptoms (McCarthy, 2018).
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 (Cooper et al., 2017).

**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.

![Peak flow meters. (Source: Hosse, 2005.)](image)

**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 before beginning
- 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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Measurement</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>80%–100% of patient’s normal</td>
<td>Asthma is under control</td>
</tr>
<tr>
<td>Yellow</td>
<td>50%–80% of patient’s normal</td>
<td>Rescue medicines should be used; a medical visit may be needed</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;50% of patient’s normal</td>
<td>Signals a medical alert; emergency care is needed</td>
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Source: ALA, 2015.

### 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, since spirometry is not usually done in children younger than 6 years because of the difficulties in obtaining reliable forced expiratory maneuvers in this age group.

Alternative measurements that require less patient cooperation have been developed for use in young children; however, they are not widely available. These alternatives include:

- **Interrupter technique (Rint)** measures airway resistance. The method is based on transient interruption of airflow at the mouth for a brief period during which alveolar pressure and mouth pressure reach equilibrium, and the pressure change at the mouth can be used to calibrate the resistant of the airways.

- **Forced oscillation technique (FOT)** assesses bronchial hyperresponsiveness by employing small-amplitude pressure oscillations superimposed on normal breathing.

- **Respiratory system resistance (Rrs)** measures the functional residual air in the lung at the end of exhalation during tidal breathing. This method requires placing the child inside a sealed whole-body box (plethysmograph), with the child breathing normally through a mouthpiece. The tidal volume is measured, and the mouthpiece is briefly occluded. While the child pants against the closed mouthpiece, pressure oscillations are measured at the mouthpiece and within the body. (Rosen & Colin, 2017)

### BRONCHODILATOR TESTING AND BRONCHIAL PROVOCATION

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.

**Bronchodilator testing** is recommended in almost all adult and adolescent patients with airflow limitation on their baseline spirometry. Acute reversibility of airflow obstruction is tested by administering two to four puffs of a quick-acting bronchodilator (e.g., albuterol) using a valved...
holding-chamber (spacer) and repeating spirometry 10 to 15 minutes later. Measurements can also be made before and after administration of a nebulized bronchodilator.

A positive bronchodilator response, however, is not sufficient to make the diagnosis of asthma, as the response may be seen with other conditions such as COPD. Asthma is normally distinguished from these other conditions by the capacity for a large increase in FEV1. The definition of a “large response,” however, is not standardized.

**Bronchoprovocation** is useful for diagnosing asthma in patients with normal baseline airflow. It can be used to identify or exclude airway hyperresponsiveness in patients with an atypical presentation or isolated symptoms of asthma, especially cough. During this test, a direct provocative stimulus (e.g., inhaled methacholine, inhaled mannitol) or an indirect provocative stimulus (e.g., exercise, hyperventilation of warm or cold dry air) is used to stimulate bronchoconstriction. People with asthma are more sensitive to such stimuli than those who do not have asthma.

*Direct responsiveness* refers to bronchial reactions to stimuli that act directly on specific airway smooth muscle receptors. *Indirect responsiveness* results from stimuli that affect cells other than smooth muscles (e.g., inflammatory cells, epithelial cells, and nerves).

A positive bronchoprovocation test is not entirely specific for asthma. False negative results are uncommon, and a negative test performed in a patient off of asthma controller therapy does reliably exclude the diagnosis of asthma.

Other specialized testing can be used when assessing for exercise-induced bronchoconstriction as well as evaluation for possible occupational asthma by obtaining measurements before and after a work shift (Fanta, 2017a; Borak & Lefkowitz, 2016).

### CASE: Bronchial Provocation and Bronchodilator Testing

Calvin 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 methacholine 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)**

In vivo tests are quick, fairly reliable, and cost effective. The results are often available within an hour of testing. They are used for patients with poorly controlled asthma, trouble breathing, or at high risk of anaphylactic reactions.

In a skin prick test, a series of tiny drops of allergens are placed on the skin, and the skin underneath each drop is pricked with a needle. If the person has an allergy to an allergen, a dime-sized wheal will appear at the prick site and will be red and itchy.

If the skin prick test is negative, an intradermal test may be done, in which the allergen is injected into the skin. This is most often used for environmental and drug allergies. It may be more accurate but can be falsely positive.

Another type of skin testing is the patch test, in which an allergen is applied to a patch and placed on the skin, where it remains for 48 hours. If the skin becomes red, irritated, and itchy, the results may indicate an allergy.

![Allergy skin testing. (Source: Ihloff, 2008.)](image)

In vivo allergy testing is not without risk. 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.

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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, 2018; Bhargave, 2018).

**In Vitro Tests**

In vitro tests use a blood sample from the patient to detect circulating IgE antibodies to specific allergens. The most commonly used in vitro tests are **immunoassays**, which include the enzymes-linked immunosorbent assay (ELISA or EIA) and variations on this technique (fluorescent enzyme immunoassays [FEIA] and chemiluminescent immunoassays).

A positive immunoassay test only confirms the presence of the antibody, but actual reactivity must be determined by the patient’s history or by a supervised challenge. An allergen-inhalation challenge is done in specialized centers able to handle potentially significant reactions. This test is often needed to help diagnose occupational asthma.

Skin testing is preferred over in vitro testing because it is quicker, less expensive, and more sensitive. In certain circumstances, however, in vitro testing is advantageous over skin testing because it does not pose a risk of an allergic reaction. It is used in older adults with cardiovascular disease, patients with sensitivities to allergens that are associated with severe anaphylactic reactions, and patients with histories of severe reaction to very small amounts of the allergen.

Another advantage is that in vitro tests are not affected by medications that might cause confusion with skin testing.

Immunoassays are available for:

- Foods
- Insect venoms
- Environmental allergies such as pollen or dust, mites, or cockroaches
- Natural rubber latex
- Some beta-lactam drugs such as penicillin or cephalosporins
- Some occupational allergens
  
  (Kowal & DuBuske, 2017)

**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 screen for eosinophilia or significant anemia and to evaluate blood cells to provide information on infection and inflammation

- Alpha-1 antitrypsin level for lifelong nonsmoker, to exclude emphysema

- 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

- Tuberculin testing, to rule out tuberculosis (endobronchial tuberculosis can mimic asthma and is an important factor to consider in a patient with chronic cough and treatment-resistant asthma; it is often misdiagnosed as asthma)
  (Fanta, 2017a; Baris et al., 2015)

Other laboratory tests related to asthma may include:

- Blood gases (ABGs), during severe asthma attacks, to predict respiratory failure and the consequent need for mechanical ventilation (only patients whose oxygenation is not restored to over 90% with oxygen therapy require an ABG)

- 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. When airways are inflamed, nitric oxide levels are higher than normal
  (Morris, 2017)

KIT-ON-A-LID-ASSAY (KOALA)
KOALA 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 (Sackmann et al., 2014).
PULSE OXIMETRY

Pulse oximetry (PO) is used to determine hypoxemia in patients with acute asthma. PO is often used for infants and young children who are having an asthma attack. Because they cannot do lung function tests, PO indicates the severity of an asthma attack and whether the child requires hospitalization. Pulse oximetry measures the percentage of hemoglobin that is carrying oxygen.

A pulse oximeter device is placed on the finger, toe, or earlobe, and a beam of light is passed through to the blood in the capillaries. The amount of oxygen in the blood is measured, along with the pulse rate (Morris, 2017).

When taking a measurement using a finger, the sensor is placed at the base of the nail. It may be less accurate in patients with very dark skin, who are wearing nail polish or artificial nails, or who have cold hands or poor circulation.

![A finger mounted pulse oximeter with pulse bar taking measurements through the fingernail. (Source: ThinkPaul, 2011.)](image)

An oxygen saturation (SpO₂) reading greater than 95% is normal for a healthy individual. A reading of 91% to 95% is clinically acceptable but low and may be due to the patient being a smoker. Readings from 70% to 90% are unsafe levels and indicate hypoxemia. Less than 70% indicates extreme lack of oxygen.

It is important to note that the normal range can vary from patient to patient, and those with chronic respiratory disease may have an SpO₂ level below 90% without any acute respiratory problems (Morris, 2017).

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 and bronchial dilatation, which will not be present in certain other causes of cough (Morris, 2017).

**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, 2017).

**NUCLEAR IMAGING**

Ventilation scanning has been used as an indicator of ventilation defects in asthmatic children, as well as to assess distribution of aerosol and particulates from asthma medications (Morris, 2017).

**24-HOUR pH PROBE**

A 24-hour pH probe can be used to help diagnose GERD if a patient is not being managed effectively with asthma therapy (Morris, 2017).

**Classifying Asthma Severity**

There are two methods for classifying asthma severity:

- The **Global Initiative for Asthma (GINA) Guidelines** classify asthma according to treatment requirements.

- The **National Asthma Education and Prevention Program (NAEPP) Guidelines** (undergoing updating in 2018) classify asthma in adults based on signs and symptoms and in children based on signs, symptoms, and treatment requirements.

<table>
<thead>
<tr>
<th><strong>GINA 2018 GUIDELINES</strong></th>
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<tbody>
<tr>
<td><strong>Asthma Classification</strong></td>
</tr>
<tr>
<td>Mild</td>
</tr>
<tr>
<td>Moderate</td>
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</tbody>
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### Severe
Requires high-dose inhaled corticosteroids combined with long-acting beta-2 agonists to prevent uncontrolled asthma or asthma that remains uncontrolled despite this treatment


### NAEPP GUIDELINES*

<table>
<thead>
<tr>
<th>Asthma Classification</th>
<th>Signs, Symptoms, Treatment Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children 0 to 4 Years</strong></td>
<td><strong>Adults &amp; Children 5 Years and Above</strong></td>
</tr>
<tr>
<td>Intermittent (most common and least severe form of asthma)</td>
<td>• Symptoms 2 or fewer days per week&lt;br&gt;• Absence of nighttime awakenings&lt;br&gt;• Rescue medication used 2 or fewer days per week&lt;br&gt;• No interference with normal activity</td>
</tr>
<tr>
<td>Mild persistent</td>
<td>• Symptoms more than 2 days per week, but not daily&lt;br&gt;• Nighttime awakenings 1 to 2 times per month&lt;br&gt;• Rescue medication used more than 2 days per week but not daily&lt;br&gt;• Minor interference with normal activity</td>
</tr>
<tr>
<td>Moderate persistent</td>
<td>• Symptoms daily&lt;br&gt;• Nighttime awakenings 3 to 4 times per month&lt;br&gt;• Some limitation with normal activity&lt;br&gt;• Daily rescue medication use</td>
</tr>
</tbody>
</table>
**Severe persistent**

- Symptoms throughout each day
- Nighttime awakenings more than once a week
- Physical activities severely limited
- Rescue inhaler use several times per day

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* Undergoing updating in 2018.

Sources: Morris, 2017; Fanta, 2017a.

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**ASTHMA TREATMENT**

The goals of treatment for asthma include:

- Preventing long-term symptoms that interfere with daily living
- Maintaining lung function near the person’s personal best measurement
- Preventing repeated asthma attacks
- Providing the best medicine treatment with the fewest possible side effects

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 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.

PROPER USE OF INHALERS

It is important to read the device-specific instructions for proper use of any inhaler if they are to be effective. The following are general instructions for 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. All patients who are prescribed medications using inhalers should receive initial instructions and careful follow-up to ensure proper use.
These are the essential steps whether or not a spacer or VHC is used:

1. Take the cap off, inspect to make certain mouthpiece and spray hole are clean, and shake the inhaler 10 to 15 times.

2. Take a breath in and fully exhale the air in the lungs.

3. Hold the inhaler upright with finger on the top of the canister and thumb holding the bottom of the inhaler.
4. Put the inhaler in the mouth above the tongue and between the teeth. Seal lips around the inhaler. Close the lips around the mouthpiece (closed-mouth technique) or hold the mouthpiece 1 to 2 inches in front of the open mouth.

5. Begin to breathe in slowly. Press down on the inhaler one time and keep breathing in. (If the inhaler has a spacer or holding chamber, press down on the inhaler and wait 5 seconds before beginning to inhale.)

6. Hold the breath for 5 to 10 seconds.
7. Open the mouth and breathe out slowly.

Source: CDC, 2018c.

If taking 2 puffs of the quick-relief medication, wait 15 to 30 seconds and shake the inhaler again before taking the second puff. For other medicines it is not necessary to wait before taking the prescribed number of puffs. If using a steroid inhaler, rinse the mouth with water, gargle, and spit out the water (Hess & Dhand, 2018).

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.

INHALER CLEANING

It is important to keep the inhaler clean. Any powder in or around the hole where the medicine sprays out should be cleaned.

1. Remove the metal canister from the L-shaped plastic mouthpiece. Do not wash the canister or immerse it in water.
2. Rinse only the mouthpiece and cap by running warm tap water through them for 30 to 60 seconds.
3. Shake off excess water and allow the mouthpiece and cap to air dry overnight.
4. In the morning, put the canister back inside. Put the cap on.
5. Release one puff from the inhaler into the air away from the face.
6. Replace the mouthpiece cover.
7. Follow the manufacturer’s instructions for cleaning a dry powder inhaler.
   (Hess & Dhand, 2018)
CASE: Inhaler Education

Kamiko is a 35-year-old woman who has recently been diagnosed with asthma and has returned for her second follow-up appointment. 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 care physician.

When Kamiko was newly diagnosed with asthma and prescribed a rescue inhaler, she was given training in the proper use of the inhaler and was able to demonstrate proper technique and understanding of care of the device.

Today before Kamiko leaves the office, the nurse asks her to demonstrate the use of her inhaler again. 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 Kamiko’s 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, showing that she can now use her inhaler correctly. She is given a pamphlet to refer to at home that visually guides her through the technique, and another follow-up appointment is made with the nurse for reevaluation in two weeks.

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 (Chogtu et al., 2017).
Age, race, gender, and vision do not predict rates of inhaler misuse. Older patients, however, may be at risk for misuse due to a higher rate of low health literacy. A disparity has been shown between older and younger patients in their ability to learn proper inhaler techniques (Chogtu et al., 2017).

A recent study done found a suboptimal number of medical professionals—including physicians, respiratory therapists, registered nurses, and pharmacists—have the proper knowledge base and technical skill to teach different inhaler device techniques. The study found that respiratory therapists had the highest score, followed by pharmacists, RNs, and physicians. With the introduction of new inhalers requiring new techniques of administration, many patients may not be getting the medication they need (Alismail et al., 2016).

**Bronchodilators**

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 bronchoconstriction. There are three classes of bronchodilators:

- Beta-2 agonists
- Anticholinergics
- Methylxanthines
SHORT-ACTING BETA-2 AGONISTS (SABA)

Short-acting beta-2 agonists are often referred to as “quick-relief” or “rescue” medications. The smooth muscle in bronchioles (small airways) is relaxed by beta-2 adrenergic agonist drugs, which reverse and prevent further contraction of muscle cells.

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 and the effect then lasts for 3 to 6 hours.

### SHORT-ACTING BETA-2 AGONISTS (INHALED AND ORAL)

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuterol</td>
<td>Proventil HFA</td>
</tr>
<tr>
<td></td>
<td>Ventolin HFA</td>
</tr>
<tr>
<td></td>
<td>AccuNeb</td>
</tr>
<tr>
<td></td>
<td>Proair HFA</td>
</tr>
<tr>
<td></td>
<td>Proair Respiclick</td>
</tr>
<tr>
<td>Levalbuterol</td>
<td>Xopenex</td>
</tr>
<tr>
<td></td>
<td>Xopenex HFA</td>
</tr>
<tr>
<td>Terbutaline</td>
<td>None</td>
</tr>
</tbody>
</table>

**Side effects:**

- Tachycardia
- Tremors
- Jitteriness
- Palpitations

**Precautions:**

- Patients with heart disease, hyperthyroidism, seizure disorder, or hypertension should be closely monitored

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)
ANTICHOLINERGICS

Another group of bronchodilators, anticholinergics, are muscarinic receptor antagonists (parasympatholytics). They are used along with beta-agonists for treatment of severe symptoms. They are not, however, intended for acute asthma attacks.

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.

ANTICHOLINERGICS

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipratropium bromide</td>
<td>Atrovent HFA</td>
</tr>
<tr>
<td>Long-acting tiotropium</td>
<td>Spiriva Respimat</td>
</tr>
</tbody>
</table>

ANTICHOLINERGIC AND BETA-2 AGONIST COMBINATION

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipratropium and albuterol</td>
<td>Combivent Respimat</td>
</tr>
</tbody>
</table>

Side effects:

- Dry mouth

Precautions:

- Individuals with glaucoma should be carefully monitored by an ophthalmologist.
- Persons with allergy to soya lecithin (e.g., soybeans, peanuts) should not take these drugs.

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)
METHYLXANTHINES

Methylxanthines is the class of bronchodilators that includes caffeine. These drugs have 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. Methylxanthines can be helpful for relief of nighttime asthma symptoms.

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.

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

### METHYLXANTHINES

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theophylline (short-acting)</td>
<td>Elixophyllin</td>
</tr>
<tr>
<td></td>
<td>Theochron</td>
</tr>
<tr>
<td>Theophylline (long-acting)</td>
<td>Theo-24</td>
</tr>
<tr>
<td>Theophylline and dextrose injectable</td>
<td>None</td>
</tr>
<tr>
<td>Aminophylline (injectable)</td>
<td>None</td>
</tr>
</tbody>
</table>

**Side effects:**

- Severe nausea or vomiting
- Tremors
- Muscle twitching
- Seizures
- Severe weakness
- Confusion
- Irregular heartbeat

**Less severe side effects include:**

- GERD
- Loss of appetite
- Upset stomach
• Nervousness
• Restlessness
• Insomnia
• Loose stools

Precautions:

• Because theophylline is related to caffeine, ingesting large amounts of caffeine in coffee, tea, chocolate, or soft drinks may increase theophylline side effects.

• Some drugs, such as cimetidine (Tagamet), erythromycin (E.E.S.), and ciprofloxacin (Cipro), may increase theophylline levels.

• Phenytoin (Dilantin) and carbamazepine (Tegretol) may decrease theophylline levels.

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)
LONG-ACTING BETA-2 AGONISTS

Long-acting beta-2 agonists (LABA) are bronchodilators used for persistent asthma that is difficult to control. They open airways and reduce swelling for at least 12 hours. These medications are not rescue inhalers and should not be used as treatment for sudden asthma symptoms. They are used on a regular schedule to control moderate to severe asthma and to prevent nighttime symptoms along with or in combination with inhaled corticosteroids.

Long-acting beta-2 agonists are administered via a metered-dose inhaler or dry powder inhaler.

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmeterol</td>
<td>Serevent Diskus</td>
</tr>
<tr>
<td>Formoterol</td>
<td>Foradil</td>
</tr>
<tr>
<td>Albuterol</td>
<td>VoSpire ER</td>
</tr>
</tbody>
</table>

Side effects:

- Palpitations
- Tremor
- Headaches

Precautions:

- LABAs, when used by themselves, have been linked to severe asthma attacks and an increased risk of death. They are, therefore, only taken along with or combined with an inhaled corticosteroid.

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)
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 (ICS)

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. A small amount of ICS is swallowed with each dose, but it is much less than that of an oral corticosteroid.

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 two puffs twice a day; using DPI inhalers, patients typically take inhalations twice a day. Patients should rinse their mouths of any excess medicine after each treatment.

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beclomethasone dipropionate</td>
<td>QVAR</td>
</tr>
<tr>
<td></td>
<td>QVAR Redihaler*</td>
</tr>
<tr>
<td>Budesonide</td>
<td>Pulmicort</td>
</tr>
<tr>
<td>Fluticasone propionate</td>
<td>Flovent HFA</td>
</tr>
<tr>
<td></td>
<td>Flovent Diskus</td>
</tr>
<tr>
<td></td>
<td>Arnuity Ellipta</td>
</tr>
<tr>
<td></td>
<td>Armonair Respiclick</td>
</tr>
<tr>
<td>Mometasone</td>
<td>Asmanex HFA</td>
</tr>
<tr>
<td></td>
<td>Asmanex Twisthaler</td>
</tr>
<tr>
<td>Ciclesonide</td>
<td>Alvlesco</td>
</tr>
<tr>
<td>Flunisolide</td>
<td>Aerospan HFA</td>
</tr>
</tbody>
</table>

*QVAR Redihaler is the first and only breath-actuated aerosol inhaled corticosteroid for use in patients 4 years of age and older.
Side effects:

- Mouth and throat irritation
- Oral yeast infections

Precautions:

- Individuals with status asthmaticus or acute asthma attack should not use these drugs, as they are of limited benefit due to their slow action.
- ICS may decrease growth in children, so the lowest dose possible should be prescribed.
- ICS may increase risk of serious or fatal infections in those exposed to serious viral infections (e.g., chickenpox, measles).
- ICS can cause cataracts or glaucoma.
- ICS can increase the risk of pneumonia.

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)

INHALED CORTICOSTEROIDS COMBINED WITH LONG-ACTING BETA-2 AGONISTS

Combination inhalers contain both a corticosteroid and bronchodilator. They work so that the effectiveness of each may be enhanced when given simultaneously.

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formoterol and budesonide</td>
<td>Symbicort</td>
</tr>
<tr>
<td>Formoterol and mometasone</td>
<td>Dulera</td>
</tr>
<tr>
<td>Salmeterol and fluticasone</td>
<td>Advair Diskus</td>
</tr>
<tr>
<td></td>
<td>Advair HFA</td>
</tr>
<tr>
<td>Fluticasone furoate and vilanterol</td>
<td>Breo Ellipta</td>
</tr>
</tbody>
</table>

SYSTEMIC CORTICOSTEROIDS

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 in short “bursts” of 5 to 14 days. The frequency of initial oral use may be as often as 3 to 4 times daily for 1 to 2 days following an acute asthma attack. Oral corticosteroids should be taken daily upon awakening to coincide with the body’s normal biological rhythm. The smallest possible dose should be given to avoid long-term effects. Some can control symptoms with every-other-day dosing.

Intravenous injection may be given in the emergency room for a severe acute asthma attack.

### SYSTEMIC CORTICOSTEROIDS

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral prednisone</td>
<td>Prednisone Intensol</td>
</tr>
<tr>
<td></td>
<td>Rayos</td>
</tr>
<tr>
<td>Oral prednisolone</td>
<td>Orapred ODT</td>
</tr>
<tr>
<td></td>
<td>Pediapred</td>
</tr>
<tr>
<td></td>
<td>Prelone</td>
</tr>
<tr>
<td></td>
<td>Medrol</td>
</tr>
<tr>
<td>Injectable methylprednisolone</td>
<td>A-Methapred</td>
</tr>
<tr>
<td></td>
<td>Dep-Medrol</td>
</tr>
<tr>
<td></td>
<td>Solu-Medrol</td>
</tr>
<tr>
<td>Oral methylprednisolone</td>
<td>Medrol</td>
</tr>
<tr>
<td>Injectable triamcinolone</td>
<td>Kenalog</td>
</tr>
<tr>
<td></td>
<td>Aristospan</td>
</tr>
<tr>
<td></td>
<td>Triesence</td>
</tr>
</tbody>
</table>

**Side effects:**

- Increased appetite
- Indigestion
- Loss of appetite if taking triamcinolone
- Nervousness or restlessness
Side effects with long-term use:

- Mood changes
- Osteoporosis
- Sleep irregularities
- Cataracts
- Glaucoma
- Roundness of the face (moon facies)
- Intestinal bleeding
- Muscle weakness
- Decreased resistance to infection
- Hypertension
- Reduced growth in children
- Suppression of the body’s corticosteroid production

Precautions:

- When taking steroids chronically, they should not be abruptly discontinued. Tapering the drug allows the adrenal glands time to return to normal secretion patterns.
- Patients may experience withdrawal symptoms, including:
  - Weakness
  - Fatigue
  - Decreased appetite
  - Weight loss
  - Nausea
  - Vomiting
  - Diarrhea
  - Abdominal pain

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)
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. Leukotriene modifiers work in two ways:

1. By binding to cysteinyl leukotrienes receptors and blocking their activation and subsequent inflammatory cascade
2. By stopping or inhibiting the production of the enzyme 5-lipoxygenase, a precursor to the production of leukotrienes

Leukotriene modifiers can help prevent symptoms for up to 24 hours, are well tolerated, and 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.

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leukotriene receptor agonists</strong></td>
<td></td>
</tr>
<tr>
<td>Montelukast</td>
<td>Singulair</td>
</tr>
<tr>
<td>Zafirlukast</td>
<td>Accolate</td>
</tr>
<tr>
<td><strong>5-lipoxygenase inhibitor</strong></td>
<td></td>
</tr>
<tr>
<td>Zileuton</td>
<td>Zyflo</td>
</tr>
<tr>
<td></td>
<td>Zyflo CR</td>
</tr>
</tbody>
</table>

Side effects:

- Headache
- Earache
- Sore throat
- Increased risk for respiratory infections.

Precautions:

On rare occasions montelukast has been linked to psychological reactions such as:

- Agitation
- Aggression
• Hallucinations
• Depression
• Suicidal thinking

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)

Immunomodulators

MONOCLONAL ANTIBODY THERAPY

Monoclonal antibody (biologic) therapy uses monoclonal antibodies to bind to certain cells or proteins. They are add-on maintenance treatments for relief of acute asthma, providing an alternative to systemic corticosteroids. The first of these was a drug that targeted IgE, a component of the allergic cascade.

Recently two additional monoclonal antibodies have been approved as add-on therapy for poorly controlled eosinophilic asthma. These drugs target interleukin-5, which is a key cytokine in promoting eosinophil differentiation, survival, and recruitment.

Mepolizumab binds to interleukin-5, resulting in a decrease of certain inflammatory chemicals. Adults and children older than 12 years who have elevated eosinophils receive mepolizumab by injection every 4 weeks.

The cost for treatment with the immunomodulator omalizumab is estimated to be $12,000 to $15,000 per year.

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omalizumab (anti-IgE) Inj.</td>
<td>Xolair</td>
</tr>
<tr>
<td>Mepolizumab (anti-IL5) Inj.</td>
<td>Nucala</td>
</tr>
<tr>
<td>Benralizumab (anti-IL-5) Inj.</td>
<td>Fasenra</td>
</tr>
<tr>
<td>(for ages 12 and older)</td>
<td></td>
</tr>
<tr>
<td>Reslizumab (anti-IL5) Inj.</td>
<td>Cinquair</td>
</tr>
<tr>
<td>(for ages 18 and older)</td>
<td></td>
</tr>
</tbody>
</table>

Side effects:

• Pain or swelling in the area of injection
Precautions:

- Omalizumab has the rare potential to induce anaphylaxis, so it must be administered only in a closely observed clinic.
- The FDA has issued a warning about a slight increased risk for heart and brain blood vessel problems with omalizumab.

(Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018)

**MAST CELL STABILIZERS**

Mast cell stabilizers are inhaled medications that prevent the release of histamine and other inflammatory substances from mast cells. Mast cell stabilizers are not as potent as ICS. They prevent the release of histamines and other chemicals from mast cells that cause asthma symptoms.

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 and is not effective until 3 to 4 weeks after starting it. The effects last only 6 to 8 hours, requiring frequent dosing on a daily basis. For exercise-induced asthma, cromolyn can be taken within 10 to 15 minutes before, but not more than 60 minutes before. This drug is very safe and has few, if any, side effects (Fanta, 2017b; Schiffman, 2017; U.S. FDA, 2018).

Immunotherapy may be prescribed if asthma cannot be controlled by avoiding triggers. After allergens have been identified through skin or blood testing, injections are given once a week for a few months, and then once a month for 3 to 5 years. In some cases, desensitization may occur sooner. Over time, sensitivity to the allergic is lost (Fanta, 2017b).

**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 recommends the steps described in the following table:
## GINA STEP THERAPY

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>As needed short-acting beta-2 agonist (SABA) with no controller</td>
<td>Regular low-dose inhaled corticosteroid (ICS) for patients with exacerbation risks</td>
</tr>
<tr>
<td>2</td>
<td>Regular low-dose ICS plus as-needed SABA</td>
<td>• Leukotriene receptor agonist (LTRA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ICS + long-acting beta-2 agonist (LABA)</td>
</tr>
<tr>
<td>3</td>
<td>Low-dose ICS + LABA or medium-dose ICS plus as-needed SABA</td>
<td>• Medium-dose ICS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• For children 6–11 years, medium-dose ICS or low-dose ICS + LABA</td>
</tr>
<tr>
<td>4</td>
<td>Low-dose ICS + formoterol maintenance and reliever therapy, or medium dose ICS + LABA as maintenance plus as-needed SABA</td>
<td>• Add-on tiotropium by soft-mist inhaler for 12 years and over with a history of exacerbations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High-dose ICS + LABA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extra controller LTRA or slow-release theophylline for adults</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Children 6–11 years, refer for expert assessment and advice</td>
</tr>
<tr>
<td>5</td>
<td>Refer for expert investigation and add-on treatment with omalizumab</td>
<td>• Add-on tiotropium by soft-mist inhaler for 12 years and over</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Add-on anti IgE for 6 years and over</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Add-on Anti-IL-5 for 12 years and over</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• IV resizumab for 18 years and over</td>
</tr>
</tbody>
</table>


## WHEN TO REFER

Referral to a pulmonologist or allergist/immunologist is recommended in the following circumstances:

- A patient has experienced a life-threatening asthma attack
- The patient has required hospitalized or more than two bursts of oral glucocorticoids in a year
- The adult and pediatric patient over 5 years of age that requires step 4 care or higher or a child under 5 years who requires step 3 or higher
- For patients whose asthma is not controlled after 3 to 6 months of active therapy and monitoring
- The patient who appears to be unresponsive to therapy
• The diagnosis of asthma is uncertain
• Other conditions exist that complicate management
• When additional diagnostic tests are needed
• If the patient is a candidate for allergen immunotherapy
• The patient is a candidate for therapy with biologics or bronchial thermoplasty
• The adult or child older than 5 years who requires step 3 care or higher
• The child under 5 who requires step 2 or higher
• Patients with possible occupational triggers
• Patients with psychosocial or psychiatric problems which interfere with asthma management
  (Fanta, 2017b)

Nonpharmacologic Asthma Procedures

For patients with severe asthma that remains unimproved with the use of inhaled corticosteroids or long-term asthma medication, a minimally invasive procedure has been developed known as *bronchial thermoplasty*.  

**Bronchial thermoplasty** takes place over three hour-long sessions and involves heating the inside of the airways in the lungs with an electrode. This causes a reduction in smooth muscle, which limits the ability of the airways to tighten, thus making it easier to breathe and possibly reducing asthma attacks. Currently, however, this treatment is not widely available (Fanta, 2017b).

MANAGEMENT OF ASTHMA EXACERBATIONS (ATTACKS)

The most effective strategy for dealing with an *asthma attack* is early recognition and treatment. In ideal situations, patients assess the severity of an asthma attack at home by following an individualized asthma action plan (see “Developing an Asthma Action Plan” later in this course).

Some patients are more sensitive to an increase in asthma symptoms than others who may not recognize a problem until reduced airflow becomes more severe. This group may not know that asthma is worsening until a PEF measurement shows a decrease. It is helpful to identify these patients and provide education stressing that recognition of early signs of worsening asthma should be based on PEF monitoring.
Patients with a history of the following are at high risk for a fatal asthma attack:

- Previous severe exacerbation (e.g., intubation, intensive care unit admission)
- Hospitalization for asthma in the past year
- Three or more emergency department visits for asthma in the past year
- Currently not using inhaled glucocorticoids
- Recent or current course of oral glucocorticoids
- Use of more than one canister of SABA per month
- Difficulty perceiving asthma symptoms or severity exacerbations
- Poor adherence with asthma medication and/or written asthma action plan
- Illicit drug use and major psychosocial problems including depression
- Comorbidities (e.g., cardiovascular or chronic lung disease)
  (Fanta, 2018)

**Basic Principles of Asthma Management**

Basic principles of management of asthma to control hypoxia and to reverse airflow obstruction include:

- Assess the severity of the attack.
- Assess potential triggers.
- Use inhaled short-acting beta-2 agonists (SABA) early and frequently.
- Consider concomitant use of ipratropium for severe exacerbations.
- Start systemic glucocorticoids if there is not an immediate and marked response to the inhaled SABA.
- Make frequent (every 1 to 2 hours) objective assessments of response to therapy until definite, sustained improvement is documented.
- Admit patients who do not respond well after 4 to 6 hours to a setting of high surveillance and care.

**Initial Home Management**

The goals for home management are to relieve symptoms and prevent worsening of the attack to a severe and possibly life-threatening event. Patients should follow the instructions in their asthma action plan, which may include:
• SABA: 2 to 8 puffs preferably using a spacer (valved holding chamber device) or via nebulizer. This dose may be repeated every 20 minutes for the first hour as needed. A mild asthma attack usually responds to 2 to 4 puffs every 3 to 4 hours. A more severe attack may require 6 to 8 puffs every 1 to 2 hours.

• After the first hour, if there is improvement with SABA, a PEF measurement should be done. Patients should contact their clinician if they require high doses of inhaled SABA beyond the first hour of self-treatment.

• If there is a good response to home treatment and repeat PEF increases to >80% of the patient’s baseline over the course of about one hour, then the patient can safely continue home treatment.

• If there is an incomplete response, the clinician should be contacted for advice and possible initiation of oral glucocorticoids, 40 to 50 mg daily for 5 to 7 days.

• The single most effective strategy for reducing emergency department visits and hospitalization for acute asthma is the timely administration of oral glucocorticoids.

• If initial home treatment is unsuccessful and there are signs or symptoms of severe asthma, or if the peak flow is <50% of the patient’s baseline, urgent medical attention should be sought.

The patient should not drive him or herself to the urgent care setting, and inhaled SBA should continue to be used while waiting for help to arrive (Fanta, 2018; Morris, 2017).

ASTHMA HOME MANAGEMENT FOR INFANTS AND CHILDREN

When children or their caregivers recognize the onset of an exacerbation, an inhaled SABA should be administered using an MDI with spacer or nebulizer. Two to 4 puffs of albuterol or 1.25 mg nebulized solution per dose. Symptoms should be assessed in 10 to 30 minutes, and if needed, the dose can be repeated (Scarfone, 2018).

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.

• Loosen clothing.
• 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 breathing 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 black tea), which can help open 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.)

• Seek emergency medical help if wheezing, coughing, and breathing difficulty do not subside after a period of rest.

(SGH, 2016; AHC, 2017.)

CASE: Responding to an Attack

Gabriela, an RN, volunteers at her town’s summer concert series. The concerts are held once a month at one of the local parks, and people sit on blankets or folding chairs on a hillside overlooking the lake and stage.

Shortly after the first intermission starts, a frantic mother and teenager enter the first aid tent. The mother shouts, “My daughter Mattie needs hot coffee RIGHT NOW!” Mattie is pale, bent forward clasping her chest, struggling for breath, and obviously anxious. The mother tells the volunteers that her daughter is having an asthma attack, doesn’t have her inhaler, and that her doctor said hot black coffee could be used while waiting for an ambulance. She tells them Mattie had been exposed to cigarette smoke up on the hillside and that it’s one of her asthma triggers.

Gabriela remains with Mattie and her mother while another volunteer goes to a nearby concession stand for the coffee and a third calls 911. Mattie tells Gabriela that her chest feels tight and that she can’t breathe. Gabriela tells her to sit down and sit up straight. She talks calmly to Mattie while applying a pulse oximeter to her finger, telling her to start taking slow deep breaths, to breathe in through her nose, and to breathe out through her mouth while pursing her lips. Mattie’s SaO₂ is 95% on room air, and Gabriela tells Mattie that her “oxygen number” is within a safe range, the coffee is coming, and the ambulance will arrive shortly. Gabriela continues to talk calmly to both Mattie and her mom and notes that as they talk, Mattie appears less anxious and her SaO₂ drifts between 94% and 96%.

The hot coffee arrives and Mattie drinks it slowly but steadily, grimacing because she “hates coffee.” The ambulance arrives, and the EMTs assess Mattie, whose SaO₂ is now 96% on room
air. Per protocol, they administer a bronchodilator by nebulizer and monitor her response. Mattie responds well to the nebulizer treatment and meets criteria for discharge-to-home with an SaO₂ of 99%.

During the entire treatment, Mattie’s mom vacillates between holding her daughter’s hand and berating herself for forgetting to bring the inhaler. One of the other volunteers stays with her and encourages her to be a bit easier on herself and try to remain calm to help Mattie relax.

As Mattie’s primary volunteer care provider, Gabriela tells Mattie, who is 17 and a high school senior, that she is not blaming either her or her mom for forgetting the inhaler but encourages her to take responsibility for making certain she has her inhaler with her at all times. She also asks if Mattie has a written asthma action plan, to which she replies yes.

When Mattie and her mother leave, they assure themselves and the volunteers that this has been a scary but valuable lesson. At the end of the concert, they stop by the tent to report that Mattie is doing fine and has had no further problems.

### Asthma EMS Management

EMS management begins with assessment, which may be complicated by a setting that includes noise, distractions from bystanders or family, and an anxious hypoxic patient who is unable to provide a complete history.

The primary goal in EMS treatment of asthma is the reversal of bronchospasm with short-acting beta-2 agonists (SABA) and anticholinergic (ipratropium) bronchodilators, with a secondary goal of reducing inflammation, typically with corticosteroids.

Nebulized albuterol, connected to oxygen at 6–8 L/min, is the first EMS treatment for asthma. CPAP (continuous positive airway pressure) is a prehospital treatment option for moderate to severe asthma attacks. CPAP increases the pressure that the patient exhales against, which pushes open lower airways and improves gas exchange. Nebulized bronchodilators should be administered through CPAP, which provides an air-tight seal to help direction medication into the lower airways.

Ipratropium bromide can be mixed with albuterol in a nebulizer, which causes bronchodilation and inhibits mucus secretion. Both can be administered until the patient’s symptoms improve. Magnesium sulfate intravenously may also be administered for its effect as a smooth muscle relaxant.

For patients who are anxious or combative during a severe asthma attack, ketamine IV or IM is the ideal medication for sedation, as it causes bronchodilation and does not carry a risk of respiratory depression. It may help patients tolerate having an oxygen mask or CPAP applied.

Patients who have taken multiple doses of quick-relief medications without response may be in the late phase of an asthma attack, and albuterol and ipratropium will be unable to go past the
upper airways. At this point parenteral beta-agonist therapy may be given; epinephrine or terbutaline may be administered subcutaneously or intramuscularly.

An IV is started and normal saline is run wide open to hydrate the patient and loosen secretions. Methylprednisolone or dexamethasone IV is then given to reduce inflammation.

Asthma patients with impending respiratory arrest require assisted ventilation starting with a bag valve mask and may later require intubation (Gandy, 2017; Sullivan, 2015).

**CAPNOGRAPHY**

One recent addition to assist in assessment is waveform capnography. Capnography is a noninvasive measurement during inspiration and expiration of the concentration of carbon dioxide in the respiratory gases. End tidal capnography (EtCO₂) is the measurement of the amount of carbon dioxide at the end of an exhaled breath. The results are displayed on a screen in waveforms, and provide an immediate picture of the patient’s condition.

![Capnography waveform measuring amount of exhaled carbon dioxide.](Source: Rschiedon at Dutch Wikipedia, CC BY-SA 3.0.)

**CASE: EMS Response to an Asthma Attack**

EMS crew 3 is called to the home of Howard by his wife, who reports he is experiencing a severe asthma attack. When they arrive, they find Howard wheezing and extremely dyspneic. The patient’s wife tells the team he has been using his rescue inhaler multiple times over the last few hours without relief.

The crew determines Howard is nearing respiratory arrest as evidence by his inability to speak two words in a row, severely reduced tidal volume, cool and clammy skin, and rapid heart rate and breathing.

Paramedic Jordan administers 0.5 mg IM epinephrine 1:100 IM immediately, and EMT Sharon places the patient on CPAP at 5 mmHg. Jordan starts an IV of normal saline followed by
administration of 125 mg of methylprednisolone. Magnesium sulfate 2 gm IV is then started to run over 10 minutes. Capnography is used to monitor Howard’s response to treatment, which begins to show improvement, and he is then transported to the hospital emergency department.

**Emergency Department Management**

The general approach to management of a patient with acute asthma in the emergency department begins with an initial quick assessment to determine whether the patient has any of the risk factors for potentially fatal asthma or signs and symptoms that may suggest a potential fatal asthma attack. Such signs include:

- Use of accessory muscles
- Heart rate >120 bpm
- Respiratory rate >25 to 30 per minute
- Difficulty speaking due to dyspnea or fatigue
- Altered level of conscious
- Quiet chest in a patient with dyspnea or reduced level of consciousness
- Diaphoresis
- Inability to lie supine
- PEF <30% of predicted or FEV1 <25% of predicted 1 to 2 hours after initial therapy
- Oxygen saturation <90%
- Cyanosis

Symptoms include:

- Sense of progressive breathlessness or air hunger
- Sense of fear of impending doom
- Progressive agitation or anxiety

Patients who meet these criteria should be closely monitored within the ED for 1 to 2 hours after arrival, IV should be inserted, and pulse oximetry used to continuously monitor oxygenation.

Following assessment, immediate goals for treatment of asthma include the rapid reversal of airflow obstruction and correction of severe hypercapnia or hypoxemia.
In the ED, **standard treatment** includes:

- **Supplemental oxygen** titrated to maintain the SpO₂ at >92% (>95% for pregnant patients).

- **SABA** (albuterol) 2.5 to 5 mg by jet nebulization every 20 minutes for 3 doses, then 2.5 to 10 mg every 1 to 4 hours as needed.
  - Alternatively, 4 to 8 puffs of albuterol by MDI with a spacer can be given every 30 minutes for 3 doses, and then 4 to 8 puffs every 1 to 4 hours as needed.
  - For critically ill patients, albuterol can be given continuously by nebulizer administering 10 to 15 mg over one hour.
  - Oxygen or compressed air delivery for nebulizer should be at a rate of 6 to 8 L/min for children with 0.15 mg/kg (minimum dose 2.5 mg) every 20 minutes for 3 doses, then 0.15 to 0.3 mg/kg up to 10mg every 1 to 4 hours as needed.

- For patients who are seriously ill and do not respond to serial treatment with SABA or other more established therapies, parenteral SABA such as 0.25 mg terbutaline or 0.3 mg of 1:1000 concentration of epinephrine may be administered subcutaneously.

- Inhaled **ipratropium** may be helpful for patients with severe exacerbations. This is administered by nebulizer 500 mcg every 20 minutes for 3 doses as needed for up to 3 hours. In children with moderate to severe asthma, ipratropium combined with SABA may be given by nebulizer every 20 to 30 minutes for 3 doses or continuously.

- **Systemic glucocorticoids** should be administered to all patients with moderate or severe asthma, or to those in which inhaled SABA did not fully correct the peak flow. **Prednisone** is usually given 40 to 60 mg per day in a single dose or two divided doses.

- A one-time infusion of **magnesium sulfate**, 2 grams administered intravenously over 20 minutes, is recommended for patients with life-threatening exacerbations or for those whose exacerbation remains severe after one hour of intensive conventional therapy.

- **Heliox** (a helium-oxygen mixture) is currently under investigation as a treatment for persons with asthma; it may provide benefits for patients with severe exacerbations. Helium is about 10% as dense as room air and, consequently, travels more easily down narrowed airway passages. This is valuable for patients at risk for intubation, as it decreases the work of breathing rapidly, and when used to drive the nebulizer, it results in better delivery of the bronchodilator.

Patients should be closely monitored, including serial measurements of vital signs, pulse oximetry, lung function, and arterial blood gases if necessary to assess response to treatment.
WHEN TO HOSPITALIZE

Despite efforts, if there is no response after 4 to 6 hours of intensive therapy, patients with PEF >50% but <80% may need hospitalization, especially if they have new onset asthma, are at high risk for fatal asthma, or presented while on a course of oral glucocorticoids.

Indications for hospitalization are based on findings from repeated assessment of the patient after receiving three doses of inhaled bronchodilator and include:

- Duration and severity of asthma symptoms
- Severity of airflow obstruction
- Course and severity of prior exacerbations
- Medication use and access to medications
- Home conditions and adequacy of support
- Presence of psychiatric illness

Decision to intubate and initiate mechanical ventilation during a severe asthma attack is based on:

- Slowing of respiration rate
- Depressed mental status
- Inability to maintain respiratory effort
- ABGs indicating worsening hypercapnia and associated respiratory acidosis
- Inability to maintain an oxygen saturation >92% despite high-flow supplemental oxygen

Close to 5% to 10% of all hospital admissions for asthma are admitted to the intensive care unit. These include patients who require close supervision. Patients are admitted to the ICU who:

- Are at very high risk of requiring intubation
- Were intubated in the emergency room
- Require ventilator support
- Fail to respond to therapy as evidenced by:
  - Deteriorating PEF
  - Persisting or worsening hypoxia
  - Hypercapnia
  - ABGs showing hypoxia or hypercapnia
Exhaustion, feeble respirations
Drowsiness, confusion, altered conscious state
Respiratory arrest

Patients being transferred to intensive care units should be accompanied by a provider suitably equipped and skilled to intubate if necessary (Fanta 2018; Morris, 2017).

DISCHARGE FROM THE ED

Most patients with improving symptoms and a PEF >60% of predicted can be safely discharged if they are knowledgeable about their asthma and have the availability of follow-up care. Even with a rapid improvement, patients should be watched for 30 to 60 minutes to be certain they are stable before being released.

The patient should be discharged with oral glucocorticoids (e.g., prednisone 40 to 60) for a period of 5 to 7 days. Intramuscular injection of a long-acting glucocorticoid formulation is occasionally given to patients who do not have access to oral medication or are at a high risk for medical nonadherence.

Every single patient who has had an asthma attack severe enough to require emergency management should be given an inhaled glucocorticoid as part of the discharge medication plan.

Patient education includes a brief, focused session providing information about asthma, how to avoid asthma triggers, and how to provide initial home management in the event of further exacerbations. If the patient does not already have one, a personalized asthma action plan is provided.

Follow-up care with a primary provider is recommended and facilitated whenever possible (Fanta, 2018).

CASE: Emergency Department Response

Manuel, a 20-year-old college student, arrives with his girlfriend, Jimena, to the emergency department complaining that he cannot breathe. Jimena tells the triage nurse that Manuel has a history of asthma and that he has been using his controller medication only sporadically because he has no health insurance and cannot afford to refill his medication. This week she says he has been using his quick-relief inhaler every day, and today he did not have a response. She says she believes the canister is empty.

The triage nurse, Jake, immediately places Manuel in a room and positions him in high Fowler’s. He begins assessment of Manuel and notes his breathing is labored; he has audible wheezing and can only speak in two- or three-word sentences.

A focused examination shows a pulse of 122 bpm and respiratory rate of 34. Continuous pulse oximetry is begun, with initial O2 saturation of 89%. Jake applies supplemental oxygen per
nasal cannula at 2 L/min and places Manuel on a cardiac monitor, which indicates sinus tachycardia.

The ED physician examines Manuel and finds he has diminished breath sounds and expiratory wheezing in all lung fields. Oxygen is increased to 3 L/min to reach an $O_2$ saturation of 92%.

A nebulized SABA bronchodilator is begun. An IV is started, and Jake administers IV glucocorticoid. He obtains an arterial blood gas sample, which indicates hypoxia and hypercapnia.

The albuterol nebulizer treatment is repeated for a total of three treatments over the next hour. Monitoring of response to the nebulized treatment after the second treatment shows an increase in wheezing, a sign of improvement, as the bronchodilator has begun to open the airways.

After Manuel’s third treatment, his pulse is 100, respiratory rate 22, and $O_2$ saturation 97%. Auscultation reveals improved air flow through all lung fields and only a few expiratory wheezes.

Manuel is now able to answer questions without difficulty and remains under observation in the emergency department for an hour to ensure resolution.

Prior to discharge, Manuel is given an intramuscular injection of a long-acting glucocorticoid in lieu of the fact he has not been medication adherent in the past. He is supplied with a combination controller inhaler as well as a quick-relief inhaler with instructions in their use.

An individualized asthma action plan is prepared for Manuel in collaboration with Jake, the respiratory therapist, and the physician. He is given a list of available Pharmaceutical Assistance Programs (PAPs) for free or low-cost asthma medications and instructed to have a follow-up with a primary care provider within 12 to 24 hours. He is given a list of clinicians and clinics in his area.

**ASTHMA EXACERBATION MANAGEMENT IN CHILDREN**

Several clinical asthma severity scores for pediatric patients have been developed for use in evaluation of initial exacerbation severity, response to treatment, and determination of the need for hospitalization. These include:

- **PRAM** (Pediatric Respiratory Assessment Measure) uses five variables: wheezing, air entry, contraction of scalene, suprasternal retraction, and oxygen saturation.
- **PIS** (Pulmonary Index Score) is based on five clinical variables: respiratory rate, degree of wheezing, inspiratory-to-expiratory ratio, accessory muscle use, and oxygen saturation.
- **PASS** (Pediatric Asthma Severity Score) is for patients aged 1 to 18 and includes three clinical findings: wheezing, prolonged expiration, and work of breathing.
• **RAD** (Respiratory rate, Accessory muscle use, and Decreased breath sounds) is used for children aged 5 to 17 years.

Continuous pulse oximetry monitoring should be done. Small children should be placed on infant oxygen flow meters to allow accurate weaning below 1 L/min of flow.

Criteria for admission of children to inpatient care are based on clinical and social factors. Children who were moderately to severely ill on arrival and who show little improvement following initial therapy with SABA and systemic glucocorticoids require hospitalization. This includes children who continue to have significant wheezing and retracting, poor aeration, or altered mental status (e.g., drowsiness or agitation). It also includes children who require supplemental oxygen, those with a history of rapid progression of severity in past exacerbations, and those with poor adherence to outpatient medication regimen.

Social criteria include inadequate access to medical care, including lack of transportation back to the hospital if deterioration occurs, poor social support system at home with inability of caregivers to provide medical care and supervision (Scarfone, 2018; Sawicki & Haver, 2018).

**ASTHMA EXACERBATION MANAGEMENT IN PREGNANT WOMEN**

Exacerbations are a major clinical problem during pregnancy, with nearly 45% of women needing to seek medical help, resulting in poor outcomes for mothers and their babies (Murphy, 2015). Severe and/or poorly controlled asthma has been associated with numerous adverse perinatal outcomes, including:

- Preeclampsia
- Uterine hemorrhage
- Preterm labor
- Premature birth
- Congenital anomalies
- Neonatal seizures
- Tachypnea
- Neonatal intensive care unit admission

Pregnant patients who present with typical mild exacerbation should be placed on a cardiac monitor and pulse oximetry. They are treated in the same way that nonpregnant women with similar symptoms would be using bronchodilator therapy and steroids.

Concerns have been raised regarding use of systemic glucocorticoids, including a slight increased risk of congenital malformations (primarily cleft palate), preeclampsia, low birth weight, and neonatal adrenal insufficiency. These risks are considered small compared to the
higher risk to both mother and fetus of severe, uncontrolled asthma (Schatz & Weinberger, 2018).

Supplemental oxygen should be administered to maintain oxygen saturation higher than 95%, and fetal monitoring is important after 20 weeks of gestation during severe asthma attacks.

Criteria for inpatient hospitalization include:

- Arterial blood gas oxygen saturation <70 mmHg
- Signs of fetal distress:
  - Decreased movement
  - Abnormal cardio tocodynamometry (electronic monitoring and recording of uterine contractions)
  - Uterine contractions
- Multiple medication use (three or more medications simultaneously)
- A protracted course with poor response
- History of severe asthma requiring intubation or ICU admission
- Inadequate home conditions and transport/access to ED (Little, 2016)

**ASTHMA 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:
  o Done on admission and every 4 hours x 12 hours
  o After 12 hours, every 6 hours
• Monitoring PEF rate:
  o If the patient is on hourly nebulizer treatments, peak flow every hour
  o Pre- and post- twice-daily nebulizer treatments
• Monitoring oxygen saturation with spirometry:
  o Provide supplemental oxygen to keep O₂ saturation adequate (>90% for adults, >95% for children)
  o Discontinue when O₂ saturation is adequate for 4 hours and patient is on general ward
  o Continue spot checks of O₂ saturation with vital signs or as needed for respiratory distress
• Telemetry monitoring indications:
  o Albuterol nebulizer treatments required more often than every 4 hours
  o For child, corroborate telemetry reading with spirometry reaching as child’s movements make O₂ saturation inaccurate
• Obtaining ABGs on admission
• Evaluating pulmonary function tests. Criteria:
  o PEF <30%
  o Prior history of pCO₂ >40
  o Failure to improve in 4 hours of therapy
  o Clinical asthma score >7
• Monitoring for and treating electrolyte imbalances:
  o Nausea or vomiting
  o IV fluids administered for more than 24 hours
  o Beta agonist use more often than every 4 hours for 24 hours
• Evaluating for signs of improvement:
  o Minimal or no wheezing
  o Less than two night awakenings for mild asthma symptoms
  o Good activity tolerance
- Pulmonary function test: PEF or FEV1 >70% of baseline
- Adequate O₂ saturation off supplemental oxygen

- Determining the need for more intensive treatment options (ICU):
  - Admit to ICU if no improvement in 6 to 12 hours
  - Presence of red flags suggestive of impending respiratory failure

- Criteria for discharge:
  - Patient requires inhaled beta agonist no more than once every 4 hours
  - Parenteral steroids switched to oral corticosteroids
  - Adequate O₂ saturation on room air

- Preparing for discharge:
  - Asthma education, including:
    - Instructions and return demonstration for use of inhaled controller medications
    - Patient uses inhaled corticosteroid at the bedside correctly
    - Instruction in obtaining peak flow measurements at home
  - Completing a personalized asthma action plan
  - Appointment made for follow-up in 7 to 10 days after discharge

(HPN, 2018)

**Inpatient Nursing Management**

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 to the patient’s individual needs. In the creation of a care plan, specific problems are identified, related factors are acknowledged, defining characteristics are considered, and a nursing diagnosis is made. Common nursing diagnoses for a patient with asthma 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, ineffective cough, and decreased energy or fatigue as evidenced by:

- Abnormal breath sounds
- Abnormal rate rhythm/depth
- Excessive secretions
- Cyanosis
- Inability to cough up secretions
- Ineffective or absent cough
- Orthopnea

Goals/outcomes of nursing interventions are that the patient will:

- Maintain clear and open airways as evidence by:
  - Normal breath sounds
  - Normal rate/depth of respirations
  - Effective cough after treatment and deep breaths
  - Increased air exchange

Nursing Assessment

- Auscultate lungs for airway patency and for abnormal breath sounds:
  - Decreased or absent breath sounds
  - Wheezing (high-pitched whistling)
  - Expiratory grunt
  - Rales (clicking, rattling, crackles)
  - Rhonchi (low-pitched rattle)
  - Stridor (high-pitched musical sound)

- Assess rate and depth of respirations:
  - Hyperventilation
  - Tachypnea
• Assess for changes in mental status:
  o Increased lethargy
  o Confusion
  o Restlessness
  o Irritability

• Assess vital signs:
  o Elevated temperature may indicate infection

• Assess effectiveness of cough and productivity.

• Assess sputum for quality, amount, color, and constancy:
  o Signs of infection (odor and discoloration)
  o Signs of dehydration (thick, tenacious)

• Assess hydration status:
  o Skin turgor
  o Mucous membranes
  o Tongue

• Assess for abdominal or thoracic pain:
  o Cause for shallow breathing and ineffective cough

**Nursing Interventions**

• Teach and assist with effective ways to remove secretions, such as taking a deep breath, holding it for 2 seconds, and then coughing two or three times in succession.

• Position patient in high Fowler’s, if tolerated, to improve lung exchange and air exchange.

• Provide education that includes:
  o Proper sitting position to promote use of abdominal muscles for more forceful cough
  o Use of incentive spirometry
  o Importance of ambulation and frequent changes in position to promote secretion mobilization

• Maintain humidified oxygen to reduce thickness of secretion.

• Encourage fluid intake to 3 L/day if tolerated to minimize mucosal drying.
• Give medications as prescribed and document effectiveness and side effects.
• Coordinate with respiratory or physical therapy for chest physical therapy and nebulizer management.
• Provide oral care every 4 hours.
• Pace activities to avoid fatigue and promote energy-conservation techniques.
  (Wayne, 2016)

INEFFECTIVE BREATHING PATTERN

Ineffective breathing pattern exists when the patient’s inhalations and exhalations do not allow for adequate ventilation. Patients with asthma are prone to dysfunctional breathing patterns most often related to hypoxia, the underlying inflammatory process, tracheobronchial constriction, decreased energy, fatigue, or anxiety as evidenced by:

• Cough
• Cyanosis
• Dyspnea
• Nasal flaring
• Prolonged expiration
• Changes in respiratory depth
• Tachypnea
• Accessory muscle use

Goals/outcomes of nursing interventions are that the patient will:

• Reach and maintain optimal breathing pattern as evidenced by:
  o Relaxed and normal breathing pattern
  o Normal breathing rate
  o Absence of dyspnea

Nursing Assessment

• Assess vital signs for evidence of hypoxia and hypercapnia:
  o Decreased blood pressure
  o Decreased heart rate
• Assess respiratory rate, depth, and rhythm for signs of impending respiratory failure:
  o Inability to breath, cyanosis related to hypoxemia
  o Increased respiratory rate, confusion related to hypercapnia
• Assess breath sounds for signs of respiratory failure:
  o Decreased wheezing
  o Indistinct breath sounds
• Assess relationship of inspiration to expiration.
• Assess for signs of dyspnea:
  o Flared nostrils
  o Chest retractions
  o Accessory muscle use
• Assess for conversational dyspnea (inability to converse without difficulty).
• Assess for fatigue (may lead to respiratory failure).
• Assess for the presence of pulsus paradoxus greater than 12 mmHg or greater during inspiration (decrease in systolic blood pressure and pulse amplitude during inspiration).

Nursing Interventions

• Plan for periods of rest between activities to reduce metabolic rate and oxygen requirements.
• Maintain elevated head of bed to 45 degrees.
• Demonstrate and encourage diaphragmatic and pursed-lip breathing.
• Administer medications as ordered.
• Monitor oxygen saturation levels (normal is 95%–100%).
• Monitor PEF and FEV1 as taken by respiratory therapy.
  (Martin, 2016)

IMPAIRED GAS EXCHANGE

Impaired gas exchange is excess or deficit in oxygenation and/or carbon dioxide related to altered oxygen supply due to bronchospasm, mucosal edema, and mucus plug formation as evidenced by the same manifestations as patients with both impaired airway clearance and impaired breathing pattern but also:
• Abnormal arterial blood gases
• Changes in vital signs, tachycardia
• Restlessness
• Irritability
• Anxiety
• Cyanosis
• Decreased O₂ saturation

Goals/outcomes of nursing management:
• Absence of respiratory distress signs and symptoms
• Oxygen saturation persisting at >90%
• Improved arterial blood gases
• Normal mentation

Nursing Assessment
• Assess and monitor skin and mucous membranes for peripheral cyanosis (nailbeds) or central cyanosis (lips/earlobes). Duskeness and central cyanosis indicate advanced hypoxemia.
• Auscultate breath sounds for decreased airflow and adventitious sounds.
• Assess for signs of hypoxemia:
  o Tachycardia
  o Restlessness
  o Diaphoresis
  o Headache
  o Lethargy
  o Confusion
  o Somnolence

Nursing Interventions
• Monitor arterial blood gases for signs of respiratory failure.
• Elevate 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.

• Encourage prone position as tolerated to increase PaO₂.

• Encourage expectoration of secretions and suction as needed.

• Monitoring oxygen saturation utilizing continuous pulse oximetry.

• Evaluate level of activity tolerance:
  - Pace activities and schedule rest periods to prevent fatigue.
  - Resume activity gradually.

• Encourage deep breathing using incentive spirometry as indicated.

• Evaluate sleep:
  - Provide quiet environment.
  - Group care or monitoring activities to avoid interrupting sleep.

• Monitor vital signs and cardiac rhythm. Tachycardia, dysrhythmias, and blood pressure change reflect effect of systemic hypoxemia on cardiac function

• Anticipate the need for intubation and mechanical ventilation.

• Administer medications as prescribed and monitoring effectiveness.

(Wayne, 2016)

ASTHMA 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 the primary care provider

**Asthma Inpatient Respiratory Therapy**

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, ECG, and pulse oximetry
- Administer and titrate oxygen therapy

For patients with severe exacerbations, respiratory therapists play a key role in ICU management of arterial lines, blood gases, and mechanical ventilation (Kacmarek et al., 2017).

**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.

**ASTHMA MEDICATION MANAGEMENT**

Medication management for a patient diagnosed with asthma is based on the patient’s severity of symptoms and follows step-therapy guidelines (see “Pharmacology Step Therapy” above). Patients should be seen 1 to 3 months after starting treatment and every 3 to 12 months thereafter. Pregnant women, however, should be reviewed every 4 to 6 weeks. Once control of asthma is achieved and maintained for at least 3 months, a gradual reduction of the maintenance
therapy should be tried in order to identify the minimum therapy required to maintain control (GINA, 2018).

ASSESSING ASTHMA CONTROL

Achieving and maintaining asthma control are the goals of therapy. Accurate assessment is difficult due to the complex nature of asthma control and to the limitations of assessment methods. Lung function testing is insufficient because patients may have normal spirometry readings between exacerbations. Asthma control level is often overestimated by both clinicians and patients. Patients often under-report asthma symptoms, failing to recognize how asthma affects their daily activities. There are several standardized tools developed to quantify the level of asthma control. These tools are simple and easy for patients to complete and include:

- Asthma Control Test (ACT)
- Childhood Asthma Control Test (cACT)
- Asthma Control Questionnaire (ACQ)
- Asthma Therapy Assessment Questionnaire (ATAQ)
- Lara Asthma Symptom Scale (LASS)

The Asthma Control Test (ACT) is used for patients older than 12 years. It is a patient-centered/completed questionnaire that assesses only symptom control and asks about:

- Asthma symptoms (nocturnal and daytime)
- Use of rescue medications
- Effect of asthma on daily functioning
- Patient’s perception of asthma control over the previous 4 weeks

The cACT is used for children 4 to 11 years old. Both child and caregiver perspectives are assessed for the previous 4 weeks. It is composed of 7 questions, 4 child-reported and 3 caregiver-reported.

The Asthma Control Questionnaire (ACQ) is valid for adults as well as children 6 to 17 years of age and involves asking patients to recall their symptom control over the previous week. It is the only tool that includes lung function testing.

The Asthma Therapy Assessment Questionnaire (ATAQ) is a brief, self-administered tool for use in adults 18 and older which assesses the level of asthma control during the prior 4 weeks. It includes questions about symptoms, missed work or school, effect on activities of daily living and use of rescue inhalers. A parent-completed ATAQ version is available for children and adolescents 5 to 17 years old.
The Lara Asthma Symptom Scale (LASS) measures asthma control in both children and adults and is the only tool that evaluates the risk of asthma exacerbations as part of its assessment. It is a tool designed for both English- and non-English-speaking populations (Alzahrani & Becker, 2017).

Once asthma has been diagnosed, lung function is useful as an indicator of future risk and should be done at time of diagnosis, 3 to 6 months after starting treatment, and periodically after that. Most patients should have lung function measured at least every 1 to 2 years, more often in children and those at higher risk of flare-ups or lung function declines (GINA, 2018).

**ASSESSING QUALITY OF LIFE**

Health-related quality of life is considered an important variable to be managed in patients with asthma. Besides physical symptoms, patients may experience fatigue, psychomotor sluggishness, irritability, and mood and cognitive disturbances. The combination of physical symptoms and emotional and functional problems may diminish a patient’s quality of life.

The Asthma Quality of Life Questionnaire (AQLQ) is one of several assessment tools 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 appropriate for 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 patient’s caregiver should take that role. With their primary care provider, 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 more 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 each patient; they should also listen to be certain that they are working on their patients’ goals.

**ASTHMA PATIENT EDUCATION**

The plan of action should include patient education. It is known that clinician care is necessary, but such care is not sufficient for a patient to achieve control of asthma. The patient also must be taught effective self-management strategies that result in:

- Improved quality of life
- Improvement in symptoms
- Fewer activity limitations
- Improved medication adherence
• Fewer urgent care visits
• Fewer hospitalizations
• Reduced asthma-related expenditures

Patient education begins at the initial visit and is reinforced with every visit thereafter. Both patients and caregivers are involved in the educational process, which includes instruction and demonstration of understanding of:

• Pathophysiology of asthma and causes for airflow obstruction that leads to the symptoms of asthma
• Recognition of various symptoms of a potential asthma attack
• Medications used for treatment of asthma, including clear instructions and demonstration of the correct use of each type of inhaler and spacer or chamber device being considered for treatment
• Explanation for and demonstration of the use of a peak flow meter to help detect changes in airflow before symptoms are present and to obtain objective confirmation of changes in airflow when symptoms do develop
• Prevention and treatment of symptoms

The patient and/or caregiver should work collaboratively in the development of a plan of care referred to as an asthma action plan (Apter, 2017).

CASE: Patient Education

JONAH, AGE 11 (continued from earlier in this course under “Comorbid Factors”)

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

1. The nurse gave Jonah the inhaler, described how to use it, 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 his primary care provider, 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. Because Jonah’s identical twin brother also has asthma, the nurse discussed with his mother some issues that might arise between the two brothers. This might include competing between them to see who waits the longest before using a rescue inhaler or other ways they may find in which to compare and contrast their illness.

6. 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 ASTHMA 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 (CDC, 2018d).

For children, peak flow monitoring is not used universally because results are dependent upon effort and may not accurately reflect the maximal flow. Symptom-based asthma action plans are superior to peak flow–based plans in reducing the need for acute care visits in children. Parents or caregivers should monitor for other manifestations of an exacerbation, such as persistent cough, increased respiratory rate, retractions, wheezing, or inability to speak in full sentences (Scarfone, 2018).

The following is an example of an action plan that includes recommendations and directions for both adults and children.
SAMPLE ASTHMA ACTION PLAN

Patient Name:
Date of Birth: ___/___/____
Today’s Date: ___/___/____

Allergies:

Asthma severity classification:
___ Intermittent
___ Mild Persistent
___ Moderate Persistent
___ Severe Persistent

Personal best peak flow:

Avoid known asthma triggers:

<table>
<thead>
<tr>
<th>MEDICINE</th>
<th>AMOUNT</th>
<th>HOW OFTEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Take controller medicines every day:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Take these prescribed medications (i.e., antihistamines and nasal sprays):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Take this medicine 15 minutes before exercise:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### YELLOW ZONE: CAUTION

- Asthma symptoms such as coughing, wheezing, shortness or breath, or chest tightness (if not better in 24–48 hours, call healthcare provider)
- Waking at night due to wheeze or cough more than two times a month
- Cannot do regular activities
- Using quick relief medicine more than 2 times a week (not counting use before exercise)
- Peak flow: ___ to ____ (50% to 79% or more of best peak flow)

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Amount</th>
<th>How Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Keep taking green zone medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Start rescue medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. If not improving or symptoms worsen, increase or add the following:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RED ZONE: DANGER

- Asthma symptoms severe or not responding to yellow zone treatments
- Very short of breath, fast breathing
- Nonstop coughing
- Skin pulling between the ribs or around the neck
- Peak flow less than: ______ (50% of best peak flow)

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Amount</th>
<th>How Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase rescue medications:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Repeat rescue medication in 20 minutes. <strong>If symptoms do not improve, contact healthcare provider, call 911, or go to nearest emergency department.</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**CASE: Asthma Action Plan**

Sixteen-year-old Nadia, 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 daily state or level of Nadia’s asthma (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.
Recognizing Asthma Triggers and Exposure Reduction

Patients will usually know many of the things that trigger or worsen their asthma symptoms. As the patient and clinician 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 “Asthma Triggers and Aggravating Factors” earlier in this course.)

EXPOSURE REDUCTION STRATEGIES FOR COMMON ASTHMA TRIGGERS

Pets (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.
- Wash pets once a week if possible.
- Wash hands and change clothes after playing with a pet.
- 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 to lower than 50% and do not use humidifiers.
- Wash mattress covers and bedding in hot water (130 °F to 140 °F) each week.
- Wrap mattresses, box springs, and pillows in mite-proof covers.
- Keep stuffed animals off the beds; wash them weekly and dry completely.
- Steam clean bedding, mattresses, and furniture that cannot be washed.
- Remove carpeting from the home.
- Wipe away dust with a damp cloth and vacuum weekly with a HEPA vacuum cleaner.
- Avoid lying on upholstered furniture.
- Get rid of upholstered furniture. Use wooden, leather, or vinyl furniture instead.
- Replace slatted blinds and cloth draperies with pull-down shapes to reduce dust collection.
- Keep closets clean and closet doors closed.
Cockroaches and rodents (mice and rats)

- Do not leave food or garbage uncovered.
- Do not leave dirty dishes in the sink.
- 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.
- Do not let trash pile up inside, including bags, newspapers, and cardboard boxes.

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.
- Keep sinks and tub dry and clean.
- Defrost refrigerator often.
- Do not let damp clothes sit in a basket or hamper.
• Clean moldy surfaces with a diluted bleach solution (one cup per gallon of water). If that does not work, have surfaces cleaned by professionals.
• Lower the humidity in the home with a dehumidifier and do not use vaporizers or humidifiers.
• Measure moisture in the home, especially in bathrooms, basement, and kitchen, using an inexpensive hygrometer.
• Use an exhaust fan when taking a shower.
• 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.
• Clean or replace shower curtains if mold appears.
• Disinfect cleaned surfaces with a penetrating fungicide.
• Add mold inhibitors to paints before application and repaint disinfected surfaces with a paint-fungicide mixture.

Cigarette, cigar, or pipe 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.

Indoor air pollution (fireplace or woodstove smoke, strong odors and sprays, chemical vapors, gas stoves)

• 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. Open fireplace flue and ensure stove doors fit tightly.
• Avoid air fresheners.
• Vent all stoves to the outside. For gas stoves, use exhaust fan that vents outside.
• No matter the type of heating system, have it cleaned and inspected annually.
• When in a workplace with chemical vapors, limit or avoid exposure altogether by using respiratory protective gear.
Outdoor air pollution

- When the level of outdoor pollution is high, stay indoors as much as possible and avoid exertion when being outdoors.
- Save outside activities for late afternoon or after a heavy rain.
- Wear a face mask while doing outdoor activities.
- Do not dry clothes outdoors.
- Avoid cutting grass or wear a face mask.
- 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.
- Persons with asthma should not play or exercise near major highways.

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.

Nonselective beta blockers (can cause bronchoconstriction and make airway constriction difficult to reverse with quick-relief medicines)

Avoid taking any of the following drugs:

- Carteolol
- Carvedilol
- Labetalol
- Bucindolol
- Nadolol
- Oxyprenolol
- Penbutolol
- Pindolol
- Propranolol

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• Sotalol
• Timolol

Recreational drugs

Avoid taking:

• Ecstasy and speed (increases activity and energy expenditure)
• Cannabis (can cause anxiety, which can bring on asthma symptoms)
• Cocaine (increases severity of asthma attacks)

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)

• Avoid aspirin and NSAIDS if sensitive to them.

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, yelling)

• 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.
**Weather changes** (cold, windy, stormy, sudden or extreme temperature changes, high humidity)

- Wear scarf over the mouth and nose when outside in very cold weather.
- If hot, use air conditioning, which cleans, cools, and dries the air.
- Drink plenty of water to prevent dehydration.
- Stay indoors before, during and after a thunderstorm, and keep windows closed.

(Sources: Laskowski, 2017; ALA, 2018a; Asthma UK, 2016; Asthma UK, 2018.)

**INTERDISCIPLINARY THERAPIES**

**Pulmonary rehabilitation** is a program that involves a team of healthcare providers who work to improve the well-being of people who have chronic respiratory disorders. This team often includes physicians, nurses, respiratory therapists, physical and occupational therapists, dietitians or nutritionists, psychologists, and social workers. Pulmonary rehabilitation is an outpatient program based in a hospital or clinic, and some therapies can also be provided in a patient’s home.

Pulmonary rehabilitation has many benefits, including:

- Improved quality of life
- Better functioning in the activities of daily living
- Increased exercise tolerance
- Decreased symptoms
- Management of anxiety and depression

(NHLBI, 2018)

Patients with severe asthma (particularly those with airway remodeling) or asthma-COPD overlap who have daily symptoms and substantial function and health status limitation despite bronchodilator and controller therapy are appropriate for pulmonary rehabilitation (Nici & ZuWallack, 2015).

**Respiratory Therapy**

Respiratory therapists (RTs) are key members of the asthma pulmonary rehabilitation team providing treatment to patients from infants to adults. They may work in acute care settings, patients’ homes, outpatient clinics, emergency departments, and in the community providing patients with asthma trigger management and asthma education and assisting with the implementation of the patient’s asthma action plan. RTs are involved in diagnosis, acute
treatment, follow-up, and monitoring. In diagnosing asthma, RTs often perform the lung function testing that indicates the presence of airflow obstruction.

Other services provided by respiratory therapists include:

- Spirometry
- Evaluating bronchodilator responsiveness
- CPAP initiation and/or management
- Six-minute walk testing
- Educating patients about their disease and developing an action plan
- Demonstrating or evaluating the proper use of aerosol delivery systems
- Overseeing medication adherence with respect to use of respiratory devices

Respiratory therapists may assist with routine monitoring of patient respiratory symptoms and lung function, controlling trigger factors, and controlling comorbid respiratory conditions. An in-home asthma management program can be effectively delivered by respiratory therapists and may reduce hospitalizations, in-patient days, and cost and improve measures of health-related quality of life and patient satisfaction in a population prone to asthma exacerbation (AARC, 2016).

(Respiratory therapists may also provide some of the treatments described below under “Physical Therapy.”)

**Physical Therapy**

Physical therapists are concerned with developing, maintaining, and restoring an individual’s maximum movement and functional ability. Physical therapy has been shown to improve asthma symptom control, exercise capacity, and sense of well-being. The majority of patients who receive physical therapy treatment are seeking relief from dyspnea and hyperventilation.

Physical therapy works to:

- Maintain or improve exercise tolerance
- Improve functional abilities
- Maintain and improve physical activity, coaching patients toward improving health behavior
- Reduce breathlessness and the work of breathing
- Improve the efficiency of ventilation
- Mobilize and aid the expectoration of secretions
• Improve knowledge and understanding of the disease process
• Reduce thoracic pain

BREATHING RETRAINING TECHNIQUES

Breathing retraining improves symptoms, psychological well-being, and quality of life in adults with asthma. They may also be effective in reducing rescue bronchodilator medication usage. Patients with mild to moderate asthma may benefit the most from breathing retraining techniques. The goal is to normalize breathing patterns by stabilizing respiratory rate and increasing expiratory airflow. The instructions provided by the physical therapist include:

• Decrease breaths taken (reduce respiratory rate).
• Take smaller breaths to reduce tidal volume.
• Use diaphragmatic deep breathing with abdominal muscles and lower thoracic chest movement.
• Breathe through the nose.
• Relax and control breathing.
• Decrease expiratory flow through pursed-lip breathing.

All of these techniques help control breathing and reduce airflow turbulence, hyperinflation, variable breathing pattern, and anxiety.

BUTEYKO TECHNIQUE

This technique is specific for reducing hyperinflation. It is based on the theory that bronchospasm is caused by hyperventilation that leads to a low PaCO₂, resulting in asthmatic symptoms. The goal of this technique is to reduce ventilation and subsequently lung volume. The instructions for this technique include:

1. Breathe normally through the nose for 2 to 3 minutes.
2. Breathe out normally; close the nose with one’s fingers and hold.
3. Remember the number of seconds to be recorded.
4. On the first need to breathe, release the nose and return to nasal breathing (control pause).
5. Wait 3 minutes.
6. Repeat and hold the breath for as long as possible (maximum pause).

Persons with mild asthma can hold the breath for up to 20 seconds, those with moderate for 15 seconds, and those with severe asthma for up to 10 seconds. This is practiced twice a day, with the goal of increasing the control pause to 60 seconds and the maximum pause to 2 minutes.
the aim is reduction in minute volume by reducing respiratory rate and increasing carbon dioxide levels (Courtney, 2017; Tehrany et al., 2017; Mackey, 2015).

**PHYSICAL TRAINING**

Physical training increases fitness and cardiorespiratory performance, reduces symptoms, and improves quality of life. The development of asthma symptoms while exercising can reduce patients’ willingness to exert themselves physically. Because of this fear, further deterioration in physical health and quality of life may occur, which can result in anxiety and depression (Mackey, 2015).

**RESPIRATORY MUSCLE TRAINING**

Hyperinflation increases lung volume, which leads to an alteration in inspiratory muscle mechanics. The muscles become shortened, resulting in a poor length-tension relationship for contraction. There is a decreased capacity for tension generation when breathing that causes the use of accessory muscles for inspiration.

This training involves breathing exercises done using an external device that makes breathing more difficult. The device used sets up a load to breathe against. The respiratory muscles must then work harder, resulting in increased strength, which leads to easier diaphragmatic breathing and reduced hyperinflation (Courtney 2017; Mackey, 2015).

**AIRWAY CLEARANCE TECHNIQUES**

Physical therapy assists in the removal of secretions in the airways using:

- **Percussions:** The clapping of the chest with a cupped hand to vibrate the airways. This moves mucus from smaller airways into larger ones where it can be coughed up. This can also be done using a device designed to vibrate the chest.

- **Effective coughing:** There are two extremely effective techniques for coughing:
  - Deep coughing:
    - Start by inhaling deeply and hold the breath for 2 to 3 seconds.
    - Using stomach muscles, forcefully expel the air while avoid a hacking cough or just clearing the throat.
  - Huff coughing:
    - Take a breath that is slightly deeper than normal.
    - Using stomach muscles, exhale rapidly three times with the mouth open, making a “ha-ha-ha” sound.
    - Follow this by controlled diaphragmatic breathing and a deep cough if mucus is felt to be moving.
• **Postural drainage:** This technique uses gravity to help drain mucus by placing the body in specific positions to drain the five lobes of the lungs. (Asthma & Lung Center, 2017; Mackey, 2015)

Postural drainage positions.
(Source: Adapted from Potter & Perry, 1997.)
Occupational Therapy

Occupational therapists work with patients with pulmonary diseases such as asthma to increase their potential for independence. They play a major role in pulmonary rehabilitation, combining 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. Occupational therapists 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 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.

Occupation therapy assists patients to learn to:

- Identify their symptoms of stress (physical, emotional and behavioral)
- Recognize and understand causes of stress
- Identify personal strengths and skills
- Learn ways to change self-defeating beliefs or thoughts to improve quality of life
- Learn new coping skills and ways to relax
- Make lifestyle changes to balance work, recreation, and rest
- Assist with smoking cessation or elimination of other undesirable health behaviors
- Learn different relaxation and meditation techniques

Learning to relax is an essential tool in the arsenal for management of the disease. Occupational therapists teach techniques such as:

- Deep breathing
- Progressive muscle relaxation
- Autogenic therapy, in which the patient is taught to connect mind and body so that the body responds to the mind's commands
- Guided imagery
- Mindfulness-based meditation
- Cognitive behavioral therapy
- Solution-focused therapy
- Therapeutic use of activity
- Motivational interviewing
  (CAOTA, 2015; MHW, 2018)

Biofeedback techniques are also utilized by occupational therapists to improve self-awareness of the effects of stress. One such technique is pneumographic feedback. This technique is used to provide feedback about the movement of the chest and abdomen, measuring breathing and respiration. It can be used to detect abnormal breathing patterns in patients with asthma and stress (LUHS, 2018).

ENERGY CONSERVATION

Occupational therapists are knowledgeable about activity analysis, grading activities, ergonomics, and body mechanics. Energy conservation and work simplification techniques reduce unnecessary oxygen expenditure while the patient is involved in activity. Five important principles are incorporated into daily activities and routines in order to conserve energy, including:

1. Plan and organize daily routines and activities.
   - Alternate between heavy and light tasks and simplify tasks as much as possible.
   - Prepare ahead for tasks by gathering and organizing necessary tools and or supplies.
   - Have adequate rest periods after completing activities and before starting another one.

2. Use appropriate equipment to simplify activities.
   - Use modern household utensils or electric appliances.
   - Use assistive devices such as long-handed reachers to reduce the need for stooping or bending over to pick things up from the floor.
   - Use kitchen trolleys to assist with pushing and carrying objects.

3. Work with appropriate pacing.
   - Allow adequate time for completion of an activity, remain relaxed, and complete the task at a gentle pace.
   - Rest when feeling tired to prevent exhaustion.

4. Avoid inappropriate posture that may affect breathing.
   - Sit down to perform daily activities whenever possible.
• Avoid activities that require long periods of standing, squatting or stooping.
• Avoid moving arms above shoulder level.

5. Use correct body mechanics.
• Keep posture upright while performing an activity to conserve energy.
• Keep arms close to the body while carrying objects.
• Carry a load equally between both arms at the same time.
• Keep elbows on the table or other firm surface while performing an activity such as shaving or grooming.
• Maintain proper posture: When sitting down to rest, keep the body straight and lean forward slightly. Relax shoulders and keep hands on tights. Feet should both be on the floor.

(Alam, 2016)

RECOMMENDATIONS FOR ADLs

Cooking
• Use a ventilation fan in the kitchen for cooking to avoid cooking vapors and smoke inhalation.
• Sit to perform cooking preparation activities such as peeling or chopping vegetables.

Eating
• Ensure good posture and avoid stooping or semi-inclined positions.
• Support elbows on the table.
• Place all dishes within reach.
• Eat lighter and more frequent meals to minimize shortness of breath.

Grooming
• Sit in front of the sink for cleaning the face, brushing the teeth, shaving, and combing or styling the hair.
• Support elbows on the sink rim.
• Use a small-sized towel.
• Use an electric toothbrush and razor to minimize upper limb exertion.
Dressing and Undressing

- Do not wear tight clothing or clothing with zippers or buttons in the back.
- Wear shoes without shoelaces to avoid having to bend to tie them.
- Sit when possible.

Toileting

- Do not strain during bowel movements; use coordinated breathing.
- Eat a diet with adequate fruits and vegetables to prevent constipation.
- Use raised toilet seat to ensure proper height and ease of rising.

Bathing

- Choose a time of day when energy and stamina is the greatest.
- Use bronchodilators if prescribed.
- Prepare and keep all necessary supplies close at hand.
- Use a shower chair to sit if needed.
- Use bath grab rails while bathing in a tub.

Laundry

- Minimize repeated squatting when loading and unloading washer and dryer.

House Cleaning

- Plan one task a day to do such as laundry on Monday, dusting on Tuesday, etc.
- Use a mask when dusting.

Shopping

- Use a planned route and map for shopping.
- Use online ordering and delivery for heavy groceries.
- Use a wheeled cart for shopping.

(Alam, 2016)
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).

Alternative or Complementary Treatment

Alternative and complementary medicine refers to treatments not considered standard in current practice.

- Alternative treatments are those used in place of conventional practices.
- Complementary treatments refer to the use of these techniques in combination with conventional practices.

A number of people with asthma look for alternative treatments to control or enhance control of asthma symptoms. Such alternative or complementary treatments might include herbs, dietary supplements, acupuncture, chiropractic, massage therapy, biofeedback, homeopathy, nutrition, and botanicals. Because there have been limited research studies on such treatments for asthma, the effectiveness and safety of many are unknown, they are not approved by the FDA or by the medical profession, and they are not prescribed by physicians.

Some treatments include:

- **Salt therapy** (referred to as *halotherapy*) involves the use of salt lamps or salt inhalers and based on the 19th-century observation that persons working in salt mines never developed respiratory diseases.

- **Yoga breathing exercises** have been shown to cause a significant reduction in inhaler use and overall better asthma control (Bottrell, 2017).

- **Acupuncture** in addition to routine asthma care has been found by recent studies to result in clinically significant improvement in symptoms and quality of life when compared to patients who received routine care alone (Brinkhaus et al., 2017).

- **Herbal supplements** marketed for asthma treatment have not been thoroughly tested, and the FDA does not regulate them in the same way as medicines. Some have been found to interact with other drugs and others have been found to be ineffective and associated with a number of side effects. Licorice root, thought to calm and soothe airways, can elevate blood pressure. Ephedra used as a bronchodilator has been linked to serious side effects including death. Echinacea taken with other medications has been shown to worsen asthma symptoms and cause skin rashes and possible liver damage.
Other supplements considered to be herbal are garlic, ginger, and turmeric. Both garlic and ginger are believed to decrease inflammation and turmeric is thought to influence histamines (Bottrell, 2017).

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

Asthma, to varying degrees, has an impact on physical, psychological, and social well-being. A perceived negative impact is more pronounced among those with severe or poorly controlled asthma, and although asthma places a high burden on children, the relative importance of asthma’s impact increases with age, particularly in elderly women.

Poorly controlled asthma can result in psychological problems including stress, anxiety and depression.

Asthma is responsible for a high number of missed school and/or work days. It can cause early permanent disability and premature death. In fact, asthma can be associated with significant limitations on physical, social, and professional/student aspects of living.

Individuals whose asthma is not controlled have greater interruptions in work and school due to a greater frequency of hospitalization and high numbers of emergency department visits (Nunes et al., 2017).

A recent survey showed that sexual dysfunction reduces the quality of life for patients with asthma. Sexual dysfunction is more prevalent in women with asthma, people 50 years of age and older, those with a primary school education, the unemployed, those in need of healthcare, and those who have had uncontrolled asthma for 11 years or more (Avci & Dogan, 2017).

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 (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. Influenza can affect the lungs, causing inflammation and narrowing of airways, which can trigger symptoms or an asthma attack. 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, 2017).

A very serious complication is status asthmaticus (SA), a significant medical emergency that requires immediate and aggressive treatment. This is a severe asthma attack of either long duration or abrupt onset in which symptoms continue and respiratory function declines despite treatment. SA can range from mild to severe and can lead to prolonged hospitalization or respiratory failure and ultimately death. As many as 10% of those individuals who experience SA will die from it (Loengard, 2018).

Patients with asthma are at higher risk for serious illness, complications, and even death related to pneumonia. Asthma may make the lungs more receptive to infection by pneumococcal bacteria, and corticosteroids may increase the risk due to suppression of the immune system (AAFA, 2018d).

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 tension pneumothorax, a condition in which the mediastinal structures shift to one side of the chest. This can quickly cause irreversible shock and death (Daley, 2017).

A rare complication of an acute exacerbation of asthma is pneumomediastinum. It is an uncommon event that occurs most often among infants and children. 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 are high when it is associated with pneumothorax. During a serious attack, the combination can prove fatal (Carolan, 2017).

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 form of eczema is not caused by allergies but stems from a defective gene that interferes with the production of filaggrin, a protein that prevents skin dryness and may also protect the airway linings. As a result, inflammation occurs, leading to eczema and asthma. This is relatively uncommon, occurring most often in elderly males (Swanson, 2017).
Complications Related to Asthma Medication Use

Iatrogenic (drug-related) Cushing’s syndrome can develop with the prolonged use of corticosteroid medications for treatment and control of asthma. Signs and symptoms of this condition include:

- Fatty deposits under the skin, especially of the face (moon facies), upper back, torso, and supraclavicular region
- Skin changes, including pink or purple stretch marks, easy bruising, thinning, and fragility
- Increased lanugo facial or body hair (very soft and downy)
- Steroid acne
- Progressive proximal muscle weakness
- Menstrual irregularities/amenorrhea
- Infertility, decreased libido in men and women, and impotence in men
- Psychological problems, including depression, emotional lability, and cognitive problems
- Osteopenia, osteoporotic fractures
- Emotional lability
- Depression
- Immunosuppression with slow wound healing and increased infections
- New-onset or worsening of hypertension or diabetes mellitus
- Growth retardation in children
  (Nguyen, 2017)

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

It is not uncommon for adults in their 70s or 80s to develop asthma symptoms for the first time. Asthma in older adults is more dangerous, as they are more likely to develop respiratory failure, even during mild attacks. Older patients with mild asthma symptoms can have the same level of breathing difficulty as younger asthma patients experiencing a severe asthma episode. Unlike younger persons, asthma in the older adult rarely goes into remission. Instead, it is more likely to remain a potentially serious and often disabling disease.

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. In addition, wheezing, shortness of breath, tightness in the chest, and chronic cough that occurs with regular activities such as housework, shopping, gardening, or walking may be attributed to the decrease in activity that occurs as the person ages.

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 patients are more likely than younger ones to have mental confusion or memory problems. This may be the result of normal aging or of an illness such as Alzheimer’s disease. Whatever the cause, such problems can make it hard for certain older patients to follow treatment instructions, especially if the person also takes medication for a variety of other health conditions.

In addition, many asthma medications come in the form of metered dose inhalers, which require a certain degree of manual coordination and dexterity. Older adults are more likely to have difficulty with this type of medication delivery device, and in using it, may not receive the correct dose. Dry powder inhalers or oral medications may be of help in this instance (AAFA, 2018e).

Pregnant Women

The goal of asthma management during pregnancy is maintaining adequate oxygenation of the fetus through prevention of hypoxic episodes in the mother. Pregnancy is associated with a 25% increase in oxygen consumption and a 15% increase in maternal metabolic rate. Progesterone has
a stimulatory effect on the respiratory center, producing a 30% to 50% increase in the volume of air inhaled or exhaled per minute (minute volume) and the volume of air inhaled when at rest (tidal volume); however, respiratory rate remains unchanged. Pregnancy does not change FEV1 or PEF.

As pregnancy advances, the increased size of the uterus pushes the diaphragm upward, reducing functional residual capacity by about 18%, which leads to a more rapid desaturation during periods of shallow breathing due to loss of lung volume reserve. In general, pregnant patients with acute asthma should rest in a seated or lateral position, rather than supine, particularly in the third trimester to avoid aortocaval compression by the uterus.

Maternal compensatory mechanisms will maintain systemic arterial pressure and oxygenation to vital organs at the expense of uterine blood flow. Increased maternal CO₂ levels may cause fetal acidosis, and maternal hypoxemia (<95 mmHg) rapidly results in decreased oxygen to the fetus. Chronic hypoxemia may cause intrauterine growth retardation and low birth weight.

Asthma severity during pregnancy does not appear to differ from asthma severity during the year prior to pregnancy in women who continue the use of prescribed medications. The use of regular preventive asthma medications during pregnancy does not appear to be associated with increased risk of adverse events, and it is deemed safer for the pregnant woman and the fetus to be treated with asthma medications than to have asthma symptoms and exacerbations.

Serial ultrasound examination starting at 32 weeks gestation is recommended for women with suboptimal controlled asthma or moderate-to-severe persistent asthma. Asthma status is monitored during prenatal visits, and women are instructed to self-monitor fetal activity (fetal kicks over time). When assessing severity and treatment response, fetal activity is also monitored (Einarsson et al., 2018; Schatz & Weinberger, 2018).

PERINATAL EFFECTS

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

- Preterm labor and premature delivery
- 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
  (Einarsson et al., 2018; Little, 2016)

**Infants and Children**

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.

Most babies, toddlers, and preschoolers are treated for asthma by their pediatrician. However, if asthma symptoms are not under control with 3 to 6 months, or if symptoms are severe and persistent, or if asthma episodes required emergency treatment, it is recommended they be seen by an asthma specialist such as an allergist/immunologist or pulmonologist (AAFA, 2018f).

Infants and children are often cared for in childcare centers or family daycare. Parents should be offered information on how to evaluate the childcare setting to avoid asthma triggers and discuss special needs with the care providers. The Asthma and Allergy Foundation of America provides a checklist that can be used by both parents and childcare providers (AAFA, 2018g).

Respiratory morbidity is frequent in children younger than 2 years with asthma, making evaluation of pulmonary function all the more important in these children. Children older than 5 years with asthma are tested using spirometry at each asthma office visit (Rosin & Colin, 2017).

**Surgical Patients**

Patients with asthma face a higher risk of complications during the perioperative period and increased risk of various complications following surgeries. Complications increase in older adults and in those with active asthma.

Among surgical patients with asthma, preoperative emergency visits, hospitalizations, or ICU stays because of asthma significantly increase postoperative adverse events. Preoperative use of systemic corticosteroids is also an independent risk factor for postoperative complications and mortality due to inhibition of the immune system and reduced inflammatory response. This predisposes patients to infection, including pneumonia, septicemia, and urinary tract infections.

A number of perioperative medications including drugs used in anesthesia can induce allergic reactions in the operating room. Bronchospasm can be provoked by cold inspired gases, tracheal intubation or extubation, and airway suctioning. Increased airway tone resulting from vagal
stimulation can be caused by endoscopy or peritoneal or visceral stretching during surgery (Lin et al., 2016).

**Dental Patients**

Patients with asthma have increased risk for dental caries, enamel defects, increased gingivitis and periodontal disease, more calculus, oral candidiasis, xerostomia (dry mouth), decreased salivary flow rate, and salivary pH.

It is recommended that patients with asthma schedule dental procedures for late morning, when asthma attacks are less likely. The increased risk for an asthma attack (i.e., due to dental anxiety, tooth extraction, allergic reactions) also requires patients to bring their quick-relief medicines to their appointment, and some dentists recommend taking a prophylactic inhalation at the beginning of treatment.

Certain items and materials in a dental office are known to have a potential to exacerbate asthma. These include sealants, rubber dams, tooth enamel dust, prophy paste, acrylic dust, and acrylic liquid. Patients taking corticosteroids may have a high tendency to have an adverse reaction to sulfites. Patients who are mouth-breathers have increased height of the palatal vault and greater risk for malocclusions (Fried, 2016; Little et al., 2017).

**Asthma at 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 a recent asthma action plan on file at the school and 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, 2018b).

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, 2018b)

**Asthma in the Workplace**

It is recommended that patients who are diagnosed with occupational asthma induced by a sensitizing agent completely avoid exposure to that agent.

For workers with mild occupational asthma who have a strong preference for remaining in the workplace, it is recommended that exposure be reduced by engineering controls or respiratory protective devices. However, there is conflicting evidence that this is effective, and “safe” levels of exposure have not been established. For these people, careful ongoing surveillance is advised to detect any further deterioration in lung function.

Workers with severe occupational asthma may be unable to work for several months or longer even after cessation of exposure to the trigger agent. Improvement of occupational asthma after cessation of exposure is most often gradual, reaching a plateau about two years following cessation of exposure. Most patients show incomplete resolution of asthma, airway responsiveness, and inflammation even many years following cessation of exposure.

Even if asthma control improves with complete avoidance, patients with occupational asthma have persistent problems with depression and anxiety that are more severe than for patients with similar severity of non-work-related asthma.

Patients with asthma in any workplace setting 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 (Lemière & Bernstein, 2017).
Travel

Patients with asthma must take precautions when traveling to avoid triggers most apt to bring about asthma symptoms. For example, when traveling by airplane, bad air quality can be a problem, especially for patients on full-capacity flights. Most airlines have banned smoking on board, but some international flights may still allow smoking. Federal law requires that airlines allow service animals in passenger cabins of planes, which increases the risk for those whose triggers include pet dander.

When traveling by car or bus, mites and molds in upholstery can trigger asthma symptoms. Patients who rent a car should request a late-model nonsmoking vehicle.

Patients who are going on a cruise should notify cruise operators beforehand. Larger reputable cruise lines have medical facilities on the ship, but others may not. River cruises can pass through areas with heavy pollen and mold concentrations.

Persons with asthma should request nonsmoking rooms in hotels or resorts. Generally, cheaper accommodations and those that do not have a regular cleaning service are more likely to contain asthma triggers.

Patients should be instructed to ensure they have adequate medications for their time away, carry their medications with them wherever they go, know where they can obtain medical attention when necessary, and make certain when traveling abroad that devices such as nebulizers are equipped with an electrical current converter (Cleveland Clinic Foundation, 2018b; AAFA, 2018h).

CONCLUSION

Asthma is a chronic respiratory disease in which patients experience 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, a person with asthma 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 or, in extremely severe cases, leads to death.

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.

RESOURCES

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

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

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

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

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

Global Initiative for Asthma (GINA)
https://www.ginasthma.com

What is asthma? (NHLBI)
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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. Which is a correct statement concerning asthma around the world?
   a. Asthma prevalence and incidence is decreasing.
   b. The number of people with asthma is estimated to decrease by 2025.
   c. The highest disease burden is among children 14 years old and younger.
   d. Prevalence rate in high-income countries is increasing worldwide.

3. Which is a correct statement concerning asthma prevalence rates in the United States?
   a. Females are more likely to have asthma than males.
   b. Girls and boys are affected equally before puberty.
   c. Asthma prevalence is lowest among blacks.
   d. People living in the South have the highest asthma prevalence.

4. The primary pathophysiologic 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. Long-term airway damage caused by repeated bouts of untreated inflammation is referred to as:
   a. Mast cell degeneration.
   b. Airway remodeling.
   c. Hyperresponsiveness.
   d. Airway obstruction.
6. Circadian and hormone changes are consistent with which type of asthma?
   a. Exercise-induced
   b. Occupational
   c. Nocturnal
   d. Cough-variant

7. 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.

8. Which is a correct statement about environmental contributors to asthma?
   a. When pregnant women smoke, byproducts do not pass through the placenta to the fetus.
   b. Energy-efficient homes lead to decreases in exposure to inhaled substances.
   c. Breathing in ground-level ozone does not affect people who do not already have asthma.
   d. Thunderstorm asthma is an uncommon event but can be life-threatening.

9. A comorbid condition associated with asthma is:
   a. Endogenous Cushing’s syndrome.
   b. Congestive heart failure.
   c. Obesity.
   d. Hypertension.

10. Coughing from asthma is a symptom of airway irritation and:
    a. Is always productive in a patient with asthma.
    b. Indicates the patient will have asthma in later life.
    c. Is always dry in a patient with asthma.
    d. Can be a patient’s only symptom of asthma.

11. The most accurate predictor of a fatal asthma attack is having a history of:
    a. Administration of beta-agonist inhalers.
    b. Requiring a hospitalization for an asthma attack.
    c. The frequent need for quick-relief asthma medication.
    d. Requiring an intubation for a severe asthma attack.
12. Which is an atopic illness that should be noted in the family history section of the medical history for a patient with asthma?
   a. Pneumonia
   b. Eczema
   c. Meningitis
   d. Gastroenteritis

13. Indications of life-threatening hypoxia because of a severe asthma attack include:
   a. Somnolence and near absence of breath sounds.
   b. Inability to lie flat and loud expiratory wheezing.
   c. Breathlessness and inability to talk in sentences.
   d. Rising pCO₂ and hyperventilation.

14. Spirometry, the most common pulmonary function test, measures:
   a. Alveolar elasticity and airway responsiveness.
   b. Rate of airflow through the airways.
   c. The shallowness of respirations.
   d. The depth of respirations.

15. The forced expiratory volume that can be exhaled in one second of forced exhalation (FEV₁) 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.

16. Which is a correct statement concerning peak flow meter measurements?
   a. A reading in the yellow zone means asthma is under control.
   b. The lowest reading is called the patient’s “personal best.”
   c. Readings should be taken at different times each day.
   d. A reading in the red zone signals a medical alert.

17. 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.
18. A diagnostic test that can diagnose asthma even in patients experiencing no symptoms is:
   a. Kit-on-a-lid-assay (KOALA).
   b. Exhaled nitric oxide.
   c. Sputum cytology.
   d. Arterial blood gases.

19. 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

20. Which is a correct statement about the proper use of inhalers?
   a. If using a steroid inhaler, rinse the mouth, gargle, and spit out the water.
   b. Proper use is identical for all types of inhalers.
   c. It is necessary to wait one full minute between puffs for all types of inhaled medications.
   d. To clean an inhaler, submerge the canister and mouthpiece in hot water.

21. “Quick-relief” medications used to reverse bronchoconstriction include:
   a. Corticosteroids.
   b. Beta-2 agonists.
   c. Methylxanthines.
   d. Leukotriene modifiers.

22. It is important not to consume large amounts of chocolate, caffeinated coffee, tea, or soft drinks when taking:
   a. Albuterol.
   b. Salmeterol.
   c. Theophylline.
   d. Prednisone.

23. Which type of medication should only be taken along with or combined with an inhaled corticosteroid?
   a. Short-acting beta-2 agonists
   b. Anticholinergics
   c. Methylxanthines
   d. Long-acting beta-2 agonists
24. A serious side effect from the long-term use of systemic corticosteroids is:
   a. Palpitations.
   b. GERD.
   c. Glaucoma.
   d. Restlessness.

25. The GINA pharmacology step therapy is based on:
   a. Severity of symptoms and patient’s age.
   b. Type of medication to be prescribed.
   c. Use of inhaled corticosteroids and SABA.
   d. Height and weight of the patient.

26. 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.

27. Which intervention used by EMS personnel reduces the work of breathing by holding airway structures open and allowing bronchodilators to enter the lower airways?
   a. Heliox administration
   b. CPAP device use
   c. Epsom salt administration
   d. Small-volume nebulizer use

28. Standard treatment in the emergency room for treatment of asthma attack begins with:
   a. Epinephrine or terbutaline.
   b. Ipratropium intravenously.
   c. Nebulized SABA (albuterol).
   d. Systemic glucocorticoids.

29. When patients are discharged from the ED after an asthma attack, they:
   a. Will still have significant asthma symptoms.
   b. Receive a brief, focused session of asthma education.
   c. Will still be on supplemental oxygen.
   d. Should receive a prescription for epinephrine (Epinen).
30. Which is a **true** statement about management of mild asthma exacerbations in pregnant women?
   a. Pregnant women are never given glucocorticoids.
   b. Pregnant women are only given nebulized short-acting beta-2 agonists.
   c. They are treated in the same way as nonpregnant women.
   d. O₂ saturation should be at least 92% on room air.

31. A nursing intervention specific to the management of mucus secretions 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.

32. A sign of impaired gas exchange indicating advanced hypoxemia is:
   a. The need for suctioning.
   b. Abnormal arterial blood gases.
   c. Central cyanosis.
   d. A decline in activity tolerance.

33. Which is a **true** statement about assessing a patient’s asthma control?
   a. Lung function testing is the preferred method.
   b. Asthma control is often underestimated by both clinicians and patient.
   c. Asthma assessment tools such as the ACT are ineffective.
   d. Patients often under-report symptoms.

34. Which peak flow rate in an asthma action plan indicates that a patient is in the danger zone?
   a. Peak flow is greater than the patient’s personal best.
   b. Peak flow is the same as the patient’s personal best.
   c. Peak flow is between 50% and 79% of the patient’s personal best.
   d. Peak flow is less than 50% of the patient’s personal best.

35. 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.
36. 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.

37. Which medication can trigger bronchoconstriction and should be avoided by patients with asthma?
   a. Atrovent
   b. Albuterol
   c. Nonselective beta-blockers
   d. Acetaminophen (Tylenol)

38. 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.

39. Which physical therapy technique is applied specifically for reducing hyperinflation?
   a. Physical training
   b. Breathing retraining
   c. Buteyko technique
   d. Postural drainage

40. 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.

41. A very serious complication of asthma that is a medical emergency requiring immediate and aggressive treatment is:
   a. Status asthmaticus.
   b. Pneumothorax.
   c. Pneumomediastinum.
   d. Nummular eczema.
42. A serious complication that can be caused by long-term use of oral corticosteroids is:
   a. Preeclampsia.
   b. Cushing’s syndrome.
   c. Thrush.
   d. Intracerebral hemorrhage.

43. 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.

44. The main goal of asthma management during pregnancy is to:
   a. Help pregnant women to follow their asthma action plan correctly.
   b. Avoid the use of corticosteroids.
   c. Prevent maternal hypoxic episodes.
   d. Increase minute and tidal volumes.

45. Which is a true statement concerning surgical patients with asthma?
   a. The risk of complications is the same for adults of all ages who are undergoing surgery.
   b. Preoperative use of systemic corticosteroids increases the risk of infection.
   c. Preoperative control of asthma does not impact the risk of complications.
   d. Perioperative medications do not have a role in surgical complications.

46. For children with asthma, all 50 states have laws that:
   a. Require asthma quick-relief inhalers to be kept with and administered by a school nurse.
   b. Allow only the child’s teacher to keep and administer quick-relief inhalers.
   c. Require a child to be transported to a medical facility for quick-relief inhaler administration.
   d. Allow students with asthma to carry and self-administer quick-relief inhalers.