Continuing Education (CEU) course for healthcare professionals. View the course online at wildirismedicaleducation.com for accreditation/approval information, course availability and other details, and to take the test for CE credit. The information provided in this course is to be used for educational purposes only. It is not intended as a substitute for professional healthcare.

Contact Hours: **10**

Asthma Patient Care

BY Judith Swan, MSN, BSN, ADN

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 to address potential knowledge gaps include:

- Define "asthma" and its types.
- Discuss the impacts of asthma.
- Review the pathophysiology, signs and symptoms, etiology, and contributing factors related to the development of asthma.
- Describe the diagnostic process and assessment of asthma severity.
- Review the pharmacologic and nonpharmacologic treatments for asthma.
- Describe the management of acute asthma attacks.
- Summarize the elements of long-term asthma management.
- Identify 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.

DEFINING ASTHMA

The Global Initiative for Asthma (GINA, 2021) provides a clinical definition of asthma, describing it as a heterogeneous disease (a condition that has several etiologies) usually characterized by **chronic airway inflammation**. Asthma is defined by the history of such respiratory symptoms as:

- Wheezing
- Shortness of breath
- A feeling of tightness in the chest
- Cough that varies over time and in intensity
- Variable expiratory airflow limitation

These symptoms and airflow limitations may resolve by themselves or in response to medication, and may be absent sometimes for weeks or months at a time. For other individuals, however, episodic flare-ups of asthma may be life threatening.

Asthma Phenotypes and Endotypes

A disease *phenotype* describes clinically observable characteristics of a disease without direct relationship to an underlying pathophysiology. *Endotypes*, however, describe subtypes of a disease defined by an intrinsically distinct pathogenetic mechanism; they refer to specific cells or molecules in blood or sputum.

ALLERGIC (EXTRINSIC) ASTHMA

Allergic (extrinsic) asthma is the result of antigen/antibody reaction in the respiratory tract, causing release of inflammatory mediators from mast cells which elicits the clinical response associated with an asthma attack. This is the most recognizable phenotype. It most often begins

in childhood and is associated with a past and/or a family history of allergic diseases (e.g., eczema). Common allergies may include, but are not limited to:

- Tobacco smoke
- Animal dander (cats, birds, dogs)
- Dust mites
- Cockroaches
- Molds
- Pollens
  (GINA, 2021)

NONALLERGIC (INTRINSIC) ASTHMA

Nonallergic (intrinsic) asthma is the result of neurological imbalances in the autonomic nervous system in which alpha and beta adrenergic as well as cholinergic sites of the system are not properly coordinated. The autonomic nervous system plays an important role in asthma, primarily through the parasympathetic pathway, promoting bronchoconstriction. The airways of people with nonallergic asthma respond to such factors as:

- Cold or dry air
- Heat and humidity
- Fragrances
- Stress
- Anxiety
- Strenuous exercise
- Hormonal changes

In addition, any factor that diminishes oxygen availability can also play a part in intrinsic asthma. These may include:

- Anemia
- Dehydration
- Tissue alkalosis
- Neuromuscular disease (thoracic cage, diaphragm, and accessory muscles)

Patients with nonallergic asthma often demonstrate less short-term responses to inhaled corticosteroids (GINA, 2021).

Occupational Asthma

Occupational asthma is a type of intrinsic asthma caused by exposure to inhaled irritants in the workplace. It is often a reversible condition, meaning that symptoms may disappear when the irritants that caused the asthma are avoided. However, permanent damage can result if the person experiences prolonged exposure. Examples of workplace irritants include:

- **Animal substances**, such as proteins found in dander, hair, scales, fur, saliva, and body wastes
- **Chemicals** used to make paints, varnishes, adhesives, laminates, soldering resin, insulation, packaging materials, foam mattresses, and upholstery
- **Enzymes** used in detergents and flour conditioners
- **Metals**, particularly platinum, chromium, and nickel sulfate
- **Plant substances**, including proteins found in natural rubber latex, flour, cereals, cotton, flax, hemp, rye, wheat, and papain (digestive enzyme derived from papaya)
- **Respiratory irritants**, such as chlorine gas, sulfur dioxide, and smoke

Specific symptoms of occupational asthma include airway irritation, obstruction, and inflammation, worsening after arriving at work and improving on weekends or during extended periods away from work (Johns Hopkins Medicine, 2021; Mayo Clinic, 2020a).

Eosinophilic Asthma

Eosinophilic asthma, a nonallergic intrinsic endotype of the disease, is characterized by an increase in the number of eosinophils in the blood, lung tissue, and mucus in the respiratory tract. The entire respiratory tract is involved in airflow obstruction, from the sinuses to the small or distal airways.

Eosinophils release a number of different mediators with the capacity to cause airway hyperresponsiveness and are major effectors of lung tissue damage in asthma, contributing to airway remodeling. Early eosinophilia is an early feature of asthma exacerbations (also referred to as *asthma attacks*).

Eosinophilic asthma is rare and usually begins in adults ages 35–50. The symptoms are often severe and can be persistent. The medications used in the treatment of asthma do not have much effect on eosinophilic asthma, even at high doses (APFED, 2020).

Obesity-Associated Asthma

Obesity-associated asthma, a type of intrinsic asthma, occurs in both children and adults. Both asthma and obesity have a considerable hereditary component, and potential underlying mechanisms include a shared genetic complement, dietary and nutritional factors, alterations in the gut microbiome, systemic inflammation, metabolic abnormalities, and changes in lung anatomy and function.

Maternal obesity and weight gain during pregnancy are independently associated with an increased risk of asthma in their children. Excessive weight gain in infancy has also been linked to recurrent wheezing and asthma (Peters et al., 2018).

Aspirin-Exacerbated Respiratory Disease (AERD)

AERD is a distinct intrinsic eosinophilic phenotype of severe asthma consisting of three key features: asthma, nasal polyps, and severe respiratory symptoms that are exacerbated by aspirin, other nonsteroidal anti-inflammatory drugs, and beta blockers. This asthma phenotype is characterized by the initial symptoms of rhinosinusitis and then progresses to severe asthma symptoms.

AERD usually begins in young adulthood, although children can be affected, and may not include any other allergies (Comhair et al., 2018)

Cough-Variant Asthma

Asthma may present as an apparently nonspecific cough. When cough is the only asthma symptom, it is known as cough-variant asthma. In this type of asthma, the cough may come and go with the seasons, appear after an upper respiratory infection, or become worse when the person is exposed to cold air or certain chemicals or fragrances. Cough-variant asthma may cause coughing during the day or night, sometimes disrupting sleep.

Specific symptoms include a chronic, nonproductive cough with a sensitive cough reflex. In some children, chronic cough can be the most prominent presenting symptom of asthma. The cough is typically dry, and there is an absence of wheezing, exertional dyspnea, or atopy (genetic predisposition for allergies). It is possible for this form of asthma to progress to asthma with all of its other symptoms.

Most studies have indicated that asthma is an uncommon cause of cough in children, as some children show no benefit from treatment with beta agonists and steroids (Mayo Clinic, 2019; Marchant & Chang, 2020).

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. Nocturnal asthma is associated with circadian patterns in which the best lung function occurs at around 4 p.m. and

worst at around 4 a.m. It is also associated with more severe disease and increased mortality, with over 50% of asthma deaths occurring at night.

Nocturnal asthma is caused by:

- Neurohormonal change
- Lung function and bronchial hyperresponsiveness
- Distal airway inflammation
- Inhibition of the anti-inflammatory effect of glucocorticoids
- Increased pulmonary capillary blood volume
- Reduced beta-2 adrenoceptor function and gene function
- Gastroesophageal reflux with aspiration
  (Martin, 2021)

EXERCISE-INDUCED BRONCHOCONSTRICTION

Exercise-induced bronchoconstriction (EIB) was formerly referred to as *exercise-induced asthma*, wrongly suggesting that exercise causes asthma. EIB is a narrowing of the airways in the lungs triggered by strenuous exercise. EIB occurs in up to 90% of people with asthma and up to 20% of those without asthma. Elite athletes have an increased prevalence of up to 70%.

EIB is caused by an acute large increase in the amount of air entering the airways that requires heating and humidifying. This can result in inflammatory, neuronal, and vascular changes, ultimately leading to bronchoconstriction and symptoms of asthma.

EIB symptoms usually begin during exercise and become worse 5 to 10 minutes after stopping exercise. Symptoms most often resolve in another 20 to 30 minutes and can range from mild to severe. Occasionally, some individuals will experience a second wave or late phase of symptoms 4 to 12 hours after stopping exercise. These symptoms are frequently less severe and can take up to 24 hours to resolve (Physiopedia, 2021a).

IMPACTS OF ASTHMA

Given the absence of a definitive laboratory test or biomarker for the diagnosis of asthma, many definitions and methods of data collection have been used and reported in epidemiologic studies in the past. To discuss the topic epidemiologically, asthma is now defined as bronchial hyperresponsiveness in the presence of wheezing in the previous 12 months (Litonjua & Weiss, 2020a).

Asthma Worldwide

Presently, asthma is a major chronic disease, affecting an estimated 262 million people worldwide in 2019. With the number of cases rising, this number is expected to reach 400 million by 2025. Asthma is one of the most common chronic diseases among children and affects all age groups, races, and ethnicities. However, ethnicity and socioeconomic status do influence the prevalence, morbidity, and mortality of asthma throughout the world.
Asthma worldwide accounts for over 15 million disability adjusted years annually and ranks highest for disability among children.

Individuals who live in developed countries have higher asthma prevalence compared to those who have similar genetic predispositions and reside in developing countries. The higher prevalence rates are hypothesized to be more related to environmental and lifestyle causes than genetic differences.

Factors that account for the lower prevalence in developing countries include lower rates of atopy, more breastfeeding, larger household size, and sometimes, rural residency during childhood. Another factor may be substantial underdiagnosis of asthma in some less-developed countries.

Mortality from asthma worldwide is low compared to other chronic diseases, and according to the World Health Organization (WHO) mortality database, South Africa has the highest age-standardized asthma mortality among low- and middle-income countries, while the Netherlands has the lowest among the high-income countries. The WHO estimates that asthma caused 461,000 deaths globally in 2019, with underprescription of inhaled glucocorticoids and insufficient access to emergency medical care or specialist care playing a part in most asthma deaths (WHO, 2021; Enilari & Sinha, 2019; Litonjua & Weiss, 2020a).

Asthma in the United States

Data from the CDC have shown that the prevalence of asthma increased in the United States from the early 1980s to the early 2000s and subsequently decreased slightly (Litonjua & Weiss, 2020a).

Approximately 25 million Americans have asthma (about 1 in 13), including 8% of adults and 7% of children. About 20 million adults ages 18 and over have asthma, and asthma is more common in adult women than adult men. Asthma is the leading chronic disease in children, and currently there are about 5 million children under the age of 18 with asthma.

ASTHMA PREVALENCE IN THE UNITED STATES, 2019	
Age (years)	**Individuals with Asthma** (thousands)
0–4	518
5–14	3,725
15–19	1,529
20–24	2,093
25–34	3,575
35–64	9,594
65+	4,069
(CDC, 2021a)	

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 (AAFA, 2021a).

ASTHMA PREVALENCE BY GENDER, 2019	
Gender	**Individuals with Asthma**
Males (total)	10,487,151
<18 years	3,123,923
18+ years	7,364,299
65+	1,236,000
Females (total)	14,643,981
<18 years	1,981,487
18+ years	12,662,493
65+	2,834,000
(CDC, 2021a)	

Asthma is more prevalent in males in **childhood** until they reach puberty and more prevalent in females after puberty. This has been explained by smaller airways in relation to lung size in boys compared with girls under age 10 years. This predisposes boys to worsened airway reactivity compared with girls. Boys are also more likely than girls to experience a decrease in symptoms by late adolescence. After puberty, smaller airway caliber is then observed in females. Known differences in asthma may also be due to other factors such as hormonal effects, genetic susceptibility, and immunologic response (Trivedi & Denton, 2019).

Asthma prevalence is increased in very young persons and very old persons because of airway responsiveness and lower levels of lung function. Two thirds of all asthma cases are diagnosed before the patient is 18 years old, and about half of all children with asthma have a decrease or disappearance of symptoms by early adulthood (Morris, 2020).

Women are more likely to be aware of worsening symptoms at times of hormonal change such as puberty, menstruation, pregnancy, and perimenopause. One third of women report worse asthma symptoms before or during a menstrual period. Some women, particularly those with severe asthma, have worse symptoms during pregnancy. Many women do, however, notice an improvement or no change at all when pregnant (Asthma UK, 2020).

Women with severe or poorly controlled asthma during pregnancy might increase the risk of various problems, including:

- Hypertension and kidney damage (preeclampsia)
- Restricted fetal growth
- Premature birth
- Need for cesarean section

In extreme cases, the baby's life might be in jeopardy (Mayo Clinic, 2020b).

RACE/ETHNICITY

The CDC reports that asthma prevalence in 2019 among respondents diagnosed with asthma was distributed by race and ethnicity as shown in the table below.

ASTHMA PREVALENCE BY RACE/ETHNICITY, 2019	
Race/Ethnicity	**Asthma Prevalence**
Puerto Rican	14%
American Indian/Alaska Native	10.7%
Black Non-Hispanic	10.6%
Mexican American	8.4%
White Non-Hispanic	7.7%
Hispanic	6.6%
Asian Non-Hispanic	3.8%
(CDC, 2021a)	

Racial and ethnic disparities in asthma are caused by complex factors including:

- Structural determinants (systemic racism, segregation, and discriminatory policies)
- Social determinants (socioeconomic status, education, neighborhood and physical environment, employment, social support networks, and access to healthcare)
- Biological determinants (genes and ancestry)
- Behavioral determinants (tobacco use and adherence to medications)

Minority populations are impacted by asthma more than the White population in the United States. The population impacted the most are Puerto Ricans.

Non-Hispanic Black people have a higher death rate per thousand (2.3) than non-Hispanic White people (0.8), and Black women have the highest rates of death due to asthma. Non-Hispanic Black people have higher rates of emergency room visits (17.6) compared to non-Hispanic White people (6.4) and higher rates of hospitalizations (88.5) compared to non-Hispanic White people (23.6).

Non-Hispanic Black children have a death rate eight times that of non-Hispanic White children. They are five times more likely to be admitted to the hospital for asthma as compared to non-Hispanic White children.

Black children exposed to secondhand tobacco smoke are at increased risk for acute lower respiratory tract infections, such as bronchitis. Black children living below or near the poverty level are more likely to have high levels of blood cotinine, a breakdown product of nicotine, compared to children living in higher-income families (CDC, 2021a; OMH, 2021; AAFA, 2021a).

GEOGRAPHY

The prevalence of asthma differs based on geography. Related factors include:

- Poverty
- Air pollution, including ozone and small particles
- Pollen levels
- Smoking laws
- Access to specialists

According to the National Health Interview Survey, 2018, the states with the highest prevalence of asthma were:

- West Virginia, 12.3%
- Maine, 12.3%
- Oregon, 11.6%
- Kentucky, 11.6%

The states with the lowest asthma prevalence were:

- Texas, 7.4%
- South Dakota, 7.9%
- Iowa, 7.9%
- Nevada, 8%
- Minnesota, 8.3%

(CDC, 2021a)

Asthma rates in 2018 among children ranged from 5.0% in Nebraska to 10.9% in Washington, D.C. (ALA, 2020a).

Regional trends indicate **two "asthma belts"** in the United States in the Ohio Valley area and the Northeast Mid-Atlantic region.

- In the Ohio Valley cities of Cleveland, Dayton, Columbus, Louisville, and Detroit, poverty and air pollution are key factors.
- In the Northeast Mid-Atlantic asthma belt, extending from Massachusetts to North Carolina, poverty, air pollution, and access to specialists are key risks.
- The "asthma capital" in the United States is Allentown, Pennsylvania.
  (AAFA, 2021b)

ASTHMA EXACERBATION PREVALENCE

The latest data from 2018 reports that the number of physician office visits with asthma as a primary diagnosis was 9.8 million for all ages and emergency department visits with asthma as a primary diagnosis was 1.6 million.

The asthma emergency department visit rate per 10,000 population for asthma exacerbation was significantly higher among children (88.1) than among adults (42.1), and among women (50.4) than among men (31.1).

The rate significantly decreased with increasing age:

- 62.7 among adults ages 18–34 years
- 36.9 among adults ages 36–64 years
- 18.2 among adults ages 65 years and over

Regardless of age group, the rate of asthma exacerbations was significantly higher among Black persons (163.5), followed by Hispanic persons (59.9), then White persons (31.3) (CDC, 2021b).

ASTHMA MORTALITY

On average, 10 Americans die from asthma each day. In 2019, 3,524 people died from asthma in the United States. Many asthma deaths are avoidable with proper treatment and medical care. Adults are five times more likely to die from asthma than children. Women are more likely to die than men; however, boys are more likely to die from asthma than girls. Black Americans are nearly three times more likely to die from asthma than White Americans (AAFA, 2021b).

ASTHMA AND QUALITY OF LIFE

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, socially, cognitively, and financially.

- **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. In addition, asthma can affect the individual's sleep, mobility, activities of daily living, vitality, and sexual activity.

- **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. Depression and asthma are common comorbid diseases and are associated with poor asthma outcomes.

- **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.

- **Cognitively,** adults with longer asthma duration and lower lung function are at greatest risk for cognitive impairment owing to the increased risk of intermittent cerebral hypoxia.

- **Financially**, people with asthma may incur the costs of medications, outpatient visits, emergency healthcare, and admission to a hospital for treatment and monitoring. (AAAAI, 2018; Esmaeel & Aly, 2018; Rhyou & Nam, 2020)

ASTHMA PATHOPHYSIOLOGY

The pathophysiology of asthma is complex and involves:

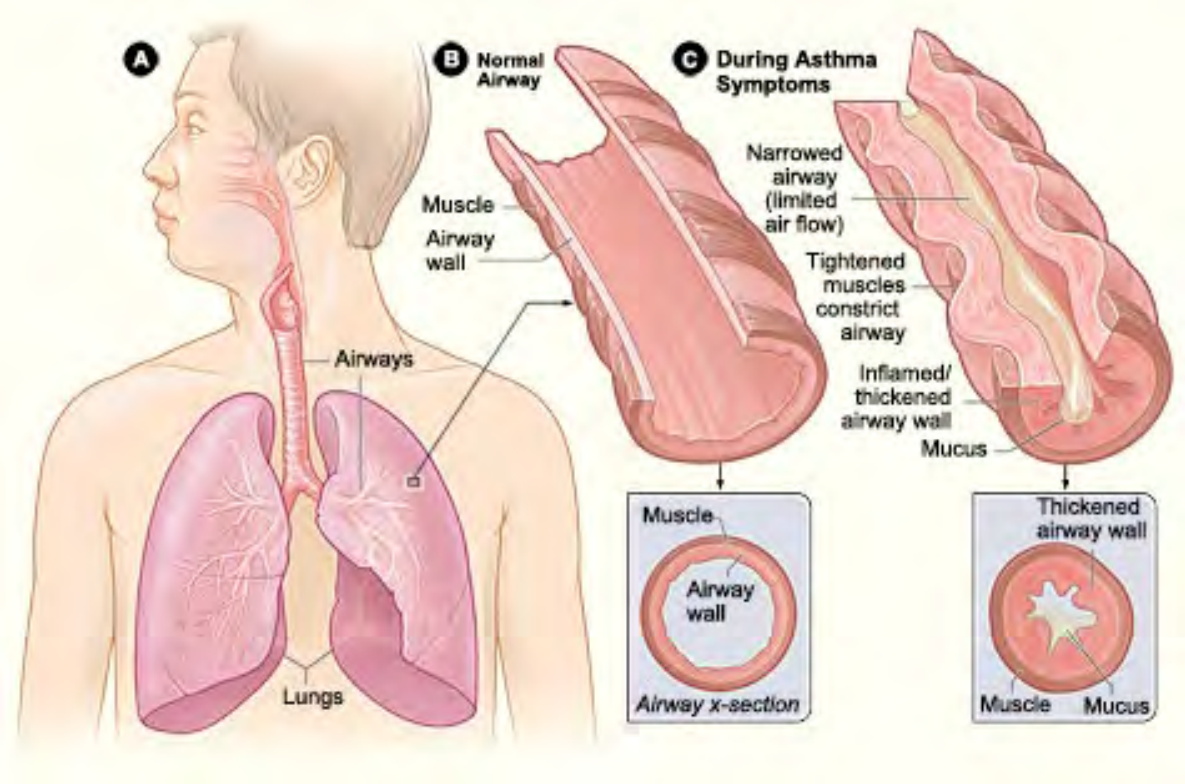
- Airway inflammation
- Airway hyperresponsiveness
- Intermittent airflow obstruction
- Airway remodeling

The important role of inflammation has been substantiated, but evidence is emerging for considerable variability in the pattern of inflammation, indicating differences in phenotype, which may have a significant influence on responses to treatment.

The mechanism of inflammation may be either acute, subacute, or chronic, and the presence of airway edema and mucus secretion contributes to airflow obstruction and bronchial reactivity. Varying degrees of mononuclear cell and eosinophil infiltration, mucus hypersecretion, desquamation of the epithelium, smooth muscle hyperplasia, and airway remodeling are present.

Airway hyperresponsiveness is an exaggerated response to numerous exogenous and endogenous stimuli. The mechanisms involved include direct stimulation of airway smooth muscle and indirect stimulation by substances from mediator-secreting cells such as mast cells or nonmyelinated sensory neurons.

The progression of the underlying disease severity does not appear to be prevented by current asthma treatment with anti-inflammatory medications (Morris, 2020).



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: National Institutes of Health: National Heart, Lung, Blood Institute.)

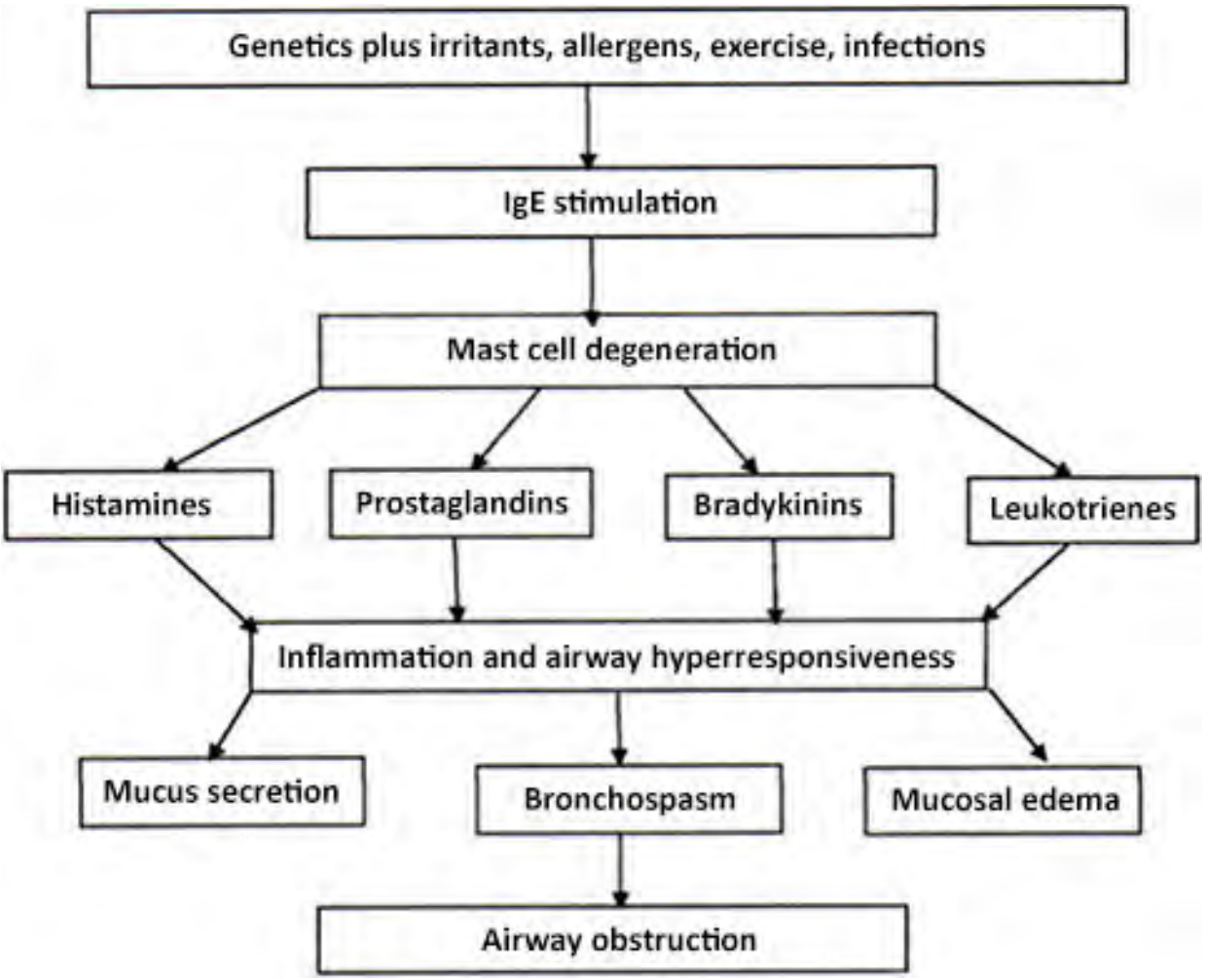
The Asthma Cascade

The asthma cascade is the well-defined constellation of signs and symptoms produced by an allergen or by other factors. Allergens are normally harmless substances that the immune system treats as health threats. When a person who has the allergic type of asthma comes into contact with one of these substances after becoming sensitized to it, the immune system responds to combat it. In patients with nonallergic asthma, when something other than an allergen (e.g., exercise, cold weather) induces asthma symptoms, the immune system responds in the same manner.

Within minutes following such an exposure, the person has a reaction caused by the release of mast cells, which degenerate and release histamines, prostaglandins, bradykinins, and leukotrienes. These substances affect nerve cells, smooth muscle cells, goblet cells that secrete mucus, and endothelial cells that affect blood vessels. This results in:

- Increased capillary permeability
- Mucosal edema
- Bronchoconstriction (bronchospasm)
- Thick tenacious mucus secretion

- Hyperresponsiveness of bronchial smooth muscle
- Reversible air flow obstruction
  (MacNaughton, 2019)



Asthma cascade. (Source: Author.)

Over time, damage to the epithelial cells affect ciliary function, impairing the removal of mucus and cellular debris and resulting in the formation of airway plugs. In addition, long-term damage caused by repeated bouts of untreated inflammation results in **airway remodeling** by epithelial cells, which may worsen inflammation and aggravate asthma over time if not treated and managed correctly.

Irreversible airway obstruction may develop in some patients with asthma who have moderate to severe asthma, which leads to poor prognosis and is highly associated with smoking and male gender. In these patients, the structure and function of the airway changes cannot be reversed in spite of ongoing anti-inflammatory or bronchodilator treatment (Boulet et al., 2020).

Asthma Development in Children and Adolescents

Asthma usually develops in children before the age of 5 years. Many children who have allergies develop asthma, but not all.

Usually, symptoms begin in the first years of life. It has been found that about 25 out of 100 children with persistent asthma began wheezing before they were 6 months old, and about 75 out of 100 began wheezing by the age of 3 years. As a child grows, approximately:

- 15 out of 100 infants who wheeze develop persistent wheezing and go on to develop asthma.
- 60 out of 100 infants who wheeze no longer wheeze by age 6.
- 50 out of 100 preschool-age children who wheeze have persistent asthma later in childhood.

In most cases of intermittent asthma associated with respiratory infections (rather than allergies), symptoms tend to become less severe and may disappear by adolescence. But asthma seems to continue in adolescence in children who have moderate to severe asthma, and these children may have asthma as adults.

Children with persistent asthma:

- Developed symptoms before age 3
- Had allergies in infancy and childhood
- Have a family history of allergies
- Wheeze without a viral infection present
- Have recurrent asthma attacks associated with viral infections (e.g., respiratory syncytial virus)
- Have been exposed to tobacco smoke including before birth

Other risk factors that increase a child's likelihood of developing asthma include:

- Living in an area with high pollution
- Obesity
- Being male
- Being Black or Puerto Rican

(UM, 2020; Mayo Clinic, 2021a)

Asthma Development in Adults

Asthma can develop at any point in life. 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. However, some people who had childhood asthma tend to experience reappearance of symptoms through their 30s and 40s at various levels of severity.

Unlike children who often have experienced intermittent asthma symptoms in response to allergy triggers or respiratory infections, adults with newly diagnosed asthma generally have persistent symptoms, and daily medications may be required to keep their asthma under control.

There are several factors that make a person more likely to develop adult-onset asthma. Being a woman increases the risk after age 20, and obesity appears to significantly increase the risk. Individuals who had asthma as a child may see asthma recur later in life.

At least 30% of adult asthma cases are triggered by allergies, especially those who are allergic to cats. Exposure to allergens or irritants such as cigarette smoke, chemicals, mold, dust, or other substances commonly found in the person's environment, including home or work, may trigger the first asthma symptoms, and prolonged exposure to certain occupational workplace materials may set off asthma symptoms in adults.

Hormonal fluctuations in women may play a role in the development of adult-onset asthma, and some women first develop asthma symptoms during or after pregnancy. Women going through menopause can also develop asthma symptoms for the first time.

Different illnesses, viruses, or infections can be a factor in the development of adult-onset asthma, and a serious cold or bout with influenza is often a factor. Smoking is not a cause of adult-onset asthma; however, smoking or being exposed to secondhand smoke may provoke asthma symptoms (AAFA, 2021c).

Asthma Development in Older Adults

Asthma can develop in anyone at any age, and it is not uncommon for adults in their 70s or 80s to develop asthma symptoms for the first time. The most common triggers for the appearance of asthma include respiratory infections or virus, exercise, allergens, and air pollution. Up to half of older people with an asthma diagnosis are current or former smokers. Tobacco smoke damages the airways, which then respond with asthma symptoms, and contributes to worsened control of symptoms (AAFA, 2021d).

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. Over 100 different genes are thought to be linked to asthma, and through linkage studies (i.e., gene "hunting" and genetic testing), the following novel genes for asthma have been identified:

- ADAM33: A gene that influences lung function in early life and affects how people inhale and exhale
- VDR: Provides instruction for making vitamin D receptors, allowing the body to respond to vitamin D, low levels of which are linked to increased risk of asthma attacks
- DPP10: A rare mutation associated with asthma that encodes a protein that binds specific voltage-gated potassium channels that play a significant role in cytokine production and airway smooth muscle cell and goblet cell function
- PHF11: A regulator of human atopic disease
- HLA: Genes involved in the regulation of immune-specific responses to common allergens
- GPR154: Increased expression of this gene in ciliated cells of the respiratory epithelium and in bronchial smooth muscle cells
- BPFIB1: A key component for clearance of mucus containing inhaled particles and pathogens from the airway
  (Donoghue et al., 2020; Weiss, 2020)

Lung Microbiome

The notion that the lungs are sterile has been abandoned now that evidence has been found of bacterial populations (microbiome) in the lung and that intestinal microbiota provide these bacteria. Each person has their own unique microbiota, and when microbial populations are disturbed, a negative impact occurs known as *dysbiosis*. A higher microbial abundance and species variation are observed in chronic disease states of the respiratory tract, including asthma.

It has been reported that several fungi associated with intestinal dysbiosis could enhance the severity of asthma since intestines and lungs communicate and work in tandem. Specific types of proteobacteria are pronounced in asthma and are usually associated with uncontrolled asthma. In addition, Firmicutes with the genus *Lactobacillus* have been isolated in asthmatic patients as well as the genus *Clostridium* in children with airway allergies (Stavropoulou et al., 2021).

OXIDATIVE STRESS AND ENZYME ANTIOXIDANTS

Asthma and asthma exacerbations are characterized by high oxidative stress and impaired macrophage function. 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.

Oxidative stress is associated with a decreased capacity of macrophages to respond to pathogens, and this appears to be crucial in the insufficient initial response to exacerbating stimuli. Measuring oxidative stress levels or altering stress levels are being investigated as clinical approaches in trying to predict, prevent, and/or diminish the severity of asthma exacerbations (Groot et al., 2019).

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.

TOBACCO PRODUCTS

Tobacco smoke irritates the lining of the airways and is a powerful trigger of asthma symptoms. This is true for adults, but especially so for children. Tobacco smoke harms the smoker and people exposed to secondhand smoke by:

- Damaging the cilia that sweep particles and mucus out of the airways
- Causing an increase in mucus, which together with the damaged cilia, leads to mucus and other irritating substances building up in the airways
- Introducing many cancer-causing substances into the lungs

Secondhand smoke is a combination of smoke from a burning tobacco product and smoke that has been exhaled by a smoker. Inhaling secondhand smoke may be even more harmful than actually smoking the product because the smoke that burns off the end of a cigar or cigarette contains more harmful substances (tar, carbon monoxide, nicotine, and others) than the smoke inhaled by the smoker.

Adults and children who live with a smoker are more likely to develop respiratory illnesses such as asthma. Children with asthma are especially sensitive to secondhand smoke. They are more likely to develop asthma symptoms and more likely to develop lung and sinus infections, which can make asthma symptoms worse and more difficult to control.

Use of tobacco products, including cigarette smoking, smokeless tobacco, and electronic cigarettes, is harmful to both mothers and unborn children, as nicotine and other substances cross

the placenta and go directly to the fetus. Smoking in pregnancy causes structural changes in the placenta and impaired oxygen delivery to the fetus. Children of mothers who smoked during pregnancy are more likely to have respiratory problems and are ten times more likely to develop asthma (Cleveland Clinic, 2021a; Rodriguez, 2021).

For those who live in multi-unit housing, such as an apartment, duplex, or condo, secondhand smoke from another resident's indoor smoking can trigger asthma symptoms. Secondhand smoke can migrate from other units and common areas and travel through doorways, cracks in walls, along electrical lines, via plumbing, and through ventilation systems (ALA, 2020b).

AIR POLLUTION

Poor air quality due to an increase in the amount of carbon dioxide emitted into the atmosphere can trigger asthma symptoms. Carbon dioxide is created by the burning of fossil fuels like coal and oil. Increases in global atmospheric CO_2 concentration stimulates earlier and greater production of pollen allergens and airborne fungal spores, both known aggravators of asthma (Sims et al., 2020).

Increased temperatures lead to increased ground-level ozone, which causes airway inflammation and damages lung tissue. Ground-level ozone can be the most harmful for people living with asthma. It is created by a chemical reaction between nitrogen oxide and organic compounds when exposed to sunlight. These compounds can include emissions from industrial facilities, motor vehicle exhaust, and gasoline fumes. Ground-level ozone is very likely to reach unhealthy levels on hot sunny days in urban environments and is a major component of urban smog.

The populations most vulnerable to ground-level ozone are children, older adults, people with lung disease, or people who spend a great deal of time 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, 2021e).

Each year wildfires occurring across the country have a significant effect on air quality. Smoke is made up of a complex mixture of gases and fine particles produced when wood and other organic materials burn. The biggest threat from smoke is from fine particles that can penetrate deep into the lungs. Children and those with respiratory disease like asthma are at high risk for asthma episodes when the air quality is poor. Wildfires not only affect those in the immediate fire area; smoke can blow and impact people hundreds of miles away (EPA, 2021a; AAFA, 2020).

PRENATAL ULTRAFINE PARTICLE EXPOSURE

Ultrafine particles penetrate deeper into the lungs, have greater ability to induce oxidative stress, and more readily enter the circulatory system. When these particles enter into the bloodstream of a pregnant woman, they cross over into the placenta and enter the bloodstream of the fetus. Because fetal development occurs through sequential biologic events, toxins that disrupt these processes can have a variable effect, depending on the nature of the pollutant as well as timing and/or exposure level.

Researchers have found that children who are exposed to ultrafine particles from air pollution in utero are more likely to develop asthma than unexposed children. Girls have a higher risk for development of asthma when exposed during late pregnancy, while boys have a higher risk if exposed across the entire pregnancy (Wright & Coull, 2019).

INDOOR AIR POLLUTION

Many reports and studies have found that the following populations may be disproportionately impacted by indoor asthma triggers:

- Children
- Older adults
- Low-income individuals
- Minority populations

Indoor air quality can be up to five times more polluted than outdoor air. Sources of indoor air pollution include:

- Fuel-burning combustion appliances
- Tobacco products
- Dust, pet dander, molds
- Cockroach allergens
- Building materials, furnishings, upholstery, carpets
- Household cleaning and maintenance products
- Personal care products
- Hobby supplies
- Central heating and cooling systems
- Humidifiers (high humidity can lead to higher dust mite levels)
- Excess moisture
- Outdoor sources such as radon, pesticides, air pollution (especially for low-income and communities of color who are far more likely to live in areas with heavy pollution)
- Inadequate ventilation
- Cooking (oil and fat particulates)

If too little fresh air enters indoors, pollutants can accumulate to levels that can pose health and comfort problems. If clean outdoor air does not replace indoor air often, then allergens and pollutants may stay in the home and recirculate. The indoor air in newer, more energy-efficient

homes may become more polluted because these homes do not have the same gaps and cracks as older homes to allow air circulation (EPA, 2021b).

WEATHER

Thunderstorm asthma results when a potent mix of pollen and weather conditions trigger severe asthma symptoms in a large number of people over a short period of time. Epidemic thunderstorm asthma (ETSA) outbreaks have occurred globally over the last four decades. Thunderstorm asthma has been reported in the United Kingdom, Australia, Canada, Italy, and the United States. Australia has been particularly susceptible, with nearly half of all episodes reported internationally.

Pollen grains from grasses are large and normally unable to enter the bronchial tree. However, in storms these grains get swept up in the wind and carried for long distances. Some burst open and release tiny particles that are concentrated in the wind just before the storm. These particles are small enough to go deep into the lungs, making it difficult to breathe. This can become very severe, very quickly and may be life-threatening (GINA, 2021; Thien et al., 2020).

DIETARY FACTORS

Several food and food groups have been found to influence the development and course of asthma.

- **High fat/low fiber intake:** A high-fat and low-fiber diet results in increased airway hyperresponsiveness via enhanced cytokine production in the lungs.
- **Dairy products:** Frequent dairy consumption has been found to increase the odds of developing childhood asthma. The mechanism is unclear but may include responses to milk protein or milk lipids.
- **Plant-based diet:** Diets emphasizing fruits, vegetables, and whole grains, while placing less emphasis on high-fat meats and dairy products, have been associated with **reduced asthma risk** in children and a reduced risk of lifetime diagnosis of asthma.
- **Vitamin E deficiency:** Vitamin E interrupts lipid peroxidation to inhibit oxidant-induced damage in human tissue. An isoform of vitamin E scavenges reactive nitrogen species, which can become elevated with acute neutrophilic inflammation. Children born to mothers with vitamin E deficiency are more likely to develop symptoms of asthma requiring medication.
- **Vitamin D deficiency and insufficiency:** Both deficiency and insufficiency in vitamin D levels are significantly higher in asthma patients. Children who are vitamin D deficient have been found to be five times as likely to have asthma, and those who are vitamin D insufficient were three times as likely. Vitamin D insufficiency has also been associated with increased risk of hospitalization or emergency department visits. Low maternal vitamin D intake during pregnancy is associated with an increased risk of children developing asthma in the first 10 years of life.
  (Alwarith et al., 2020)

RESPIRATORY INFECTIONS

Respiratory infections are common and can affect lungs, nose, sinuses, and throat, especially in children and adults with preexisting asthma.

Respiratory tract infections are a main asthma trigger and can result in severe asthma symptoms. A respiratory tract infection causes inflammation, and asthma is an inflammatory condition. Together they deliver an inflammatory onslaught that triggers an asthma attack. People with asthma can have a more severe illness and take longer to recover from respiratory infections (Cleveland Clinic, 2020).

Viral Infections

There is a large body of evidence that demonstrates a link between early viral infections and asthma inception and exacerbation. Viral respiratory tract infections are the most common cause of wheezing illnesses and asthma exacerbations in both children and adults. Respiratory viruses can induce symptoms of acute bronchiolitis, croup, and recurrent wheezing in young children (Mikhail & Grayson, 2019; Kakumanu, 2021).

Respiratory viruses infect and cause cytopathic damage to airway epithelium. This damage then induces the release of proinflammatory agents, which then propagate eosinophilia and stimulate the release of cytokines that promote asthma and atopic disease. Some viruses may not damage the epithelium directly but rather interact with macrophages, T cells, or mast cells to stimulate allergic airway inflammation and modulate the host's response to allergens and irritants in the environment (Kakumanu, 2021).

Specific viruses associated with the development of asthma include:

- **Respiratory syncytial virus (RSV)** in children under 2 years of age is the most common cause of wheezing and is an important risk factor for intrinsic asthma, with severe infections conferring greater risk.

- **Rhinovirus (RV)** (the common cold) is a more important risk factor for the development of extrinsic asthma, likely through T-helper 2-biased inflammation. Rhinovirus is more significant in adults and children older than 2 years, causing increased symptomatology in patients with preexisting asthma.

- **Parainfluenza** can cause lower respiratory tract infections and is 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.

- **Human metapneumovirus (hMPV)** presents similar to RSV and is a common cause of upper and lower respiratory tract infections in infants and children. It also affects adults, particularly older adults, and those with weakened immune

systems. Lower airway infections have been shown to trigger asthma attacks in those with existing asthma.

- **Coronavirus (CoV)** infections can range from a mild common cold to more severe disease such as COVID-19, which can be fatal.

- **Adenovirus (AdV)** has been found to initiate chronic, more persistent, and severe asthma. How AdV affects asthmatic patients, however, remains unclear. (Kakumanu, 2021; Jarrti et al., 2020)

Bacterial Infections

Similar to viruses, airway bacteria have also been suggested as early-life risk factors for later development of asthma. Also, the gut microbiome, considered to be a risk factor for later development of asthma, might influence the susceptibility to viral infections in the airway.

In addition, there is substantial evidence of an interaction between bacteria and viruses in the airways. Rhinovirus has been found to be associated with increased bacterial pathogens, and *Moraxella catarrhalis* and *Streptococcus pneumoniae* seem to contribute to the severity of respiratory tract illness and asthma.

Several mechanisms are involved in which viral infections can increase the risk of bacterial infections, including immune suppression, epithelial damage, and changes in the local lung environment, altering the growth conditions for pathogenic bacteria and viruses (Jartti et al., 2020).

CESAREAN SECTION

Children born by cesarean section have a higher risk of asthma than those born by vaginal delivery, particularly children of parents with allergies. There are two possible causes that have been hypothesized:

- Lack of contact by the infant with the mother's bacteria. Neonates born by vaginal delivery acquire most of their intestinal flora by being exposed to their mother's vulvovaginal/bowel flora during birth, which influences early immune modulation (Litonjua & Weiss, 2020b).

- Infants delivered by cesarean section have less contact with stress hormones and chest pressure that normally occurs during vaginal delivery, which has a negative effect on lung function because these mechanisms are associated with the reabsorption of amniotic fluid from the lungs (Darabi et al., 2019).

Neonates who are born following a planned cesarean section without labor do not experience labor-related stress and immune modulation and are at increased risk of asthma up to the age of 12 years.

In an attempt to restore normal neonatal colonization of cesarean-born neonates, vaginal seeding has been suggested; however, both the safety and effectiveness of this practice is unproven and is only recommended in research trials (Norwitz, 2021).

Comorbid Factors

OBESITY

Obesity is a risk factor for asthma, particularly in adult women, and the greater the body mass index (BMI), the greater the risk of asthma. An increased prevalence of asthma also occurs in children with obesity. Among adults with severe asthma, nearly 60% are obese. This is related to a complex interplay of biologic, physiologic, and environmental factors. Asthma in patients who are obese is often severe and difficult to control.

In some people, obesity precedes asthma, and obesity is a risk factor for later development of asthma. In others, asthma precedes obesity, suggesting that asthma may be a risk factor for the development of obesity.

Obesity results in mechanical changes. It increases the collapsibility of the peripheral airways and parenchyma, especially among people with late-onset asthma. Excessive accumulation of fat in the thoracic and abdominal cavities leads to lung compression and an attendant reduction in lung volume. Other factors that are likely contributors to the increased risk and severity of asthma in obese individuals include:

- Genetics, evidenced by twin studies suggesting 8% of genetic component is shared with asthma
- Air pollution and parental smoking, which are independent risk factors for both obesity and asthma
- Dietary factors, including high sugar or saturated fat intake or low antioxidant or fiber intake
- Lung growth in children (e.g., increased lung volume relative to airway caliber)
- Adipose tissue proinflammatory mediators
- Immune cell function alterations (e.g., suppression of T-helper lymphocyte function or lymphoid cell response to intrinsic damage)
- Increased oxidative stress with late-onset asthma
  (Dixon & Nyenhuis, 2021)

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 (ACO), although specific features that can be used to make a diagnosis of ACO have yet to be agreed upon.

Despite the lack of a well-accepted definition, there are a range of features that support the diagnosis of ACO, including:

- Age 40 years or older
- Persistent respiratory symptoms, but variability in symptoms may be prominent
- Airflow limitation that is not fully reversible
- History of doctor-diagnosed asthma at some point
- History of atopy or allergies
- Exposure to a risk factor such as tobacco smoking or equivalent indoor/outdoor pollution

Research efforts are needed to better understand asthma and COPD phenotypes and what types of biomarkers (physiologic, radiologic, or biologic) help to distinguish those patients with ACO who are most responsive to specific therapies (Han & Wenzell, 2020).

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, and anyone—including infants, children, and teens—can develop GERD. 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:

- 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.

- 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. GERD may also be related to eating specific foods or, rarely, to food allergies (AAFA, 2021f).

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 in Jonah, 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 been diagnosed with 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.

But asthma symptoms vary from patient to patient. Symptoms can 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, 2021b).

Most children with asthma have symptoms before they turn 5. In very young children, it may be difficult for parents and clinicians to recognize that the symptoms are due to asthma. Symptoms of pediatric asthma can range from a nagging cough that lingers for days or weeks to sudden and scary breathing emergencies.

While other conditions can cause the same symptoms as asthma, the pattern of symptoms in people who have asthma usually has some of the following characteristics:

- They come and go over time or within the same day.
- They start or get worse with viral infections, such as a "cold."
- They are triggered by exercise, allergies, cold air, or hyperventilation from laughing or crying.
- They are worse at night or in the morning.
  (NHLBI, 2020a)

Coughing

Coughing may be the only symptom of asthma, especially in cases of exercise-induced bronchoconstriction or nocturnal asthma. Usually, the cough is nonproductive and nonconvulsive. A cough that keeps coming back is a symptom of asthma. It is more likely to be asthma if the cough is accompanied by other asthma symptoms; however, not everyone with asthma coughs.

Frequent coughing, especially at night, is usually dry and nonproductive, but in some people with uncontrolled asthma, there may be thick, clear mucus. Children with nocturnal asthma tend to cough after midnight and during the early hours of the morning (Asthma UK, 2021a; Morris, 2020).

Wheezing

Wheezing is a musical, high-pitched, whistling sound caused by airflow turbulence. It is one of the most common symptoms of asthma. Wheezing is produced by air being forced through narrowed airways, and in asthma the affected airways are mainly the small bronchioles of the lungs. Asthma can occur without wheezing, however, when the obstruction predominately involves the small airways.

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 (Morris, 2020).

Many babies and young children wheeze due to colds or viruses and do not develop asthma as they get older. The diagnosis of asthma in children usually cannot be made until they are older, by age 4 or 5 (Sawicki & Haver, 2019).

Dyspnea

Dyspnea, or shortness of breath, has many causes and is very common. The experience of dyspnea arises from interactions among multiple physiologic, psychological, social, and environmental factors. Bronchoconstriction leads to a series of sensations as the degree of constriction worsens, from chest tightness to an increased effort to breathe to a sensation of air hunger. Patients often complain of an increased effort to breathe.

Asthma is most likely the cause of dyspnea when:

- It is accompanied by coughing and wheezing
- Symptoms seem to be triggered by specific things (e.g., allergens, cold air, exercise)
- The person is an adult who had asthma or asthma-like symptoms as a child

- The person has hay fever or other allergies or family members with allergies or asthma (Schwartzstein, 2020; Li, 2020)

Airway Mucus Hypersecretion

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.

Inflammation and oxidative stress cause the inner lining of airways to swell and produce mucus. Patients with hypersecretion have more dyspnea, have poorer asthma control and quality of life, and experience more exacerbations. They are significantly older, with a longer duration of disease and more frequent severe asthma. They also have greater airflow obstruction and a higher number of emergency department visits.

The mucus produced in asthma is thicker and stickier (more viscous) than normal. Additionally, in persons with asthma the cilia (specialized cells 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., 2018).

Sleep Disturbances

About 75% of people with asthma are wakened by nighttime symptoms at least once a week. Around 40% of people with asthma experience nocturnal symptoms every night. Having poorly controlled severe asthma makes a person more likely to experience nocturnal symptoms.

The mechanism underlying this is not fully understood but may be related to normal circadian hormonal changes that take place in the evening. These changes may contribute to inflammation in the airways, increasing the risk of nocturnal asthma symptoms. Other mechanisms may also include obesity, GERD, and environmental triggers (Newsom, 2021).

Signs and Symptoms Unique to Children

Asthma in children is not different from asthma in adults, but children face unique challenges. Infants and young children with asthma display the following characteristics:

- Breathlessness at rest
- Loss of interest in feeding
- Sitting upright
- Talking in words, not sentences
- Usually agitated
- Chest retractions
- Vomiting with cough

With imminent respiratory arrest, the child displays the symptoms mentioned above and is also drowsy and confused. Adolescents, however, may not have these symptoms until they are in frank respiratory failure (hypoxia, hypercarbia, increased work 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 (Sharma, 2021)

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, 2021).

History

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, 2021)

EXACERBATION HISTORY

The exacerbation history is important with respect to the following:

- Usual prodromal signs or symptoms
- Rapidity of onset
- Associated illnesses
- Number in the last year
- Need for emergency department visits, hospitalizations, ICU admissions, and intubations
- Missed days from work or school
- Activity limitation
  (Morris, 2020)

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, 2021)

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 worsen in the morning and improve throughout the day)
  (Sawicki & Haver, 2019)

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.

POTENTIAL ASTHMA TRIGGERS AND AGGRAVATORS	
Type	**Examples**
Infections and comorbid conditions	• Respiratory infections (respiratory syncytial virus, rhinovirus) • Sinusitis (most common factor associated with more severe and harder-to-control asthma) • Rhinitis
Hormonal changes	• Premenstrual days, pregnancies • Estrogen and progesterone
Inhaled substances	• Biological allergens: mold, fungal spores, pollen (weeds, grasses, trees), pets with fur or hair, dust mites, cockroaches • Chemical vapors: perfumes, cleaning products, aerosol sprays, chlorine (e.g., in indoor pools), industrial solvents (e.g., paint thinner) • Air pollutants: particulates, sulfur dioxide, ozone, nitrogen oxide, tobacco smoke, dust • Wood fires • Charcoal grills • Specific items: old books, pieces of stuffed furniture, mattresses
Ingested substances	• Foods or drinks (e.g., homemade wine or beer) • Sulfites (preservatives) and tartrazine dyes • Foods high in nitrites • Monosodium glutamate (MSG) • Medicines: aspirin, NSAIDs (e.g., ibuprofen), beta-adrenergic blockers
Physical factors	• Temperature extremes: heat, cold • Weather: storms, wind, humidity
Comorbid conditions	• Allergic bronchopulmonary aspergillosis • Obstructive sleep apnea • Chronic obstructive pulmonary disease (COPD) • Gastroesophageal reflux disease (GERD) • Obesity • Nasal polyps • Pregnancy

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 • Travel • Altered workplace, altered workplace processes or materials used • Weather (dry, windy, cold air; sudden changes; thunderstorms) • School or daycare setting
Exercise	• Hyperventilation • Winter sports more commonly than summer sports
Emotional situations	• Stress • Anger • Frustration • Fear • Excitement • Yelling • Laughter • Crying • Anxiety • Depression
(AAFA, 2019a)	

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

Of great significance is a past near-fatal asthma exacerbation requiring endotracheal intubation, which is the greatest single predictor of death from bronchial asthma (Chakraborty & Basnet, 2021).

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 collected the following information:

- 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 4–5 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 (Morris, 2020).

SOCIAL HISTORY

Social history includes:

- Smoking
- Workplace or school characteristics
- Educational level
- Employment
- Social support
- Factors that may contribute to nonadherence of asthma medications
- Illicit drug use
  (Morris, 2020)

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, and 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, individuals with asthma 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, 2021)

CASE: Patient History

Deborah is a 24-year-old teacher's aide who works in an 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 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
    - Swollen or boggy normal structures (turbinates)
    - Pale and violet-colored nasal mucosa due to allergic rhinitis
    - Amount, color, and consistency of any nasal discharge
    - Abnormal structures such as 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
    - Increased anteroposterior diameter of chest in children due to hyperinflation, causing an abdominal breathing pattern
    - 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, unequal breath sounds or any other abnormal sounds
    - Prolonged end-expiratory wheeze (in a child who is not sick, forced exhalation may reveal expiratory wheezing)
    - Hyperresonance found during percussion, related to trapped air in the lungs

(Morris, 2020)

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
- Supraclavicular and intercostal retractions and nasal flaring in children
- Abdominal breathing in children
- Have a pulse rate between 100–120 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
- Have no interest in feeding
- Commonly exhibit suprasternal retractions
- Have a pulse greater than 120 bpm
- Exhibit pulsus 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

EXAMINATION DURING IMMINENT RESPIRATORY ARREST

When children are in imminent respiratory arrest, in addition to the symptoms mentioned above, they are drowsy and confused; but adolescents may not have these symptoms until they are in frank respiratory failure.

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 pCO_2 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 CO_2 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, 2020; Sharma, 2021).

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. These include:

- Upper airway diseases:
    - Allergic rhinitis and sinusitis
- Obstructions involving large airways:
    - Foreign body in trachea or bronchus
    - Vocal cord dysfunction
    - Vascular rings or laryngeal webs
    - Laryngotracheomalacia, tracheal stenosis, or bronchostenosis
    - Enlarge lymph nodes or tumor
- Obstructions involving small airways:
    - Viral bronchiolitis or obliterative bronchiolitis
    - Cystic fibrosis
    - Bronchopulmonary dysplasia
    - Heart disease
- Other causes:
    - Recurrent cough not due to asthma
    - Aspiration from swallowing mechanism dysfunction or gastroesophageal reflux

(AIM, 2021)

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, 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 to establish baseline lung function, evaluate dyspnea, detect pulmonary disease, monitor effects of therapies used to treat respiratory disease, evaluate respiratory

impairment or disability, evaluate operative risk, and perform surveillance for occupational-related lung disease.

During the process, the technician applies a clamp to the patient's nose to keep it shut. The patient is asked to inhale deeply and blow out as hard, as quickly, and as long as possible into the mouthpiece of the spirometer. The patient should exhale for at least 6 seconds, and at the end of the forced exhalation, the patient should again inhale as fully and as rapidly as possible. The forced vital capacity (FVC) should then be compared with the inhaled volume to verify that the forced expiratory maneuver did start from full inflation.

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.

Child undergoing spirometry testing. (Source: 50Martin50, CC SA 3.0.)

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.
  (McCarthy, 2020)

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

Peak flow meters. (Source: Hosseman.)

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		
Zone	**Measurement**	**Finding**
Green	80%–100% of patient's normal	Asthma is under control
Yellow	50%–80% of patient's normal	Rescue medicines should be used; a medical visit may be needed
Red	<50% of patient's normal	Signals a medical alert; emergency care is needed
(ALA, 2020c)		

Body plethysmography, also known as a *lung volume test,* measures the amount of air the person can hold in the lungs and the amount of air that remains after forced exhalation. It is used to determine whether exposure to substances in the home or workplace have caused lung damage and whether there is a need for a change in treatment (McCormack, 2020).

Gas diffusion test or **diffusing capacity of the lung for carbon monoxide (DLCO)** determines how well the alveoli are delivering oxygen to and removing carbon dioxide from the blood into the capillaries surrounding them. The person inhales air containing a very small amount of carbon monoxide and a tracer gas, such as methane or helium, holds the breath for 10 seconds, and then rapidly exhales. The exhaled gas is tested to determine how much of the tracer gas was absorbed during the breath. Another name for this test is *lung diffusion testing* (NIH, 2021a).

FRACTIONAL EXHALED NITRIC OXIDE TESTING (FeNO)

FeNO testing can help determine how much inflammation is present in the airways. It does not test directly for asthma but can assist in confirming an asthma diagnosis in adults and children ages 5 and older. It is also done if spirometry cannot be performed. Exhaled nitric oxide testing is technically complex and is not routinely used in monitoring (Cloutier et al., 2020).

CHILDREN AND LUNG FUNCTION TESTING

Most children who have asthma develop their first symptoms before 5 years of age. Asthma in children ages 0–5 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, including lung airways and rig cage during tidal breathing (normal, restful breathing). 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)** and **impulse oscillometry system (IOS)** are both widely used in pediatric settings. They are noninvasive techniques performed during tidal breathing, requiring only minimal cooperation from the patient. FOT and IOS assess bronchial hyperresponsiveness by employing small-amplitude pressure oscillations superimposed on normal breathing.

- **Multiple breath washout (MBW)**, also referred to as *gas dilution,* measures the clearance of a gas from the lungs. It is performed during tidal breathing, during which a marker gas, usually helium, less frequently nitrogen, is washed out with 100% oxygen. Preschool children perform the test in a seated position, and a video can be used for distraction and to promote a regular breathing pattern.

- **Single-breath counting (SBC)** is a novel technique for measuring pulmonary function in children. SBC is the measurement of how far the child can count using a normal speaking voice after one maximal effort inhalation. The count is in cadence to a metronome that is set at two beats per second. SBC has been found to correlate well with standard measures of pulmonary function.

  (Rosen & Colin, 2020; Morris, 2020)

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 20 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. Several types of bronchoprovocation testing are available to assess airway responsiveness in specific patient situations. These may include:

- Pharmacologic drugs to cause narrowing of the airways, including methacholine or mannitol

- Exercise challenge
- Eucapnic voluntary hyperpnea, which mimics the effect that prolonged exercise has on the airway
- Food additive challenge
- Antigen challenge

During this test, a direct provocative stimulus is used to stimulate bronchoconstriction. People with asthma are more sensitive to such stimuli than those without asthma. Although these challenges are very safe, they may make the patient feel dizzy or uncomfortable and can cause symptoms of an asthma attack.

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 (Irvin, 2020; ALA, 2021a).

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 must identify the allergens that cause them trouble.

As a first step in building a list of probable offending allergens, the patient keeps 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. There are three common methods of allergy skin testing.

In a **skin prick test** (also called a *puncture* or *scratch test*), a series of tiny drops of allergens are placed on the skin, and the skin underneath each drop is pricked with a needle or lancet so that the allergen will penetrate beneath the skin surface. Several allergens can be tested at the same time. 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. In adults, the test is usually done on the forearm, and children may be tested on the upper back.

Skin prick test. (Source: National Institutes of Health.)

If the skin prick test is negative, an **intradermal test** may be done, in which the allergen is injected into the skin. This test is more likely to be used to find out if the patient is allergic to bee venom or a drug (e.g., penicillin). Or it may be used if the skin prick test was negative and the clinician still thinks the patient is allergic to the allergen.

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. The clinician looks at the area in 72 to 96 hours, and if the skin has become red, irritated, and itchy, the results may indicate an allergy (NIH, 2021b).

Intradermal skin testing. (Source: Wikimedia, CC SA 2.0.)

Intradermal testing carries a slightly higher risk of provoking significant allergic reactions than other methods. In rare instances a patient can have a severe, immediate allergic reaction (anaphylaxis) and require emergency management.

Intradermal tests can also be more accurate than skin prick and patch tests, but sometimes they may be falsely positive. In some cases, a person may have a positive response to a substance but have no problems with that substance in everyday life. Also, if the dose of allergen is large, even people who are not allergic to it can have a positive reaction (Mustafa, 2021; Mayo Clinic, 2020c; Bhargave, 2020).

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 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, more sensitive, and does not require submitting a blood sample. 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.

Immunoassays are valid for infants as young as 6 weeks of age and can be performed on capillary blood samples. In vitro tests may be preferable for those with skin conditions, such as widespread and severe atopic dermatitis, or dermographism (exaggerated weal and flare response occurring within minutes of skin being stroked or scratched). In vitro tests are often indicated to confirm negative skin tests. 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, dust mites, or cockroaches
- Natural rubber latex

- Some beta-lactam drugs such as penicillin or cephalosporins
- Some occupational allergens
  (Kowal & DuBuske, 2021)

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 nonsmokers to exclude emphysema
- Comprehensive metabolic panel, to evaluate overall body organ function, including kidney, liver, and lungs
- Sweat test or trypsin/chymotrypsin, to rule out cystic fibrosis in both children and adults
- AFB tuberculin testing, to rule out tuberculosis and nontuberculous mycobacteria
- Lung biopsy, to evaluate lung tissue for damage and for cancer
  (Fanta, 2020a; Lab Tests Online, 2021)

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
  (Morris, 2020)

PULSE OXIMETRY

Pulse oximetry (PO) measures the percentage of hemoglobin that is carrying oxygen to determine hypoxemia in patients with acute asthma. PO is often used in children to grade the severity of an acute asthma exacerbation and to determine whether the child requires hospitalization.

A pulse oximeter device is placed on the finger, nose, toe, earlobe, or forehead, 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.

A pulse oximetry reading should always be considered an **estimate** of the oxygen saturation. Therefore, numbers from a pulse oximeter should not be used in isolation. A reading may be anywhere from 2% to 4% higher or lower than the actual oxygen level in the arterial blood (ALA, 2021b).

A finger-mounted pulse oximeter with pulse bar taking measurements through the fingernail. (Source: Thinkpaul, CC SA 3.0.)

FDA ALERT

In February 2021, the FDA issued an alert on limitations of pulse oximeters. The pulse oximeter may not give accurate or consistent readings in persons with poor circulation, dark skin pigmentation, thick skin, current tobacco usage, cool skin temperature, dark fingernail polish, long artificial nails, or soiled fingers (FDA, 2021a).

An oxygen saturation (SpO_2) reading of 95% or higher is normal for a healthy individual. A reading of 91%–95% is clinically acceptable but low and may be due to the patient being a smoker. Readings from 70%–90% are unsafe levels and indicate hypoxemia. Less than 70% indicates extreme lack of oxygen. However, clinical correlation is always necessary since the exact cutoff below which tissue hypoxia ensues has not been defined.

Patients with chronic lung disease often have a degree of hypoxia, in which case target saturation rates generally fall between 88%–92%. These patients are often aware of what is normal for them. A drop of 3% or more below what is normal for the patient warrants further assessment, and a drop of 4% or more may require hospital admission (Yale Medicine, 2021).

IMAGING STUDIES

A **chest X-ray** is valuable for revealing complications or alternative causes of wheezing. It is usually more useful in the initial diagnosis of asthma than in the detection of exacerbation, although it is valuable in excluding complications, including pneumonia and asthma mimics, even during exacerbation.

In most patients with asthma, chest X-ray findings are normal or may indicate hyperinflation. Because pneumonia is one of the most common complications of asthma, chest X-ray is indicated in those with fever to rule out pneumonia.

For diagnostic purposes, atypical presentations, and hospital admissions, chest X-rays should be taken. In asthma, X-rays 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, foreign body aspiration, and lung cancer (Morris, 2020).

High-resolution CT (HRCT) is a second-line examination useful for patients with chronic or recurring symptoms and those with possible complications, such as allergic bronchopulmonary aspergillosis and bronchiectasis. Findings in bronchial asthma include:

- Bronchial wall thickening
- Bronchial dilatation
- Cylindrical and varicose bronchiectasis
- Reduced airway luminal area (the major determinant of airway resistance)
- Mucoid impaction of the bronchi
- Centrilobular opacities, or bronchiolar impaction
- Linear opacities
- Air trapping, as demonstrated or exacerbated with expiration
- Mosaic lung attenuation, or focal and regional areas of decreased perfusion (Morris, 2020)

ECG

ECG is done to determine whether the heart is the cause of severe asthma symptoms, such as irregular heartbeat, an enlarged heart, or previous damage to the heart muscle. It is also done to determine if the patient's heart is healthy enough for medications that may be prescribed for asthma management (Asthma UK, 2021b).

Patients who are severely symptomatic should have ECG monitoring. Sinus tachycardia and ECG evidence of right heart strain are common in patients with acute asthma (Morris, 2020).

NUCLEAR IMAGING

Technetium-99m DTPA radioaerosol lung scintigraphy is a classic technique that shows the extent of major airway distribution, peripheral distribution, and absorption in the oronasal air passages. 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, 2020).

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. This is an outpatient procedure done to measure the pH or amount of acid that flows into the esophagus from the stomach during a 4-hour period (Morris, 2020).

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** classify asthma in adults based on signs and symptoms and in children based on signs, symptoms, and treatment requirements.

GINA 2021 GUIDELINES	
Asthma Classification	**Treatment Requirements**
Mild	Well-controlled with rescue medication alone or with low-dose controller treatment such as low-dose inhaled corticosteroids (ICS), leukotriene receptor antagonists, or chromones
Moderate	Well-controlled with low-dose inhaled corticosteroids (ICS) combined with long-acting beta-2 agonists (LABA)
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
(GINA, 2021)	

NAEPP GUIDELINES		
Asthma Classification	**Signs, Symptoms, Treatment Requirements**	
	Children 0 to 4 Years	**Adults & Children 5 Years & Above**
Intermittent (most common and least severe form of asthma)	• Symptoms 2 or fewer days per week • Absence of nighttime awakenings • Rescue medication used 2 or fewer days per week • No interference with normal activity	• Cough, wheezing, chest tightness, or difficulty breathing less than 2 times a week • Sleep interrupted by asthma symptoms less than twice a month • Flare-ups brief; intensity may vary • No symptoms between flare-ups • Lung function test FEV1 ≥80% above normal values and PEF varies <20% from a.m.-to-p.m., p.m.-to-a.m., day to day
Mild persistent	• Symptoms more than 2 days per week, but not daily • Nighttime awakenings 1 to 2 times per month • Rescue medication used more than 2 days per week but not daily • Minor interference with normal activity	• Symptoms more than 3 to 6 times a week • Nighttime symptoms 3 to 4 times a month • Exacerbations affect activity levels • Lung function test FEV1 ≥80% above normal values • PEF varies 20%–30%
Moderate persistent	• Symptoms daily • Nighttime awakenings 3 to 4 times per month • Some limitation with normal activity • Daily rescue medication use	• Symptoms daily • Nighttime symptoms 5 or more times a month • Exacerbations affect activity level • Lung function tests abnormal (>60% to <80% of normal values) • PEF varies more than 30%
Severe persistent	• Symptoms throughout each day • Nighttime awakenings more than once a week • Physical activities severely limited • Rescue inhaler use several times per day	• Symptoms throughout each day • Nighttime symptoms often, sometimes every night • Physical activities severely limited • Lung function tests abnormal (≤60%) • PEF varies more than 30%
(Morris, 2020)		

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 medical 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.

There are four **types of asthma medicines and treatments**:

- Quick-relief medicines that work quickly and are taken as needed at the first sign of symptoms
- Controller medicines that treat asthma by correcting the underlying changes in the airways, such as swelling and mucus hypersecretion; can be combined with other medications
- Combination of quick-relief and controller medicines used for both short-term relief and control
- Biologics given by injection or infusion to target a cell or protein to prevent swelling inside the airways, used for certain types of persistent asthma
  (AAFA, 2021g)

Drug Administration: Inhalation

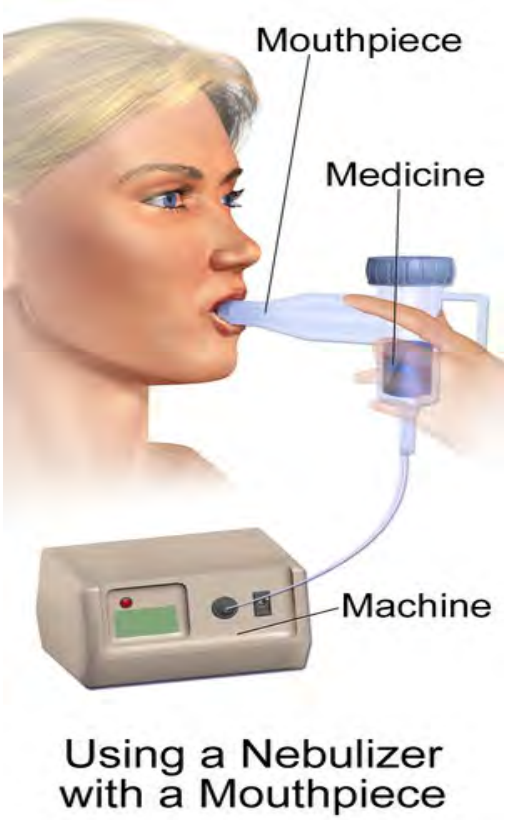
Many asthma drugs are administered by inhalation to send the medication directly to the target tissue, the inner linings of the airways of the lung. Higher concentrations of medicine can be delivered this way with fewer systemic side effects.

TYPES OF AEROSOL DEVICES

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

Nebulizer

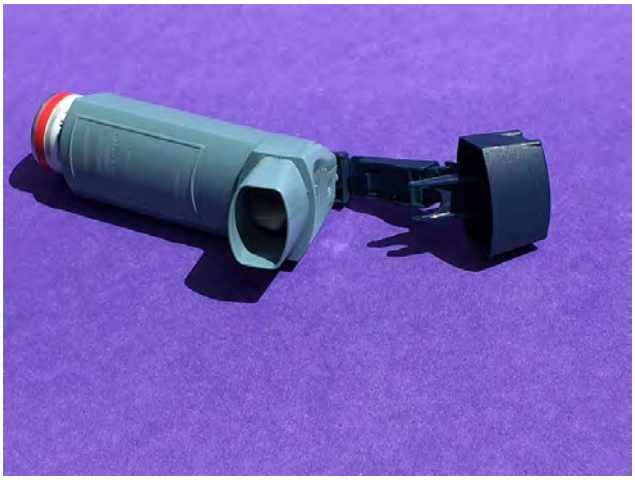
A nebulizer is a drug delivery device used to change medication from a liquid to a mist so that it can be more easily inhaled into the lungs through a mouthpiece or mask worn over the nose and mouth. A nebulizer is the most common device used to deliver medications to infants, small children, and patients requiring hospitalization.



(Source: BruceBlaus, CC SA 4.0 International.)

Metered-Dose Inhaler (MDI)

An MDI is 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.



Metered-dose inhaler (MDI). (Source: NIAID, CC 2.0 Generic.)

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.

Child using inhaler with spacer. (Source: Michael J. Ermarth, FDA.)

Dry Powder Inhaler (DPI)

This 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. A DPI is not indicated for use in children younger than 12 years because of the requirement of a high inspiratory flow.

Dry powder inhalers (left to right): Turbuhaler, Accuhaler, Ellipta devices.
(Source: NIAID, CC SA 4.0 International.)

Soft Mist Inhaler (SMI)

A soft mist inhaler is a newer type of device that creates a cloud of medicine that is inhaled without the assist of a propellant. Because the mist contains more particles than MDIs and DPIs and the spray leaves the inhaler more slowly, more of the drug enters the lungs (Hess & Dhand, 2020).

PROPER USE OF INHALERS

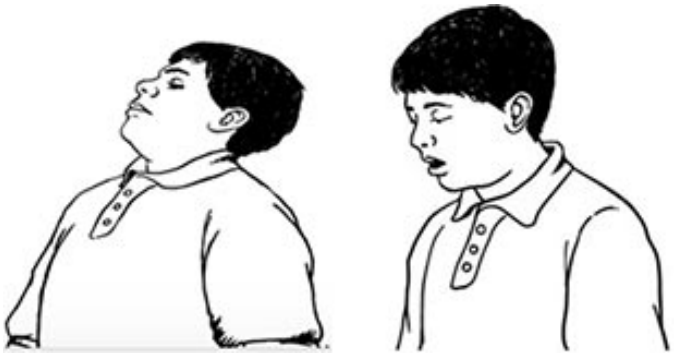
It is important to read the device-specific instructions for proper use of any inhaler if it is to be effective. The following are general instructions for use of inhalers.

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, 2018.)

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, 2020).

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 30–60 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. Replace the mouthpiece cover.
6. If it is necessary to use the inhaler before the mouthpiece is dry, shake off excess water, replace canister, and test spray two times (away from the face).
7. Follow the manufacturer's instructions for cleaning a dry powder inhaler.
   (Hess & Dhand, 2020)

INHALER MISUSE

A study of patients from adult and pediatric clinics has shown that up to 92% of individuals with asthma 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. Another study found that 1 in 4 patients had never received instructions on proper inhaler technique. It is obvious, therefore, that improving techniques will improve clinical outcomes (AAFA, 2019b; Makhinova et al., 2020).

For MDI users, the most common errors involve coordination, speed and/or depth of inspiration, and postinhalation breath-hold. The most common errors among dry-powder inhaler users were incorrect preparation, no full expiration after inhalation, and no postinhalation breath-hold.

Incorrect inhaler technique is linked to a significantly greater risk for inhaled corticosteroid overuse. Unintentional nonadherence to first-line rescue inhalers can lead to use of long-acting inhaled medications that might not otherwise be needed. Improper use of inhaled corticosteroids can increase the risk of pneumonia and other direct and indirect complications. These findings highlight the importance of inhaler technique training.

The gold standard for teaching inhaler technique is **Teach-To-Goal (TTG)**, which combines assessment and education through rounds of demonstration and patient teach-back. Teach-back has been associated with a statistically significant improvement in inhaler use and may require multiple sessions to ensure skills are retained (Rodriguez, 2019a).

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 using the Teach-To-Goal technique 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.

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 (SABAs)

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, reversing and preventing 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 2–4 hours.

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

Side effects:

- Tachycardia
- Tremors

- Jitteriness
- Palpitations

Precautions:

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

(AAAI, 2021)

LONG-ACTING BETA-2 AGONISTS (LABAs)

LABAs are recommended for use only in conjunction with inhaled steroids in asthma. Long-acting bronchodilators are used to provide control, not quick relief of asthma. They should only be used with inhaled steroids for long-term control of asthma symptoms (AAAI, 2021).

LONG-ACTING BETA-2 AGONISTS	
Generic Name	**Brand Name**
Formoterol fumarate inhalation powder	Foradil
Salmeterol	Serevent Diskus
Oldodaterol	Striverdi Respimat

ANTICHOLINERGICS

Another group of bronchodilators, anticholinergics, are **muscarinic receptor antagonists** (parasympatholytics). They are used along with beta-2 agonists for treatment of severe symptoms. They are not, however, intended for acute asthma attacks.

Whereas beta-2 agonists affect the bronchioles (small airways), anticholinergics affect the muscles around the bronchi (large airways) by blocking receptors that cause spasm and by decreasing secretion of mucus. 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	
Generic Name	**Brand Name**
Ipratropium bromide	Atrovent HFA
Long-acting tiotropium	Spiriva Respimat
Umeclidinium	Anora Ellipta Incruse Ellipta

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.

(AAFA, 2021h; Schiffman, 2020; FDA, 2021b)

METHYLXANTHINES

Methylxanthines belong to 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. They also have 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 an add-on or 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 (ethylenediamine is an additive that increases pH sufficiently enough to dissolve theophylline).

METHYLXANTHINES	
Generic Name	**Brand Name**
Theophylline (short-acting)	Elixophyllin Theochron
Theophylline (long-acting)	Theo-24
Theophylline and dextrose injectable	None
Aminophylline (injectable)	None

Methylxanthines have a narrow therapeutic range and thus a high incidence of adverse effects.

Mild side effects:

- Nausea and vomiting
- Increased gastric acid secretion and subsequent GERD
- Polyuria
- Insomnia

- Palpitations
- Headache
- Tremors
- Weakness

Severe side effects:

- Intractable vomiting
- Arrhythmias
- Tachycardia or bradycardia
- Cardiac arrest
- Allergic skin reactions
- Seizures

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.
- Certain diets, such as high-protein/low-carbohydrate or vice versa, may change the effect of theophylline.
- Phenytoin (Dilantin) and carbamazepine (Tegretol) may decrease theophylline levels.

Contraindicated for people with the following:

- Cardiovascular disease
- Cystic fibrosis
- Hepatic impairment
- Hypo or hyperthyroidism
- Peptic ulcer disease
- Seizure disorder
- Pregnancy and breast feeding

(FDA, 2021b; Gottwalt & Tadi, 2021)

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

Inhaled corticosteroids (ICSs) are considered the most potent and consistent anti-inflammatory agents currently available for preventing exacerbations in patients with persistent asthma. Regular use of these medications reduces the frequency of asthma symptoms, bronchial hyper-responsiveness, and risk of serious exacerbation, and improves quality of life.

ICSs work directly at the cellular level by reversing capillary permeability and lysosomal stabilization to reduce inflammation. The onset of action is gradual and may take from several days to several weeks for maximal benefit with consistent use. Recently updated guidelines recommend ICSs be used for acute asthma symptoms in conjunction with beta-2 agonists in adolescents and adults.

ICSs come in liquid capsule formulation given through a nebulizer machine, metered-dose inhalers (MDIs) administered through spacers, and dry powder inhalers (DPIs). These medications are initiated in a stepwise fashion based on the frequency and severity of asthma symptoms. Low-, medium-, and high-dose inhaled corticoids are available to treat mild, moderate, and severe persistent asthma (Liang & Chao, 2021).

INHALED CORTICOSTEROIDS	
Generic Name	**Brand Name**
Beclomethasone dipropionate	QVAR Redihaler*
Budesonide	Pulmicort Flexhaler Pulmicort Respules
Fluticasone propionate	Flovent HFA Flovent Diskus Advair HFA+ Arnuity Ellipta Armonair Digihaler Armonair Respiclick
Mometasone	Asmanex HFA Asmanex Twisthaler
Ciclesonide	Alvlesco
*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
- Dysphonia
- Oral yeast infections
- Reflex cough
- Bronchospasm
- Risk of bone fractures with high doses

Precautions:

- ICSs may decrease growth in children, so the lowest dose possible should be prescribed.
- ICSs may increase risk of serious or fatal infections in those exposed to serious viral infections (e.g., chickenpox, measles).
- ICSs can cause cataracts or glaucoma.
- ICSs can increase the risk of pneumonia.
- Symptomatic patients on long-term, high-dose ICS should be screened for:
    - Cataracts
    - Glaucoma
    - Hypothalamic-pituitary-adrenal axis dysfunction
    - Impaired glucose metabolism

Contraindications:

- There are very few absolute contraindications to ICS. These include hypersensitivity to the medications and severe hypersensitivity to milk proteins/lactose.

(Liang & Chao, 2021; FDA, 2021b)

INHALED COMBINATION MEDICATIONS

An asthma combination inhaler combines two or three medications, which can ease hyperresponsiveness of airways and help prevent an asthma attack. They are used for the long-term control of asthma symptoms.

INHALED COMBINATION MEDICATIONS	
Generic Name	**Brand Name**
Formoterol (LABA) and budesonide (ICS)	Symbicort
Formoterol (LABA) and mometasone (ICS)	Dulera
Salmeterol (LABA) and Fluticasone (ICS)	Advair Diskus Advair HFA
Vilanterol (LABA) and Fluticasone (ICS)	Breo Ellipta
Vilanterol/ umeclidinium (anticholinergic) and Fluticasone (ICS)	Trelegy

(AAFA, 2021h; FDA, 2021b; AAAAI, 2021; Schiffman, 2020; Gottwalt & Tadi, 2021; Liang & Chao 2021)

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.

In emergency settings, intravenous corticosteroids are used, and sometimes oral systemic steroids are taken in high doses for several days. This is referred to as a *steroid burst*.

Oral steroids can also be used to control symptoms in people with severe persistent asthma. When used for this purpose, the drug is taken daily at a lower dose than is used during an asthma exacerbation. The smallest possible dose should be given to avoid long-term effects. Some people can control their symptoms with every-other-day dosing.

SYSTEMIC CORTICOSTEROIDS	
Generic Name	**Brand Name**
Oral prednisone	Prednisone Intensol Rayos
Oral prednisolone	Orapred ODT Pediapred Prelone Medrol
Injectable methylprednisolone	Dep-Medrol Solu-Medrol
Oral methylprednisolone	Medrol
Injectable triamcinolone	Kenalog Aristospan Triesence

Side effects with short-term use:

- Weight gain (fat deposits in abdomen, face, nape of neck)
- Fluid retention
- Upset stomach
- Hypertension
- Mood swings
- Memory or behavior problems
- Confusion or delirium

Side effects with long-term use:

- Growth suppression
- Hyperglycemia
- Cataracts
- Glaucoma
- Osteoporosis and fractures
- Thin skin, bruising, and slower healing
- Muscle weakness
- Increased risk for infections
- Adrenal gland hormone suppression
    - Severe fatigue
    - Loss of appetite
    - Nausea
    - Muscle weakness

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.
- Any acute infections should be treated and fully resolved before starting oral corticosteroids.
- Avoid use in patients with adrenal insufficiency.
- Use with caution in people with glaucoma/cataracts and osteoporosis.

- Patients may experience withdrawal symptoms, including:
    - Weakness
    - Fatigue
    - Body aches
    - Joint pain
    - Decreased appetite
    - Weight loss
    - Nausea
    - Vomiting
    - Diarrhea
    - Abdominal pain

(Lexicomp, 2021; Pichardo, 2020; FDA, 2021b)

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:

- By binding to cysteinyl leukotrienes receptors and blocking their activation and subsequent inflammatory cascade
- 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 often used in addition to inhaled corticosteroids to avoid the use of oral corticosteroids and are an alternative, but not preferred, therapy to low- to medium-dose inhaled corticosteroids.

Guidelines suggest a trial of an antileukotriene in patients with severe asthma who are not controlled on high-dose inhaled corticosteroids and long-acting beta-2 agonists.

LEUKOTRIENE MODIFIERS (granules, tablets, chewable tablets)	
Generic Name	**Brand Name**
Leukotriene receptor agonists	
Montelukast	Singulair
Zafirlukast	Accolate

5-lipoxygenase inhibitor	
Zileuton	Zyflo Zyflo CR

Side effects of montelukast:

- Headache
- Earache
- Sore throat
- Abdominal pain
- Cough
- Dyspepsia
- Increased risk for respiratory infections

Precautions for montelukast:

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

- Insomnia
- Anxiety
- Nightmares
- Aggression
- Hallucinations
- Depression
- Suicidal thinking

Contraindications for montelukast:

- Persons with phenylketonuria (PKU) should not take the chewable tablets that contain aspartame (an artificial sweetener that contains phenylalanine).

Side effects for zafirlukast:

- Headache
- Upper respiratory infections
- Nausea
- Vomiting
- Dyspepsia

- Abdominal pain
- Diarrhea
- Malaise
- Rarely, elevation of liver enzymes, acute hepatitis, and hyperbilirubinemia

Contraindications for zafirlukast:

- Not for use in patients with hepatic impairment

(Choi & Azmat, 2021; FDA, 2021b)

Immunomodulators

Immunomodulators are asthma therapy medications used to help regulate or normalize the immune system.

MONOCLONAL ANTIBODY THERAPY

Monoclonal antibody (biologic) therapy uses laboratory-produced substitute 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.

Omalizumab is a newer asthma medication that may be used for persons with persistent moderate to severe asthma due to seasonal allergies that is not controlled by inhaled corticosteroids. A disadvantage is that it is very expensive ($12,000 to $15,000 per year). Omalizumab works by binding to human immunoglobulin E (IgE) on the surface of mast cells and basophils, resulting in reduced release of allergy-inciting chemicals.

Mepolizumab is also used for moderate to severe asthma. This agent works by binding to interleukin 5, resulting in decreased eosinophils which contribute to the development of asthma attacks.

Anyone over the age of 12 can be given an omalizumab injection every two to four weeks. For individuals with elevated eosinophils, mepolizumab is given by injection every four weeks.

Dupilumab is used for the treatment of moderate to severe eosinophilic asthma in people ages 12 and older. It reduces asthma exacerbations, enables oral corticosteroid tapering, and improves lung function.

IMMUNOMODULATORS	
Generic Name	**Brand Name**
Omalizumab (anti- IgE) injection	Xolair
Mepolizumab (anti-IL5) injection	Nucala
Benralizumab (anti-IL-5) injection (for ages 12 and older)	Fasenra
Reslizumab (anti-IL5) injection (for ages 18 and older)	Cinquair
Dupilumab	Dupixent

Side effects:

- Pain or swelling in the area of injection
- Oropharyngeal pain
- Eosinophilia

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, such as ministrokes, heart attacks, hypertension in the pulmonary arteries, and blood clots.
- Avoid use of live vaccines in patients being treated with dupilumab.

(Wenzel, 2021; Schiffman, 2020; Morris, 2020; FDA, 2021b)

MAST CELL STABILIZERS

A mast cell stabilizer is an inhaled medication that prevents the release of histamine and other inflammatory substances from mast cells in response to an allergic that causes asthma. A mast cell stabilizer is not as potent as ICSs.

The only available mast cell stabilizer available for use in asthma is cromolyn sodium solution delivered via nebulizer. It may be used alone or with other asthma medications, such as bronchodilators or corticosteroids.

Symptoms may improve soon after starting cromolyn, but it could take up to 4 weeks before the full benefit of the medication is realized. Frequent dosing is necessary, as its effects last only 6 to 8 hours.

Common side effects:

- Coughing
- Nausea
- Throat dryness or irritation

Rare side effects:

- Dysphagia
- Pruritis
- Increased wheezing
- Dyspnea
- Hypotension
- Swelling of face, lips, or eyelids
- Chest tightness

Contraindications:

- Do not use in children younger than 2 years of age.

Precautions:

- Use with caution in those with heart disease or cardiac arrhythmias.

(Mayo Clinic, 2021b; FDA, 2021b)

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.

ASTHMA STEP THERAPY		
Step	**Asthma Severity**	**Preferred Therapy**
Ages 12 Years and Older		
1	Intermittent	• SABA PRN for symptom relief
2	Mild persistent	• Low-dose ICS or ICS/LABA daily • SABA for quick relief of symptoms
3	Moderate persistent	• Low-dose ICS/LABA or medium-dose ICS daily or • ICS/LAMA for those who cannot tolerate LABAs • Alternative, but less effective: ICS and leukotriene modifier
4	Severe persistent	• Medium-dose ICS/LABA
5	Severe persistent	• High-dose ICS/LABA • Leukotriene modifier or monoclonal antibody may be added
Ages 5–11 Years		
1	Intermittent	• SABA PRN for symptom relief
2	Mild persistent	• Daily low-dose ICS and SABA PRN
3	Moderate	• Daily and PRN combination low-dose ICS/LABA
4	Severe persistent	• Daily and PRN combination medium-dose ICS/LABA
5	Severe persistent	• Daily high-dose ICS/LABA and SABA PRN
6	Severe persistent	• Daily high-dose ICS/LABA and oral systemic corticosteroid and SABA PRN
Ages 0–4 Years		
1	Recurrent wheezing	• SABA PRN and short course of daily ICS
2	Mild persistent	• Daily low-dose ICS and SABA PRN
3	Moderate persistent	• Daily low-dose ICS/LABA and SABA PRN or daily low-dose ICS plus montelukast or daily medium-dose ICS and SABA PRN
4	Severe persistent	• Daily medium-dose ICS/LABA and SABA PRN
5	Severe persistent	• Daily high-dose ICS/LABA and SABA PRN
6	Severe persistent	• Daily high-dose ICS/LABA and oral systemic corticosteroids and SABA PRN
(Fanta, 2020b; NHLBI, 2020b)		

For patients whose asthma has been well-controlled for three to six months on a stable regimen, controller medications can be reduced in a step-wise fashion. The purpose for **stepping down therapy** is to reduce long-term exposure to high doses of inhaled glucocorticoids (Fanta, 2020b).

WHEN TO REFER

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

- Difficulty confirming a diagnosis of asthma
- 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 or inability to discontinue oral glucocorticoids
- Need for step 4 care in adult or child older than 5 years
- Need for step 2 care or higher in a child under 5 years
- Poor asthma control after 3 to 6 months of active therapy and monitoring
- Anaphylaxis or confirmed food allergy
- Presence of complicating comorbidity
- Need for additional diagnostic tests
- Candidate for monoclonal antibody therapy
- Candidate for allergen immunotherapy
- Patients with possible occupational triggers
- Patients with psychosocial or psychiatric problems which interfere with asthma management

  (Fanta, 2020b)

Nonpharmacologic Asthma Procedure

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 limited to academic medical centers, which many patients are unable to access (Fanta, 2020b).

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)
- Asthma attack despite current course of oral glucocorticoids
- More than one hospitalization for asthma in the past year
- Three or more emergency department visits for asthma in the past year
- Food allergy in a patient with asthma
- 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 severe 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, 2021a)

Basic Principles of Asthma Management

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

- Assessing the severity of the attack and risk for asthma-related death
- Assessing potential triggers
- Using inhaled short-acting beta-2 agonists (SABAs) early and frequently
- Considering concomitant use of ipratropium for severe exacerbations

- Starting systemic glucocorticoids if there is not an immediate and marked response to the inhaled SABA
- Making frequent (every 1–2 hours) objective assessments of response to therapy until definite, sustained improvement is documented
- Advising patients who are not responding to go to an acute care facility or their asthma provider immediately, especially if they have a history of near-fatal asthmatic attacks (Fanta, 2021a)

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:

- Administer SABA, 2 to 4 puffs, preferably using a spacer, 2 puffs for mild to moderate symptoms and 4 puffs for more severe symptoms, or via nebulizer.
- SABA may be repeated every 20 minutes for the first hour as needed. A mild asthma attack usually responds to 2–4 puffs every 3–4 hours.
- After the first hour, if there is improvement with SABA, based on action plan or clinician guidance, a determination about seeking additional medical attention should be made.
- 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 according to the patient's prednisone-based action plan.
- 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 themself to the urgent care setting, and inhaled SBA should continue to be used while waiting for help to arrive (Fanta, 2021a; Morris, 2020).

ASTHMA HOME MANAGEMENT FOR CHILDREN YOUNGER THAN 2 YEARS

When children or their caregivers recognize the onset of an exacerbation, an inhaled SABA should be administered using an MDI with spacer or nebulizer, 2–4 puffs of albuterol or 1.25 mg

nebulized solution per dose. Symptoms should be assessed in 10–20 minutes, and if needed, the dose can be repeated. Based on the initial response, the patient should either continue self-care or seek medical attention.

If there is a good response within 4 hours, continue with home management using SABA every 4–6 hours as needed. If there is an incomplete response, start oral glucocorticoids, if available, and contact the clinical providers for advice. Timely administration of oral glucocorticoids is probably the single most effective strategy for reducing ED visits and hospitalizations.

If there is a poor response, continue administering SABA and seek immediate medical attention in the ED (Sawicki & Haver, 2020).

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.
- 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 for an hour or two. (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.

(SingHealth, 2021)

CASE: Responding to an Asthma 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 SaO_2 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 SaO_2 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 SaO_2 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 SaO_2 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.

It is important to determine treatment provided to the patient before EMS arrival. If the patient is having a prolonged attack that has not responded to several doses of SABA/ipratropium, epinephrine IM is administered immediately. If available, terbutaline is an acceptable substitute.

Following assessment, the primary goal in EMS treatment is reversal of bronchospasm with nebulized SABA, connected to oxygen at 6–8 LPM. Ipratropium bromide can be mixed with SABA in a nebulizer, and both can be administered until the patient's symptoms improve. As soon as IV access is obtained, normal saline is run wide open to prevent dehydration.

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 airtight seal to help direct medication into the lower airways. Care must be taken to avoid applying too much pressure, as air sacs are hyperinflated, and it is possible to cause a pneumothorax.

Magnesium sulfate intravenously over 20 minutes may also be administered for its effect as a smooth muscle relaxant.

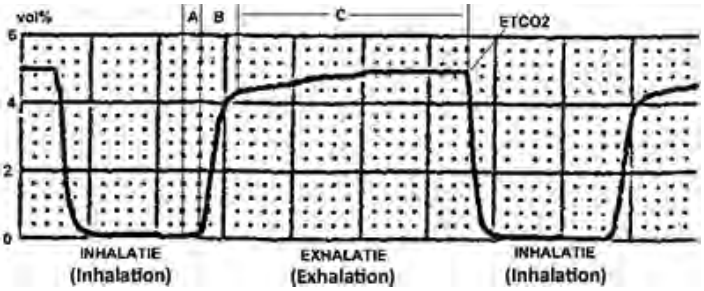
For patients who are anxious or combative during a severe asthma attack, **ketamine** IV or IM is the ideal medication for sedation, as it causes bronchodilation and does not carry a risk of respiratory depression. It may help patients tolerate having an oxygen mask or CPAP applied.

Methylprednisolone or **dexamethasone** IV is then given to reduce inflammation. At this point, the airway is reassessed to determine if the patient is responding to the drugs or if intubation is required.

Asthma patients with impending respiratory arrest require assisted ventilation starting with a bag valve mask and may later require intubation (Gandy, 2021; Sullivan, 2021).

CAPNOGRAPHY

One recent addition to assist in assessment is waveform capnography. Waveform capnography is a valuable tool to differentiate an asthma attack from other causes of respiratory distress (Sullivan, 2021). Capnography is a noninvasive measurement during inspiration and expiration of the concentration of carbon dioxide in the respiratory gases. End tidal capnography ($EtCO_2$) 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 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 evidenced 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

In an acute care setting, assessment of asthma exacerbation severity is based on symptoms, physical findings, peak expiratory flow, or less commonly, forced expiratory volume in one second measures, pulse oxygen saturation, and in certain circumstances, arterial blood gas measurement.

A focused history and physical are obtained while treatment is initiated, assessing for signs of severe exacerbation, which may include:

- Tachypnea
- Tachycardia
- Use of accessory muscles
- Diaphoresis
- Inability to speak in full sentences or phrases
- Inability to lie supine due to breathlessness
- Pulsus paradoxus

It is important to note that up to 50% of patients with severe airflow obstruction will not manifest any of these signs.

Assessment is made for symptoms such as fever or purulent sputum in order to rule out alternative diagnoses. Chest X-ray is obtained when a complicating cardiopulmonary process is suspected, when a patient requires hospitalization, and when the diagnosis is uncertain.

Pulse oximetry is obtained for noninvasive screening for hypoxia, and a peak flow measurement is made in those without signs of impending respiratory failure.

In the ED, **standard treatment** includes:

- Supplemental oxygen is administered for all patients with hypoxemia, usually via nasal cannula but occasionally by face mask if needed.
- Inhaled SABA is standard therapy for initial care. Typically, three treatments are administered within the first hour. Delivery method varies with the setting and severity of the attack.
- Ipratropium, an inhaled anticholinergic agent (short-acting muscarinic antagonist, or SAMA) may be added.
- Systemic glucocorticoids are essential for resolution of an exacerbation that does not respond to intensive bronchodilator therapy. Glucocorticoids speed the rate of improvement, but this is not clinically apparent until as long as six hours after administration.
- Intravenous administration of magnesium sulfate is warranted for patients presenting with a life-threatening exacerbation or who have a severe exacerbation that is not responding to initial therapy.

After the first hour of intensive treatment, a patient whose symptoms have resolved and whose PEF is 80% of predicted with good self-care skills and a supportive home environment may be discharged to continue treatment at home. Otherwise:

- Those who have an incomplete response and PEF of 60%–80% of predicted should continue intensive and close observation and treatment for approximately 1–3 more hours.
- Those who have worsening symptoms and declining PEF or pulse oxygen saturation require hospitalization and may need intensive care.
- Patients continuing treatment in the ED who have worsened or not improved after an additional 1–3 hours of frequent inhaled SABA treatments and oral glucocorticoids should continue care in an observation unit or be hospitalized.

LIFE-THREATENING ASTHMA EXACERBATION

In patients presenting to the ED with impending or actual respiratory arrest, in addition to the treatments outlined above, options for ventilatory support must be assessed and implemented immediately if needed.

Signs of impending arrest that require **rapid sequence intubation** may include:

- Slowing of respiratory rate
- Depressed mental status
- Inability to maintain respiratory effort
- Inability to cooperate with administration of inhaled medications
- Worsening hypercapnia and associated respiratory acidosis
- Inability to maintain an oxygen saturation >92% despite face mask supplemental oxygen

Noninvasive ventilation (NIV) is increasingly used in patients with severe asthma exacerbations in an effort to avoid invasive mechanical ventilation. Noninvasive positive-pressure ventilation (NPPV) using a mask that conducts gas from a positive-pressure ventilator into the airways has become the predominant means of administering NIV. A short trial of NIV may be appropriate in cooperative patients not responding to medical therapy who do not require immediate intubation (Fanta, 2021b).

WHEN TO HOSPITALIZE

The decision to admit to the hospital is based on findings from repeat assessment of a patient after receiving three doses of an inhaled bronchodilator, including the following criteria:

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

Patients who should be admitted to ICU for close observation and monitoring may exhibit the following:

- Rapidly worsening asthma or a lack of response to the initial therapy in the ED
- Confusion, drowsiness, signs of impending respiratory arrest, or loss of consciousness
- Impending respiratory arrest, as indicated by hypoxemia despite supplemental oxygen and/or hypercarbia

Intubation is required because of the continued deterioration of the patient's condition despite aggressive treatments.

Status asthmaticus, an acute severe asthmatic episode that is resistant to appropriate outpatient therapy, is a medical emergency requiring aggressive hospital management. This may include admission to the ICU for treatment of hypoxia and dehydration, and possibly for assisted ventilation due to respiratory failure (Fanta, 2021b; Morris, 2020).

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 30–60 minutes to be certain they are stable before being released.

The patient should be discharged with oral glucocorticoids (e.g., prednisone) for a period of 5–7 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. Disadvantages of this route is that duration is not predictable, and cutaneous atrophy and depigmentation at the injection is possible.

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. Assessment and retraining of inhaler use technique should be included. If the patient does not already have one, a personalized asthma action plan is provided.

Follow-up care with a primary provider or asthma specialist is recommended and facilitated whenever possible (Fanta, 2021b).

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 that 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 his assessment of Manuel and notes that the patient's breathing is labored, he has audible wheezing, and he can speak only 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 O_2 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 for free or low-cost asthma medications and instructed to have a follow-up with a primary care provider within 12–24 hours. Manual is also given a list of clinicians and clinics in his area.

ASTHMA EXACERBATION MANAGEMENT IN CHILDREN

Most children with moderate or severe asthma exacerbations should be managed in an emergency department setting. 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 muscles, 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 ages 1–18 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 5–17 years.

Oral systemic glucocorticoids should be started as soon as possible after arrival in the ED, followed by administration of SABA via small-volume nebulizer or metered-dose inhaler with spacer. If repeated doses are needed, they should be given every 20 to 30 minutes for three doses.

For moderate exacerbation, nebulized SABA combined with ipratropium bromide should be administered every 20 to 30 minutes for three doses or continuously for one hour.

For severe exacerbations, most children will need ongoing administration of continuous rather than intermittent nebulized SABA, unless they have a dramatic improvement after the first hour.

Children with very poor inspiratory flow or severely ill children who cannot cooperate with nebulizer therapy should be treated with epinephrine or terbutaline IM or SC. Intravenous methylprednisolone can be started as soon as intravenous access is obtained. Intravenous magnesium may also be administered if needed.

Consultation with a pediatric intensive care unit and/or anesthesia is indicated when a child has signs of impending respiratory failure, including:

- Cyanosis
- Inability to maintain respiratory effort
- Depressed mental status
- Pulse oxygen saturation <90% and/or respiratory acidosis noted on venous, arterial, or capillary blood gas sample

IV terbutaline in addition to inhaled SABAs and noninvasive positive pressure ventilation or endotracheal intubation may be indicated. Clinicians must be prepared to manage acute deterioration after intubation. The clinician most experienced in airway management should perform the procedure.

Children who have marked improvement in clinical parameters within the first one to two hours of therapy may be discharged home. Marked improvement is manifested by diminished or absent wheezing and retracting and increased aeration that is sustained at least 60 minutes after the most recent SABA dose.

Children who were moderately to severely ill on arrival and who have little improvement or worsen after initial therapy with SABAs and systemic glucocorticoids require hospitalization, including those who continue to have significant wheezing, retractions, and poor aeration.

Additional factors include:

- Beta-2 agonist therapy more often than four hours
- Requirement for supplemental oxygen/low oxygen saturation on pulse oximetry an hour or more after starting therapy
- Inability to self-hydrate
- History of rapid progression of severity
- Poor adherence with outpatient medication regimen
- Recent treatment with systemic glucocorticoids or beta agonist overuse
- Inadequate access to medical care, including lack of transportation back to hospital if deterioration occurs
- Poor social support system at home, with inability of caregivers to provide medical care and supervision

(Scarfone, 2020; Sawicki & Haver, 2020)

ASTHMA EXACERBATION MANAGEMENT IN PREGNANT WOMEN

Mild and well-controlled moderate asthma can be associated with excellent maternal and perinatal pregnancy outcomes. Severe and/or poorly controlled asthma has been associated with numerous adverse perinatal outcomes as well as maternal morbidity and mortality.

Pregnant patients who present with typical mild exacerbation are placed on a cardiac monitor and pulse oximetry. Fetal heart rate monitoring is the best available method for determining whether the fetus is adequately oxygenated.

The recommended pharmacotherapy of acute asthma during pregnancy is substantially identical to the management in nonpregnant patients. When considering asthma medication use in a pregnant woman or a woman anticipating pregnancy, concerns about potential risks of asthma medication are generally outweighed by the potential adverse effects of untreated asthma. Careful follow-up by clinicians experienced in managing asthma is essential.

Inhaled corticosteroids are the preferred medication for all levels of persistent asthma during pregnancy, with the goal of maintaining adequate oxygenation of the fetus by prevention of hypoxic episodes in the mother (Morris, 2020; Schatz & Weinberger, 2020).

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.

The purpose for hospitalization is to closely monitor the patient and to have aggressive interventions available in the event the asthma worsens. Hospitalization serves the purpose of removing the patient from the stimuli in the home environment that may have aggravated asthma, to ensure medication compliance, and to permit inactivity during recovery. In many instances, airway obstruction remains unstable, with wide swings in expiratory flow over minutes or hours.

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

- Obtaining ABGs on admission
- Monitoring and responding to changes in vital signs:
    - Done on admission and every 4 hours for 12 hours
    - After 12 hours, every 6 hours
- Monitoring PEF rate:
    - If the patient is on hourly nebulizer treatments, peak flow every hour
    - Pre- and post- twice-daily nebulizer treatments
- Monitoring oxygen saturation with spirometry:
    - Provide supplemental oxygen to keep O_2 saturation adequate (>90% for adults, >95% for children)
    - Discontinue when O2 saturation is adequate for 4 hours and patient is on general ward
    - Continue spot checks of O2 saturation with vital signs or as needed for respiratory distress
- Telemetry monitoring indications:
    - Patient is receiving SABA nebulizer treatments more often than every 4 hours

For infants or young children, corroborate O_2 saturation monitor with pulse rate as a child's movements make oxygen saturation inaccurate. A decrease in oxygen saturation increases pulse rate.

MEDICATIONS

- Administer SABA by nebulizer
- IV methylprednisolone (Solu-Medrol)
- Change to oral prednisone when SABA is spaced at 4 hours or more and patient is tolerating oral intake

EVALUATION

- Arterial blood gases
- Pulmonary function tests. Criteria:
    - PEF <30%
    - Prior history of pCO_2 >40
    - Failure to improve in 4 hours of therapy
    - Clinical asthma score >7
- Indications to monitor serum electrolytes:
    - Nausea or vomiting
    - IV fluids administered for >24 hours
    - Beta agonist use more often than every 4 hours for 24 hours
- Chest X-ray indications:
    - First episode wheezing
    - Marked breath sound asymmetry
    - History of exam suggestive of pneumonia
- Signs of improvement:
    - Minimal or no wheezing
    - Less than two awakenings at night due to mild asthma symptoms
    - Good activity tolerance
    - Pulmonary function test: PEF or FEV1 >70% of baseline
    - Adequate O_2 saturation off supplemental oxygen

MORE INTENSIVE TREATMENT OPTION

- Admit to intensive care unit if no improvement in 6 to 12 hours

PREPARATION FOR DISCHARGE

- Assess for asthma-related death risk factors:
    - Requires inhaled SABA no more frequently than once every 4 hours
    - Parenteral steroids switched to oral corticosteroids
    - Adequate O_2 saturation on room air
- Asthma education, including:
    - Instructions and return demonstration for use of inhaled controller medications
    - Instruction in obtaining peak flow measurements at home
    - Completing a personalized asthma action plan
    - Appointment made for follow-up in 7–10 days after discharge

  (Moses, 2021)

Inpatient Nursing Management

Upon arrival to a nursing unit, the admitting nurse performs a complete nursing assessment and develops 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 problems for a patient with asthma may include, but are not limited to:

- Inability to clear airways effectively
- Altered breathing patterns
- Altered exchange of gases in the lungs
- Anxiety

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 is implemented, and each intervention and outcome are assessed for effectiveness.

INABILITY TO CLEAR AIRWAYS EFFECTIVELY

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 respiratory rate, rhythm, and depth
- Excessive secretions
- Dyspnea

- Hypoxemia/cyanosis
- Inability to cough up secretions
- Ineffective or absent cough
- Orthopnea

Goals/Outcomes

- Patient will maintain clear and open airways as evidenced by:
    - Normal breath sounds
    - Normal rate/depth of respirations
    - Effective cough after treatment and deep breathing
    - Increased air exchange
- Patient will explain methods to enhance secretion removal
- Patient will recognize the significant of changes in sputum, including:
    - Color
    - Character
    - Amount
    - Odor
- Patient will identify and avoid specific factors that inhibit effective airway clearance

Nursing Assessment

- Airway patency and abnormal breath sounds:
    - Decreased or absent breath sounds
    - Wheezing (high-pitched whistling)
    - Expiratory grunt
    - Rales (clicking, rattling, coarse crackles)
    - Rhonchi (low-pitched rattle)
    - Stridor (high-pitched musical sound)
- Respirations:
    - Rate and depth
    - Pattern
    - Flaring of nostrils
    - Dyspnea on exertion

    - Evidence of splinting
    - Use of accessory muscles
    - Position taken for breathing
- Changes in mental status:
    - Increased lethargy
    - Confusion
    - Restlessness
    - Irritability
- Vital signs (elevated temperature may indicate infection)
- Effectiveness of cough and productivity
- Sputum
    - Quality, amount, color, and consistency
    - Signs of infection (odor and discoloration)
    - Signs of dehydration (thick, tenacious)
    - Submit a sputum specimen for culture and sensitivity testing, as appropriate
- Oxygen saturation, using pulse oximetry
- Arterial blood gases
- Hydration status:
    - Skin turgor
    - Mucous membranes
    - Tongue
- Abdominal or thoracic pain (as possible cause for shallow breathing and ineffective cough)
- Peak airway pressures and airway resistance, if on mechanical ventilation
- Patient's understanding of the disease process (depending on patient's acute state as well as cognitive level)
- Patient's use of herbal treatments that may result in drug interactions with prescribed medications (e.g., echinacea, goldenseal, ma huang)

Nursing Interventions

- Teach and assist with effective ways to remove secretions, i.e., 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:
    - Proper sitting position to promote use of abdominal muscles for more forceful cough
    - Use of pillow or hands to splint the abdomen when coughing
    - Use of quad and huff techniques:
        - Hold breath for two or three seconds
        - Exhale forcefully but slowly to move mucus from smaller to larger airways
        - Repeat two more times
        - End with one strong cough to clear mucus from larger airways
    - Use of incentive spirometry
    - Importance of ambulation and frequent position changes
    - Proper use of prescribed medications and inhalers
    - Need for adequate fluid intake even after discharge
- Perform nasotracheal suctioning PRN, especially if cough is ineffective.
- Maintain humidified oxygen to reduce thickness of secretion.
- Encourage fluid intake to 3 L/day within limits of cardiac reserve and renal function.
- Give medications as prescribed and document effectiveness and side effects.
- Coordinate with respiratory or physical therapy for chest physiotherapy and nebulizer management.
- Provide postural drainage, percussion, and vibration as prescribed.
- Provide oral care every 4 hours.
  (Wayne, 2019)

ALTERED BREATHING PATTERN

Breathing pattern alterations can result in 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

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

Nursing Assessment

- Vital signs for evidence of hypoxia and hypercapnia:
    - Decreased blood pressure
    - Decreased heart rate
- Respiratory rate, depth, and rhythm for signs of impending respiratory failure:
    - Inability to breath, cyanosis related to hypoxemia
    - Increased respiratory rate, confusion related to hypercapnia
- Breath sounds for signs of respiratory failure:
    - Decreased wheezing
    - Indistinct breath sounds
- Relationship of inspiration to expiration
- Signs of dyspnea:
    - Flared nostrils
    - Chest retractions
    - Accessory muscle use
- Conversational dyspnea (inability to converse without difficulty)
- Fatigue (may lead to respiratory failure)
- Presence of pulsus paradoxus greater than 12 mmHg 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, 2020)

ALTERED EXCHANGE OF GASES IN THE LUNGS

Alterations in the exchange of gases in the lungs results in an excess or deficiency 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:

- Changes in vital signs above baseline
- Oxygen saturation <90%
- Anxious appearance
- Diaphoresis
- Restlessness
- Irritability
- Confusion
- Altered skin color: pallor, cyanosis, duskiness
- Abnormal lung sounds, rate, rhythm, and depth
- Tripod position
- Dyspnea

Goals/Outcomes

- Absence of respiratory distress signs and symptoms
- Vital signs within patient's normal limits
- Clear breath sounds
- Oxygen saturation persisting at >90%
- Normal mentation

Nursing Assessment

- Characteristics of respirations (rate, rhythm, depth, use of accessory muscles)
- Oxygen saturation, monitoring continuously
- ABGs, monitoring frequently
- Lung sounds, auscultating at least every 2–4 hours, listening for adventitious breath sounds
- Ability to cough and clear secretions, noting characteristics of sputum: amount, color and consistency
- Skin and mucous membranes, monitoring for peripheral cyanosis (nailbeds) or central cyanosis (lips/earlobes, tongue) (duskiness and central cyanosis indicate advanced hypoxemia)
- Mentation, for irritability, restlessness, and confusion, and lethargy and somnolence as late signs of hypoxia
- Patient's level of stress and anxiety
- Nutritional status
- Low hemoglobin level

Nursing Interventions

- Monitor oxygen saturation utilizing continuous pulse oximetry.
- Administered oxygen as ordered to maintain oxygen saturation above 90%.
- Administer medications as ordered and assess for effectiveness and side effects.
- Elevate the head of the bed (30 to 45 degrees) to minimize difficulty breathing and promote maximum lung expansion, using high Fowler's position or over-the-table positioning whenever possible.
- Adjust position frequently to maintain correct body alignment for easier ventilation and gas exchange.
- Encourage prone position as tolerated to increase PaO_2.
- Consider a rotorone bed or mattress with a percussion function to help loosen and remove secretions.
- Encourage frequent pulmonary hygiene measures:
    - Cough and deep breathing exercises
    - Use of incentive spirometry
    - As directed by respiratory therapy, use of a flutter valve to loosen secretions (a handheld device that causes airway vibration and positive expiratory pressure)

- Provide small frequent meals and add supplements.
- Encourage ambulation as tolerated.
- Provide rest periods between activities of daily living (ADLs) and pace activities.
- Provide reassurance for the patient who is anxious.

For the critical care patient:

- Anticipate need for intubation
- Suction airway as needed

ANXIETY

Asthma causes stress, which in turn causes anxiety. As symptoms worsen, the patient may become more anxious, which then increases asthma symptoms, resulting in a sensation of panic. Anxiety and stress are also known triggers for asthma exacerbations.

Common **factors** may include:

- Change in environment
- Change in health status
- Loss of control
- Hypoxia
- Respiratory distress

Common **assessment cues** include:

- Apprehensiveness
- Dyspnea
- Fear of being left alone in a room
- Restlessness
- Tachycardia
- Tachypnea

Goals/Outcomes

- Use an effective coping mechanism
- Verbalize a reduction in level of anxiety experienced
- Demonstrate reduced anxiety as evidenced by a calm demeanor and cooperative behavior

Nursing Assessment

- Signs of anxiety:
  - Feelings of panic, fear, uneasiness
  - Tachycardia
  - Cold or sweaty hands or feet
  - Shortness of breath
  - Restlessness
- Oxygen saturation

Nursing Interventions

- Encourage verbalization of concerns.
- Provide comfort measures (e.g., a calm, quiet environment; soft music).
- Explain every procedure in a simple and concise manner.
- Update significant others of the patient's progress (since family anxiety can be easily transferred to the patient).
- Stay with the patient and encourage slow, deep breathing.
- Assure the patient and significant others of close, consistent monitoring that will ensure prompt intervention.
- Encourage use of relaxation techniques:
  - Progressive muscle relaxation
  - Diaphragmatic and pursed-lip breathing
  - Use of imagery, repetitive phrases

(Martin, 2020)

ASTHMA PATIENT TEACHING

The nursing team has a large role to play in teaching patients and families throughout the inpatient stay, providing education on the asthma disease process and symptom recognition, among other topics. Patient teaching includes:

- Cough and deep breathing methods
- Types of oxygen therapy to be used at home, if applicable
- Early signs of decreased oxygenation and interventions
- Education on smoking cessation and resources that can help

- Correct use of medications:
    - Indications for use
    - Dosage
    - Frequency
    - Differentiating between rescue and controller medications and effects
- Demonstration and verification of correct inhaler use
- Demonstration and verification of correct nebulizer use
- Development or updating of the asthma action plan
- Environmental control of triggers and aggravators
- Demonstration and verification of correct peak flow meter use
- Importance of posthospitalization follow-up with the primary care provider
- Consult with occupational therapy to provide education on energy conserving techniques

(RTZ, 2021)

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:

- Recommend, administer, and evaluate the pharmacology regimen for a patient
- Perform airway clearance:
    - Pulmonary hygiene techniques
    - Deep breathing exercise
    - Chest physiotherapy
- Recommend, administer, and evaluate oxygen therapy
- Perform rest and exercise oximetry
- Perform arterial blood gas sampling and interpretation
- Recommend, administer, and evaluate humidification/aerosol therapy
- Recommend, administer, and evaluate noninvasive positive pressure ventilation therapy
- Recommend, administer, and evaluate airway management
- Recognize the causes of ventilator/respiratory failure and recommend, perform, and evaluate ventilator management

- Establish and maintain mechanical ventilation with a given ventilator
- Perform and interpret pulmonary function tests
  (NSCC, 2020)

CHEST PHYSIOTHERAPY

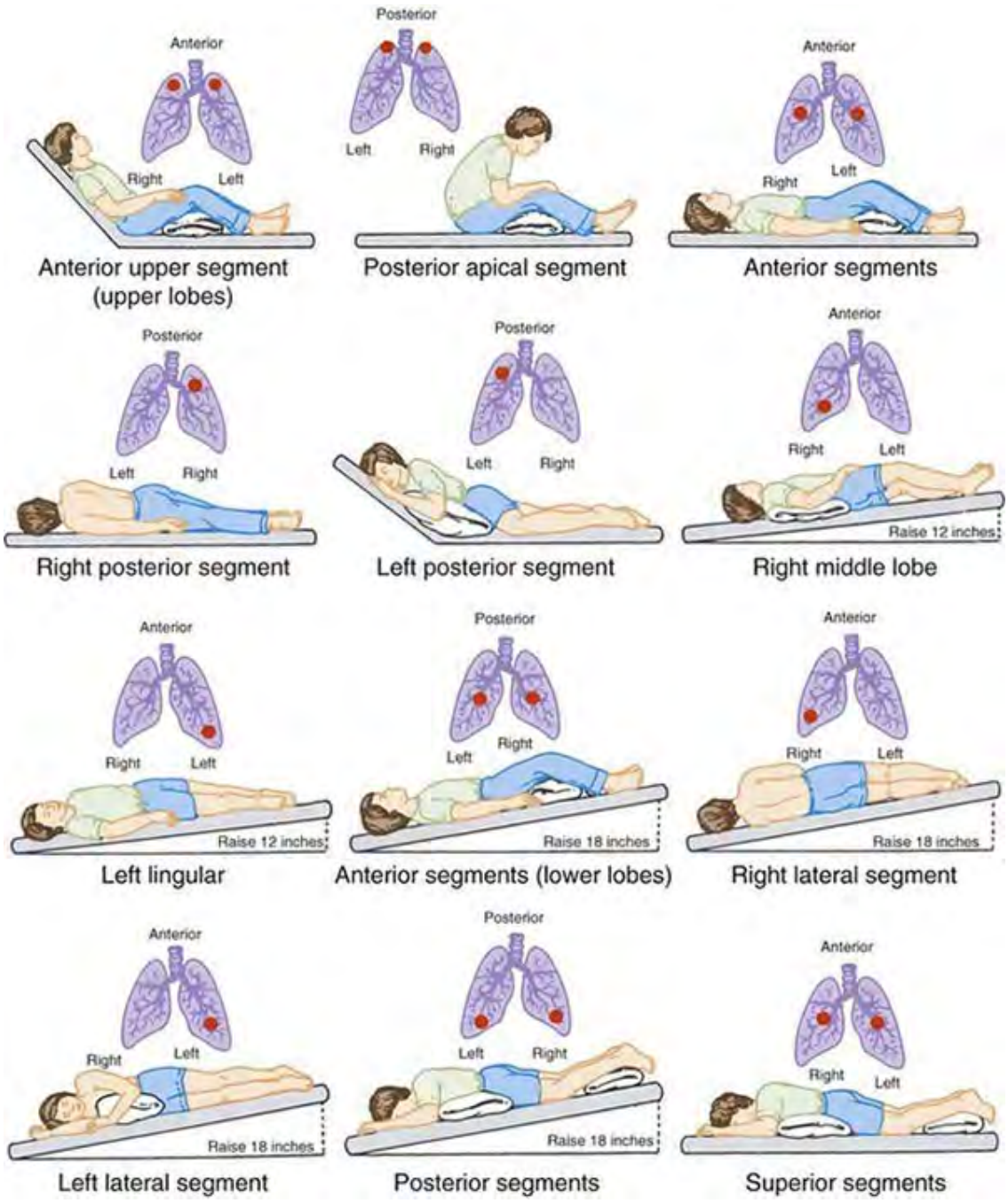
Chest physiotherapy is routinely carried out by both respiratory and physical therapists depending on a facility's policies and staffing. Chest PT involves a group of treatments meant to eliminate secretions in the airway and works best if applied along with a bronchodilator. The purpose of these treatments is to:

- Facilitate removal of retained airway secretions
- Optimize lung compliance and prevent collapse
- Decrease the work of breathing
- Optimize ventilation-perfusion ratio and improve gas exchange

Postural drainage involves placing the patient in a position in which gravity can assist in airway clearing. Positions vary based on specific segments of the lungs with a large amount of secretions. Each position should generally be held for 3–15 minutes.

Percussion is also called *cupping.* Its purpose is to intermittently apply kinetic energy to the chest wall and lungs by rhythmically striking the chest with a cupped hand or mechanical device directly over the area of the lung being drained.

Vibration involves the use of a fine tremorous action over the area being drained. The rapid vibratory impulse is transmitted through the chest wall from the hands of the therapist to loosen and dislodge the airway secretions (Physiopedia, 2021b).



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

(See also "Physical Therapy Management" later in this course.)

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 exacerbations 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. Asthma control, adherence, and inhaler technique are assessed at every visit, and not just when the patient presents because of their asthma.

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 1–3 months after starting treatment and every 3–12 months thereafter. After an exacerbation, a review visit within 1 week should be scheduled.

Pregnant women, however, should be reviewed every 4 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, 2021).

ASSESSING ASTHMA CONTROL

Asthma control has two domains that require assessment: symptom control and future risk of adverse outcomes. Lung function is an important part of the assessment of future risk and should be measured at the start of treatment, after 3–6 months of treatment (to identify the patient's personal best), and periodically thereafter for ongoing risk assessment (GINA, 2021).

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, including the following:

- **Asthma Control Test (ACT)** is a 5-item questionnaire for patients ages 12 and older. It is a patient-centered/completed questionnaire that assesses only symptom control (night and day) and asks about symptom control over the prior 4 weeks, including:
    - Activity limitation
    - Shortness of breath
    - Use of rescue medications
    - Night time awakening
    - Patient's perception of asthma control

- **Childhood Asthma Control Test (cACT)** is used with children ages 4 to 11 years. Both child and caregiver perspectives are assessed for the previous 4 weeks. It is composed of seven questions, four child-reported and three caregiver-reported.

- **Asthma Control Questionnaire (ACQ),** a 5- 6- or 7-item questionnaire, including spirometry for ages 11 and older, involves asking patients to recall their symptom control over the previous week. It is the only tool that includes lung function testing.

- **Asthma Therapy Assessment Questionnaire (ATAQ)** is a brief, self-administered tool for use in adults 18 and older that 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 ages 5–17 years.

- **Global Initiative for Asthma (GINA),** provides a 4-item questionnaire for ages 5 and older about daytime and nighttime symptoms, reliever inhaler use, and activity limitation (University of Newcastle, 2020; Oppenheimer, 2019).

- **Asthma Daytime Symptoms Diary (ADSD)** and **Asthma Nighttime Symptom Diary (ANSD)** are 6-item daily measures of asthma symptom severity that assess breathing symptoms, chest symptoms, and cough. Together, they are intended for twice-daily completion, once upon awakening referring to symptoms during the night and once in the evening referring to symptoms experienced during the day (FDA, 2020).

Once asthma has been diagnosed, lung function is useful as an indicator of future risk and should be done at time of diagnosis, 3–6 months after starting treatment, and periodically after that. Most patients should have lung function measured at least every 1–2 years, more often in children and those at higher risk of flare-ups or lung function declines (GINA, 2021).

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 ages 17–70 with asthma. There are also several questionnaires appropriate for pediatric patients with asthma. (See also "Resources" at the end of this course.)

ADDRESSING CHALLENGES

There are many challenges to successfully maintaining asthma control. **Adherence to asthma medication regimens** tends to be very poor, with reported rates of nonadherence ranging from 30%–70%. Medication-related factors include difficulties with inhaler devices, complex regimens, side effects, dislike of medication, distant pharmacies, and especially the price of inhalers (Apter, 2021).

HIGH COST OF ASTHMA MEDICATIONS

Asthma is an expensive condition to manage in the United States compared to other developed countries. In some states as many as 20% of people with asthma do not have insurance and are forced to pay out-of-pocket for their inhalers. Individuals lacking insurance tend to live in lower-income areas that also tend to have higher rates of asthma.

An analysis of cash prices for asthma inhalers shows that prices climbed about 35% from 2013 to 2018, from an average price of around $280 in 2013 to more than $380. The average cash price for one inhaler of Advair, for example, increased from $316 in 2013 to $496 in 2018 (56%) (Marsh, 2020).

Other challenges to asthma control that are not related to medications include:

- Misunderstanding or lack of instruction
- Fears about side effects
- Dissatisfaction with healthcare professionals
- Unexpressed/undiscussed fears or concerns
- Inappropriate expectations
- Poor supervision/training or follow-up
- Anger about one's condition or its treatment
- Underestimation of severity
- Cultural issues
- Stigmatization
- Forgetfulness or complacency

- Attitudes toward ill health
- Religious issues
- Social barriers such as work schedules
- Stress, depression, and comorbidities

In addition to the above challenges, **adolescents** face developmental challenges that can affect adherence. At this age, individuals are searching for greater autonomy and have a need to be accepted by peers. Challenges may include:

- Denial of asthma diagnosis or severity
- Burdensome medication routine that conflicts with the need for greater autonomy
- Embarrassment around the use of inhalers in front of peers
- Greater risk of depression and anxiety among this age group

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 design a plan that is realistic, and the patients and caregivers must then ensure that the plan is carried out. To these ends, it is important that providers and patients design an action plan together.

The more patients understand the reasons 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 (Apter, 2021b; Kaplan & Price, 2020).

ASTHMA PATIENT EDUCATION

The plan of action includes 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
- Premedicating to prevent onset of symptoms and treatment of symptoms
  (Apter, 2021b)

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, 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. The nurse gave Jonah and his mother a list of patient education websites and videos addressing asthma in children, including a link to an online video series on asthma education for children. (See "Resources" at the end of this course.)

6. Because Jonah's identical twin brother also has asthma, the nurse discussed with his mother some issues and challenges that might arise between the two brothers. This might include competing between themselves 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.

7. The nurse made a separate copy of the mother's instructions for the school nurse, which Jonah's mother indicated she would 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 their healthcare provider. An action plan is a written worksheet that indicates 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, 2020a).

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

SAMPLE ASTHMA ACTION PLAN

Person's name:_____
Primary care provider:_____
Provider's phone number:_____
Hospital or emergency department phone number:_____
Date:_____

Personal best peak flow:_____

GREEN ZONE: DOING WELL		
• No cough, wheeze, chest tightness, or shortness of breath during the day or night • Can do usual activities • Peak flow more than:_____(80% of best peak flow)		
Medicine	**How much to take**	**When to take it**
Long-term control medicines (include an anti-inflammatory):		
Before exercise:		
	Number of puffs:_____	5 minutes before exercise

YELLOW ZONE: ASTHMA IS GETTING WORSE		
• Cough, wheeze, chest tightness, shortness of breath (if not better in 24–48 hours, call primary care provider) • Waking at night due to asthma • Can do some, but not all, usual activities • Peak flow:___to____(50% to 79% of best peak flow)		
Medicine	**How much to take**	**When to take it**
1. Keep taking green zone medications.		
2. Add quick relief medicines (short-acting beta-2 agonist).		
3. If symptoms (and peak flow) do not return to Green Zone after 1 hour of treatment, increase or add the following:		
4. Call the doctor before/within _____ hours after taking an oral steriod		

RED ZONE: MEDICAL ALERT!

- Very short of breath, fast breathing, or
- Trouble walking and talking due to shortness of breath, or
- Lips or fingernails are blue, or
- Quick-relief medicines have not helped, or
- Cannot do usual activities, or
- Symptoms are same or get worse after 24 hours in Yellow Zone
- Peak flow less than:_____(50% of best peak flow)

Medicine	**Amount**	**How Often**
1. Take these medications:		
2. Call your primary care provider now. **Go to your hospital or call an ambulance** if you are still in the Red Zone after 15 minutes and you have not reached your provider.		

(See also "Resources" at the end of this course for a link to the NHLBI "Asthma Action Plan" worksheet.)

(Adapted from NHLBI, 2020c.)

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 asthma action 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

Dust mites are tiny insects, too small to see, that can be found in every home in dust, mattresses, pillows, carpets, cloth furniture, sheets and blankets, clothes, stuffed toys, and other cloth-covered items. If sensitive:

- Use mattress and pillow covers that prevent dust mites from going through them, along with high-efficiency particulate air (HEPA) filtration vacuum cleaners.
- Launder bedding weekly in hot water.
- Do not use down-filled pillows, quilts, or comforters.
- Consider reducing indoor humidity to below 50% using a dehumidifier or central air conditioning system.

Cockroaches and rodents leave droppings that may trigger asthma. If sensitive:

- Consider professional pest management.
- Keep food and garbage in closed containers to decrease chances for attracting roaches and rodents.
- Use poison baits, powders, gels, pastes (e.g., boric acid), or traps to catch and kill pests.
- If using a spray to kill roaches, stay out of the room until the odor goes away.

Animal dander (the flakes of skin or dried saliva from animals with fur or hair) are an allergen to some people. If sensitive:

- Consider keeping pets outdoors.
- Confine pets to common areas of the home only and keep out of bedrooms.

Indoor mold:

- Explore professional mold removal or cleaning to support complete removal.
- Wear gloves to avoid touching mold with bare hands if removing it by oneself.
- Ventilate the area if using a cleaner with bleach or strong smell.
- Dry damp or wet items within 24–48 hours.
- Do not let damp clothes sit in a basket or hamper.
- Fix water leaks throughout the home.
- Remove carpet from basements, bathrooms, and bedrooms.
- Replace absorbent materials, such as ceiling tiles and carpet, if mold is present.
- Use an inexpensive hygrometer to check humidity levels and keep humidity no higher than 50%.
- Empty, defrost, and clean refrigerators regularly.
- Empty and clean air conditioning drip pans regularly.
- Run the bathroom exhaust fan or open a window when showering.

Pollen and outdoor mold. When pollen or mold spore counts are high:

- Keep windows closed.
- If possible, stay indoors with windows closed from late morning to afternoon, which is when pollen and some mold spore counts are highest.
- When traveling by car, keep windows closed and air conditioning on in the recirculation mode.
- Leave lawn mowing, weed pulling, and other gardening chores to others.
- After going outside, change clothes as soon as possible and put dirty clothes in a covered hamper or container to avoid spreading allergens in the home.
- Wear a pollen mask if doing outside chores.
- Talk with a healthcare provider to see if it is necessary to increase anti-inflammatory medicine before the allergy season starts.

Tobacco smoke:

- Quit smoking (or ask a healthcare provider for assistance).
- Ask and encourage family members to quit smoking.
- Do not allow smoking in the home or the car.

Smoke, strong odors, and sprays:

- If possible, avoid using a wood-burning stove, kerosene heater, or fireplace.
- Vent gas stoves to outside the house.
- Avoid air fresheners.
- Avoid strong odors and sprays, such as perfume, talcum powder, hair spray, and paints.

Vacuum cleaning:

- Enlist someone else to vacuum once or twice a week, if possible. Stay out of rooms while they are being vacuumed and for a short while afterward.
- If one must vacuum, use a HEPA filtration vacuum cleaner.

Foods and medications:

- To avoid sulfites in foods and beverages, do not drink beer or wine or eat dried fruit, processed potatoes, or shrimp if they cause asthma symptoms.
- Inform a healthcare provider about all medicines being taken. Include aspirin, vitamins, and other supplements as well as nonselective beta blockers (including those in eyedrops).

Weather:

- Monitor the weather forecast to be prepared for changes that may trigger asthma symptoms.
- Carry a small scarf to go over the nose and mouth in windy or cold weather.

Physical activity and exercise:

- Use rescue medicines before sports or exercise to prevent symptoms, if included in asthma plan.

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, per provider recommendations.
- Get a pneumonia vaccine if over the age of 65.
- Get the COVID-19 vaccine if eligible.

Recreational drugs increase the risk of life-threatening exacerbation and can cause missed doses of prescribed asthma medications.

- Avoid use of recreational drugs, including cannabis, cocaine, crack cocaine, hallucinogens and dissociative drugs, heroin, inhalants, and poppers.

Strong emotions (laughing, crying, feeling stressed or anxious, anger, fear, yelling):

- Avoid stress-inducing situations whenever possible.
- Use relaxation exercises and techniques.
- Take advantage of work breaks and lunch hour.

(NHLBI, 2021; Mayo Clinic, 2020d; CDC, 2020b; CDC, 2021c; Asthma UK, 2019)

INTERDISCIPLINARY THERAPIES

Pulmonary Rehabilitation

Pulmonary rehabilitation is a program that involves a team of healthcare providers who work to improve the well-being of people with chronic respiratory disorders. While professional roles may overlap, each individual brings their own expertise to the rehabilitation effort. This team often includes physicians, nurses, respiratory therapists, physical therapists, 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
- Management of anxiety and depression
- Muscle strength
- Management of routine activities, work, outings, and social activities
(NHLBI, 2021)

The pulmonary rehabilitation team performs lung function, exercise, and possibly blood tests to help develop an individualized care plan. The patient's medical history and prescribed treatment plan are reviewed, along with an assessment of mental health and diet. The team works together to create a plan that fits the individual patient's needs in the areas described below (Celli, 2020).

Exercise training is designed to improve endurance and muscle strength. It may include:

- Endurance training
- Lower-extremity exercise
- Upper-extremity exercise
- Interval exercise training
- Resistance/strength training
- Alternative exercise training
    - Breathing retraining
    - Ventilatory muscle training
- Tai chi
- Flexibility training
- Transcutaneous electrical nerve stimulation

Nutritional counseling can be included in the pulmonary rehab program, since being either overweight or underweight can affect breathing. An eating plan can be developed to help the patient work toward a healthy weight.

Education about asthma and how to manage symptoms may include:

- How to avoid situations that make symptoms worse
- How to avoid infections
- When and how to take prescribed medications
- Proper use of inhalers

Promotion of healthy behaviors and health preservation may include:

- Smoking cessation
- Regular exercise
- Nutritional counseling and weight management
- Vaccines

A pulmonary rehab program may include teaching the individual **energy-saving techniques** for performing daily tasks, such as ways to avoid reaching, lifting, or bending.

Stress relieving techniques may be included since stress can affect energy breathing.

Breathing techniques can be used to increase oxygen levels, decrease how often breaths are taken, and keep airways open longer.

Psychological counseling and/or group support may be part of the pulmonary rehab program, as individuals with chronic lung disease are more prone to depression, anxiety, and other emotional problems. These comorbidities are associated with poor asthma control, greater functional disability, lower quality of life, and more frequent hospitalizations and physician's visits (Rodriguez, 2019b).

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 in the development and implementation of the patient's asthma action plan. RTs are involved in diagnosis, acute treatment, follow-up, and monitoring.

Respiratory therapists help identify the patient's asthma triggers and how to manage them, demonstrate new medical devices and new medications, and perform testing such as spirometry and the 6-minute walk test (State of Indiana, 2021).

Physical Therapy

Physical therapists are concerned with developing, maintaining, optimizing, and restoring an individual's physical and functional mobility capabilities. 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 (Mackey et al., 2021).

CHEST WALL MOBILIZATION

Structured chest wall mobilization is a physical therapy technique designed for the maintenance or improvement of mobility of the chest wall, trunk, and shoulder girdles. Chest mobilization exercises can also be used to increase chest wall mobility, flexibility, and thoracic compliance. Chest wall mobilization includes:

- Lateral flexion of the chest wall
- Chest wall extension
- Lateral gliding of thoracic spine
- Pectoralis major muscle stretching
  (Swapna et al., 2020)

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 $PaCO_2$, 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 then 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 asthma 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 (Mackey et al., 2021).

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. It has been suggested that behavior change intervention focusing on increasing participation in physical activity may have an impact on asthma and quality of life (Mackey et al., 2021).

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 results in 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. During inspiration, air is only released when enough effort is used to force open the values of the device. The respiratory muscles must then work harder, resulting in increased strength, which leads to easier diaphragmatic breathing and reduced hyperinflation (Mackey et al., 2021).

AIRWAY CLEARANCE TECHNIQUES

Physical therapy may assist in the removal of secretions in the airways using:

- **Percussions/vibrations:** 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.
  (Physiopedia, 2021b; Mackey et al., 2021)

(See also "Asthma Inpatient Respiratory Therapy" earlier in this course.)

EDUCATION

Besides specific exercises and positional instruction, physical therapists provide extensive patient education, including (but not limited to):

- Asthma disease process
- Use of bronchodilator and other medications
- Prevention of chest infection
- Correct standing and sitting posture to allow for appropriate chest expansion and lung function
  (Mackey et al., 2021)

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.

Occupational 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 asthma. 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

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 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-handled 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 ACTIVITIES OF DAILY LIVING

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 a raised toilet seat to ensure proper height and ease of rising.

Bathing

- Choose a time of day when energy and stamina are 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 for their children.

Alternative or Complementary Treatments

A number of people with asthma look for alternative or complementary treatments to control or enhance control of asthma symptoms. Such treatments might include herbs, dietary supplements, acupuncture, chiropractic, massage therapy, biofeedback, homeopathy, nutrition, and botanicals. Because there have been limited research studies done 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:

- **Breathing exercises:** Papworth method and yogic breathing (pranayama) can help prevent hyperventilation. These practices may offer modest benefits, if any, and do not seem to improve the allergic reaction that triggers asthma symptoms. However, breathing exercises may help with relaxation.

- **Acupuncture:** Some research suggests that acupuncture may reduce the need for inhaled steroids in children, but more definitive studies are needed.

- **Chiropractic manipulation:** Some studies have found that spinal manipulation may help reduce the number of asthma attacks and need for medication, particularly in children.

However, there is not enough evidence to support its use as an effective asthma treatment.

- **Diet, vitamins, and supplements:** Studies show that certain vitamins and nutrients found in foods may help relieve asthma symptoms in some people. Three promising ones include antioxidants, omega-3 fatty acids, and vitamin D.

- **Massage:** Studies suggest that massage may help children with asthma breathe more easily, including a recent study of children ages 4–8 whose lung function improved greatly after receiving gentle, 20-minute bedtime back rubs by a parent.

- **Relaxation techniques:** Medication, biofeedback, hypnosis, and progressive muscle relaxation have been shown to help lower blood pressure and slow breathing. It is uncertain if they help improve asthma, but they can help reduce stress.

- **Herbal supplements** marketed for asthma treatment have not been thoroughly tested, and the FDA does not regulate them in the same way as medicines. Issues of concern include lack of quality and dose control, minor to severe side effects, and drug interactions. Use of supplements should be discussed with one's healthcare provider. (Mayo Clinic, 2020e)

ASTHMA COMPLICATIONS

Asthma is a serious chronic inflammatory disease that 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. 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 isolation, 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.

- People with asthma experience a **financial burden**, including decreased earning capacity triggered by absenteeism. This may be followed by difficulty in being able to afford prescribed and over-the-counter medications.

- **Functional limitation** is characterized by a decline in ability to complete daily activities and other types of physical activities.

- **Medication side effects** related to the use of oral corticosteroids may include weight gain, sleep disturbance, and neuropsychiatric symptoms. Relationships and sexual intimacy are also affected by medications used in severe asthma.

- **Persistent coughing** is a major quality of life issue. Chronic cough and symptoms of depression are closely related, and improvement of cough correlates with improved depression scores. Isolation due to fear of severe coughing in public places and negative effects on relationship with family members and coworkers can also result. The greatest impact has been observed in women 65 years of age and older.

Often these impacts are not addressed during standard asthma consultations. Pharmacologic and nonpharmacologic interventions such as education sessions, written asthma action plans, active symptom monitoring, physical activity, and psychological interventions may promote living well with severe asthma (Stubbs et al., 2019; Hin & Kim, 2020).

Respiratory Complications

Persons with asthma have a high risk for developing other respiratory problems.

People with moderate to severe or uncontrolled asthma are more likely to be hospitalized from **SARS-CoV-2 infection and COVID-19**. The mortality rate for COVID-19 patients with underlying asthma (7.8%) has been found to be significantly higher than that of other patients (2.8%). Patients with severe asthma showed significant prolonged duration of admission compared to those with mild asthma (Choi et al., 2021).

Individuals with asthma 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, 2021c).

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 slow or sudden 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 1.5% of people hospitalized for status asthmaticus do not survive (Loengard, 2019).

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, 2021h).

Another serious respiratory complication is secondary spontaneous **pneumothorax**. This can be caused by increased airway pressure or as a result of mechanical ventilation. Superimposed infection can also occur in intubated patients. Patients may require a chest tube and aggressive antibiotic therapy for a superimposed infection (Saaden, 2020).

A rare complication of an acute exacerbation of asthma is **pneumomediastinum**. It is an uncommon event, and the mean age of affected patients is 11 years. This is a condition in which 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, 2019).

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:

- Weight gain, especially in the face, supraclavicular region, upper back, and torso
- Skin changes, including purpose stria, easy bruising, and other signs of skin thinning
- Proximal muscle weakness
- Menstrual irregularities and decreased libido in women
- Decreased libido and impotence in men
- Psychological problems, including depression, cognitive dysfunction, and emotional lability
- New or worsening hypertension and diabetes mellitus
- Difficulty with wound healing
- Increased infections
- Osteopenia and osteoporotic fractures
- Steroid acne
- Immunosuppression with slow wound healing and increased infections
- Growth retardation in children
  (Nguyen, 2020)

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), which is common with the use of inhaled corticosteroids and may be due to myopathy and spasm of laryngeal muscle, mucosal irritation, or laryngeal candidiasis; reversible when treatment is withdrawn
- **Cough and throat irritation,** sometimes accompanied by reflex bronchoconstriction
- **Unusual complications,** such as perioral dermatitis, tongue hypertrophy, and increased thirst
  (Saag et al., 2021)

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 in 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.

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 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 thus may not receive the correct dose. Dry powder inhalers or oral medications may be of help in this instance (AAFA, 2021i).

Pregnant Women

Asthma severity during pregnancy is related to asthma severity before pregnancy. Symptoms are more likely to worsen in women with severe asthma. About one third of pregnant women will see their asthma symptoms worsen, and another third will stay the same. The last third will see their asthma symptoms improve. Most women with asthma whose symptoms change in any way during pregnancy will return to their prepregnancy condition within 3 months following delivery.

Asthma exacerbations affect 20%–36% of pregnant asthmatic patients, and these tend to occur during the middle trimester. Gestational asthma is associated with a small increase in pregnancy complications, such as preeclampsia, restricted fetal growth, need for cesarean section, preterm labor, and in extreme instances, fetal demise. Appropriate therapy and good asthma control minimize these complications.

The primary goals of asthma management are unchanged in the setting of pregnancy, and the benefit of active treatment to maintain asthma control and prevent exacerbations outweighs the potential risks of routinely using asthma medications.

Careful follow-up by clinicians experienced in managing asthma is essential, and frequency of follow-up is determined based on the degree of prepregnancy asthma control. It is important to monitor pulmonary function, since diminished pulmonary function during pregnancy is associated with adverse perinatal outcomes.

Spirometry is minimally affected by pregnancy, but other pulmonary function test measurements do change. Total lung capacity may decrease slightly in the last trimester. Residual volume and functional residual capacity normally decrease during pregnancy due to diaphragm elevation from the enlarging uterus. Minute ventilation increases during pregnancy presumed to be due to circulation progesterone levels. Normal blood gases reveal a high PaO_2 and a lower $PaCO_2$.

For acute asthma exacerbations that require emergency management or hospitalization, fetal monitoring may be indicated in addition to routine monitoring for asthma. Early consultation with obstetrics service for comanagement is appropriate. Fetal heart rate monitoring is the best choice for determining fetal oxygenation (Mayo Clinic, 2020f; Weinberger & Schatz, 2020).

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.

Medications to treat asthma symptoms in infants and toddlers are often given in liquid form by using a nebulizer with a facemask or an inhaler with a spacer and facemask. Some toddlers and preschoolers are able to use an inhaler with a spacer and mask attachment.

Most babies, toddlers, and preschoolers are treated for asthma by their pediatrician. However, if asthma symptoms are not under control within 3–6 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.

Approximately 50% of children with asthma "outgrow" it once they reach or pass through adolescence, although it may return when they are adults, as their respiratory tract remains sensitive to asthma triggers for life (AAFA, 2021j).

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, 2021k) (see "Resources" at the end of this course).

Respiratory morbidity is frequent in children with asthma who are younger than 2 years, making evaluation of pulmonary function all the more important in these children. Children with asthma who are older than 5 years are tested using spirometry at each asthma office visit (Rosen & Colin, 2020).

Surgical Patients

Surgical patients with asthma face a higher risk of complications during the perioperative period and an increased risk of various complications postoperatively. Preoperative identification and optimization of patients with asthma before elective surgery are critical in preventing harm, along with a well-planned anesthetic. When patients present for surgery, it is important to determine whether the patient's asthma is well-controlled or poorly controlled in order to mitigate perioperative complications. Elective surgery is postponed until asthma is well controlled.

Induction of general anesthesia, airway manipulation, and emergence represent the most critical times for perioperative respiratory complications. Ensuring expert personnel are involved is essential. A pediatric anesthesiologist for children has been shown to reduce risk for adverse effects.

In patients with well-controlled asthma, routine mechanical ventilation can be used. However, when airflow obstruction is present, mechanical ventilation becomes more difficult. Allowing ample time for exhalation during mechanical ventilation is critical to avoid dynamic hyperinflation, a feared complication in patients with asthma.

Postoperatively, patients are monitored very closely and returned to their preanesthesia asthma regimen as soon as possible (Kamassai et al., 2020).

Dental Patients

Drugs used to treat asthma, such as beta-2 agonists and inhaled steroids, may promote a higher risk of cavities, dental erosion, periodontal disease, and oral candidiasis. The main mechanism involved is the reduction of salivary flow. Other mechanisms include acid pH in the oral cavity induced by inhaled drugs (particularly dry powder), lifestyle (poor oral hygiene and high consumption of sweet and acidic drinks), GERD, and impairment of local immunity.

Patient management protocols include minimizing stressors, which are the most common cause of asthma exacerbations in the dental office. 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. Dental treatment can be postponed in the event of an upper respiratory tract infection or exacerbation of asthma.

All dental product manufacturers are required to provide a declaration statement detailing all ingredients and possible allergens in a product. Dental materials that may cause reactions are many, including amalgam, latex, sealant materials, sodium hypochlorite, titanium, nickel-chromium alloy composites, local anesthetics, and impression materials (Metro-Sanchez, 2019; Świątkowska-Bury & Olczak-Kowalczyk, 2020).

Children in the School Setting

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. However, some are still being denied access to these medications during the school day. Fourteen states have laws or state administrative guidelines allowing schools to stock quick-relief medications for students with asthma. 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.

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, 2020d)

Asthma in the Workplace

It is recommended that patients who are diagnosed with occupational asthma induced by a sensitizing agent be completely and promptly removed from further exposure. Patients with occupational asthma generally have progressive deterioration in lung function if they remain in the same environment.

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.

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, 2019).

Traveling with Asthma

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. Federal law requires that airlines allow service animals in passenger cabins of planes, which increases the risk for those whose triggers include pet dander. Those with asthma may request being seated away from animals but should be aware that all flights will have pet dander because it comes off people's clothing.

When traveling by car, it is important to replace air filters and clean the ventilating and air conditioning system. Windows should be rolled up and air conditioning turned on.

Persons with asthma may request nonsmoking, mold-free, and pet-free rooms in hotels or resorts. They can use the air conditioning in the hotel room and keep the windows closed. If allergic to dust mites, they should bring their own pillow and hypoallergic cover.

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 (AAFA, 2021l; Cleveland Clinic, 2021c).

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 lessen 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 action plan (NHLBI)
https://www.nhlbi.nih.gov/files/docs/public/lung/asthma_actplan.pdf

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 Questionnaire
http://www.qoltech.co.uk/questionnaires.htm

Children's asthma education video series (University of North Carolina)
https://www.uncchildrens.org/uncmc/unc-childrens/care-treatment/asthma/patient-education/asthma-videos/

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

Smokefree.gov
https://smokefree.gov

REFERENCES

Alam M. (2016). Occupational therapy in respiratory medicine: global challenge in the 21st century. *Int J Respir Med, 1*(1). Retrieved from https://www.alliedacademies.org/articles/occupational-therapy-in-respiratory-medicine-global-challenge-in-the-21stcentury.pdf

Alwarith J, Kahleova H, Crosy L, Brooks A, et al. (2020). The role of nutrition in asthma prevention and treatment. *Nutrition Reviews, 78*(1), 928–38. doi:10.1093/nutrit/nuaa005

American Academy of Allergy Asthma & Immunology (AAAAI). (2021). Drug guide. Retrieved from https://www.aaaai.org/Tools-for-the-Public/Drug-Guide

American Academy of Allergy Asthma & Immunology (AAAAI). (2018). Association between asthma and depression. Retrieved from https://www.aaaai.org/Tools-for-the-Public/Latest-Research-Summaries/The-Journal-of-Allergy-and-Clinical-Immunology-In/2018/depression

American Lung Association (ALA). (2021a). Methacholine challenge test. Retrieved from https://www.lung.org/lung-health-diseases/lung-procedures-and-tests/methacholine-challenge-test

American Lung Association (ALA). (2021b). Pulse oximetry. Retrieved from https://www.lung.org/lung-health-diseases/lung-procedures-and-tests/pulse-oximetry

American Lung Association (ALA). (2020a). Current asthma demographics. Retrieved from https://www.lung.org/research/trends-in-lung-disease/asthma-trends-brief/current-demographics

American Lung Association (ALA). (2020b). Asthma and indoor air. Retrieved from https://www.lung.org/blog/asthma-and-indoor-air

American Lung Association (ALA). (2020c). Measuring your peak flow rate. Retrieved from lung.org/lung-health-diseases/lung-disease-lookup/asthma/living-with-asthma/managing-asthma/measuring-your-peak-flow-rate

American Lung Association (ALA). (2020d). Creating asthma-friendly environments. Retrieved from https://www.lung.org/lung-health-diseases/lung-disease-lookup/asthma/living-with-asthma/creating-asthma-friendly-environments

American Partnership for Eosinophilic Disorders (APFED). (2020). Eosinophilic asthma. Retrieved from https://apfed.org/about-ead/eosinophilici-asthma/

Apter A. (2021a). Enhancing patient adherence to asthma therapy. *UpToDate*. Retrieved from https://www.uptodate.com/contents/enhancing-patient-adherence-to-asthma-therapy

Apter A. (2021b). Asthma education and self-management. *UpToDate*. Retrieved from https://www.uptodate.com/contents/asthma-education-and-self-management

Asthma and Allergy Foundation of America (AAFA). (2021a). Asthma facts and figures. Retrieved from https://www.aafa.org/asthma-facts/

Asthma and Allergy Foundation of America (AAFA). (2021b). Asthma capitals 2021. Retrieved from https://www.aafa.org/asthma-capitals/

Asthma and Allergy Foundation of America (AAFA). (2021c). Adult-onset asthma. Retrieved from https://asthmaandallergies.org/asthma-allergies/adult-onset-asthma/

Asthma and Allergy Foundation of America (AAFA). (2021d). Asthma in older adults. Retrieved from https://asthmaandallergies.org/asthma-allergies/asthma-in-older-adults/

Asthma and Allergy Foundation of America (AAFA). (2021e). Climate and health. Retrieved from http://www.aafa.org/page/climate-and-health.aspx

Asthma and Allergy Foundation of America (AAFA). (2021f). Asthma and gastroesophageal reflux disease. Retrieved from https://asthmaandallergies.org/asthma-allergies/asthma-and-gastroesophageal-reflux-disease/

Asthma and Allergy Foundation of America. (AAFA). (2021g). Asthma medicines and treatment. Retrieved from https://www.aafa.org/asthma-treatment/

Asthma and Allergy Foundation of America (AAFA). (2021h). Asthma medicine and treatment. Retrieved from https://www.aafa.org/asthma-treatment/

Asthma and Allergy Foundation of America (AAFA). (2021i). Asthma in older adults. Retrieved from http://asthmaandallergies.org/asthma-allergies/asthma-in-older-adults/

Asthma and Allergy Foundation of America (AAFA). (2021j). Asthma in infants and young children. Retrieved from http://asthmaandallergies.org/asthma-allergies/asthma-in-infants-and-young-children/

Asthma and Allergy Foundation of America (AAFA). (2021k). Asthma-friendly child care checklist. Retrieved from http://asthmaandallergies.org/asthma-allergies/childcare-asthma-checklist/

Asthma and Allergy Foundation of America (AAFA). (2021l) Traveling with asthma and allergies. Retrieved from http://www.aafa.org/page/traveling-with-asthma-allergies.aspx

Asthma and Allergy Foundation of America (AAFA). (2020). Wildfire season has begun and it affects air quality and asthma. Retrieved from https://community.aafa.org/blog/wildfire-season-has-begun-and-it-affects-air-quality-and-asthma

Asthma and Allergy Foundation of America (AAFA). (2019a). What causes or triggers asthma? Retrieved from https://www.aafa.org/asthma-triggers-causes/

Asthma and Allergy Foundation of America (AAFA). (2019b). Improper inhaler use can affect asthma control. Retrieved from https://community.aafa.org/blog/improper-inhaler-use-can-affect-asthma-control

Asthma Initiative of Michigan (AIM). (2021). Diagnosis of asthma in infants/children. Retrieved from https://getasthmahelp.org/asthma-diagnosis-infants.aspx

Asthma UK. (2021a). Symptoms of asthma. Retrieved from https://www.asthma.org.uk/advice/understanding-asthma/symptoms/#coughing

Asthma UK. (2021b). Tests for severe asthma. Retrieved from https://www.asthma.org.uk/advice/severe-asthma/diagnosing-severe-asthma/tests-for-severe-asthma/#xray

Asthma UK. (2020). Female hormones. Retrieved from https://www.asthma.org.uk/advice/triggers/hormones/

Asthma UK. (2019). Recreational drugs. Retrieved from https://www.asthma.org.uk/advice/triggers/recreational-drugs/

Bhargave H. (2020). Allergy tests and asthma. *WebMD.* Retrieved from https://www.webmd.com/asthma/guide/allergy-tests-and-asthma#2

Boulet L, Boulay M, Coxson H, Hague C, et al. (2020). Asthma with irreversible airway obstruction in smokers and nonsmokers: links between airway inflammation and structural changes. *Respiration, 99,* 1090–1100. doi:10.1159/000508163

Carolan P. (2019). Pneumomediastinum. *Medscape*. Retrieved from https://emedicine.medscape.com/article/1003409-overview

Celli B. (2020). Pulmonary rehabilitation. *UpToDate.* Retrieved from https://www.uptodate.com/contents/pulmonary-rehabilitation

Centers for Disease Control and Prevention (CDC). (2021a). Most recent national asthma data. Retrieved from https://www.cdc.gov/asthma/most_recent_national_asthma_data.htm

Centers for Disease Control and Prevention (CDC). (2021b). Asthma stats. Retrieved from https://www.cdc.gov/asthma/asthma_stats/default.htm

Centers for Disease Control and Prevention (CDC). (2021c). Flu & people with asthma. Retrieved from https://www.cdc.gov/flu/highrisk/asthma.htm

Centers for Disease Control and Prevention (CDC). (2020a). Tools for asthma control. Retrieved from https://www.cdc.gov/asthma/tools_for_control.htm

Centers for Disease Control and Prevention (CDC). (2020b). Common asthma triggers. Retrieved from https://www.cdc.gov/asthma/triggers.html

Centers for Disease Control and Prevention (CDC). (2018). Know how to use your asthma inhaler. Retrieved from https://www.cdc.gov/asthma/pdfs/Inhaler_Spacer_FactSheet.pdf

Chakraborty R & Basnet S. (2021). Status asthmaticus. *StatPearls.* Treasure Island, FL: StatPearls Publishing.

Choi J & Azmat C. (2021). Leukotriene receptor antagonists. *StatPearls*. Treasure Island, FL: StatPearls Publishing.

Choi Y, Park J. Lee H, Suh J, et al. (2021). Effect of asthma and asthma medication on the progress of patients with COVID-19. *European Respiratory Journal, 57*, 2002228. doi:10.1183/13993003.02226-2020

Cleveland Clinic. (2021a). Smoking & asthma. Retrieved from https://my.clevelandclinic.org/health/articles/4584-smoking--asthma

Cleveland Clinic. (2021b). Asthma. Retrieved from https://my.clevelandclinic.org/health/diseases/6424-asthma

Cleveland Clinic. (2021c). The best ways to prevent your allergies on vacation. Retrieved from https://health.clevelandclinic.org/best-tips-for-traveling-with-allergies/

Cleveland Clinic. (2020). Why asthma puts you at greater risk this flu season. Retrieved from https://health.clevelandclinic.org/why-asthma-puts-you-at-greater-risk-this-flu-season/

Cloutier M, Baptist A, Teach S, Umscheid C, et al. (2020). 2020 focused updates to the asthma management guidelines: A report from the National Asthma Education and Prevention Program coordinating committee expert panel working group*. J Allergy and Clinical Immunology, 146*(6), 1217–70.

Comhair S, Bochenek G, Baicker-McKee S, Wang Z, et al. (2018). The utility of biomarkers in diagnosis of aspirin exacerbated respiratory disease. *Resp Res 19,* 210. doi:10.1186/s12931-018-0909-6

Darabi B, Rahmati S, HafeziAmadi M, Badfar G, & Azami M. (2019). The association between caesarean section and childhood asthma: an updated systematic review and meta-analysis. *Allergy, Asthma & Clinical Immunology, 15,* 62. doi:101186/s13223-019-367-9

Dixon A & Nyenhuis S. (2021). Obesity and asthma. *UpToDate.* Retrieved from https://www.uptodate.com/contents/obesity-and-asthma

Donoghue L, Markovetz M, Morrison C, McFadden K, et al. (2020). BPIFB1 loss alters airway mucus properties and diminishes mucocilliary clearance. *bioRxiv,* preprint. doi:10.1101/2020.06.17.155846

Enilari O & Sinha S. (2019). The global impact of asthma in adult populations. *Annals of Global Health, 85*(1), 2. doi:10.5334/aogh.2412

Esmaeel H & Aly H. (2018). Psychological assessment of patients with bronchial asthma: focus on some predictors of abnormalities. *Egypt J Bronchol, 13,* 35–42. doi:10.4103/sjb.ejb_42_18

Fanta C. (2021a). Acute exacerbations of asthma in adults: home and office management. *UpToDate*. Retrieved from https://www.uptodate.com/contents/acute-exacerbations-of-asthma-in-adults-home-and-office-management

Fanta C. (2021b). Acute exacerbations of asthma in adults: emergency department in inpatient management. *UpToDate.* Retrieved from https://www.uptodate.com/contents/acute-exacerbations-of-asthma-in-adults-emergency-department-and-inpatient-management

Fanta C. (2020a). Diagnosis of asthma in adolescents and adults. *UpToDate.* Retrieved from https://www.uptodate.com/contents/diagnosis-of-asthma-in-adolescents-and-adults

Fanta C. (2020b). An overview of asthma management. *UpToDate*. Retrieved from https://www.uptodate.com/contents/an-overview-of-asthma-management

Gandy W. (2021). In a prolonged asthma attack, start at the end. Retrieved from https://www.emsworld.com/article/12339676/in-a-prolonged-asthma-attack-start-at-the-end

Global Initiative for Asthma (GINA). (2021). Global strategy for asthma management and prevention. Retrieved from https://ginasthma.org/wp-content/uploads/2021/05/GINA-Main-Report-2021-V2-WMS.pdf

Global Initiative for Asthma (GINA). (2019). Understanding thunderstorm asthma: prevention and treatment methods. Retrieved from https://ginasthma.org/understanding-thunderstorm-asthma-prevention-and-treatment-methods/

Gottwalt B & Tadi P. (2021). Methylxanthines. *StatPearls.* Treasure Island, FL: StatPearls Publishing.

Groot L, Van der Veen A, Martinez F, et al. (2019). Oxidative stress and macrophages: driving forces behind exacerbations of asthma and chronic obstructive pulmonary disease. *American Journal of Physiology, 315*(2), L369–84. doi:10.1152/ajplung.00456.2018

Han M & Wenzell S. (2020). Asthma and COPD overlap (ACO). *UpToDate.* Retrieved from https://www.uptodate.com/contents/asthma-and-copd-overlap-aco

Hess D & Dhand R. (2020). The use of inhaler devices in adults. *UpToDate.* Retrieved from https://www.uptodate.com/contents/the-use-of-inhaler-devices-in-adults

Hin H & Kim C. (2020). Understanding the impact of chronic cough on the quality of life in the general population. *Allergy Asthma Immuno Res, 12*(6), 906–9.

Irvin C. (2020). Bronchoprovocation testing. *UpToDate*. Retrieved from https://www.uptodate.com/contents/bronchoprovocation-testing

Jartti T, Bønnelykke K, Feleszko W, et al. (2020). Role of viruses in asthma. *Semin Immunopathol, 42*(1), 61–74. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7066101/

Johns Hopkins Medicine. (2021). Occupational asthma. Retrieved from https://www.hopkinsmedicine.org/health/conditions-and-diseases/asthma/occupational-asthma

Kakumanu S. (2021). Role of viruses in wheezing and asthma: an overview. *UpToDate.* Retrieved from https://www.uptodate.com/contents/role-of-viruses-in-wheezing-and-asthma-an-overview

Kamassai J, Aina T, & Hauser J. (2020). Asthma anesthesia. *StatPearls.* Treasure Island, FL: StatPearls Publishing.

Kaplan A & Price D. (2020). Treatment adherence in adolescents with asthma. *J Asthma Allergy 13,* 39–49.

Kowal K & DuBuske L. (2021). Overview of in vitro allergy tests. *UpToDate.* Retrieved from https://www.uptodate.com/contents/overview-of-in-vitro-allergy-tests#H1

Lab Tests Online. (2021). Asthma. Retrieved from https://labtestsonline.org/conditions/asthma

Lemière C & Bernstein D. (2019). Occupational asthma, management, prognosis, and prevention. *UpToDate.* Retrieved from https://www.uptodate.com/contents/occupational-asthma-management-prognosis-and-prevention

Lexicomp. (2021). Prednisone: drug information. *UpToDate*. Retrieved from https://www.uptodate.com/contents/prednisone-drug-information

Li J. (2020). Trouble breathing: could it be asthma? Retrieved from https://www.mayoclinic.org/diseases-conditions/asthma/expert-answers/trouble-breathing/faq-20057865

Liang T & Chao J. (2021). Inhaled corticosteroids. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK470556/

Litonjua A & Weiss S. (2020a). Epidemiology of asthma. *UpToDate.* Retrieved from https://www.uptodate.com/contents/epidemiology-of-asthma

Litonjua A & Weiss S. (2020b). Risk factors for asthma. *UpToDate*. Retrieved from https://www.uptodate.com/contents/risk-factors-for-asthma

Loengard A. (2019). Status asthmaticus: when asthma gets serious. Retrieved from https://www.verywellhealth.com/status-asthmaticus-when-asthma-gets-serious-3866901

Mackey C, Hunter C, Dokhnan S, Lowe R, & Thomas E. (2021). Asthma. Retrieved from https://www.physio-pedia.com/Asthma

MacNaughton K. (2019). Understanding the role of allergic cascade in asthma attacks. Retrieved from https://asthma.net/living/allergic-cascades-attacks

Makhinova T, Walker B. Guiguis L, et al. (2020). Checking inhaler technique in the community pharmacy: predictors of critical errors. *Pharmacy (Basel), 8*(1), 6.

Marchant J & Chang A. (2020). Causes of chronic cough in children. *UpToDate.* Retrieved from https://www.uptodate.com/contents/causes-of-chronic-cough-in-children

Marsh T. (2020). Here's why asthma inhalers are so expensive. Retrieved from https://www.goodrx.com/blog/heres-why-asthma-inhalers-are-so-expensive/

Martin P. (2020). 8 asthma nursing care plans. Retrieved from https://nurseslabs.com/asthma-nursing-care-plans/

Martin R. (2021). Nocturnal asthma. *UpToDate*. Retrieved from https://www.uptodate.com/contents/nocturnal-asthma

Mayo Clinic. (2021a). Childhood asthma. Retrieved from https://www.mayoclinic.org/diseases-conditions/childhood-asthma/symptoms-causes/syc-20351507

Mayo Clinic. (2021b). Cromolyn (inhalation route). Retrieved from https://www.mayoclinic.org/drugs-supplements/cromolyn-inhalation-route/proper-use/drg-20067594?p=1

Mayo Clinic. (2020a). Occupational asthma. Retrieved from https://www.mayoclinic.org/diseases-conditions/occupational-asthma/symptoms-causes/syc-20375772

Mayo Clinic. (2020b). Pregnancy week by week. Retrieved from https://www.mayoclinic.org/healthy-lifestyle/pregnancy-week-by-week/in-depth/pregnancy-and-asthma/art-20047303

Mayo Clinic. (2020c). Allergy skin tests. Retrieved from http://www.mayoclinic.org/tests-procedures/allergy-tests/basics/risks/prc-20014505

Mayo Clinic. (2020d). Seasonal allergies: nip them in the bud. Retrieved from https://www.mayoclinic.org/diseases-conditions/hay-fever/in-depth/seasonal-allergies/art-20048343

Mayo Clinic. (2020e). Asthma treatment: do complementary and alternative approaches work? Retrieved from https://www.mayoclinic.org/diseases-conditions/asthma/in-depth/asthma-treatment/art-20044554

Mayo Clinic. (2020f). Pregnancy and asthma: managing your symptoms. Retrieved from https://www.mayoclinic.org/healthy-lifestyle/pregnancy-week-by-week/in-depth/pregnancy-and-asthma/art-20047303

Mayo Clinic. (2019). Chronic cough. Retrieved from https://www.mayoclinic.org/diseases-conditions/chronic-cough/symptoms-causes/syc-20351575

McCarthy K. (2020). Pulmonary function testing. *Medscape.* Retrieved from https://emedicine.medscape.com/article/303239-overview

McCormack M. (2020). Overview of pulmonary function testing in adults. *UpToDate*. Retrieved from https://www.uptodate.com/contents/overview-of-pulmonary-function-testing-in-adults

Metro-Sanchez A. (2019). Protecting patients with allergies to dental products. Retrieved from https://www.rdhmag.com/patient-care/article/14068499/protecting-patients-with-allergies-to-dental-products

Mikhail I & Grayson M. (2019). Asthma and viral infections: an intricate relationship. *Annals of Allergy, Asthma & Immunology, 123*(4), 352–8. doi:10/1016/j.anai.2019.06.020

Morris M. (2020). Asthma. *Medscape.* Retrieved from https://emedicine.medscape.com/article/296301-overview#a6

Moses S. (2021). Asthma inpatient management. Retrieved from https://fpnotebook.com/Lung/Asthma/AsthmInptntMngmnt.htm

Mustafa S. (2021). Skin test for allergy. Retrieved from https://www.medicinenet.com/skin_test_for_allergy/article.htm#what_is_a_skin_test

National Asthma Council Australia (NACA). (2021). *The Australian asthma handbook.* Retrieved from http://www.asthmahandbook.org.au/about

National Heart, Lung, and Blood Institute (NHLBI). (2021). How to control things that make your asthma worse. Retrieved from file:///C:/Users/Judith/Downloads/_sites_default_files_publications_Asthma-Action-Plan-2020_rev_508%20(3).pdf

National Heart, Lung, and Blood Institute (NHLBI). (2020a). Asthma. Retrieved from https://www.nhlbi.nih.gov/health-topics/asthma

National Heart, Lung, and Blood Institute (NHLBI). (2020b). 2020 focused updates to the asthma management guidelines. Retrieved from https://www.nhlbi.nih.gov/health-topics/all-publications-and-resources/2020-focused-updates-asthma-management-guidelines

National Heart, Lung, and Blood Institute (NHLBI). (2020c). Asthma action plan. Retrieved from https://www.nhlbi.nih.gov/health-topics/all-publications-and-resources/asthma-action-plan-2020

National Institutes of Health (NIH). (2021a). Lung diffusion testing. Retrieved from https://medlineplus.gov/ency/article/003854.htm

National Institutes of Health (NIH). (2021b). Allergy testing—skin. Retrieved from https://medlineplus.gov/ency/article/003519.htm

Newsom R. (2021). Asthma and sleep. Retrieved from https://www.sleepfoundation.org/sleep-related-breathing-disorders/asthma-and-sleep

Nguyen H. (2020). Iatrogenic Cushing syndrome. *Medscape*. Retrieved from https://emedicine.medscape.com/article/117365-overview

North Shore Community College (NSCC). (2020). Respiratory care program. Retrieved from https://www.northshore.edu/academics/programs/rsp/files/rsp-handbook.pdf

Norwitz E. (2021). Cesarean delivery on maternal request. *UpToDate*. Retrieved from https://www.uptodate.com/contents/cesarean-delivery-on-maternal-request

Oppenheimer J. (2019). Allergic and environmental asthma. *Medscape.* Retrieved from https://emedicine.medscape.com/article/137501-overview

Peters U, Dixon A, & Forno E. (2018). Obesity and asthma. *J Allergy Clin Inmunol, 14*(4), 1169–79.

Physiopedia. (2021a). Exercise induced asthma. Retrieved from https://www.physio-pedia.com/Exercise_Induced_Asthma

Physiopedia. (2021b). Respiratory physiotherapy. Retrieved from https://www.physio-pedia.com/Respiratory_Physiotherapy

Pichardo A. (2020). Asthma treatments. *WebMD.* Retrieved from https://www.webmd.com/asthma/asthma-treatments

Respiratory Therapy Zone (RTZ). (2021). Impaired gas exchange. Retrieved from https://rnlessons.com/impaired-gas-exchange/

Rhyou H & Nam Y. (2020). Association between cognitive function and asthma in adults. *Annals of Allergy, Asthma & Immunology, 126*(1), 69–74. doi:10.1016/J.anai.2020.08.022

Rodriguez D. (2021). Cigarette and tobacco products in pregnancy: impact on pregnancy and the neonate. *UpToDate*. Retrieved from https://www.uptodate.com/contents/cigarette-and-tobacco-products-in-pregnancy-impact-on-pregnancy-and-the-neonate

Rodriguez T. (2019a). Inhaler misuse in asthma and COPD: undoing 40 years of incorrect technique. Retrieved from https://www.pulmonologyadvisor.com/home/topics/asthma/inhaler-misuse-in-asthma-and-chronic-obstructive-pulmonary-disease/

Rodriguez T. (2019b). The asthma-mental health connection: expert clinicians weight in. Retrieved from https://www.pulmonologyadvisor.com/home/topics/asthma/asthma-and-mental-health-disorders-may-share-connection/

Rosen D & Colin A. (2020). Overview of pulmonary function testing in children. *UpToDate*. Retrieved from https://www.uptodate.com/contents/overview-of-pulmonary-function-testing-in-children

Saaden M. (2020). What causes pneumothorax in status asthmaticus? *Medscape.* Retrieved from https://www.medscape.com/answers/2129484-46298/what-causes-pneumothorax-in-status-asthmaticus

Saag K, Furst D, & Barnes P. (2021). Major side effects of inhaled glucocorticoids. *UpToDate.* Retrieved from http://www.uptodate.com/contents/major-side-effects-of-inhaled-glucocorticoids

Sawicki G & Haver K. (2020). Acute exacerbation in children younger than 2 years: home/office management and severity assessment. *UpToDate*. Retrieved from https://www.uptodate.com/contents/acute-asthma-exacerbations-in-children-younger-than-12-years-home-office-management-and-severity-assessment

Sawicki G & Haver K. (2019). Patient education: asthma symptoms and diagnosis in children (beyond the basics). *UpToDate.* Retrieved from https://www.uptodate.com/contents/asthma-symptoms-and-diagnosis-in-children-beyond-the-basics

Scarfone R. (2020). Acute asthma exacerbations in children: emergency department management. *UpToDate.* Retrieved from https://www.uptodate.com/contents/acute-asthma-exacerbations-in-children-emergency-department-management

Schatz M & Weinberger S. (2020). Management of asthma during pregnancy. *UpToDate.* Retrieved from https://www.uptodate.com/contents/management-of-asthma-during-pregnancy

Schiffman G. (2020). Asthma medications. Retrieved from https://www.emedicinehealth.com/understanding_asthma_medications/article_em.htm#leukotriene_inhibitors_for_asthma_use_side_effects_and_interactions

Schwartzstein R. (2020). Approach to the patient with dyspnea. *UpToDate*. Retrieved from https://www.uptodate.com/contents/approach-to-the-patient-with-dyspnea

Sharma G. (2021). Pediatric asthma. *Medscape.* Retrieved from https://emedicine.medscape.com/article/1000997-overview

Shen Y, Huang S, Wen S, et al. (2018). Management of airway mucus hypersecretion in chronic airway inflammatory disease: Chinese expert consensus. *Int J Chron Obstruct Pulmon Dis, 13,* 399–407.

Sims J, Leggett S, & Myla A. (2020). Industrial emissions and asthma prevalence*. European Journal of Environment and Public Health, 4*(2), em0046. doi:10.29333/ejeph/8288

SingHealth. (2021). How to survive an asthma attack if you're caught without your inhaler. Retrieved from https://www.healthxchange.sg/asthma/complications-management/survive-asthma-without-inhaler

State of Indiana. (2021). Respiratory therapists: patient asthma management. Retrieved from https://www.in.gov/health/reports/breatheasyville/medical/resptherapist.html

Stavropoulou E, Kantartzi K, Tsigalou C, Konstantinidis T, et al. (2021). Unraveling the interconnection patterns across lung microbiome, respiratory diseases, and COVID-19. *Front. Cell. Microbiol., 10*, 619075. doi:10.2289/fcimb.2020.619075

Stubbs M, Clark V, & McDonald V. (2019). Living well with severe asthma. *Breathe (Ssheff), 15*(22), 40–9.

Sullivan B. (2021). EMS assessment and treatment of asthma: 5 things to know. Retrieved from https://www.ems1.com/ems-products/capnography/articles/ems-assessment-and-treatment-of-asthma-5-things-to-know-dS9rXvWjowLIfyAZ/

Swapna M, Roopa HV, & Somasundari P. (2020). Effect of chest mobility exercises and myofascial release on chest expansion and dyspnoea in subjects with chronic obstructive pulmonary disease. *IJPESH, 7*(4), 4–10. Retrieved from https://www.kheljournal.com/archives/2020/vol7issue4/PartA/7-3-38-728.pdf

Świątkowska-Bury M & Olczak-Kowalczyk D. (2020). Patient with bronchial asthma in a dentist's office - review of the literature on treatment. *Borgis-Nowa Stomatologia,* 41–9. doi:10.25121/NS2020.25.2.41

Thien F, Davies J, Jew M, Douglass J, & O'Hehir R. (2020). Thunderstorm asthma: an overview of mechanisms and management strategies. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/1744666X.2021.1826310?journalCode=ierm20

Trivedi M & Denton E. (2019). Asthma in children and adults—what are the differences and what can they tell us about asthma? *Frontiers in Pediatrics, 7,* 256. doi:10.3389/fped.2019.00256.

U.S. Department of Health and Human Services, Office of Minority Health (OMH). (2021). Asthma and African Americans. Retrieved from https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=4&lvlid=15

U.S. Environmental Protection Agency (EPA). (2021a). How smoke from fires can affect your health. Retrieved from https://www.epa.gov/pm-pollution/how-smoke-fires-can-affect-your-health

U.S. Environmental Protection Agency (EPA). (2021b). Introduction to indoor air quality. Retrieved from https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality

U.S. Food & Drug Administration (FDA). (2021a). Pulse oximeter accuracy and limitations: FDA safety communication. Retrieved from https://www.fda.gov/medical-devices/safety-communications/pulse-oximeter-accuracy-and-limitations-fda-safety-communication

U.S. Food & Drug Administration (FDA). (2021b). Drugs@FDA: FDA-approved drugs. Retrieved from https://www.accessdata.fda.gov/scripts/cder/daf/

U.S. Food & Drug Administration (FDA). (2020). DDT COA #000006: asthma daily symptoms diary (ADSD). Retrieved from https://www.fda.gov/drugs/clinical-outcome-assessment-coa-qualification-program/ddt-coa-000006-asthma-daily-symptom-diary-adsd

University of Michigan (UM). (2020). How asthma develops in children. Retrieved from https://www.uofmhealth.org/health-library/ug2983

University of Newcastle. (2020). Questionnaires. Retrieved from https://toolkit.severeasthma.org.au/diagnosis-assessment/questionnaires/

Wayne G. (2019). Ineffective airway clearance. Retrieved from https://nurseslabs.com/ineffective-airway-clearance/

Weinberger & Schatz. (2020). Management of asthma during pregnancy. *UpToDate.* Retrieved from https://www.uptodate.com/contents/management-of-asthma-during-pregnancy

Weiss S. (2020). Genetics of asthma. *Medscape.* Retrieved from https://emedicine.medscape.com/article/2068244-overview

Wenzel S. (2021). Treatment of severe asthma in adolescents and adults. *UpToDate.* Retrieved from https://www.uptodate.com/contents/treatment-of-severe-asthma-in-adolescents-and-adults

World Health Organization (WHO). (2021). Chronic respiratory diseases: asthma. Retrieved from https://www.who.int/news-room/q-a-detail/chronic-respiratory-diseases-asthma

Wright R & Coull B. (2019). Small but mighty: prenatal ultrafine particle exposure linked to childhood asthma incidence. *Am J Respir Crit Care Med, 299*(12), 1448–50.

Yale Medicine. (2021). Pulse oximetry. Retrieved from https://www.yalemedicine.org/conditions/pulse-oximetry

DISCLOSURE

Wild Iris Medical Education, Inc., provides educational activities that are free from bias. The information provided in this course is to be used for educational purposes only. It is not intended as a substitute for professional healthcare. Neither the planners of this course nor the author have conflicts of interest to disclose. (A conflict of interest exists when the planners and/or authors have financial relationship with providers of goods or services which could influence their objectivity in presenting educational content.) This course is not co-provided. Wild Iris Medical Education, Inc., has not received commercial support for this course. There is no "off-label" use of medications in this course. All doses and dose ranges are for adults, unless otherwise indicated. Trade names, when used, are intended as an example of a class of medication, not an endorsement of a specific medication or manufacturer by Wild Iris Medical Education, Inc. Product trade names or images, when used, are intended as an example of a class of product, not an endorsement of a specific product or manufacturer by Wild Iris Medical Education, Inc. Accreditation does not imply endorsement by Wild Iris Medical Education, Inc. of any commercial products or services mentioned in conjunction with this activity.

ABOUT THIS COURSE

You must score 70% or better on the test and complete the course evaluation to earn a certificate of completion for this CE activity.

ABOUT WILD IRIS MEDICAL EDUCATION

Wild Iris Medical Education offers a simple CE process, relevant, evidence-based information, superior customer service, personal accounts, and group account services. We've been providing **online accredited and approved continuing education since 1998**.

ACCREDITATION/APPROVAL INFORMATION FOR WILD IRIS MEDICAL EDUCATION

TEST

[Take the test online at wildirismedicaleducation.com]

1. The Global Initiative for Asthma's clinical definition states that asthma is a condition usually characterized by:

a. Chronic airway inflammation.
b. Allergic symptoms.
c. Wheezing after exercise.
d. Psychological distress.

2. Asthma that is the result of antigen/antibody reaction is called:

a. Intrinsic asthma.
b. Extrinsic asthma.
c. Eosinophilic asthma.
d. Nonallergic asthma.

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 Black people.
d. People living in the South have the highest prevalence of asthma.

4. The term "asthma cascade" can be described as:

a. Reversible airway obstruction caused by an allergen.
b. A well-defined constellation of signs and symptoms.
c. Chronic inflammatory of the airways with airway remodeling.
d. Hyperresponsiveness of the bronchial smooth muscle.

5. 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.

6. A comorbid condition associated with asthma is:

a. Endogenous Cushing's syndrome.
b. Congestive heart failure.
c. Obesity.
d. Hypertension.

7. The most accurate predictor of a death from bronchial asthma is having a history of:

a. Beta agonist inhaler use.
b. A hospitalization for an asthma attack.
c. Frequent need for quick-relief asthma medication.
d. Intubation for a severe asthma attack.

8. 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.

9. Which asthma drug delivery device is commonly used with infants and small children?

a. Metered-dose inhaler (MDI)
b. Dry powder inhaler (DPI)
c. Valved holding chamber (VHC)
d. Nebulizer

10. Which is a **correct** statement about the proper use of inhalers?

a. After using a steroid inhaler, rinse the mouth, gargle, and spit out the water.
b. The procedure for 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 for 2 minutes.

11. Standard treatment in the emergency room of an asthma attack begins with:

a. Epinephrine or terbutaline.
b. Ipratropium intravenously.
c. Inhaled SABA.
d. Inhaled glucocorticoids.

12. 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 (Epipen).

13. Which peak flow rate in an asthma action plan indicates that a patient is in the "red 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.

14. 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. Weekly washing of bedding in hot water.
d. Using humidifiers and keeping the house warmer than usual.

15. The physical therapy management technique that is most effective in reducing rescue bronchodilator medication use is:

a. Breathing retraining.
b. Buteyko.
c. Physical training.
d. Postural drainage.

16. 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.

17. Status asthmaticus is a serious complication of asthma and can be described as:

a. A severe asthma attack in which symptoms continue despite treatment.
b. Air entering the central compartment of the thoracic cavity.
c. Increased airway pressure due to mechanical ventilation.
d. Inflammation of the airways due to a secondary respiratory infection.

18. 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.

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

a. The disease often goes into remission.
b. Other health problems can mask the disease.
c. Inhaled asthma medications are not tolerated in this population.
d. The majority of older adults have only cough-variant asthma.

20. For children who are in school, all 50 states have laws that:

a. Require the parent to administer quick-relief inhalers.
b. Require transport of a child with an asthma exacerbation to the emergency department.
c. Allow students with asthma to carry and self-administer quick-relief inhalers.
d. Require a school nurse to administer quick-relief inhalers.