Targeted Education Methods for the Enhanced Understanding of Asthma

Presented in Partial Fulfillment of the Requirements for the
University Honors Program
Colorado State University

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Spring 2025

Abstract

Asthma is a chronic disease characterized by episodes of wheezing, coughing, and shortness of breath. This disease is highly prevalent in both adult and pediatric populations and can affect the day-to-day life of those afflicted. This paper serves to explore the pathophysiology of asthma, particularly the roles of bronchoconstriction, airway inflammation, and the immune response associated with it. Diagnostic techniques and classification of asthma are also discussed, particularly related to different phenotypic presentations of the disease. Treatment options and plans are also identified. Beyond the physical, the psychosocial elements of having a chronic disease are discussed, emphasizing the emotional challenges faced by adolescents. Taking the physical and psychosocial elements into consideration, the need for targeted education techniques is highlighted and explored. By combining the biological and psychosocial perspectives regarding adolescent chronic asthma, this paper advocates for a change to the patient-care approach for asthmatics.

What is Asthma?

Asthma is a chronic disease that affects the lungs' airways. It is characterized by symptoms such as coughing, wheezing, chest tightness, and shortness of breath (Sockrider and Fussner, 2020). Such symptoms are caused by the inflammation of airways and bronchospasm and can be triggered by many things, depending on the patient and phenotypic presentation of the condition. Triggers can be a variety of things, including allergies, infection, stress, exercise, or environmental aspects. Often, patients are subject to ‘asthma attacks’: the sudden worsening of symptoms and thus require immediate treatment, such as bronchodilators (Sockrider and Fussner, 2020). The condition must be diagnosed by a medical professional, usually by means of pulmonary function testing and ruling out other pulmonary afflictions, such as cystic fibrosis. Further observation can aid in diagnosing severities (Sinyor & Perez, 2023).

Pathophysiology

The main organ system affected by asthma is the respiratory system, consisting of the nose, trachea, bronchi, branching bronchioles, and alveoli within the lungs. Within the respiratory system there are two zones: the conducting zone and the respiratory zone (Sinyor & Perez, 2023). The conducting zone is the pathway from the nose through to the bronchioles and serves to prepare inhaled air for respiration deeper in the lungs. The conducting zone can be considered the first part of respiration, as it leads to the respiratory zone. Air is brought to the alveoli deep in the lungs, referred to as ventilation. Gas exchange occurs in the respiratory zone, specifically in these alveoli. This gas exchange is characterized by the diffusion of oxygen into pulmonary capillaries and the diffusion of carbon dioxide from the blood into the alveoli (Powers & Dhamoon 2023). To have effective respiration, both ventilation and perfusion (blood brought to pulmonary capillary beds) need to be unobstructed. In asthmatics, ventilation can particularly be affected and can obstruct respiration.

The main structures of the lungs that are affected by asthma are the bronchi and the bronchioles. Specifically, the body produces an inflammatory response that obstructs the bronchi. Two main phases make up exacerbation (inflammatory response), termed the early and late phase. In response to a trigger, the early phase is initiated by IgE antibodies that are released by plasma cells. These antibodies then bind to high-affinity mast cells, stimulating them to release cytokines (Sinyor & Perez, 2023). Cytokines, such as histamine, act as a chemical messenger to enact an immune response. Specifically, the cytokines act on the smooth muscle of the bronchi, causing it to contract and tighten the airways. Additionally, interleukins are released to sustain inflammation. At a later point, typically 6-8 hours later, the late phase response occurs. This is when eosinophilic inflammation and T-cell infiltration occur (Heltzer & Spergel, 2007). Both the early and late stage require medication to remediate.

A crucial feature of asthma is airway hyperresponsiveness. This hyperresponsiveness is the respiratory system's reaction to triggers, defined as the above-mentioned early phase. It is characterized by an exaggerated bronchoconstriction and can be caused by multiple things (Sinyor & Perez, 2023). Increased histamine levels or bronchial smooth muscle mass can result in higher levels of bronchoconstriction and is correlated with decreased lung function. Additionally, increased vagal tone and free calcium levels are typically observed, which also contribute to smooth muscle contractility via calmodulin binding. Overall, the presence of airway hyperresponsiveness can exacerbate asthma in both pediatric and adult patients and requires targeted treatment (Sinyor & Perez, 2023).

In more severe cases of asthma, mucus hypersecretion can be observed. Formation of mucus plugs can thus occur and subsequently cause asphyxiation and can be fatal. Mucus can broadly be defined as the "extracellular mixture of mucins that have been secreted…," with mucins being heavily glycosylated proteins (Evans et al., 2010). Airways are normally covered by a mucus layer and are manipulated by cilia lining the airway epithelial cells. This mucus functions to trap pathogens to protect the lungs from infection. Though mucus hypersecretion requires further studies to fully understand its mechanisms in relation to asthma, it does have correlation to airway hyperresponsiveness. Quantitative studies have shown that 98% of deaths caused by asthma exhibited mucus occlusion in the lungs due to formation of plugs by hypersecretion (Evans et al., 2010).

All the above-mentioned pathophysiologies of asthma, as well as other symptoms, contribute to a long-term factor that can exacerbate the long-term manifestations of asthma: airway remodeling. Remodeling is the structural change of the airways and has both cellular and extracellular changes (Hough et al., 2020). This can look like epithelial cell apoptosis, fibroblast activation, and smooth muscle proliferation. The inflammatory response caused by asthmatic triggers can orchestrate a paracrine response that can drive airway remodeling. Remodeling can occur at any point in the disease process and can persist from childhood to adulthood (Hough et al., 2020). Airway remodeling can cause thickening of airway walls, which can be caused by other asthma symptoms, or further contribute to hyperresponsiveness and hypersecretion (Bergeron et al., 2010).

Airway remodeling, mucus hypersecretion, and airway hyperresponsiveness are all major components of asthma and affect the passage of air through the respiratory system. Without proper treatment, the severity of these pathophysiologies can increase, and result in poor patient outcomes.

Diagnosis

To diagnose asthma, multiple methodologies can be used. These methods are used to determine respiratory components such as expiratory airflow limitation (EFL), documentation of reversible obstruction, and ruling out alternative diagnoses. EFL can be better defined as air flow limitation during tidal (resting) breathing. Ultimately, it is when expiratory flow cannot be increased or continued by expiratory muscle effort (Tantucci, 2013). Putting more effort into exhaling will not increase the flow of air out of the lungs, for the maximum airflow has been reached for the patient's particular lung volume. In healthy, non-asthmatic patients, EFL does not occur at rest nor in high-intensity scenarios. The significance of EFL can indicate pulmonary obstruction and asthma and can be tested using spirometry or a peak flow meter (PFM). PFMs measure peak expiratory flow (PEF), which thus provides an "objective measure of airflow limitation" (DeVrieze et al., 2024).

To effectively use a PFM to measure PEF/EFL, maximal effort by the patient is necessary, including both primary inhalation and exhalation. The patient will place the meter mouthpiece in their mouth, ensuring a tight lock around the opening. The patient will then inhale as deeply as possible, then exhale as fast and hard as possible. Peak flow measurements should be taken multiple times to ensure accuracy (DeVrieze et al., 2024). Multiple measurements can be used to determine treatment plans and confirm diagnoses.

Typically, PEF scores are divided into zones. The green zone indicates healthy PEF, with flow values at 80-100% of the patient's best effort. The subsequent yellow and red zones indicate unhealthy conditions and call for immediate treatment. Yellow is characterized by values between 50-80% and red is below 50% (DeVrieze et al., 2024).

Though PEF is useful, spirometry is the main technique to diagnose asthma and its severities. Often called a pulmonary function test (PFT), spirometry measures the amount of air one can inhale and exhale, and how quickly one can exhale. To analyze spirometry, there are two variables and their ratio that are the most important: Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 Second (FEV1) and the FVC/FEV1 ratio. FVC is the total volume of air exhaled during the test, and FEV1 is the volume exhaled in the first second. The FVC/FEV1 ratio can indicate airway obstruction when reduced (Wood, 2024). When graphed, these values provide valuable insight into diagnostics and asthma maintenance needs.

To do a PFT (spirometry included), the patient, with their mouth around the mouthpiece, will breathe in as much as they can, with a 1 second pause at total capacity. After the pause, the patient will forcefully exhale for at least 6 seconds. The test is usually repeated at least once to ensure consistent results (Lamb et al., 2023).

The results of a PFT will come as a volume-time graph and display a flow-volume loop. The volume-time graph shows the amount of air exhaled per second, and the flow-volume loop shows airflow through the lungs. A positive value on the Y-axis (Flow in L/sec) indicates when the patient is exhaling. Under normal conditions, the flow will steeply increase and peak, then gradually decline as the patient's effort wears and total expiratory volume is reached. Once the patient inhales, the flow values turn negative.

When interpreting the results of a PFT, there are many factors that must be checked. The first is the volume-time curve. With this graph, a plateau is the desired result, indicating that the entire volume of air was exhaled and sustained for at least 6 seconds.

Next, the results of the two highest-effort PFTs must have volumes within 0.2L of each other, and their flow-volume loops are without abnormality. Abnormalities can look like flattened loops, which either indicate sub-maximal effort by the patient, or an airway obstruction (Johnson et al., 2014).

To aid spirometry, bronchoprovocation can be used to further confirm a diagnosis, especially if spirometry results appear normal. After baseline spirometric results are taken, patients can inhale methacholine, an analog of a nonspecific bronchial irritant, to detect bronchoconstriction. If bronchoconstriction occurs, a spirometry test will show at least a 20% decline in FEV1 (Wood, 2024).

If asthma is indicated using one or a combination of these tests, lab work can be done to further diagnose the phenotype the patient presents with.

Phenotypes

Regarding the immune system, the most common type of asthma is eosinophilic asthma (EA). Eosinophils are a type of white blood cell that aid in allergen and pathogen defense. There is not a direct cutoff regarding number of eosinophils in the airway that can diagnose EA, but elevated eosinophil numbers are indicative of EA. Conversely, non-eosinophilic asthma (NEA) has been diagnosed by a lack of eosinophil levels but has multiple subtypes dependent on granulocyte composition. Within NEA, a patient can be paucigranulocytic, mixed granulocytic, and neutrophilic (Carr, 2018).

Although lab work can clearly indicate EA versus NEA, the clinical presentations are not so clear. Multiple organizations, such as the Severe Asthma Research Program, have attempted to group asthmatic presentations into clear groups, but variability remains. Attempts have considered lab work, risk behaviors, age, and lung physiology, but still do not provide clear defining markers.

Table 1

Asthmatic Phenotypes

Phenotype	Clinical Characteristics	Biomarkers	Physiology
Early Onset Allergic	Childhood onset, allergen triggers, allergic rhinitis	Allergen-specific elevated IgE	Bronchospasm with allergen exposure

Early onset, obesity exacerbated	Obesity, childhood onset, allergy	Allergen specific IgE elevation, eosinophilia	Airway hyper responsiveness
Aspirin-exacerbated respiratory disease	Adult onset, severe asthma, nasal polyps	Eosinophils, leukotrienes	Bronchospasm with NSAID exposure
Allergic bronchopulmonary mycosis	Adult onset, severe asthma, pronounced mucus production	High IgE, eosinophilia, specific IgE to mold	Fixed airflow obstruction from bronchiectasis or fibrosis
Asthma-predictive index-positive preschool wheezer	>3 episodes of wheeze per year, 1 major or 2 minor atopy characteristics	Eosinophils, aeroallergen specific IgE	Increased risk of loss of lung function
Severe late onset hypereosinophilic	Adult onset, severe exacerbations, less atopic	Eosinophils, sinusitis	Variably steroid sensitive obstruction
Exacerbation prone	Frequent exacerbations, sinusitis, GERD	Eosinophils in blood	Lowered lung function
Exercise-induced	Symptoms develop with exercise, especially in cold and dry air	Some aeroallergen specific IgE, variable eosinophils	Bronchospasm with sustained exercise
Neutrophilic	Adult onset, variable severity	Elevated neutrophils	Reduced lung function, less bronchodilator reversibility
Obesity induced	Adult onset, predominantly female, highly symptomatic	Lack of Th2 biomarkers, leptin	Variable restriction, bronchial hyperreactivity
Paucigranulocytic	Mild and severe	Lack of airway inflammation	Fixed airflow obstruction, bronchial hyperreactivity
Asthma with smoking	Current or former tobacco smoke exposure, worsened quality of life, corticosteroid insensitivity	More neutrophilic	Fixed airflow obstruction

Adapted from: Carr, T. F., Zeki, A. A., & Kraft, M. (2018). Eosinophilic and Noneosinophilic Asthma. *American journal of respiratory and critical care medicine*, *197*(1), 22–37. https://doi.org/10.1164/rccm.201611-2232PP

As indicated in the above figure, allergies are commonly associated with asthma. This type of asthma is mostly triggered by aeroallergen exposure. Typically, patients with allergic asthma experience an earlier onset of the disease and are commonly seen in conjunction with allergic rhinitis and other atopic disorders. Differences between the types of asthma can be identified with certain biomarkers, including factors associated with the immune response.

Treatment

Asthma is a condition with no known cure, but it can be controlled to improve patients' quality of life. Physicians will commonly create an Asthma Action Plan to outline the procedures patients should take in the event of an asthma attack. Action plans are commonly divided into green, yellow, and red zones that correlate to normal breathing, worsening of symptoms, and emergency conditions, respectively. A patient should work with their physician to identify triggers, symptoms, and when to treat.

To control asthma, there are many types of medications that can be used, all with different purposes. Quick relief medicines are typically used as a pre-treatment or to relieve sudden symptoms and are taken on an as-needed basis. Conversely, controller medicines are typically taken daily and are not used to treat a sudden onset of symptoms. These medications treat the underlying cause of symptoms, such as excess mucus production or airway swelling. Third are biologics, which target a specific protein or cell to prevent swelling and are administered by injection or infusion (Carver, 2022).

Medications can be administered in a variety of ways, most commonly with an inhaler, which propels the medication for inhalation. Aside from inhalers, nebulizers are also common, typically with more severe asthma. These machines turn liquid medication into mist that is breathed in through a mask or mouthpiece (Carver, 2022).

Broadly, asthma medications relax bronchoconstriction and reduce airway inflammation. Bronchodilators can be either quick-relief or controller medications, and can be categorized as such:

Table 2

Bronchodilators and their Effects

Bronchodilator	Mechanism	Relief Period
Short-Acting Beta Agonists (SABA)	Bind to beta receptors, triggering smooth muscle relaxation	4-6 hours
Short-Acting Muscarinic Antagonists (SAMA)	Blocks acetylcholine receptors to inhibit contraction	4-6 hours
Long-Acting Beta Agonist (LABA)	Bind to beta receptors	Up to 12 hours
Long-Acting Muscarinic Antagonists (LAMA)	Anticholinergic	12-24 hours

Adapted from: Carver, M. (2022). *Asthma Treatment.* Asthma and Allergy Foundation of America. https://aafa.org/asthma/asthma-treatment/

Anti-inflammatories, usually steroidal, can also be prescribed to manage long-term symptoms. They reduce excess mucus and swelling within the airways. These usually come as corticosteroids and act to supplement the natural corticosteroids produced by the adrenal glands (Carver, 2022).

Psychosocial Health and Asthma

The extraordinarily complex physical ailments that asthma presents commonly present psychosocial deficiencies. Adolescents and young adults (AYAs) often display psychosocial difficulties, requiring psychological support and health services. Facilitation with the transitions from pediatric to adult care and disease self-management is particularly needed (Allen at al., 2022).

Adolescence and young adulthood are typically marked with identity differentiation and development but can be marred by the presence of a chronic illness, such as asthma. As a pediatric case, the AYA often must rely on a caregiver to manage their disease in both the physical and financial/logistical sense. This dependence can carry on to adulthood, making the transition difficult. Often, the patient does not have an adequate understanding of the physiology of the disease. Regarding the patients' social life, physician visits, morbidities and side effects can reduce the AYAs ability to engage in typical activities inherent to young adulthood (Allen et al., 2022). Such morbidities can worsen due to the above-mentioned lack of physiological awareness and further contribute to impaired social well-being.

With such difficulties, low social-emotional functioning is often reported. Reports typically include higher rates of behavioral problems, anxiety and depression, and an overall lower quality of life compared to AYAs without chronic illness (Allen et al., 2022). Patients with asthma are particularly vulnerable, with a three-fold increased risk of developing these disorders (Caulfield, 2021). Certain psychoneuroimmunology research has shown that inflammation in the body could correlate with internalized mental disorders. Asthma is broadly characterized by airway inflammation and thus could aid in defining the relationship between asthma and higher rates of anxiety (Caulfield, 2021). With further research, this correlation should indicate the importance of physical management to help mental management.

Often, AYAs with asthma report that they need social support and feel lonely, which is often exacerbated by lack of independence and knowledge for adult self-management. In a longitudinal study, AYAs with chronic illness often showed a lower rate of higher education and job employment, as well as social deficits such as lower rates of marriage (Maslow et al., 2010). This indicates a need for targeted support, which is often unavailable. Unavailability of support thus further contributes to unmet needs and a more reduced quality of life. The need for targeted education that informs a transitioning patient on their condition, physical activity, pain, and social management needs is exemplified (Allen et al., 2022).

Education and Self-Management Programs

As indicated by the rates of internalized mental disorders, the need for self-management education programs has become increasingly apparent. Education programs encompass both the physiological and psychosocial components of asthma. Holistic and sustainable approaches are becoming increasingly common to meet these requirements (Harlow & Ellard, 2004). Across the literature, studies have shown that well-structured programs both increase a patient's understanding of their asthma but also improve quality of life through psychosocial wellbeing and reduced healthcare needs.

Current education programs are often group-based and lead by healthcare professionals. Reports show that they have promoted positive health, emotional, and social behaviors using means such as peer support, increased illness awareness, and emotional validation. Participants have reported that they appreciate the program, as they were able to connect with others who "are in the same boat." These connections had led to a sense of empowerment and were analyzed to be just as significant as the clinical improvements. Additionally, the perception of the patients' illness was shifted from being an overwhelming burden to a manageable identifier. Specifically, programs reinforced that patients are "a whole person in spite of being an ill person" (Sternberg et al., 2016).

Aside from group-based education, other educational tools emphasized the importance of family involvement, particularly for AYAs. Holistic ideas were emphasized, particularly that self-management behaviors should "…require the involvement of the patient, family, community, and healthcare system in a triadic perspective," (Catarina et al., 2021). Specifically, the ACINDES model consisted of both structured programs and home-visits that intended to improve both adolescent and caregiver outcomes. Active learning was emphasized and used tools like storytelling and games to help pediatric patients understand the importance of their symptoms. This developmentally appropriate and targeted education was personalized for each family unit and was shown to be beneficial overall (Tieffenberg et al., 2000). Reduced hospital visits, higher school attendance rates, improved treatment adherence and emotional regulation were the most common beneficial outcomes reported (Capurso et al., 2024).

At-home programs regarding treatment management are also consistent with the above results. In the Airways Program, an at-home program completed by pediatric cystic fibrosis patients, management was specific to inhaler use and airway clearance treatment. Proper treatment use was increased and remained consistent at a 12-month follow-up. Increased knowledge of the disease and treatment usage was observed, with a p value of $p<0.001$ (Downs et al., 2006).

However, there are limitations within these models. Some participants experienced a sense of loss and the need for ongoing support to stay consistent with treatment. The importance of follow-up visits and long-term engagement are evident and should be considered in an educational program.

Conclusion

Asthma is an increasingly relevant chronic illness that presents unique physical, social, and psychological challenges. It requires not only medical treatment but also calls for long-term controlling techniques that also address those multifaceted psychosocial challenges. Literature overwhelmingly supports that developmentally appropriate and targeted educational methods can significantly improve an asthmatic's understanding of their condition, treatment adherence, and can create a sense of confidence.

The psychosocial benefits of educational programs for a chronic illness with such a complex variety of presentations cannot be overlooked. By shifting to a proactive and more holistic approach to asthma management, targeted educational programs can bridge the gap between clinical applications and lived experience.

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