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Review Article

An Overview of Asthma and Its Management

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ABSTRACT

Affecting many individuals globally, asthma: a chronic, hyper-sensitized airways condition. It features airway responsiveness, episodic airflow limitation, and chronic airway inflammation, which can cause wheezing, dyspnea, cough, and chest tightness. Asthma has a complex etiology, with the interaction of genetic and environmental risk factors. This is already one of the most important public health issues, with the global burden of asthma still increasing, especially in urbanized and industrialized areas. Asthma pathophysiology is characterized by immune dysregulation, airway inflammation, and structural remodeling-all of which drive disease progression and exacerbate symptoms. Management aims at pharmacological and non-pharmacological measures to alleviate symptoms and avoid complications at the same time. Inhaled corticosteroids, bronchodilators, leukotriene modifiers, and biologic therapies are the cornerstones of pharmacological treatment for but they are also an important component of the management of the disease along with patient education, avoiding triggers, and making lifestyle changes. Asthma therapy has advanced significantly, yet challenges persist with poor treatment adherence and access to healthcare. Asthma is one of the most important global disease burdens: this review describes key aspects of asthma (epidemiology, etiology, pathophysiology, and management approaches) to facilitate understanding and vision toward better disease control.

INTRODUCTION

A chronic respiratory disease, asthma is caused by the inflammation and narrowing of the airways, resulting intermittent wheezing, dyspnea, tightness in chest, and cough. This is major global health problem that affects people of all ages, leading to a great deal of morbidity, decreased quality of life, and economic burden. Asthma severity is patient-specific: while for some, symptoms may symptoms are mild, these may worsen and lead to life-threatening exacerbations (asthma attack) that occur frequently leading to emergency room visits.

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It is recognized that both hereditary and although the exact cause of the condition is unknown, environmental factors influence the development of asthma. Family history also plays a role and individuals with family history of asthma or other allergies like eczema and allergic rhinitis have higher tendency to develop the disease.[1] Asthma symptoms can be triggered or aggravated by environmental factors, such as allergens (pollen dust mites, pet dander), air pollution, tobacco smoking, respiratory infections, and occupational exposures.

Furthermore, lifestyle factors like diet, overweight, and stress can affect asthma severity and progression. Asthma is not a disease that cure, it is chronic and irreversible, but it can be therapeutic and non-pharmacological management. Nonetheless, inhaled corticosteroids are still the first- choice therapy for asthma, as they would lead to airway inflammation reduction and reduction of exacerbations. For moderate-to-severe asthma, treatment may include long-acting bronchodilators, leukotriene receptor antagonists and biologic therapies. Also, non-pharmacological approaches contribute to asthma control [patient education, triggers avoidance, pulmonary rehabilitation and lifestyle changes].[2] To prevent deterioration pf patient conditions and minimize asthma-related complications, it is pertinent to make early diagnoses, ensure regular monitoring, and adhere to treatment guidelines.

ETIOLOGY

Asthma is a heterogeneous disease driven by complex genetic-by-environment interactions. “Increased risk of asthma is seen among people with a family history of asthma or allergic disorders,” Environmental triggers that may exacerbate asthma include allergens such as: (pollen/dust mites/pet dander/mold); air pollution; and cigarette smoke. Respiratory infections during early life are very closely associated with an altered immune response and increased susceptibility to asthma, especially in the case with viral infections. Dust and fumes exposure can trigger asthma related to work too. So has a heightened risk of asthma is related to lifestyle factors like diet, lack of exercise, and obesity. Among prenatal and early childhood exposures, mother smoking, preterm delivery, and the use of antibiotics in the first year of life are major influences on the development of asthma. Together, these genetic and environmental elements produce persistent airway inflammation, which goes on to cause the hallmark symptoms of asthma. Asthma is a heterogeneous disease with multiple individual causes from both the environment and host-genetics.

Important causes include:

- **Family History:** If any family member or close relative has asthma or other atopic diseases in the past, the chance of developing asthma increases significantly.
- **Airborne Allergens:** The repeating exposure to allergens like pollen/dust mites/pet dander/mildew/air-borne pollutants will lead to the onset of asthma.
- **Respiratory infections:** Infection with both viruses and bacterial in early life is linked to later life asthma, in part because of changes they make to immune responses.
- **Industrial Irritants:** The exposure to occupational irritants such as chemicals, fumes, and dust can cause occupational asthma.
- **Lifestyle Elements:** Cigarette smoking, and being overweight or obese are associated with higher risk and more severe asthma, as are suboptimal diets.
- **Factors Pervasive in Pregnancy and Early Childhood:** Exposure to half a cigarette while in the womb, preterm birth, low birth weight and exposure to antibiotics or pollutants in

infancy may be associated with the development of asthma.[3]

EPIDEMIOLOGY

Asthma is among the most prevalent chronic obstructive airway diseases worldwide with different occurrence and prevalence rates among all ages, sex, and races. Asthma affects an estimated 300 million people worldwide and, in the context of urbanization and environmental change, prevalence is anticipated to increase further-this according to estimates by the World Health Organization (WHO). The illness is more common in children than it is adults; the incidence is higher in boys during childhood and a higher incidence in females in adulthood. Prevalence rates vary by region, with higher rates noted in developed countries attributable to environmental pollution, knowledge of lifestyle risks, and improve capacity for immunization, while diagnosis remains underreported in low-income regions.[4] Asthma is a major cause of hospital admissions and global death in low and middle-income countries due to limited across to health services and insufficient disease control. They have presented urbanization, air pollution, climate change, socioeconomic status, and genetic predisposition are ongoing contributors to the increasing global burden of asthma.

PATHOPHYSIOLOGY

These mechanisms, describe the pathophysiology of asthma which is defined as the presence of inflammation in the airways, bronchial hyper-responsiveness and episodic obstruction of airflow. In the lungs, it is a precise hyperimmune response where cells such as eosinophils, mast cells and T-helper 2 (Th2) lymphocytes arise through exposure to either an allergen or irritant. There these cells secrete many cytokines and histamines and leukotrienes, causing inflammation and edema of the airway (interleukins).[5] This leads to smooth muscle contraction, excessive mucous secretion and inflammation, airway remodeling. Airway remodeling by epithelial damage, goblet cell hyperplasia, subepithelial fibrotic tissue and increase in smooth mass clearly adds to persistent airflow limitation and airway narrowing. These inflammatory and structural alternations lead to the typical manifestations of asthma, such as wheeze, cough, dyspnea and chest tightness. The degree and frequency of these symptoms are determined by individual susceptibility, exposure to triggers, and the management of the disease.[6]

Disease is driven by a complex interplay of underlying genetic predisposition and environmental insults. The pathophysiology which permeates asthma bronchi, leads to chronic airway inflammation, which brings to:

Airway Inflammation

Bronchial inflammation is a characteristic feature of asthma and is involved in the pathogenesis of the disease. It is an underpinning immune-mediated response involving diverse inflammatory cells and mediators. It is an underpinning immune-mediated response involving diverse inflammatory cells and mediators. Just like any allergic response, native T-helper cells are primed by dendritic cells, which triggers the activation of Th2 lymphocytes after being exposed to irritate or allergens, which can cause T2 inflammation with secretion of IL-4, IL-5 and IL-3 cytokines. Together, these promote eosinophilic inflammation, mucus hypersecretion, and airway hyperresponsiveness. Histamine and leukotrienes released from mast cells and basophils further promotes bronchoconstriction, vascular permeability and hence airway edema [7]. Neutrophilic inflammation may also be observed (e.g. in severe asthma or in corticosteroid-resistant asthma). Chronic inflammation over time may

result in airway remodeling with epithelial cell damage, Goblet cell hyperplasia, smooth muscle hypertrophy, and subepithelial fibrosis. All this structural remodeling leads to irredeemable airflow obstruction and ultimately more severe asthma. Optimal management of asthma strives to control airway inflammation through inhaled corticosteroids and other anti-inflammatory therapies to reduce the risk of disease progression and flares.

- **Inflammatory Cell Activation:** Increased activation of Dendritic cells (DC), T-helper 2 (Th2) cells, mast cells, and eosinophils in the inflamed airways of patients with asthma.
- **Cytokines and Mediators Release:** Pro-inflammatory mediators (interleukins: IL-4, IL-5, IL-13), histamine, leukotrienes, and prostaglandins accumulate in the airway, causing inflammation.[8]
- **Epithelial Damage:** Chronic inflammation causes injury of the airway epithelium, rendering it more susceptible to allergens and irritants.
- **Potential for Airway Edema and Remodeling:** Chronic inflammation leads to airway wall thickening, fibrosis and hyperplasia of smooth muscle cells in the bronchioles.
- **Mucus hypersecretion:** Goblet cell hyperplasia is responsible for producing an excessive amount of mucus which contributes to airway obstruction and symptom worsening.[9]

Airflow Obstruction

Asthma-induced airflow restriction results from a combination of bronchoconstriction, airway edema, mucus hypersecretion, and airway remodeling. Bronchoconstriction is caused when inflammatory mediators cause the smooth muscle of the airways to contract in response to a number of potential stimuli, including allergens, irritants or physical activity.[10] The airways become constricted leading to reduced airflow and increased airway resistance. Airway inflammation also causes edema and swelling of the bronchial walls, which adds to the limitation of airflow. [11] They secrete mucus and can lead to airway plugging and further obstruction of conductive airways. Chronic inflammation and exacerbations caused airway remodeling, which involved airway wall thickening, collagen excess and muscle hypertrophy to repair and make an obstructive renovation for every spell; airway patent and reverse features become increasingly difficult. These pathological alterations play a vital role in the chronic & progressive characteristic of asthma, leading to a decline in lung function and greater symptom severity. As a result, in asthma patients, healthy heart function is ineffective due to airway obstruction, so effective management, including anti-inflammatory upon bronchodilators, reduces obstruction in airflow and increases respiratory function.

- **Bronchoconstriction:** Inflammatory substances such as histamines and leukotrienes stimulate contraction of airway smooth muscles, decreasing the diameter of airways and thus increasing resistance to airflow.
- **Airway Edema:** Inflammation and vascular permeability lead to airway wall thickening and further compromise of airflow. Goblet cells secrete excessive mucus which clogs the airways even further and leads to airway occlusion.[12]
- **Airway Remodeling:** These events, accompanied by structural changes in the airway (fibrosis, smooth muscle hypertrophy and excessive accumulation of extracellular matrix), can ultimately result in persistent airflow limitation and progressive decline in lung function.

- **Confirmed Airway Resistance:** Bronchoconstriction, mucus plugging and edema all lead to difficulty exhaling, hyperinflating the lungs and impairing gas exchange contributing to wheezing and shortness of breath.

Aspirin-Exacerbated Respiratory Disease (AERD)

AERD is clinically defined as asthma, chronic rhinosinusitis with nasal polyps, and the pathologic finding of hypersensitivity to aspirin, other nonsteroidal anti-inflammatory drugs (NSAIs) (an individual component of AERD, but not necessarily) which can result in severe respiratory reactions. The pathophysiology of AERD shows excessive production of leukotrienes, owing to functional inability of the cyclooxygenase-1 (COX-1) enzyme to produce pro-epoxygenases leading to inflammation, bronchoconstriction and nasal polyposis. In AERD, patients may develop an array of ailments including severe asthma exacerbations, nasal congestion, anosmia (loss of smell) and recurrent sinus infections. [14] Diagnosis is usually made on clinical history and aspirin challenge testing. Treatment includes leukotriene receptor antagonists, corticosteroids, biologic therapies targeting inflammatory pathways, and aspirin desensitization therapy in select cases. NSAID avoidance is crucial, and other pain management strategies should be undertaken.[13]

PHYSICAL EXAMINATION

The objective of physical examination in asthma is to detect typical respiratory signs and characterize disease severity. Physical examination findings typically include wheezing, prolonged expiratory phase, and decreased breath sounds. In abusive cases, there may be of respiratory distress (nasal flaring, use of accessory muscles, cyanosis).[14] Chest auscultation reveals diffuse, high-pitched wheezes, but wheezing may be absent if the patient has silent chest, which is a life-threatening exacerbation. Assessment for comorbid conditions such as allergic rhinitis or eczema, that are commonly seen with asthma, should be included in examination as well.

EVALUATION

Asthma evaluation is based on a combination of clinical symptoms, lung function tests, and triggers. It includes the following major parts:

Spirometry

Spirometry is an important method for evaluating lung function in asthmatic patients. It measures the volume of air that can be breathed in and out, and at what rate of flow, and can determine airway obstruction. Some common spirometric parameters are the FEV1/FVC, forced vital capacity (FVC), and forced expiratory volume in one-second (FEV1). In asthma, the FEV1 is typically reduced because of airway narrowing, whereas the FVC is usually normal or minimally reduced. Airflow obstruction that is reversible and shows improvement in airflow from a bronchodilator reversibility test is a standard finding of asthma, characterized by a 12% and a 200Ml gain in FEV1 after bronchodilator.[15] However, spirometry can be used to track the progression of disease and response to treatment, and it is helpful in differential diagnosis with the other obstructive lung disease such as chronic obstructive pulmonary disease (COPD). Spirometry is frequently not enough to diagnose whether is controlled or uncontrolled airway obstruction and whether the pathophysiology responsible for the obstruction (eg, bronchial hyperreactivity) exists; therefore, it may be necessary to obtain additional testing (eg, exercise challenge [in patients with exercise-induced

bronchospasm] and/or bronchoprovocation testing [with methacholine] to determine airway hyperreactivity]. Regular spirometry as a part of routine asthma management.

Bronchoprovocation Testing

Bronchoprovocation testing assesses the airway hyperresponsiveness in patients suspected of having asthma, if spirometry results are indeterminate. This is achieved by applying a particular agent, such as methacholine, histamine, exertion, or cold air, to the airways and observing whether bronchoconstriction occurs.[16] A definitive diagnosis of asthma, indicated by a positive test, is defined by a significant drop in FEV1 (20% with methacholine challenge). This test is especially helpful in cases of mild or intermittent asthma and distinguishing it from other respiratory illness. It should however be done in a medically supervised setting as it can cause severe bronchospasm.[17]

Peak Flow Meter

A small, handled device that measures a person's peak expiratory flow rate (PEFR), which is a measure of peak expiratory flow rate that is an important indicator of the severity of airway obstruction in an individual suffering from asthma and describes the quickest speed at which someone can push air from their lungs.[18] It is used for monitoring of daily lung function for home monitoring, detection of early signs of worsening asthma and monitoring of treatment effectiveness. Patients should measure their peak flow readings daily and the goal is to keep the readings above the patient's own personal best value; significant drops from the best may indicate poor air flow limitation. More than 20% variability in PEFR indicates poorly controlled asthma. Peak flow monitoring is particularly useful in asthma action plans when readings can be used to guide medication adjustments and avoid severe exacerbations. However, as peak flow measurements can be effort-dependent and less reliable than spirometry it remains the gold standard form of diagnosis.

Exhaled Nitric Oxide

FeNO testing is a non-invasive way to measure the airway inflammation in asthma through fractional exhaled nitric oxide used in the breath. Inhaled steroids are investigated in such conditions where patients have elevated airway inflammation or eosinophilic in nature which can be detected with FeNO. [19] This is especially useful for asthma diagnosis, response to inhaled corticosteroids (ICS) monitoring, and distinguishing asthma from other respiratory disorders. FeNO testing is a rapid, reproducible and useful tool for treatment decisions, particularly in patients with uncertain asthma diagnosis or difficult-to-control symptoms. But results may be affected by smoking, diet, or respiratory infections, so it is performed in conjunction with spirometry as well as clinical assessment for a complete picture.

Pulse Oximetry

Pulse oximetry is a noninvasive approach to monitoring blood oxygen levels (SpO2) and serves as an important guide to respiratory function in asthma patients. In mild-to-moderate asthma, oxygen levels are usually normal, although a marked drop in SpO2 (92-94%) suggests significant airway obstruction or respiratory distress and may require urgent medical attention. Evidence suggesting that pulse oximetry should never be used is simply false: It is especially beneficial during asthma exacerbations to determine the severity of hypoxemia and to assist in management decisions regarding supplemented oxygen. [20] It's a rapid, cheap, noninvasive and easily executory tool, but as it doesn't measure

airflow limitation or airway inflammation directly, it is most useful in combination with other diagnostic measures like spirometry or arterial blood gas in the most severe cases.

TREATMENT / MANAGEMENT

Asthma management aims for symptom control, hindrance to exacerbations, and quality of life improvements. Management options include pharmacotherapy, avoidance of triggers and education of patients.

Pharmacological Treatment:

Asthma has various medications that can be classified into two groups: relievers (or quick-relief medications) and controllers (long -term management medications).

- Short-acting beta-agonists, such as albuterol, help relieve symptoms during acute flare- ups.
- Salmeterol – a Long-Acting Beta-Agonist (LABA), used with ICS for fixed control.
- Inhaled Corticosteroids (ICS): e.g., budesonide, fluticasone, first-line treatment for persistent asthma (decreases airway inflammation).
- Leukotriene Receptor Antagonists (LTRAs): e.g., montelukast, for mild persistent asthma or exercise-induced symptoms.
- Biologic therapies: e.g., omalizumab, mepolizumab for severe eosinophilic or allergic asthma.
- Oral Corticosteroids: Use short-term for severe exacerbations, but avoid for long-term.[21]

Non-Pharmacological Management:

- Trigger Avoidance: Limiting exposure to allergens (dust mites/pollen/pet dander), smoke & pollution.
- Emphasis on lifestyle changes: Exercise, weight control, pursed-lip breathing, etc.
- Vaccination: Seasonal flu and pneumococcal vaccines for respiratory airway infection prevention.

Asthma Action Plan

A personalized asthma action plan helps patients recognize when their symptoms are getting worse and adjust medications as needed. This includes monitoring for peak flow, tracking the presence of symptoms, and managing them in an emergency. [22]

Management of acute exacerbations: Short-acting bronchodilators (SABAs) given via nebulizer or inhaled route, supplemental O2 therapy, and systemic corticosteroids in severe cases. Hospitalization for patients with persistent hypoxia (SpO2 < 92%) or life-threatening exacerbations.

Asthma is a chronic disease that can be controlled with regular follow-up, adherence to medications and patient education.

DIAGNOSIS

Asthma has overlapping symptoms with many other respiratory and non-respiratory diseases, so an accurate diagnosis is crucial. Consider the following conditions in the differential diagnosis for asthma:

Chronic Obstructive Pulmonary Disease (COPD): More prevalent in older adults, often related to smoking history. Airway obstruction resistant to bronchodilator therapy. Progressive shortness of breath on exertion, chronic cough, recurrent exacerbations.[23]

Vocal Cord Dysfunction (VCD): Abnormal vocal cord movement, makes it appear like asthma. Symptoms increase when stressed or exercising and lessen when using breathing techniques. Spirometry demonstrates decreased inspiratory flow instead of reversible obstruction.

Most ST incidents will never in fact harm you: Presents as dyspnea, wheezing, and orthopnea, particularly in elderly patients. Associated with fluid overload, swelling, and high BNP. Chess X-ray can demonstrate pulmonary congestion or cardiomegaly.

Bronchiectasis: Characterized by chronic cough, purulent sputum, and recurrent infections. Airway dilation and mucus plugging on high-resolution CT scan.

Pulmonary Embolism (PE): Acute dyspnea, chest pain, and hypoxia with normal chest radiogram. Diagnosis by means of D-dimer testing and CT pulmonary angiography.

Upper Airway Obstruction: Tracheal stenosis, tumors, or goiter. Stridor is often present and spirometry shows a fixed airflow obstruction

Gastro-Esophageal Reflux Disease (GERD): Chronic cough, wheezing and throat irritation, worse on recumbency. Symptoms are improved with PPIs and lifestyle changes.[24]

History, physical examination, spirometry and other tests are very useful to separate asthma from these disorders and to be treated appropriately.

COMPLICATIONS

Exacerbations of uncontrolled asthma can hinder a patient's quality of life and health overall. Frequent worsening of asthma can lead to status asthmaticus, where asthma becomes life-threatening and needs emergency medical treatment. Instead, chronic airway inflammation leads to airway remodeling, resulting in irreversible airflow limitation and progressive lung function decline. Inadequately controlled asthma can also predispose individuals to respiratory infections including pneumonia as a result of impaired airway clearance. Nocturnal symptoms can disrupt sleep and leave patients waking up fatigued and less productive in the daytime, with lack of concentration.[25] In children, uncontrolled severe asthma can impair growth and lung malnutrition, while in adults, chronic corticosteroid treatment for symptom control can cause osteoporosis, adrenal suppression, and metabolic derangements. Furthermore, asthma has compounds psychological complications as it is a chronic disease and along with fear of exacerbation, it leads to anxiety and depression. These complications can be prevented, therefore asthma management, compliance with the prescribed schemes and the timely contact with the physician are extremely important for the improvement of the health of the patients.

CONCLUSION

Asthma is still a major public issue worldwide, with many millions of people affected globally at all ages. Asthma, a chronic inflammatory disease, encompasses wheezing, shortness of breath, and airway obstruction episodes. The disease has a complex etiology based on its multifactorial nature, involving both genetic susceptibility and environmental factors. Yet, even these newer, more effective more diagnostic tools (e.g. spirometry, FeNO and bronchoprovocation tests) are simply not being utilized to their full potential and many of these particular patients are left undiagnosed or poorly managed. Early congenital heart disease diagnosis and accurate assessment is a key to slow down disease progression and decrease the rate of exacerbations.

Systemic therapies for asthma as previously mentioned, asthma is best managed with a multimodal strategy that involves pharmacological therapy, trigger exposure avoidance, and patient education. Inhaled Corticosteroids (ICS) are the cornerstone therapy in persistent asthma, while bronchodilators (SABAs and LABAs) offer symptomatic relief. In more serious cases, biologic therapies that specifically block individual inflammatory pathways have produced promising outcomes.

Asthma action plans and routine peak flow monitoring also give patients a degree of control over their symptoms, and the number of emergency visits declines. However, despite advances in management of this chronic obstruction, asthma control is fraught with many hurdles from non-compliance to medication to ignorance and inequities in access to health care.

As a final note, asthma is chronic but manageable disease and requires a personalized and patient-centric model of care. Although treatment and diagnosis are increasingly sophisticated, there is still a need for more focused solutions, and in addition to scientific advancement, increasing access to effective treatment is important. With appropriate education, treatment compliance, and medical follow-up, patients with asthma generally perform normal and active lives with little burden.

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