

Bronchial Asthma: A Comprehensive Review of Epidemiology, Pathophysiology, Diagnosis, and Management

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Abstract: *Bronchial asthma is a chronic inflammatory disease of the airways characterized by variable respiratory symptoms and reversible airflow obstruction. It represents a major global health burden affecting individuals across all age groups. The disease involves complex interactions between genetic predisposition, environmental exposures, and immune mechanisms, leading to airway hyperresponsiveness and remodeling. Advances in understanding molecular pathways have transformed treatment strategies from symptom relief to long-term disease control. This review summarizes current knowledge on epidemiology, etiology, pathophysiology, clinical features, diagnosis, and management of bronchial asthma, highlighting emerging therapies and future directions.*

Keywords: Bronchial asthma, airway inflammation, epidemiology, pathophysiology, diagnosis, management

I. INTRODUCTION

Bronchial asthma is a heterogeneous respiratory disorder characterized by chronic airway inflammation and variable airflow limitation. It manifests clinically with wheezing, breathlessness, chest tightness, and coughing, often varying over time and intensity. Asthma is a significant global health problem affecting millions worldwide and contributing substantially to morbidity and healthcare costs. The disease is now understood as a chronic inflammatory condition rather than merely a bronchospastic disorder, leading to the development of targeted anti-inflammatory therapies as the cornerstone of treatment.

Epidemiology

Asthma affects individuals across all age groups, with increasing prevalence in urbanized and industrialized regions. Environmental pollution, lifestyle changes, and increased allergen exposure contribute to rising incidence rates. It is one of the most common chronic diseases in children and young adults with significant social and economic impact. The disease burden is higher in children and young adults, although it can occur at any age, and its prevalence varies widely between countries due to differences in environmental exposures, lifestyle factors, and healthcare access. Developed countries historically report higher prevalence rates; however, low- and middle-income countries are experiencing a rising trend due to urbanization, pollution, and changing environmental conditions. Asthma contributes significantly to healthcare utilization, school and work absenteeism, and reduced quality of life, and it remains a major cause of morbidity globally despite advances in treatment. Mortality rates are relatively low but are largely preventable with proper disease control, early diagnosis, and adherence to guideline-based management.

Etiology and Risk Factors

Bronchial asthma is multifactorial, resulting from interactions between genetic susceptibility and environmental exposures. Genetic factors include family history of asthma or atopy and immune response polymorphisms. Environmental triggers include dust mites, pollen, animal dander, tobacco smoke, air pollution, respiratory infections,



weather changes, and stress. Genetic factors include a family history of asthma or atopy and polymorphisms affecting immune regulation and airway function, which increase the risk of developing the disease. Environmental factors play a significant role and include exposure to allergens such as house dust mites, pollen, mold spores, and animal dander, as well as air pollution, tobacco smoke, occupational irritants, and respiratory infections, particularly viral infections in early childhood. Additional contributing factors include obesity, dietary influences, psychological stress, and certain medications such as beta blockers and nonsteroidal anti-inflammatory drugs. Together, these factors interact to initiate and perpetuate airway inflammation, resulting in the clinical manifestations of asthma.

Pathophysiology

Asthma involves chronic airway inflammation with eosinophils, mast cells, and T lymphocytes. Key mechanisms include airway inflammation causing mucosal edema and mucus hypersecretion, airway hyperresponsiveness leading to bronchoconstriction, and airway remodeling such as smooth muscle hypertrophy and fibrosis. In susceptible individuals, exposure to allergens or irritants activates airway epithelial cells and immune pathways, particularly type 2 helper T-cell responses, leading to the release of cytokines such as interleukin-4, interleukin-5, and interleukin-13. These mediators promote immunoglobulin E production, eosinophilic infiltration, mast cell activation, and increased mucus secretion, resulting in airway edema and bronchoconstriction. Persistent inflammation contributes to airway remodeling, including subepithelial fibrosis, smooth muscle hypertrophy, and goblet cell hyperplasia, which may lead to partially irreversible airflow limitation over time. The combined effects of inflammation, bronchospasm, and mucus plugging produce the characteristic symptoms of wheezing, breathlessness, chest tightness, and cough, with variability and reversibility being key features of the disease.

Clinical Features

Typical symptoms include wheezing, shortness of breath, chest tightness, and chronic cough. Symptoms are episodic, often worse at night or early morning, and triggered by allergens, infections, or exercise. Bronchial asthma is characterized by episodic respiratory symptoms that vary in intensity and frequency, most commonly including wheezing, shortness of breath, chest tightness, and cough, particularly at night or in the early morning. Symptoms are often triggered by exposure to allergens, respiratory infections, exercise, cold air, or environmental irritants, and they may resolve spontaneously or with treatment. Patients may report recurrent episodes of breathlessness with prolonged expiration and relief after using bronchodilators. Physical examination during an acute episode typically reveals expiratory wheeze, use of accessory muscles of respiration, tachypnea, and prolonged expiratory phase, while between attacks the examination may be normal. In severe cases, signs such as inability to speak full sentences, tachycardia, hypoxia, and reduced air entry may indicate a life-threatening exacerbation. The variability and reversibility of symptoms over time are key clinical hallmarks that help distinguish asthma from other chronic respiratory diseases.

Classification

Asthma can be classified based on severity as intermittent, mild persistent, moderate persistent, and severe persistent. Phenotypic classifications include allergic, non-allergic, exercise-induced, and occupational asthma. Classification based on level of control includes well-controlled, partly controlled, and uncontrolled asthma, which helps in adjusting therapy according to treatment response. Additionally, asthma can be classified into phenotypes such as allergic (atopic) asthma, non-allergic asthma, late-onset asthma, exercise-induced asthma, occupational asthma, and severe refractory asthma, reflecting differences in pathophysiology and treatment response. This multidimensional classification approach allows clinicians to individualize treatment strategies and improve disease outcomes.

Diagnosis

Diagnosis is primarily clinical supported by objective testing. Spirometry demonstrating reversible airflow obstruction is the key diagnostic test. Additional tests include peak expiratory flow monitoring, allergy testing, and fractional



exhaled nitric oxide measurement. The diagnosis of bronchial asthma is primarily based on a combination of clinical history and objective evidence of variable airflow limitation. Patients typically present with recurrent episodes of wheezing, shortness of breath, chest tightness, and cough that vary over time and are often triggered by allergens, exercise, or respiratory infections. Confirmation of diagnosis is achieved through pulmonary function testing, particularly spirometry, which demonstrates reversible airflow obstruction characterized by an increase in forced expiratory volume in one second (FEV₁) following bronchodilator administration. Peak expiratory flow variability may also support the diagnosis, especially when spirometry is unavailable. Additional investigations such as fractional exhaled nitric oxide measurement, allergy testing, and assessment of blood eosinophil count can help identify underlying inflammation and phenotype. Differential diagnosis should be considered to exclude other causes of chronic respiratory symptoms, and a thorough clinical evaluation remains essential for accurate diagnosis and appropriate management planning.

Management

Management focuses on symptom control and prevention of exacerbations. Non-pharmacological measures include trigger avoidance, patient education, vaccination, and environmental control. Pharmacological therapy includes short-acting beta agonists as relievers and inhaled corticosteroids as first-line controllers, along with LABA, leukotriene receptor antagonists, and anticholinergics. Biologic therapies target inflammatory pathways in severe asthma. Bronchial asthma management aims to achieve optimal symptom control, prevent exacerbations, maintain normal lung function, and minimize treatment-related adverse effects through a comprehensive and individualized approach. Effective management includes identification and avoidance of triggers, patient education regarding inhaler technique and adherence, and regular monitoring of disease control. Pharmacologic therapy forms the cornerstone of treatment and follows a stepwise approach, beginning with inhaled corticosteroids as first-line anti-inflammatory agents, often combined with long-acting beta-agonists for moderate to severe disease, while short-acting beta-agonists are used for rapid symptom relief. Additional therapies such as leukotriene receptor antagonists and long-acting muscarinic antagonists may be added in uncontrolled cases, and biologic agents targeting specific inflammatory pathways are recommended for severe refractory asthma. Management of acute exacerbations involves oxygen therapy, repeated bronchodilator administration, and systemic corticosteroids to reduce airway inflammation. Overall, a multidisciplinary strategy incorporating pharmacologic treatment, environmental control, vaccination, and patient self-management plans is essential to improve quality of life and reduce morbidity and mortality associated with asthma.

Complications

Complications include status asthmaticus, respiratory failure, recurrent infections, and reduced quality of life. Poor adherence to inhaler therapy is a major barrier to effective control. Acute Complications

1. Status Asthmaticus

Status asthmaticus is a severe, life-threatening asthma exacerbation that does not respond to standard bronchodilator therapy. It is characterized by severe airflow obstruction, hypoxemia, and risk of respiratory failure. Immediate intensive care management is often required.

2. Acute Respiratory Failure

Severe bronchospasm and mucus plugging may lead to impaired gas exchange resulting in hypoxia and hypercapnia. Mechanical ventilation may be required in severe cases

3. Pneumothorax and Pneumomediastinum

Excessive airway pressure during severe attacks can lead to alveolar rupture, resulting in air leaks into the pleural or mediastinal spaces.



Chronic Complications

1. Airway Remodeling

Persistent inflammation leads to irreversible structural changes including subepithelial fibrosis and smooth muscle hypertrophy, resulting in fixed airflow limitation.

2. Reduced Lung Function

Long-standing uncontrolled asthma can lead to progressive decline in lung function and increased risk of chronic airflow obstruction.

3. Recurrent Respiratory Infection

Mucus stasis and airway inflammation predispose patients to repeated infections.

4. Psychological Impact

Chronic symptoms and recurrent exacerbations may lead to anxiety, depression, sleep disturbances, and reduced quality of life. Medication-Related Complications Long-term systemic corticosteroid use may cause osteoporosis, hypertension, diabetes mellitus, cataracts, and adrenal suppression.

Prognosis

With appropriate treatment and adherence, most patients achieve good symptom control. Severe asthma may lead to frequent exacerbations and long-term decline in lung function.

Future Directions

Research focuses on precision medicine approaches, biomarker-guided therapy, and targeted biologics to improve individualized care.

II. CONCLUSION

Bronchial asthma is a complex chronic inflammatory airway disease with significant global impact. Advances in understanding pathophysiology have improved diagnostic and therapeutic strategies, shifting focus toward long-term control and personalized treatment. Continued research will further enhance patient outcomes and reduce disease burden.

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