

COMPREHENSIVE REVIEW ON ASTHMA MANAGEMENT & NEW INTERVENTION TO CURE ASTHMA

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ABSTRACT

Asthma is a chronic inflammatory disorder of the airways characterized by variable and recurring symptoms, including wheezing, shortness of breath, chest tightness, and coughing. It affects individuals of all ages and is influenced by a complex interplay of genetic predisposition, environmental factors, and immune responses. The occurrence of asthma increased in the world over the last 25 years. The pathophysiology of asthma involves airway hyperresponsiveness, inflammation, and obstruction, which can be triggered by allergens, irritants, respiratory infections, and physical activity. Diagnosis is primarily based on clinical history, physical examination, and objective measures of lung function, such as spirometry. Effective management requires a comprehensive approach that includes long-term control medications, quick-relief treatments, avoidance of triggers, and patient education. Despite advancements in treatment, asthma remains a significant public health concern due to its prevalence and impact on quality of life. Ongoing research aims to improve understanding of asthma mechanisms and develop innovative therapies for better control of this chronic condition.

KEYWORDS: Asthma, airway inflammation, diagnosis, management, pathophysiology, chronic disease.

I. INTRODUCTION

Asthma is a prevalent chronic respiratory condition characterized by airway inflammation, bronchial hyperresponsiveness, and recurrent episodes of wheezing, breathlessness, chest tightness, and coughing. It affects individuals of all ages, but its onset often occurs in childhood. According to the World Health Organization, asthma affects approximately 262 million people worldwide, resulting in significant morbidity and mortality. The pathophysiology of asthma involves a complex interplay between genetic, environmental, and immunological factors. Genetic predisposition may increase susceptibility to asthma, while environmental triggers such as allergens (e.g., pollen, dust mites), irritants (e.g., tobacco smoke, air pollution), and respiratory infections can exacerbate the condition. The inflammatory process is central to asthma, with key players including eosinophils, mast cells, and T-helper cells, particularly the subset, which produces cytokines that perpetuate airway inflammation. Asthma is typically diagnosed through clinical evaluation and lung function tests, such as spirometry, which measure airway obstruction and responsiveness. Management strategies focus on both pharmacological and non-pharmacological interventions. Controller medications, primarily inhaled corticosteroids, aim to reduce inflammation and prevent exacerbations, while rescue medications provide rapid

relief during acute symptoms. Despite advancements in treatment, asthma remains a significant public health challenge, with many individuals experiencing poorly controlled symptoms that can lead to severe complications. Effective management requires a comprehensive approach that includes patient education, monitoring, and avoidance of known triggers.^[1]

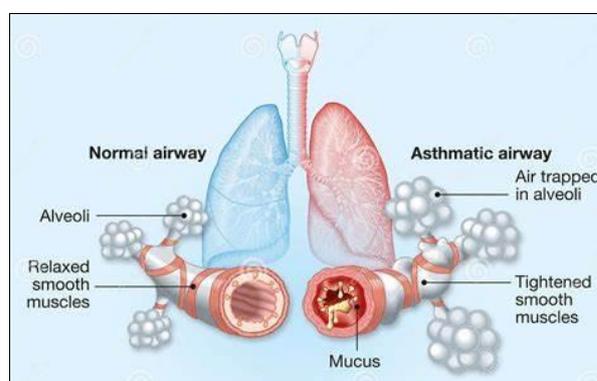


Figure No.01: Inflammation of bronchi and alveoli in asthma.

Common Symptoms

1. Shortness of breath
2. Wheezing (a whistling sound while breathing)

3. Frequent coughing, especially at night or early morning
4. Chest tightness.
5. Increased mucus production

Identifying Triggers

a) Common Triggers

- Allergens: Pollen, dust mites, pet dander, mold.
- Irritants: Tobacco smoke, air pollution, strong odors, chemicals.
- Weather: Cold air, humidity, and sudden temperature changes.
- Exercise: Physical activity can trigger symptoms in some individuals.
- Respiratory Infections: Colds and flu can exacerbate asthma.

b) Keeping a Trigger Diary

- Track symptoms, medication use, and potential triggers to identify patterns and avoid specific irritants.

II. TYPES OF ASTHMA

1. **Allergic Asthma:** Triggered by allergens like dust mites, mold, pet dander, and pollen.
2. **Non-Allergic Asthma:** Caused by factors like respiratory infections, cold air, exercise, and stress.
3. **Exercise-Induced Bronchospasm (EIB):** A type of asthma that occurs during or after physical activity.
4. **Occupational Asthma:** Caused by workplace substances like chemicals, dust, and mold.
5. **Severe Asthma:** Requires high doses of medication to control symptoms, and may require hospitalization.

6. **Steroid-Resistant Asthma:** Does not respond to corticosteroid medications.
7. **Chronic Asthma:** Long-term asthma that requires ongoing treatment.
8. **Acute Asthma:** Sudden onset of symptoms, often requiring emergency treatment.

III. Pathophysiology of Asthma

- a) **Airway Inflammation** - In asthma, the airways become inflamed and swollen due to various triggers such as allergens, irritants, and respiratory infections. This inflammation is primarily mediated by inflammatory cells, including eosinophils, mast cells, and T lymphocytes. Cytokines such as IL-4, IL-5, and IL-13 play a significant role in promoting inflammation and the production of IgE antibodies.
- b) **Airway Hyper responsiveness:** - The inflamed airways exhibit heightened sensitivity to a variety of stimuli (e.g., cold air, exercise, allergens). This hyperresponsiveness leads to bronchoconstriction and symptoms such as wheezing, coughing, and shortness of breath.
- c) **Airflow Obstruction** - The combination of bronchoconstriction, airway edema, and mucus hyper secretion contributes to the narrowing of the airways, resulting in airflow limitation. This obstruction can be reversible with bronchodilator treatment, but may become more persistent over time if inflammation is not adequately controlled.
- d) **Remodelling:** - Chronic asthma can lead to airway remodelling, which involves structural changes such as thickening of the airway wall, smooth muscle hypertrophy, and increased fibrosis. These changes can result in a permanent reduction in lung function.^[8]

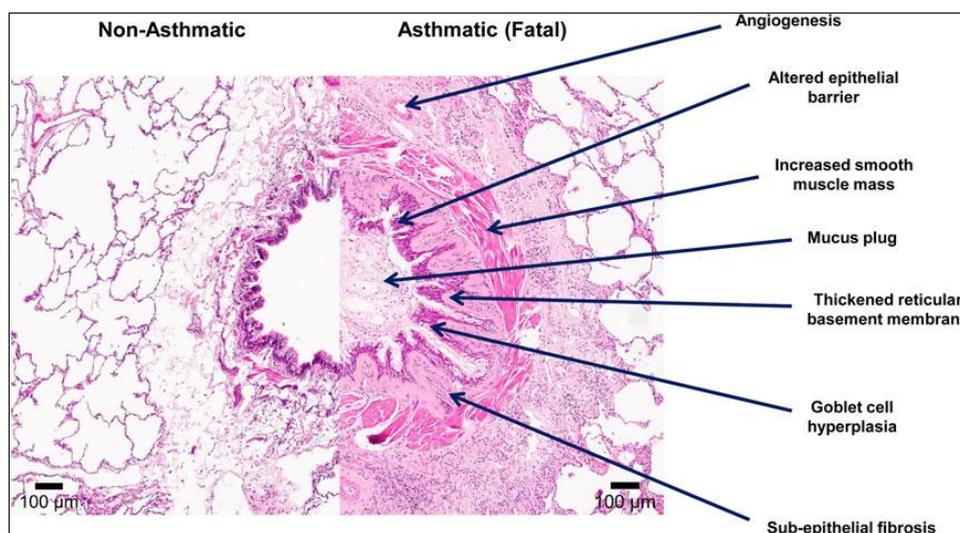


Figure No. 02: Airway remodeling in asthma.

IV. CAUSES OF ASTHMA & RISK FACTORS

- **Genetic Factors** - Family history of asthma or allergic conditions can increase the risk. Genetic predisposition plays a significant role in the likelihood of developing asthma.
- **Environmental Factors** - Allergens: Exposure to allergens such as pollen, mold, pet dander, and dust mites can trigger asthma symptoms. - Irritants: Air pollution, tobacco smoke, chemical fumes, and strong odors can exacerbate asthma.

- **Respiratory Infections:** Viral infections during early childhood, particularly those affecting the respiratory system, can increase the risk of developing asthma later in life.
- **Obesity:** Increased body weight is associated with a higher risk of asthma, possibly due to inflammation and increased pressure on the lungs.
- **Physical Activity:** - While exercise is generally beneficial, vigorous exercise in cold or dry air can trigger asthma symptoms in some individuals.

Risk Factors

- **Age:** Asthma can occur at any age, but many cases begin in childhood. Children are more susceptible due to their developing respiratory systems.
- **Allergies:** Individuals with other allergic conditions (like hay fever or eczema) are at a higher risk of developing asthma.
- **Gender:** Before puberty, boys are more likely to develop asthma; however, after puberty, girls are at a greater risk.
- **Exposure to Tobacco Smoke:** Prenatal exposure to tobacco smoke and second hand smoke increases the risk of asthma in children.
- **Occupational Exposures** - Certain jobs that involve exposure to irritants (like chemicals or dust) can increase the risk of developing occupational asthma.
- **Living Conditions** - Urban living, especially in areas with high pollution levels, can increase the prevalence of asthma due to increased exposure to allergens and irritants.

V. ASTHMA MANAGEMENT

Asthma management involves a combination of strategies to control symptoms, reduce exacerbations,

and improve overall quality of life. Here are some key components.

1. Medications

- **Quick-relief inhalers:** Medications like albuterol help to quickly open airways during an asthma attack.
- **Long-term control medications:** Inhaled corticosteroids (e.g., fluticasone, budesonide) reduce inflammation in the airways.
- **Combination inhalers:** These contain both a corticosteroid and a long-acting beta-agonist (e.g., fluticasone-salmeterol).
- **Leukotriene modifiers:** Medications like montelukast help reduce inflammation and ease breathing.
- **Oral corticosteroids:** Used for severe asthma flare-up.^[1,6]

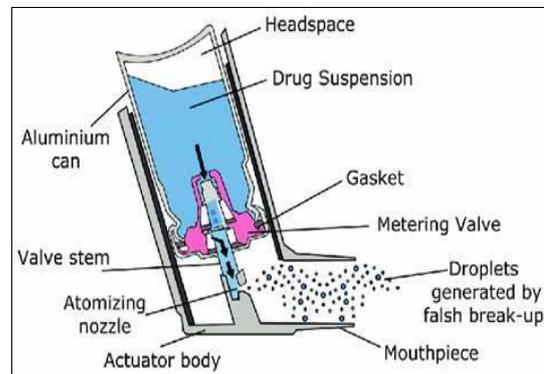


Figure No. 3: A diagram of Inhaler, Metered dose inhaler and Nebulizer.

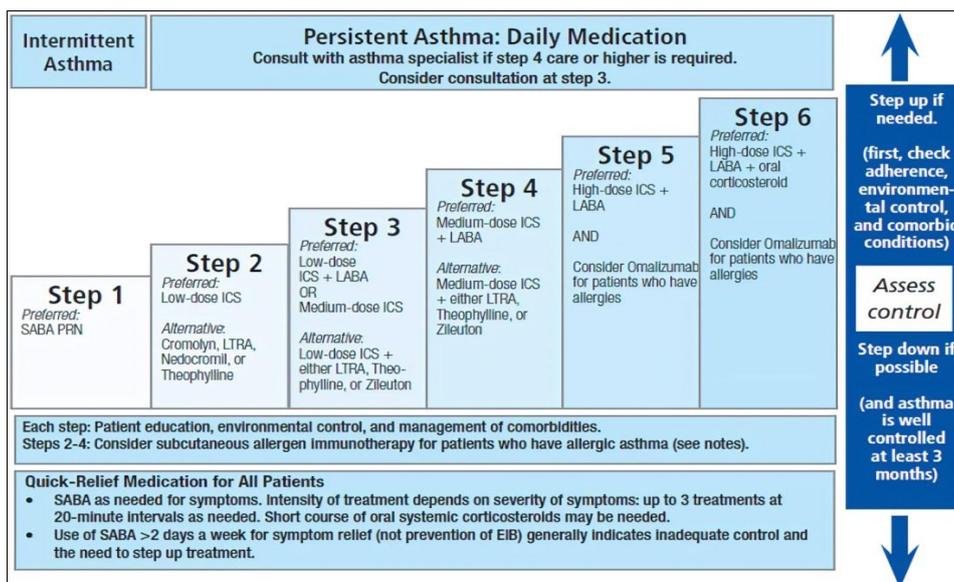


Figure No. 4: A simplified, stepwise algorithm for treatment of asthma.

2. Avoiding Triggers

- **Identify and avoid allergens:** Common triggers include pollen, dust mites, mold, and pet dander.
- **Minimize exposure to irritants:** Avoid smoke, strong odors, and chemical fumes.
- **Maintain a clean environment:** Regular cleaning can reduce dust and allergens at home.⁽⁴⁾

3. Monitoring

- **Peak flow meter:** A device to measure how well air moves out of your lungs.
- **Regular check-ups:** Routine visits with a healthcare provider to monitor asthma control and adjust treatment plans.

4. Lifestyle Changes

- **Quit smoking:** Smoking can worsen asthma symptoms.
- **Exercise regularly:** Physical activity can improve lung function and overall health.
- **Maintain a healthy weight:** Obesity can exacerbate asthma symptoms.

5. **Education and Asthma Action Plan:** A written plan developed with your healthcare provider that outlines how to manage your asthma daily and how to handle asthma attacks.
- **Education:** Understanding your condition, medications, and how to use inhalers correctly.

6. Emergency Preparedness

- **Know when to seek help:** Recognize the signs of a severe asthma attack and when to seek emergency medical care.
- 7. **Fatigue:** A sense of exhaustion or weakness, particularly after an asthma attack.

8. **Blue Lips or Fingernails:** A sign of low oxygen levels, indicating a serious asthma attack that requires immediate medical attention.^[1,6]

VI. MEDICAL HISTORY

- **Symptom Review:** - Frequency and Duration: Ask about the occurrence of symptoms such as wheezing, coughing, shortness of breath, and chest tightness. Note if symptoms are episodic or persistent.
- **Triggers:** Identify potential triggers, including allergens (pollen, dust mites, pet dander), irritants (smoke, strong odors), weather changes, exercise, and respiratory infections.
- **Personal and Family History:-** Allergies: Document any history of allergic conditions (e.g., allergic rhinitis, eczema).
- **Family History:** Inquire about a family history of asthma or other allergic conditions, as there is a genetic predisposition.

- **Medication Use:-** Discuss any current medications, particularly asthma-related medications (e.g., inhalers) and the effectiveness of past treatments.
- **Impact on Daily Life:-** Assess how asthma affects the patient's daily activities, sleep quality, and exercise tolerance.^[1]

Physical Examination

1. **General Inspection:** - Look for signs of respiratory distress, such as labored breathing, use of accessory muscles, or abnormal posture (leaning forward).
2. **Auscultation:-** Use a stethoscope to listen for wheezing, prolonged expiration, or other abnormal lung sounds that indicate airway obstruction.
3. **Vital Signs:-** Measure respiratory rate, heart rate, and oxygen saturation. Low oxygen saturation (e.g., below 92%) may indicate significant respiratory compromise.
4. **Assessment of Allergic Conditions:-** Check for signs of allergic rhinitis (e.g., nasal congestion, postnasal drip) or eczema, which can be associated with asthma.

Diagnostic Tests

- **Spirometry:** the Global Initiative for Asthma (GINA) and National Asthma Education Prevention Program (NAEPP) recommend spirometry testing in patients suspected of having asthma. Asthma is characterised by variable airway obstruction and hyperresponsiveness;. A lung function test that measures airflow obstruction. Key metrics include Forced Expiratory Volume in 1 second (FEV1) and Forced Vital Capacity (FVC). A significant improvement in FEV1 after bronchodilator use supports an asthma diagnosis.^[17]
- **Peak Flow Monitoring:-** Measuring peak expiratory flow rate (PEFR) can help assess the severity of airway obstruction and monitor asthma control over time. peak flow meter test measure how well your lungs push out air. Although they are less accurate than spirometry, these lung function tests can be a good way to regularly test your lung function at home -- even before you feel any symptoms.
- **Allergy Testing:** - Skin prick tests or specific IgE blood tests may be performed to identify allergens that could trigger asthma symptoms.
- **Exhaled Nitric Oxide (FeNO) Testing** - Measuring levels of nitric oxide in exhaled breath can indicate eosinophilic airway inflammation.^[3]

VII. PREVALENCE TRENDS OVER THE LAST DECADE

1. Global Estimates

The World Health Organization (WHO) reported that approximately 262 million people were affected by asthma in 2019, with the prevalence expected to rise in many regions.

2. United States

According to the Centers for Disease Control and Prevention (CDC), asthma prevalence among adults increased from 7.0% in 2001 to about 8.4% in 2019. In children, the prevalence increased from approximately 8.7% in 2001 to 9.6% in 2018.

3. European Trends

The European Respiratory Society has noted an increase in asthma prevalence in many European countries, particularly among children and adolescents.

VIII. GLOBAL BURDEN OF DISEASE STUDIES

Recent studies indicate that asthma is a leading cause of morbidity and mortality worldwide, with increasing hospitalizations and healthcare costs associated with the condition. The increasing prevalence of asthma in recent decades, compared to before the 1990s, can be attributed to several factors. These factors are mostly linked to changes in lifestyle, environment, and the way asthma is diagnosed and managed. Here's a breakdown of the key reasons why asthma is more widespread today.

• Environmental Factors

Air Pollution: Industrialization, urbanization, and increased vehicle emissions have led to higher levels of air pollution, including fine particulate matter (PM_{2.5}) and ozone. These pollutants can trigger or exacerbate asthma symptoms, especially in cities.

Climate Change: Rising temperatures and changing weather patterns have led to increased levels of allergens such as pollen and mold. More frequent and intense heat waves can also trigger asthma exacerbations.

Indoor Air Quality: Increased use of air conditioning and heating systems can create environments conducive to dust mites, pet dander, and mold, all of which are common asthma triggers.

• Changes in Lifestyle and Diet

Westernized Diets: The adoption of more processed and unhealthy diets, high in fats and sugars, and low in fruits and vegetables, has been linked to an increased risk of asthma. Poor diet can affect immune function, potentially leading to more allergic conditions like asthma.

Sedentary Lifestyles: Physical inactivity, especially among children and adolescents, has been associated with a higher risk of asthma. Lack of exercise can contribute to poor lung function and lower immunity.

Obesity: The rise in obesity rates, particularly in developed countries, has been linked to asthma. Excess body fat, especially abdominal fat, can increase inflammation in the body, worsening asthma symptoms.

• Increased Awareness and Diagnosis

Improved Diagnosis: In the past, asthma may have been underdiagnosed or misdiagnosed. Today, with advances in medical knowledge and diagnostic techniques, asthma is more readily identified, even in mild cases. This has led to a higher recorded prevalence. **Better Recognition**

of Asthma Symptoms: Asthma awareness campaigns and better recognition of symptoms by both the public and healthcare providers have led to more people being diagnosed with the condition. **Early Childhood Diagnoses:** In the past, many asthma symptoms in children may have been dismissed as "normal" or not related to a chronic condition. Today, pediatricians are more likely to diagnose asthma in children who experience wheezing or difficulty breathing.

• Changes in Hygiene and the "Hygiene Hypothesis"

Reduced Exposure to Infectious Agents: The hygiene hypothesis suggests that reduced exposure to bacteria and infections in early childhood (due to cleaner living conditions, fewer childhood illnesses, and increased sanitation) can lead to an increased risk of developing allergies and asthma. This is because the immune system doesn't have the necessary "training" to differentiate between harmless substances and harmful ones. **Exposure to Animals:** In the past, children were more likely to be exposed to animals like farm animals or pets. These exposures might have helped in the development of a balanced immune response, preventing asthma. Today, reduced contact with such animals due to urbanization may contribute to higher asthma rates.

• Increased Use of Allergens and Chemical

Indoor and Outdoor Allergens: The increased use of synthetic materials in everyday products, including cleaning agents, carpets, and mattresses, has raised the levels of indoor allergens like dust mites and chemicals, which can trigger asthma. Similarly, outdoor pollutants like pollen and industrial emissions have also increased. **Environmental Sensitizers:** Chemicals in household products, including cleaning agents, perfumes, and cosmetics, can act as asthma triggers. Prolonged exposure to these chemicals can contribute to respiratory issues.^[14]

IX. HERE'S HOW AI AIDS IN ASTHMA MANAGEMENT

A. AI for Diagnosis

- AI can support healthcare professionals in diagnosing asthma earlier and more accurately by analyzing patterns in patient data, such as symptoms, history, and test results. AI algorithms can be used in:
 - Medical imaging (chest X-rays, CT scans) to identify asthma-related changes in the lungs.
 - Symptom checkers that help clinicians assess whether a patient's symptoms are likely due to asthma or another condition.

B. Personalized Treatment

- AI helps create individualized treatment plans by analyzing vast amounts of data. It can:
 - Suggest the most effective medications based on patient characteristics (age, weight, history of asthma, etc.).

- Predict how a patient might respond to specific treatments, optimizing the management plan and reducing the trial-and-error approach.

C. Asthma Monitoring

- AI-powered devices, such as smart inhalers and wearable devices, enable continuous monitoring of asthma symptoms and medication usage. These devices:
- Track inhaler usage and send reminders if doses are missed.
- Monitor environmental triggers (like air quality, pollen) through connected apps to alert patients about potential asthma flare-ups.
- Measure lung functioning real-time, alerting both the patient and their healthcare provider about potential risks.

D. Predicting Exacerbations

- AI models are used to predict asthma exacerbations (flare-ups) before they happen by analyzing patient data over time. These models can:
- Identify risk factors such as poor medication adherence, environmental triggers, or changes in lung function.
- Generate alerts to warn patients about impending exacerbations, allowing for early intervention, which can help reduce hospital admissions and improve patient outcomes.

E. AI in Drug Discovery for Asthma

- AI accelerates the process of developing new asthma treatments. By analyzing large datasets of molecular information, AI can:
- Identify potential new drug candidates for asthma treatment.
- Optimize clinical trials by analyzing patient data and predicting which treatments are most likely to succeed.

F. AI for Asthma Education and Awareness

- AI-driven apps and chatbots can help educate patients about their asthma, guiding them through medication usage, symptom tracking, and understanding triggers. These tools can help improve patient engagement and adherence to prescribed treatments.
- Example AI Tools in Asthma: Propeller Health: An AI-powered platform that integrates smart inhalers to track medication usage, symptoms, and asthma triggers. Spiro scout: A device that uses AI to measure lung function and predict asthma exacerbations in real-time. Asthma: An app that uses machine learning to track symptoms and provides personalized recommendations for managing asthma.^[13]

X. CONCLUSION

Understanding the pathophysiology of asthma is crucial for effective management and treatment. Asthma is characterized by chronic inflammation of the airways, leading to hyperresponsiveness, bronchoconstriction, and mucus production. This inflammatory process is driven by a complex interplay of genetic and environmental factors, involving various immune cells (such as eosinophils and mast cells) and mediators (like cytokines and leukotrienes). Recognizing the underlying mechanisms of asthma not only aids in diagnosing the condition but also informs targeted therapies, helping to alleviate symptoms and improve quality of life for those affected.

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