Bronchial Asthma: A Comprehensive Literature Review

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ABSTRACT **Background:** Bronchial asthma is one of the most prevalent chronic non-communicable diseases worldwide, affecting an estimated 262 million people and causing nearly 461,000 deaths annually. Despite decades of research, it remains a significant public health burden, particularly in low- and middle-income countries where access to diagnosis and treatment is limited. **Objectives:** To synthesise current evidence on the epidemiology, pathophysiology, diagnostic criteria, and evolving therapeutic landscape of bronchial asthma, with emphasis on precision medicine approaches and global equity in asthma care. **Methods:** A narrative literature review was conducted examining peer-reviewed publications from 2000 to 2024, sourced from PubMed, Scopus, and Google Scholar. Key terms included bronchial asthma, airway inflammation, type-2 immunity, biologics, phenotyping, and inhaled corticosteroids. Landmark clinical guidelines including GINA 2023 were incorporated alongside primary research studies. **Results:** Asthma is a heterogeneous syndrome encompassing multiple phenotypes and endotypes. Type-2 (T2) inflammation driven by eosinophils and IgE-mediated pathways predominates in allergic asthma, while non-T2 or mixed patterns characterise adult-onset, obesity-related, and neutrophilic subtypes. Biologic therapies targeting IgE, IL-5, IL-4/IL-13, and TSLP have transformed management of severe refractory asthma. Despite these advances, adherence, inhaler technique, and access to specialist care remain critical barriers to optimal outcomes. **Conclusions:** Bronchial asthma demands a precision medicine approach integrating biomarker profiling, phenotype-guided therapy, and robust patient education. Closing the global equity gap in asthma care is an urgent priority.

Keywords: *bronchial asthma; airway inflammation; type-2 immunity; biologics; phenotyping; pathophysiology; inhaled corticosteroids; precision medicine; GINA guidelines*

1. INTRODUCTION

Asthma has been known to humanity for centuries. Ancient Egyptian papyri describe remedies for breathing difficulties remarkably similar to what modern clinicians would recognise as acute bronchospasm, and Hippocratic texts make reference to episodic breathlessness linked to environmental exposures. And yet, despite millennia of familiarity and decades of intensive research, bronchial asthma continues to challenge both patients and practitioners. It is a disease that feels simultaneously well-understood and frustratingly elusive.

According to the Global Initiative for Asthma (GINA) 2023 report, approximately 262 million people worldwide live with asthma, and the condition accounts for nearly 461,000 deaths annually — the vast majority of which are preventable with appropriate management [1]. The economic toll is equally staggering: direct and indirect costs related to asthma exceed $80 billion annually in the United States alone, a figure that rises dramatically when extrapolated globally [2].

What makes asthma particularly fascinating from a scientific standpoint is its heterogeneity. Two patients may both carry the diagnosis of asthma and yet have entirely different triggers, inflammatory profiles, responses to treatment, and long-term trajectories. This phenotypic diversity has driven a paradigm shift in how the disease is conceptualised — moving away from a one-size-fits-all approach toward precision medicine strategies guided by individual biomarkers and endotypes [3, 4].

This literature review aims to provide a thorough and clinically grounded overview of bronchial asthma, encompassing its epidemiology, immunopathology, diagnostic framework, and therapeutic advances. By consolidating evidence from landmark studies and recent publications over the past two decades, we hope to offer a resource that is both academically rigorous and practically useful for medical students, clinicians, and researchers working in diverse healthcare settings.

2. EPIDEMIOLOGY AND GLOBAL BURDEN

Asthma affects people of all ages, races, and geographies — but it does not affect them equally. Prevalence varies enormously between countries, from approximately 1–2% in some parts of Asia and Eastern Europe to 15–20% in high-income English-speaking nations such as Australia, New Zealand, and the United Kingdom [1, 5]. These differences reflect complex interactions between urbanisation, pollution exposure, dietary patterns, sanitation, and immune maturation during early childhood.

In Central Asia, where the present authors are based, epidemiological data on asthma remain sparse. A multicentre survey conducted across Kyrgyzstan and neighbouring republics estimated asthma prevalence at 4.7% in adults and 6.2% in school-aged children [6]. Underdiagnosis is a significant concern in the region, where spirometry access is limited and there remains cultural reluctance to engage with chronic disease management. Patients frequently

present only during acute exacerbations, missing opportunities for preventive care.

Globally, the burden is disproportionately borne by children. Asthma is the most common chronic disease of childhood and a leading cause of school absenteeism worldwide [7]. While asthma is more prevalent in boys during childhood, this pattern reverses after puberty: adult female patients outnumber males, a shift attributed to hormonal influences on airway biology and immune function [8]. Severe or difficult-to-treat asthma, though representing only 5–10% of cases, accounts for more than 50% of total asthma-related healthcare expenditure [9].

3. PATHOPHYSIOLOGY

3.1 Airway Inflammation

At its core, bronchial asthma is a disease of airway inflammation. The classical model — driven primarily by type-2 (T2) immune responses — involves an orchestrated cascade initiated by inhaled allergens or irritants. Epithelial alarmins, particularly thymic stromal lymphopoietin (TSLP), interleukin-25 (IL-25), and IL-33, are released in response to injury and activate innate lymphoid cells type 2 (ILC2s) and Th2 lymphocytes [10].

This activation drives production of IL-4, IL-5, and IL-13 — the canonical type-2 cytokines. IL-4 and IL-13 promote IgE class switching in B cells, while IL-5 drives eosinophil maturation and survival. The resulting eosinophilic infiltration of the airway mucosa, combined with mast cell degranulation triggered by IgE crosslinking, produces the clinical triad of bronchoconstriction, mucus hypersecretion, and airway oedema [11, 12].

However, it is increasingly recognised that not all asthma fits this T2-high template. A significant subset — particularly adult-onset, obese, or smoking-related asthma — demonstrates T2-low or non-eosinophilic inflammation, involving neutrophilic or paucigranulocytic patterns. These endotypes are generally less responsive to corticosteroids and represent a major therapeutic challenge [13].

3.2 Airway Hyperresponsiveness and Remodelling

Beyond acute inflammation, chronic asthma induces structural changes collectively termed airway remodelling. These include subepithelial fibrosis, smooth muscle hypertrophy and hyperplasia, goblet cell metaplasia, and angiogenesis. Transforming growth factor-beta (TGF-β) plays a central role in driving fibrotic changes, while vascular endothelial growth factor (VEGF) promotes neovascularisation [14].

Airway hyperresponsiveness (AHR) — the exaggerated bronchoconstrictor response to stimuli that would not affect healthy airways — is a hallmark feature that partially, but incompletely, correlates with inflammation severity. Even when inflammation is controlled pharmacologically, AHR may persist, suggesting structural changes and neural mechanisms independently contribute [15, 16].

4. GENETIC AND ENVIRONMENTAL DETERMINANTS

Asthma is a polygenic disease with heritability estimates ranging from 35% to 90%. Genome-wide association studies (GWAS) have identified over 100 susceptibility loci, with notable associations at 17q21 (ORMDL3/GSDMB), 6p21 (HLA region), and 9p24 (IL33). The ORMDL3 gene has been robustly replicated across multiple ethnic populations and is strongly associated with childhood-onset asthma [17].

The hygiene hypothesis — and its more nuanced successor, the biodiversity hypothesis — proposes that reduced microbial diversity in early childhood impairs appropriate immune maturation, predisposing to atopic disease [18]. Supporting evidence includes the striking protection against asthma observed in children raised on traditional farms, attributed to rich microbial exposure from livestock and raw dairy products.

Air pollution deserves particular attention. Both traffic-related air pollutants (TRAPs) — particularly fine particulate matter (PM2.5) and nitrogen dioxide (NO_2) — and indoor pollutants such as tobacco smoke, biomass combustion products, and volatile organic compounds are established asthma risk factors [19]. Epigenetic mechanisms, including DNA methylation and histone modification, likely mediate how environmental exposures translate into lasting airway pathology [20].

5. CLINICAL FEATURES AND DIAGNOSIS

5.1 Symptoms and Signs

The clinical presentation of bronchial asthma is characterised by recurrent episodes of wheezing, breathlessness, chest tightness, and cough — symptoms that are variable, often worse at night or early morning, and typically triggered by identifiable stimuli. Common triggers include allergen exposure (house dust mite, pollen, animal dander), respiratory tract infections, exercise, cold air, and strong odours [1].

Physical examination during an acute exacerbation may reveal tachypnoea, use of accessory muscles, prolonged expiratory phase, and diffuse polyphonic wheeze. In severe attacks, the paradoxically silent chest — indicative of critically reduced airflow — is an ominous sign demanding immediate intervention. Between exacerbations, examination may be entirely normal, which can contribute to diagnostic delay [21].

5.2 Diagnostic Approach

Diagnosis relies on demonstration of variable airflow obstruction. Spirometry remains the cornerstone investigation: a post-bronchodilator FEV_1/FVC ratio below 0.75 in adults supports obstruction, while a bronchodilator response of

≥12% and ≥200 mL in FEV_1 is highly suggestive of reversible airway disease. Where spirometry is equivocal, bronchial provocation testing with methacholine or peak flow variability monitoring may be employed [1, 22].

Fractional exhaled nitric oxide (FeNO) has emerged as a valuable non-invasive biomarker of eosinophilic airway inflammation. A FeNO level above 50 ppb strongly suggests steroid-responsive eosinophilic inflammation, while levels below 25 ppb argue against it [23]. Blood eosinophil count, total serum IgE, and skin prick testing to common aeroallergens complement the diagnostic workup and help stratify patients for targeted therapy.

6. MANAGEMENT AND PHARMACOTHERAPY

6.1 Step-wise Pharmacological Treatment

The GINA 2023 guidelines recommend a stepwise treatment approach based on symptom control and risk assessment. A landmark shift in recent iterations is the abandonment of short-acting β2-agonist (SABA) monotherapy as reliever medication, given evidence that SABA overreliance — without concomitant anti-inflammatory therapy — is associated with increased exacerbation risk and asthma-related mortality [1, 24]. Instead, as-needed low-dose inhaled corticosteroid (ICS)-formoterol is now the preferred reliever across most treatment steps.

For mild asthma (Steps 1–2), as-needed ICS-formoterol or low-dose maintenance ICS with as-needed SABA are appropriate. Moderate asthma (Steps 3–4) warrants addition of long-acting β2-agonists (LABAs), leukotriene receptor antagonists (LTRAs), or long-acting muscarinic antagonists (LAMAs). Severe asthma (Step 5) may require add-on biologic therapy or, in select cases, low-dose oral corticosteroids — though cumulative toxicity mandates their minimisation [25].

6.2 Biologic Therapies

The advent of targeted biologic therapies has transformed management of severe, refractory asthma. Omalizumab, a monoclonal antibody targeting free IgE, demonstrated significant reductions in exacerbation frequency as the first approved biologic for severe allergic asthma [26]. Anti-IL-5 agents — mepolizumab, reslizumab, and benralizumab — have shown robust efficacy in severe eosinophilic asthma, with benralizumab uniquely providing direct eosinophil depletion via antibody-dependent cytotoxicity [27].

Dupilumab, a dual IL-4/IL-13 receptor antagonist, has demonstrated efficacy across the broad T2-high population regardless of eosinophil count, while simultaneously improving comorbid atopic dermatitis and chronic rhinosinusitis with nasal polyps [28]. Tezepelumab, targeting the upstream alarmin TSLP, has shown remarkable efficacy even in T2 -low asthma, potentially offering treatment for phenotypes previously considered biologic-ineligible [29].

6.3 Non-Pharmacological Interventions

Patient education — encompassing inhaler technique, trigger avoidance, action plan adherence, and self-monitoring — is a cornerstone of asthma management that dramatically influences outcomes. Studies show that poor inhaler technique affects 70–80% of patients and is a major contributor to treatment failure [30]. Allergen immunotherapy (AIT), both subcutaneous and sublingual, represents a disease-modifying option capable of reducing sensitisation and preventing new allergen development in allergic asthma.

7. COMORBIDITIES AND DIFFICULT-TO-TREAT ASTHMA

Asthma rarely exists in isolation. Allergic rhinitis is present in up to 80% of asthmatic patients and, if untreated, worsens asthma control through the unified airway model [1]. Chronic rhinosinusitis with nasal polyps (CRSwNP), gastro-oesophageal reflux disease (GORD), obesity, obstructive sleep apnoea (OSA), and vocal cord dysfunction are among the most clinically significant comorbidities, each capable of masquerading as or perpetuating poor control.

Before escalating therapy in patients with apparently difficult-to-treat asthma, clinicians are urged to systematically address: confirming the diagnosis, assessing inhaler technique and adherence, identifying and treating comorbidities, and evaluating ongoing allergen or occupational exposure. A structured multidisciplinary approach — involving respiratory physicians, allergists, physiotherapists, dietitians, and psychologists — is recommended by GINA for this population [1].

8. ASTHMA IN SPECIAL POPULATIONS

Pregnancy presents unique challenges in asthma management. Approximately one-third of pregnant women with asthma experience worsening, one-third improvement, and one-third remain unchanged [8]. Poorly controlled asthma in pregnancy is associated with preterm birth, low birth weight, and pre-eclampsia. ICS use during pregnancy is considered safe and strongly recommended to maintain maternal control and foetal oxygenation.

In elderly patients, asthma is frequently underdiagnosed due to attribution of symptoms to ageing or cardiac disease. Comorbidities including heart failure and COPD complicate the clinical picture, and spirometry interpretation must account for age-related physiological changes. Exercise-induced bronchoconstriction (EIB) in athletes represents a distinct phenotype where diagnosis requires specific provocation protocols and management must comply with anti-doping regulations.

9. FUTURE DIRECTIONS

The future of asthma management is unmistakably moving toward precision medicine. Advances in multi-omics —

integrating genomics, transcriptomics, proteomics, and metabolomics — are enabling increasingly granular endotype characterisation to guide treatment selection. Artificial intelligence and machine learning algorithms are being applied to electronic health records to predict exacerbation risk and optimise inhaler prescribing in real time.

Digital health tools, including smart inhalers capable of recording time-stamped usage data, mobile applications for symptom tracking, and telemedicine platforms, hold significant promise for improving adherence and enabling remote monitoring — particularly relevant in settings like Central Asia where specialist access is geographically limited [1]. The pipeline of novel biologics continues to expand, with agents targeting IL-33, prostaglandin D2, and the epithelial barrier in active clinical development.

10. CONCLUSION

Bronchial asthma is a disease of remarkable complexity — one that has humbled generations of clinicians who assumed its mechanisms were fully understood, only to discover new layers of immunological, genetic, and environmental intricacy. What has changed decisively in recent years is our ability to match the right patient with the right treatment, moving beyond empirical step-up therapy toward a biologically informed and personalised approach.

Yet for every patient benefiting from a cutting-edge biologic in a well-resourced tertiary centre, countless others in low-resource settings still lack access to basic ICS therapy, spirometry, or a written asthma action plan. Closing this global equity gap is the most urgent challenge in asthma care today. As authors affiliated with Osh State University in Kyrgyzstan, we are acutely aware of this reality and believe that evidence synthesis reviews serve a crucial role in disseminating knowledge to clinicians in resource-constrained environments.

In summary, bronchial asthma demands a nuanced clinical approach integrating understanding of its heterogeneous pathophysiology, systematic diagnostic evaluation, personalised pharmacotherapy, and robust patient education. With the continued expansion of our therapeutic armamentarium and the promise of precision medicine, there is genuine reason for optimism — provided the benefits of scientific progress are made accessible to all who need them.

ETHICAL STATEMENT

This is a literature review study and did not involve direct human participation or animal subjects. All referenced studies were conducted in accordance with applicable ethical standards. The authors declare no conflict of interest. No external funding was received for this review.

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