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Impact of bronchial asthma on the occurrence of complications in patients with acute respiratory distress syndrome (ARDS)

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ABSTRACT

Acute Respiratory Distress Syndrome (ARDS) and asthma are severe lung problems. This study looked at whether having asthma makes it more likely for someone with ARDS to have complications. It focused particularly on the development of acute respiratory failure. Based on a review of literature from January 2011 to April 2025, including clinical studies, meta-analyses, and systematic reviews, researchers found that asthma modifies the course of ARDS by increasing the risk of complications such as dynamic hyperinflation-related lung injury, upper gastrointestinal bleeding, thromboembolic events, pneumothorax, and nosocomial infections. At the same time, patients with asthma showed a decreased incidence of multiple organ dysfunction syndrome (MODS) and ventilator-associated pneumonia (VAP) compared to those without this comorbidity. The study also discusses the chronic consequences of ARDS in patients with asthma, such as pulmonary hypertension, right ventricular failure, pulmonary fibrosis, and neurological disorders.

Keywords: asthma, ARDS, hypoxemia, pulmonary complications, respiratory failure

1. INTRODUCTION

Acute respiratory distress syndrome (ARDS) and asthma are respiratory diseases that can have serious health consequences. Asthma, with a global prevalence of 4-8%, leads to chronic inflammatory changes in the bronchi, which can increase the susceptibility of lungs to developing ARDS and consequently lead to complications related to ARDS. ARDS affects approximately 10–20 individuals per 100,000 each year, with higher mortality in patients with comorbidities. Patients with asthma may encounter certain complications, including an increased risk of respiratory failure, cardiovascular events, and retarded recovery from ARDS (Kurahashi, 2022; Douwes et al., 2024).

Severe lung inflammation that weakens the alveolar–capillary barrier is a stigma of acute respiratory distress syndrome (ARDS). Increased permeability resulting from this compromise causes fluid to accumulate in the alveolar spaces, impairing gas exchange. The key factors in diagnosing ARDS are the presence of hypoxemia (PaO_2 < 300 mmHg with a positive end-expiratory pressure [PEEP] ≥ 5 cm H_2O), bilateral infiltrates on imaging studies, and the exclusion of clinically significant left ventricular failure. In healthy individuals, pulmonary capillary wedge pressure (PCWP) does not exceed 18 mmHg, while the normal values of partial pressures of respiratory gases are PaO_2 80–100 mmHg and $PaCO_2$ 35–45 mmHg.

Bronchial asthma is a chronic condition in which the airways become overly sensitive and easily narrowed, making it difficult to breathe. It causes symptoms such as coughing, wheezing, shortness of breath, and a feeling of tightness in the chest.

Bronchial asthma can have various causes, including immune system responses, environmental factors, and genetic factors (Sánchez, 2023). All of these elements work together to cause persistent inflammation and structural alterations in the airways, ultimately impacting their function.

Compared to other breathing problems, asthma can have a profound impact on gas exchange in the lungs, which occurs due to the closure of small airways, lung overexpansion, and disruptions in the delivery of oxygen and the removal of carbon dioxide. During severe asthma attacks, a person's condition can quickly worsen, with oxygen levels dropping and carbon dioxide levels rising in the blood. In such cases, inhaled medications such as salbutamol or ipratropium bromide are necessary. If symptoms become severe, treatment in an intensive care unit may be required, including mechanical ventilation (Gayen et al., 2024). This kind of progression is serious, carries a high risk of complications, and puts a significant strain on the respiratory system.

This study aims to enhance the understanding of how asthma influences the clinical course of ARDS and to inform the development of tailored therapeutic strategies that optimize patient care and prognosis. Specifically, it seeks to evaluate the impact of coexisting asthma on the incidence and nature of complications in patients with acute respiratory distress syndrome (ARDS), with a particular focus on the development and outcomes of acute respiratory failure.

2. REVIEW METHODS

The analysis focused on publications including clinical trials, meta-analyses, and systematic reviews that examine the impact of asthma on complications associated with acute respiratory distress syndrome (ARDS). We conducted the literature review using the PubMed database, applying keywords such as asthma, ARDS, hypoxemia, pulmonary complications, and respiratory failure.

Studies that satisfied the following requirements, including being written in English, aimed at adults 18 years of age or older, published between January 2011 and April 2025, and accessible in full-text format. This analysis excluded studies that focused on pediatric or non-human populations. A PRISMA flow chart depicting the study selection procedure, Figure 1.

3. RESULTS AND DISCUSSION

Epidemiology of ARDS

The reported incidence of ARDS in the literature is highly variable, ranging from 7.2 to 78.9 cases per 100.000 persons per year among patients admitted to the intensive care unit (ICU). Those patients represented the incidence of ARDS, ranging from 7.1% to 19.0%. In the PANDORA study, ARDS accounted for 3.4% of ICU admissions and 7.5% of patients requiring mechanical ventilation. Hospital mortality rates for ARDS are also variable, ranging from 32% to 51% (Bardají-Carrillo et al., 2025).

In a study from Olmsted County, USA, there was a significant decrease in the incidence of ARDS from 82.4 to 38.9 cases per 100,000 persons per year over the 8-year study period ($P < 0.001$). This decline was attributed to a reduction in hospital-acquired ARDS cases, while the number of patients admitted with ARDS remained stable ($P = 0.877$) (Li et al., 2011). An anticipated increase in pneumonia and sepsis cases, which are primary risk factors for ARDS, is projected to contribute to a rising incidence of the syndrome in the coming years (Vimal, 2024).

Epidemiology of bronchial asthma

In 2021, the global prevalence of asthma was 3,340 cases per 100,000 people. Men under 20 years of age had a higher prevalence of asthma compared to other age groups (Yuan et al., 2025). Global age-standardized asthma prevalence and disability-adjusted life years (DALYs) decreased globally between 1990 and 2019. Instead, some countries, such as Vietnam, Saudi Arabia, and Oman, have seen an increase in the burden of asthma, which increases the inappropriate use of preventive medications and the lack of appropriate functional tests for diagnosis and monitoring of disease progression (Wang et al., 2023).

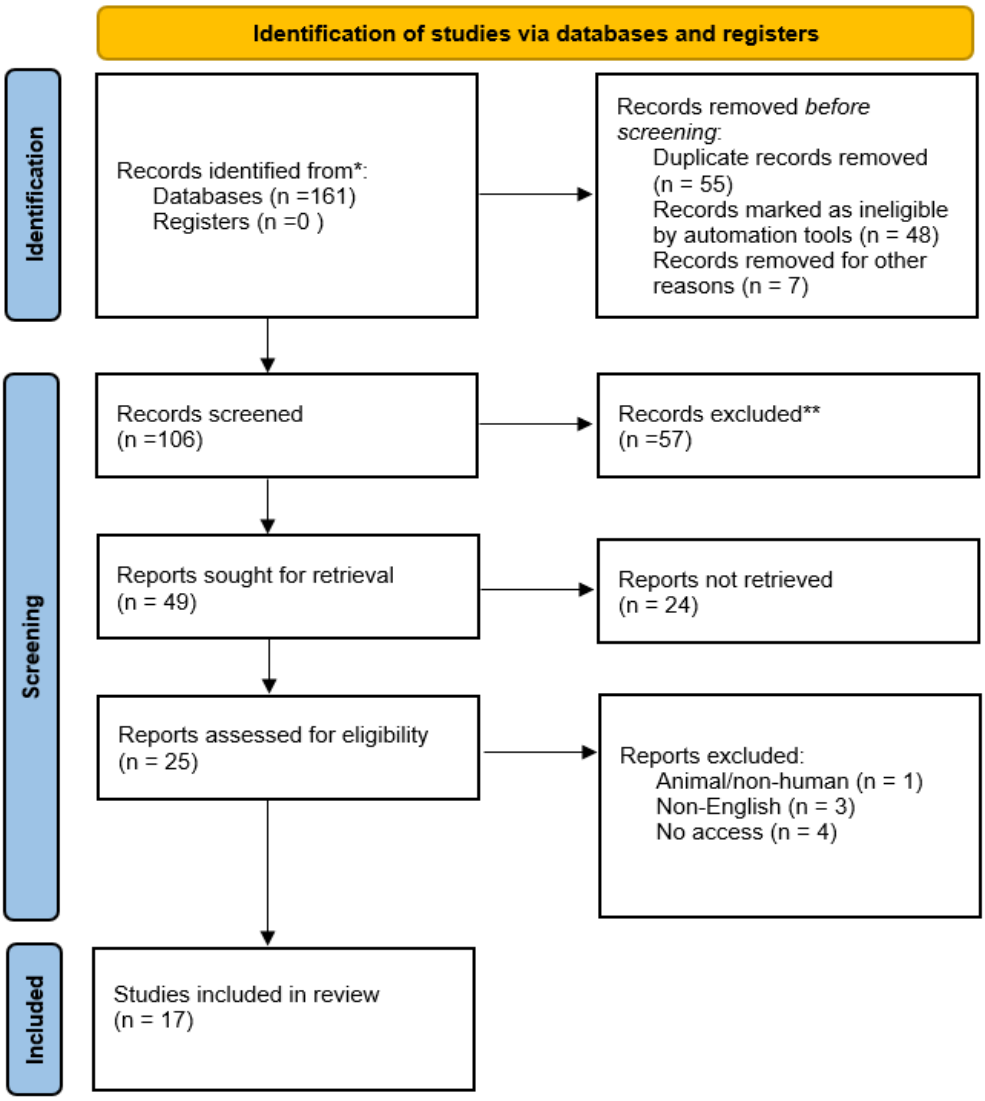

Fig 1. PRISMA consort chart of selected studies

Pathophysiology of ARDS

ARDS includes hypoxemia and the abrupt onset of lung infiltrates, not brought on by heart failure. ARDS's pathophysiology consists of:

- Damage to the alveolar-capillary barrier leads to increased capillary permeability, resulting in fluid accumulation within the alveolar space.
- Ventilation and perfusion disorders such as atelectasis, decreased lung compliance, and impaired gas exchange occur.
- Fluid retention in the alveoli results from damage to the alveolar epithelium and inactivation of surfactant.
- Endothelial and microcirculation damage lead to hemodynamic disturbances and lung tissue damage (Al-Sofyani, 2023).

Immune Mechanisms in ARDS

- *Innate immune system*: Neutrophil activation releases proteases and reactive oxygen species (ROS), contributing to lung tissue damage.
- *Inflammatory cytokines*: Elevated levels of interleukin (IL)-6, IL-8, and tumor necrosis factor-alpha (TNF-α) are associated with the severity of ARDS.
- *Inflammasomes and DAMPs*: DAMPs activate protein complexes called inflammasomes, which then produce proinflammatory cytokines, thereby increasing lung inflammation.

- *Adaptive immune system*: T lymphocyte activation and dendritic cells regulate the inflammatory response and tissue repair (Al-Sofyani, 2023).

Mortality rate in ARDS

In global studies, the mortality rate in ARDS ranges from 13.3% to 60.7%, depending on factors such as cause of ARDS, patient age, and availability of intensive care (Al-Sofyani, 2023).

Acute complications of respiratory failure

Multiple organ dysfunction syndrome (MODS) is the most common complication in asthma patients who develop acute respiratory failure. MODS is associated with an intensified systemic inflammatory response and impaired tissue perfusion, both of which contribute to hypoxemia. Additionally, changes in endothelial function and cytokine imbalance in asthma may contribute to damage to multiple organs simultaneously (Table 1). The study did not explain why multiple organ failure occurs more frequently in patients without asthma (28.2%) than in those with asthma (19.7%) (Summers et al., 2022).

Upper gastrointestinal bleeding was observed more frequently in asthma patients hospitalized due to acute respiratory failure (Gayen et al., 2024). This complication is multifactorial and may be related to high doses of systemic corticosteroids, which can cause gastric mucosal damage and hypoxemia, leading to oxidative stress and impaired gastrointestinal blood flow (Table 1).

Asthma also increases the risk of thromboembolic events, including deep vein thrombosis and pulmonary embolism. Chronic inflammation characteristic of asthma promotes activation of the coagulation system and damages the endothelium, thereby increasing the risk of thrombus formation. However, the incidence of thromboembolic events was comparable between the two patient groups (Gayen et al., 2024). Patients with asthma are prone to dynamic hyperinflation, which leads to increased intrathoracic pressure and mechanical injury to the alveoli, particularly during mechanical ventilation (Table 1) (Althoff et al., 2020).

In terms of hospital infections, including ventilator-associated pneumonia (VAP), asthmatic patients are a particularly vulnerable group. Chronic inflammatory airway disease and immunosuppressive therapy (corticosteroids) increase the risk of bacterial colonization and the development of infection, especially during prolonged mechanical ventilation. However, numerical data show the opposite trend: VAP occurs more frequently in patients without asthma (10.9%) than in those with asthma (8.3%) (Gayen et al., 2024; Althoff et al., 2020).

Similarly, the presence of asthma is associated with an increased incidence of pneumothorax in patients treated for acute respiratory failure. The pathophysiological mechanisms include excessive lung hyperinflation and alveolar microtrauma resulting from both severe asthma exacerbations and high-pressure mechanical ventilation (Althoff et al., 2020).

Table 1. Key factors involved in the development of complications from acute respiratory failure.

Complication	Mechanism of Formation	sources
Multiple organ dysfunction syndrome (MODS)	increases systemic inflammatory response, hypoxemia, and perfusion disorders.	Gayen et al., 2024
Upper gastrointestinal bleeding	steroid therapy, hypoxic stress, and mucosal blood supply disorders.	Gayen et al., 2024
Thromboembolic events	chronic inflammation, activation of the coagulation system, and endothelial dysfunction.	Gayen et al., 2024
Lung damage	hyperinflation, alveolar damage, and ventilation-induced damage.	Althoff et al., 2020
Hospital-acquired infections	are associated with immunosuppression caused by asthma treatments and with	Althoff et al., 2020

	colonization of the respiratory tract	
Ventilator-associated pneumonia (VAP)	weakened immunity, chronic inflammation, and mechanical ventilation.	Althoff et al., 2020
Pneumothorax	hyperventilation of the lungs, alveolar injuries, and high airway pressure.	Althoff et al., 2020

Chronic complications of respiratory failure

Pulmonary hypertension: Patients with a history of ARDS (including those with a history of asthma) developed pulmonary hypertension due to persistent damage to the pulmonary vessels and remodeling caused by chronic inflammation.

Right ventricular heart failure: Progressive pulmonary hypertension secondary to lung damage leads to overload and dysfunction of the right ventricle of the heart, which increases the incidence of chronic right ventricular failure in these patients.

Reduced exercise tolerance: Long-term studies have shown that patients with ARDS have significantly reduced physical capacity (up to 6–12 months after hospitalization), which is associated with impaired ventilation, limited gas diffusion, and muscle damage (Luyt et al., 2020).

Pulmonary fibrosis: Many patients develop permanent fibrotic changes in the lungs after severe respiratory failure, deepening ventilatory limitations. Long-term inflammation after asthma may further accelerate this process (Luyt et al., 2020).

Neurological changes: Asthma patients who require intensive respiratory therapy are at higher risk of cognitive impairment, depression, and PTSD symptoms even a year after discharge. Chronic hypoxemia and long-term sedation are significant factors in neurological damage (Chiumello et al., 2016).

Treatment of bronchial asthma and ARDS: an integrated approach

Treating asthma and acute respiratory distress syndrome (ARDS) together requires a careful and combined approach. Having both asthma and ARDS at the same time makes treatment more complicated because the two conditions affect the lungs in different ways.

For ARDS, the usual treatment involves using a specialized type of ventilation that protects the lungs by delivering smaller breaths and maintaining low pressure to prevent further damage. ARDS therapy includes protective ventilation of the lungs with low tidal volume (4–6 ml/kg) and maintaining the plateau pressure below 30 cm H_2O. Lying patients on their stomachs (called the prone position) helps improve oxygen levels and can lower the chance of death, especially in severe cases. Clinicians also attempt to limit the amount of fluid patients receive to reduce the risk of lung swelling (Liu et al., 2022). For asthma, the primary treatment is using steroids that work throughout the whole body to reduce inflammation.

Summary

This review emphasizes the concurrent presence of bronchial asthma and acute respiratory distress syndrome (ARDS). It accentuates the influence of asthma in the genesis and complications of acute respiratory failure. Patients with asthma may be at greater risk for developing ARDS because lung hyperresponsiveness and inflammation are associated features of asthma. ARDS, with severe hypoxemia and bilateral pulmonary opacities, has an inconsistent worldwide distribution and high mortality. Patients who have asthma and ARDS are at higher risk of complications, including the development of multiple organ dysfunction syndrome (MODS), gastrointestinal haemorrhage, thromboembolic events, and barotrauma. People with these conditions are more likely to face long-term health issues. High blood pressure in the lungs is one of these conditions, which can put additional strain on the right side of the heart and cause it to work harder or possibly fail.

Additionally, they might develop pulmonary fibrosis, a scarring of the lungs that makes breathing difficult. These patients may also have more severe or frequent brain and neurological problems.

4. CONCLUSION

By altering the risk of clinical complications, asthma has a significant impact on the development of acute respiratory distress syndrome, not acute respiratory failure. Pneumothorax, upper gastrointestinal bleeding, and lung damage brought on by dynamic

hyperinflation are among the complications that asthmatic patients are more likely to experience. Despite this, the overall risk of multiple organ dysfunction syndrome (MODS) and hospital-acquired infections, including ventilator-associated pneumonia (VAP), is lower compared with patients without asthma.

Distinct immune responses and specific pathophysiological mechanisms associated with chronic inflammatory airway disease may explain the reduced incidence of multiple organ dysfunction syndrome (MODS) and ventilator-associated pneumonia (VAP) in patients. In contrast, high-dose systemic corticosteroids and persistent inflammation in asthma increase the risk of thromboembolic events and gastrointestinal complications.

The rising incidence of pneumonia and sepsis, the leading causes of ARDS, strongly predicts a future increase in ARDS cases. Therefore, it is crucial to develop personalized prevention and treatment approaches for patients with asthma and acute respiratory failure, taking into account the specific pathophysiological characteristics of this patient group. Although asthma may worsen the prognosis of ARDS, it is worth remembering that ARDS is a complex condition, and many factors could influence its course. Treating ARDS in patients with asthma requires a holistic approach that considers both respiratory status and other factors affecting the disease course.

Author's Contributions

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All authors have read and agreed with the published version of the manuscript.

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Informed consent

Not applicable.

Ethical approval

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interest.

Data and materials availability

All data associated with this work are present in the paper.

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