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Review

Assessment of Status Asthmaticus in Children with Refractory Symptoms in Emergency Departments

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Abstract

Asthma is a multifactorial disease primarily driven by obstructive airway inflammation. Several factors contribute to the pathogenesis of asthma, including age, socioeconomic status, and genetic composition. Status asthma accounts for 20% of emergency department admissions, where patients present with adverse symptoms such as tachypnea, accessory muscle use, wheezing, and hypoxemia, and “silent chest” which indicates complete blockage of the airway. Nevertheless, assessment of status asthma is particularly challenging in the pediatric population, owing to overlapping symptoms with other pediatric conditions such as bronchitis and pneumonia. The establishment of structured approaches and guidelines, along with the advancement in understanding the underlying mechanisms, offers the opportunity for enhanced management and diagnostics. Furthermore, the employment of artificial intelligence can be a potential predictive tool for children at risk. This review aims to identify assessment and management approaches for pediatric status asthmaticus in the emergency department. It also seeks to offer a thorough explanation of the underlying mechanisms behind asthma, with the goal of prompting future research for the development of enhanced management and assessment approaches.

Keywords*: status asthmaticus, pediatrics, emergency, management, refractory*

Introduction

Asthma is the most prevalent non-communicable chronic disease among children. According to the Global Burden of Disease, a prevalence of 4.3% in the pediatric population was recorded in 2021 (1, 2). Asthma can be defined as "a heterogeneous disease characterized by chronic airway inflammation". It presents with several respiratory symptoms, such as wheeze, shortness of breath, chest tightness, and cough that vary over time and in intensity, together with variable expiratory airflow limitation (1). The prevalence of status asthma varies demographically. In detail, it is more common in boys compared to girls, and its incidence increases with age, with the rate rising from 1.4 in children aged 4 years and younger to 2.2 in those aged 5 years and older. Moreover, high-income countries, including the US and the Caribbean, have a higher incidence rate compared to low- and middle-income countries. This can be attributed to the high level of awareness and enhanced diagnostics. Thus, highlighting the impact of socioeconomic factors on the management of this prevalent disease (1).

In addition to socioeconomic factors, genetic composition, exposure to allergens and viruses, and psychological stress also contribute to the development of asthma (3). Despite the drastic decrease in prevalence, asthma still poses a persistent challenge, given that status asthma accounts for 20% of emergency department admissions and contributes to approximately 420,000 global deaths per year. Patients with severe status asthmaticus present with a prolonged expiratory phase, tachypnea, accessory muscle use, wheezing, and hypoxemia. Another detrimental sign of status asthmaticus is a "silent chest", which can indicate total blockage of airflow and imminent pulmonary failure (4). Being a dangerously fatal disease, timely diagnosis and proper management of asthma is a global issue that needs to be addressed.

Assessment of status asthma is challenging in children due to overlapping symptoms with other pediatric conditions that cause airway obstruction, such as laryngomalacia, tracheomalacia, and lymphadenopathy (5). Evaluation of status asthma is based on history taking, which includes listing potential risk factors that contributed to the attack, followed by a structured ABCDE (airway, breathing, circulation, disability, and exposure) approach. Based on the patient's clinical condition, a comprehensive history and examination can then be taken. In the emergency department, patients are then classified based on risk into those with moderate exacerbations, which are characterized by tachypnea, expiratory wheezing, use of accessory muscles, and oxygen saturations ranging from 92% to 95%. While patients with severe status asthma present with an inability to complete short sentences, the presence of both an inspiratory and expiratory wheeze, and oxygen saturations less than 92% (6). Given the severe complications of acute asthma and the complexity of its assessment, establishing specific guidelines is necessary to enhance the diagnosis and management of acute asthma. Hence, this results in better patient outcomes and lower mortality rates.

The main aim of management of status asthmaticus in the emergency department is to prevent respiratory failure and treat acute respiratory distress by reversing bronchoconstriction and reducing lung inflammation. Management starts with a bronchodilator, which is given preferably using an MDI. Nebulizers are used in case the child is hypoxic. Steroids are also used to reduce inflammation. Finally, Extracorporeal Membrane Oxygenation (ECMO) is used if the patient is non-responsive to all forms of treatment. This review aims to identify assessment and management approaches for pediatric status asthmaticus in the emergency department. It also seeks to offer a thorough explanation of the underlying mechanisms behind asthma, with the goal of prompting future research for the development of enhanced management and assessment approaches.

Methodology

This review is based on a comprehensive literature search performed on October 1st, 2025, in the PubMed and ClinicalKey databases, as well as Google Scholar. Utilizing MeSH (Medical Subject Headings) and relevant keywords such as "status",

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"asthma'','' pediatric", "refractory", "symptoms'', "emergency", "assessment". The search aimed to explore studies on the assessment and management approaches for pediatric status asthmaticus in the emergency department. It also seeks to offer a thorough explanation of the underlying mechanisms behind asthma, with the goal of prompting future research for the development of enhanced management and assessment approaches. The search was not restricted by date, language, or type of publication to ensure a broad exploration of the available literature.

Discussion

Pathophysiology

Under normal conditions, bronchial epithelial cells, which lie at the surface between the environment and the host, form an impermeable barrier, which is maintained primarily by tight junctions at the apical end of columnar cells and further reinforced via different adhesion mechanisms in the basal and basolateral surfaces of epithelial cells, including adherens junctions and (hemi) desmosomes (7). These epithelial cells serve as the first line of defense against pathogens and airborne allergens; bronchial biopsies of patients with asthma have revealed functional defects in epithelial connections (8).

Upon exposure to allergens such as house dust mites, pollens, cigarette smoke, and microbes, IgE antibodies are produced as a result of the overexpression of the T helper type 2 subset of cells. In turn, IgE antibodies bind to specific receptors on mast cells, activating them to produce histamine, prostaglandin D2, and cysteinyl leukotrienes such as LTC4, LTCD4, and LTCE4, which are released as a result of the cross-linking of allergen-specific IgE antibodies on the mast cell surface caused by further allergen inhalation. Within minutes, this mechanism causes the contraction of smooth muscles in the respiratory airways and may activate reflex neuronal circuits. The release of histamine and leukotrienes triggers the contraction and relaxation of airway smooth muscle, inducing bronchoconstriction, which leads to an asthma attack (7).

The degree of airflow blockage varies depending on the degree of airway lumen constriction. If an attack is not timely managed, the flow of neutrophils, T lymphocytes, monocytes, dendritic cells, eosinophils, basophils, and other inflammatory cells into the airways, together with the excess mucus production by goblet cells, leads to late bronchoconstriction and worsens the symptoms. Furthermore, airway remodeling may occur over time in cases of poor asthma management. In detail, chronic inflammation causes hypertrophy of the bronchial smooth muscles. Thus, the formation of new vessels and the deposition of collagen result in persistent airflow blockage, similar to that seen in chronic obstructive pulmonary disease (9). Given the detrimental effects of asthma, timely diagnosis and management are a necessity.

Clinical Assessment & Differential Diagnosis

Diagnosis and Staging

Children with status asthma present to the emergency department with coughing, wheezing, tachypnea, and extensive use of accessory muscles. An adverse sign is a silent chest, indicating complete blockage of airflow and potential respiratory failure (10).

The assessment of an asthma attack comprises an initial stage to determine the severity of the attack and regular assessments to evaluate the effectiveness of treatment. There are several scoring systems, such as the Pediatric Respiratory Assessment Measure (PRAM), which the SINA group adopted as a valid and reliable method for assessing the severity of exacerbations in children aged 2–17 years. The PRAM score is a 12-point score to evaluate oxygen saturation, suprasternal retractions, scalene muscle contractions, air entry, and wheezing. A score of 1–3 indicates a low risk (<10%) of hospital admission, a score of 4–7 indicates a moderate risk (10–50%) of hospital admission, and a score of 8–12 indicates a high risk (>50%) of hospital admission.

The PRAM assessment score for patient management has been reported to decrease the length of stay in the emergency department, with no

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adverse outcomes. Moreover, the PRAM assessment score, as reported by Douros et al. (2023), was used to determine the severity of asthma and predict the length of hospital stay in children aged 3-16 years (11).

Another assessment score is the Integrated Pulmonary Index (IPI), which is a 1-10 score that monitors four vital physiological parameters: pulse oximetry, respiratory rate, end-tidal CO2, and pulse rate. A score of 8–10 indicates normal respiratory status, a score of 5–7 indicates a need for greater attention, a score of 3–4 suggests that intervention may be necessary, and a score of 1–2 means immediate intervention is required. A recent retrospective observational study by Hanaa et al. (2025) reported that IPI can be used to predict respiratory compromise in children with severe acute asthma (12).

Initial Assessment

Assessment starts with a brief medical history taking to determine the severity and duration of symptoms, triggers that might have caused the attack, previous hospital admissions, and the current course of steroids. It is also vital to consider any other comorbidities, cardiovascular diseases, other lung conditions, and chronic psychiatric disorders. Medical history is followed by a physical examination to assess the child's vital physiological functions. Spirometry can be used to evaluate lung function. However, it is difficult to use in young children. Having several overlapping symptoms with other pediatric conditions, the physical assessment of status asthma is inadequate. Thus, differential diagnosis is indispensable.

Differential Diagnosis

Assessment of status asthma in children is challenging due to overlapping symptoms with other pediatric conditions, including bronchiolitis, foreign body aspiration, and anaphylaxis. Thus, physicians should be aware of any atypical symptoms of asthma. An alternative diagnosis should be considered if symptoms begin in the neonatal phase or if they suddenly appear without any apparent triggers or don't respond to asthma treatment. If cough is accompanied by purulent sputum, wheezing severity changes with changes in position, or respiratory symptoms are associated with chronic diarrhea, steatorrhea, failure to thrive, or vomiting. **Table 1** summarizes clinical clues and the associated alternative diagnoses (13).

Table 1: Clinical Clues for Alternative Diagnosis of Pediatric Status Asthma (Mehmet Kılıç and Öner Özdemir 2025) (14)

Clinical clue	Potential Diagnosis
Perinatal and family history	
Symptoms present from birth	Chronic lung disease in premature infants, PCD, CF
Family history of unusual chest disease	CF, Neuromuscular disorders, PCD
Severe upper respiratory tract disease	PCD
Symptoms and signs	
Persistent moist cough	PBB, bronchiectasis, recurrent aspiration, PCD, CF
Excessive vomiting	Gastroesophageal reflux disease (with/without aspiration)
Dysphagia	Swallowing problems (with/without aspiration)
Breathlessness with lightheadedness and peripheral tingling	Dysfunctional breathing, panic attacks
Inspiratory stridor	Tracheal or laryngeal disorder
Abnormal voice or cry	Laryngeal problems
Persistent wheeze	Extrinsic intrathoracic airway compression, Airway malacia, luminal obstruction, CF, FB
Finger clubbing	CF, bronchiectasis
Failure to thrive	CF, GERD

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Effective management of status asthma in the pediatric population aims at preventing respiratory failure, reversing bronchoconstriction, reducing inflammation, and lowering the risk of attack recurrence by establishing a management routine and scheduling follow-up visits. Several approaches are used to manage a status asthma attack, including the ABCDE approach, pharmacological interventions, or oxygen intake. Determining the proper approach depends on the severity of the attack (15).

The ABCDE Principle

The ABCDE approach is a structured approach in which the initial assessment and treatment of acute asthma are performed simultaneously. The mnemonic "ABCDE" stands for Airway, Breathing, Circulation, Disability, and Exposure. First, life-threatening airway problems are assessed and treated; second, life-threatening breathing problems are evaluated and treated; and so on. The aim of using this approach is to identify life-threatening issues and implement proper treatment to alleviate them (16).

Management at the Emergency Department

β-Agonists

β-Agonists are the standard treatment for status asthmaticus. They include albuterol, epinephrine, terbutaline, and isoproterenol. They stimulate the β-adrenergic receptors on the smooth muscle cells of the bronchial airway, leading to the induction of adenylyl cyclase. This enhances the activity of cAMP-dependent protein kinase A by increasing the intracellular concentration of cAMP. This will result in airway relaxation and inhibit the release of histamine and other mast cell mediators. Thus, alleviating bronchoconstriction. β-Agonists are delivered through inhalation. Side effects include tremors, nausea, vomiting, tachycardia, and lactic acidosis owing to hyperactivation of beta receptors (17, 18).

Steroids

Considering that asthma is primarily driven by inflammation, corticosteroids play a crucial part in treatment. Glucocorticoids reduce inflammation by inhibiting the release of several cytokines and adhesion molecules. Moreover, they stimulate the expression of several genes such as the β2 receptor and lipocortin-1. Thus, it reduces the production of mucus and limits capillary permeability. For the treatment of status asthmaticus, corticosteroids are administered either orally or intravenously. Research has shown that IV-injected and orally administered corticosteroids have equivalent efficacy, whereas inhaled corticosteroids were reported to be ineffective in treatment (17, 19, 20).

Magnesium sulfate

Magnesium sulfate is emerging as a second-line agent in children who do not respond to inhaled β_2-agonists and systemic corticosteroids. It exerts its action by reducing calcium entry into airway smooth muscle cells, resulting in relaxation and reduction of airway hyperresponsiveness (21, 22). The drug also inhibits acetylcholine release at the neuromuscular junction, facilitating airway dilation. A randomized controlled trial reported that a single IV dose of MgSO4, when given early, reduced hospitalizations in refractory subjects (23)A post hoc analysis substantiated its relationship with reduced admission to the emergency department for pediatric patients (24, 25). The use of nebulizers by continuous infusion has been proposed as an alternative safe, and effective therapy for adverse events that require intensive care.

Anticholinergic Agents

Muscarinic antagonists are anticholinergic agents used in the management of status asthma. They inhibit the action of acetylcholine, blocking the contraction of smooth muscles and the secretion of mucus by activating the parasympathetic system. Given its high efficacy in bronchodilation, ipratropium bromide is the anticholinergic agent used in the management of status asthma. However, further research is required to compare its efficacy with other available pharmaceutical treatments (26).

Noninvasive Ventilation

Noninvasive Ventilation approaches, including high flow nasal cannula (HFNC), continuous positive airway pressure (C-PAP), and bilevel positive

http://dx.doi.org/10.52533/JOHS.2025.51004

airway pressure (BiPAP), can be employed in cases with refractory status asthmaticus. Continuous positive airway pressure, as demonstrated in HFNC and C-PAP, has been reported to maintain the integrity of tiny airways and facilitate enhanced delivery of bronchodilators to these regions. BiPAP provides positive inspiratory pressure, diminishing the reliance on accessory muscles and recruiting collapsed alveoli to mitigate atelectasis. It can also enhance functional residual capacity. Hence, it leads to enhanced oxygenation and ventilation. Moreover, the application of noninvasive positive pressure might substantially reduce the incidence of invasive mechanical ventilation for status asthmaticus. Therefore, reducing morbidity and mortality rates associated with asthma. Nationally, the utilization of noninvasive ventilation has increased, resulting in a reduction of invasive mechanical ventilation usage. There's a lack of a standardized method for identifying patients eligible for noninvasive ventilation. Thus, further large-scale studies are required (27-29).

Extracorporeal Membrane Oxygenation (ECMO)

For patients with refractory symptoms to all forms of treatment, ECMO offers the solution. It provides extracorporeal gas exchange, allowing the lungs to rest and recover while maintaining systemic oxygenation. ECMO has been reported to reduce mortality in children with life-threatening status asthmaticus who fail conventional ventilation. However, it should only be performed in specialized centers with pediatric expertise and after all pharmacologic and ventilatory measures have failed (17).

Emerging Approaches

Understanding the underlying molecular mechanisms behind asthma and the significant role of cytokines such as interleukin (IL)-5, IL-13, and IL-33 in persistent inflammation and resistance to standard treatment has led to the development of biologic agents targeting these pathways. For instance, Omalizumab (an anti-IgE antibody) and mepolizumab (an anti-IL-5 antibody) have demonstrated effectiveness in reducing the frequency of attacks and corticosteroid dependence in severe allergic asthma. However, their role in acute management remains unsettled (17).

Given that defects in the epithelial barrier contribute to airway hyperresponsiveness and persistent inflammation, new therapeutic strategies are directed towards epithelial repair and modulation (8). Moreover, artificial intelligence has been investigated for employment in early identification of high-risk children and prediction of treatment failure using clinical data and machine learning algorithms (30, 31). Although these approaches are still in the experimental phase, they have the potential to become valuable tools for individualized management of refractory asthma in the future.

Conclusion

Asthma is a multifactorial, prevalent condition that requires continuous monitoring and management. It is particularly challenging in children, owing to poor management habits and late diagnosis. However, new structured approaches and guidelines offer promise for reducing morbidity and mortality due to status asthmaticus. In addition to improving our understanding of the pathophysiology behind the disease, the employment of AI can also enhance our ability to predict disease prognosis. Thus, providing better treatments and improving patient outcomes.

Disclosure

Statement

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Ethical Consideration

Not applicable.

Data Availability

All data is provided within the manuscript.

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