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Asthma In Children: Principles Of Diagnosis And Management

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Abstract:

Background: Asthma is a persistent affliction that affects nearly 262 million people and is the most common chronic illness in children. Given the sensitive nature of the pediatric population and the long-term side effects that might be associated with the various treatment modalities available for treating asthma, it is essential to review the latest therapies and guidelines to provide the best possible care to the children.
Objective: To objectively review the latest methodology for diagnosis and management of asthma in the pediatric population.
Materials and methods: This review is a comprehensive search of PUBMED from the year 2005 to 2025.
Conclusion: Pediatric asthma is a complex condition that requires the involvement of the patients, caregivers, and the healthcare team to administer medication and prevent any morbidities and mortality in the young patients involved. A comprehensive treatment plan with minimal adverse effects and future repercussions for the child should be considered, which should be revised regularly depending on the response to the therapy.

Keywords: Asthma; Children; Diagnosis; Diagnosis, Pediatric; Management

Introduction

Asthma is a chronic inflammatory condition that commonly affects the respiratory system- bronchioles, characterized by wheezing, coughing, dyspnea, and shortness of breath.[1] The acute exacerbations are often stimulated by allergens, pollen, dust, and other particles that might be inhaled in, consequently leading to constriction and mucus secretion, which further leads to decreased oxygen in the alveoli.[2] Asthma can be classified as atopic or non-atopic, wherein atopic refers to a predisposition to a type 1 hypersensitivity response.[3]

Etiology

The etiological factors contributing to the development of asthma are multiple and complex. The two most implicated factors are environmental and genetic. Depending on the age of onset, asthma before the age of 12 is because to genetic predisposition, while after 12 years is due to environmental conditions. [4]

Environmental

The number of environmental factors, such as pollution, allergens, and other chemical factors, is believed to be responsible for the development and exacerbation of asthma. Asthmagens are substances that are known to cause asthma in exposed individuals. These include substances like ammonia, latex, pesticides, metal or wood dust, formaldehyde, glues, and dyes.[5] GINA also implicates smoking during pregnancy and after delivery as a risk factor for asthma.[6] Low quality air due to factors like traffic pollution, ozone exposure are associated with the development of asthma and increasing the severity of the condition.[7] The American Lung Association reported that over half the cases of pediatric asthma were seen in areas with air quality that was below the EPA standards.[8] van de Loo et al reported the positive association between psychological stress during pregnancy and the development of asthma.[9] Neu et al also stated that vaginal birth decreases the probability of development compared to cesarean section due to the healthy colonization of bacteria as the neonate passes through the birth canal.[10]

Genetics

Family history is commonly implicated to be the cause of asthma. Elward et al reported that if one of the identical twins was diagnosed with asthma, the probability of the other one being affected is nearly 25%.[11]. Nearly 100 genes were discovered to be associated with asthma, some of them being GSTM1, IL10, CTLA-4, SPINK5, LTC4S, IL4R, and ADAM33.[12] Some genes have a diathesis-like predilection that, on exposure to environmental factors, leads to the onset of asthma in individuals.[13]

Exacerbations

An acute exacerbation can be seen in some individuals that otherwise have stable asthma. This condition can be triggered by multiple agents. Agents can range from benign household factors like dust, animal dander, cockroach allergens, mold, and perfumes. Upper respiratory tract infections of bacterial and viral nature may also worsen the disease.[14] Exacerbations peak for school-aged children in autumn for about 8 weeks due to factors like poor treatment adherence, increased allergen and viral exposure, and altered immune tolerance.[15]

Pathophysiology

Asthma is a chronic inflammatory condition affecting the conducting zone of the respiratory system-bronchi and bronchioles, leading to increased contractility of surrounding smooth muscles, leading to the classical symptoms of a narrowed airway and wheezing. The narrowing can correct itself with or without treatment.[6] The histopathological changes observed include eosinophilia, thickening of the lamina reticularis, and on a chronic course, may lead to hypertrophy of smooth muscles along with hyperplasia of mucous glands. Other involved components of T-lymphocytes, macrophages, neutrophils, cytokines, chemokines, histamine, and leukotrienes.[16]

Diagnosis

Pediatric asthma is clinically characterized by wheezing, shortness of breath, and cough.[17] In adults, asthma is diagnosed using spirometry analysis.[18] Wheezing is the key feature of pediatric asthma, as case diagnosis is unlikely in the absence of wheezing. Wheezing can be described as an expiratory high-pitched whistle that occurs because of inflammation and narrowing of small airways.[18] As ‘preschool wheeze’ is a common feature in children, there is a necessity to review the diagnosis and treatment plan accordingly.[19] In symptomatic children, the diagnosis is supported by personal or family history of atopic features- asthma, eczema, or rhinitis. Additional risk factors involve exposure to secondhand smoke, preterm birth, low birth weight, obesity, poor housing conditions, and air pollution.[17] The phenotype and endotype of asthma in pediatric patients are also key to determining the course of the condition and the best-suited treatment modality. Asthma can be classified into ‘type 2-high’ and ‘type 2-low’ asthma, of which type 2-high asthma is more commonly seen in childhood and is characterized by eosinophilic inflammation with raised IgE levels and fractional exhaled nitric oxide (FeNO) levels.[20]

Type 2-high asthma, in turn, responds well to inhalational corticosteroid (ICS) therapy.[17] There is no ‘gold standard’ for diagnosing pediatric asthma. Clinical diagnosis based on symptomatic patterns, evidence of variable airflow due to airway inflammation, possibility of differential diagnoses, along

with response to treatment.[17] Lung function tests are employed to diagnose asthma in children below the age of 5 years. Peak expiratory flow (PEF) and spirometry are used to assess airflow obstruction and reversibility. A characteristic feature of asthma is diurnal variation, which is measured using PEF. [17] The Global Initiative for Asthma (GINA) recommends the use of spirometry or PEF for children over 5 years of age.[21] Before the age of 3 years, lung function testing cannot be performed for diagnosis; trials of asthma treatment are the main modality of diagnosis.[17]

Spirometry

Spirometry is recommended for the diagnosis and management of asthma. If following bronchodilator administration such as salbutamol, the FEV_1 is measured and improves by 12% and increases by at least 200 milliliters, it is supportive of the diagnosis. The test may be normal in patients with a history of mild asthma.[16] Spirometry is used to monitor response to treatment every one to two years.[22]

Methacholine challenge

It is a non-specific test for diagnosis, where in increasing concentrations of a substance cause airway narrowing in predisposed individuals. It is negative for non-asthmatic individuals. [16] The various guidelines for lung function testing are listed below (Table 1). [17]

Table 1: Guidelines for lung function test [17].

Guideline	Diagnostic Criteria	Recommended Objective Testing	When To Consider Alternative Diagnosis
NICE Guidelines -UK (2017)	Under 5 years: clinical history + examination suggestive of asthma Over 5 years: clinical history + examination suggestive of asthma + spirometry with bronchodilator reversibility **or** FeNO level ≥ 35 ppb	Over 5 years: Spirometry and bronchodilator reversibility **or** FeNO levels. Additionally: Peak expiratory flow (PEF), bronchial challenge test with histamine or methacholine	Symptoms of asthma are seen but normal objective testing results
Global Initiative for Asthma (GINA)- 2022	6 years and over: clinical history + spirometry and bronchodilator reversibility + repeated PEF + positive bronchodilator challenge **or** positive exercise challenge	6 years and over: Spirometry, PEF, exercise challenge **or** bronchial challenge	Atypical asthma features, atypical clinical examination findings such as cardiac murmurs
Cardiac Thoracic Society (2021)	1-5 years of age: more than one presentation of asthma-like symptoms + response to asthma treatment trials Over 6 years: clinical history + spirometry + reversibility of airflow limitation	Over 6 years: spirometry + bronchodilator reversibility Additional tests: peak flow variability, bronchial challenge, exercise challenge	-
National Asthma Council Australia (2021)	1-5 years of age: clinical history + examination + response to treatment trial with SABA and/or ICS	1-5 years of age: none 6 years and over: spirometry	Atypical asthma features No response to treatment trials

	6 years and over: clinical history + examination + spirometry	If spirometry does not show reversibility of airway limitation of at least 12%, bronchial challenge and exercise challenge are considered	Objective testing results do not suggest asthma
International Consensus on Pediatric Asthma (2015)	Under 5 years: clinical history Over 5 years: clinical history + spirometry +bronchodilator reversibility	Over 5 years: spirometry Additional: PEF, FeNO, skin prick test	-

Biomarkers

Biomarkers are quantifiable biological indicators used for diagnosis and treatment monitoring. Biomarkers for asthma can be measured from multiple specimens, such as sputum, bronchio-alveolar lavage, exhaled breath condensate, bronchial biopsy, urine, and blood. [20] These can be used to distinguish between inflammatory types (T2-high or T2-low) or responsiveness to specific treatments (T2 cytokine-targeted therapy). [23] Biomarkers that can be used for childhood asthma, especially for T2-high asthma, include: eosinophil, IgE, periostin, and FeNO.[20]

Differential diagnosis

Due to the vague nature of clinical symptoms of asthma in children- wheezing, dyspnea, chronic cough being shared by multiple other conditions, it is essential to establish the diagnosis objectively, which proves to be difficult for children who cannot under lung function testing using spirometry.[17]

Differential diagnosis should be considered during the diagnosis of asthma, such as cystic fibrosis, primarily ciliary dyskinesia, bronchopulmonary dysplasia, bronchiectasis, laryngeal dysfunction, gastro-esophageal reflux disease, and foreign body aspiration. [17]

Management of Asthma

As asthma is not a curable condition, life-long management of the condition is done using trigger risk management, lifestyle modification, medication, and other methods.

Risk Management and lifestyle modification

Avoidance of the trigger risk is the primary method for asthma management. Avoiding common allergens, smoke from tobacco and other sources, medication like non-selective beta blockers, sulfite-containing foods, and pollution helps to decrease the occurrence of asthma attacks.[22] Stapelton et al noted that cigarette smoke and passive smoke reduce the effectiveness of medications such as corticosteroids.[24]

Carson et al noted the benefits of exercise in managing the condition in people with stable asthma.[25] Yang et al also noted the benefits of yoga in improving the quality of life and reducing the severity of symptoms of asthma.[26] Weight loss is also believed to be valuable in reducing the severity of asthma, especially given the positive correlation between obesity and asthma in children.[27][28]

Medication

The pharmacological therapies for asthma can be classified as maintenance therapies and reliever therapies. Reliever therapies are used for exacerbations in case of poor asthmatic control, while maintenance therapies are used when the reliever therapy is not needed.[17]

Table 2: Reliever therapies for asthma [17]

RELIEVER THERAPIES

Short Acting Beta-2 Adrenergic Agonists (SABA)	Salbutamol is the first line treatment for asthma symptoms.[22] SABA works by relaxing the smooth muscles rapidly, providing quick relief from symptoms. Can be delivered by spacer devices or via nebulizer with supplemental oxygen.[17]
Oral Corticosteroids	Short-term therapy in case of acute asthma attack to decrease inflammation and alleviate symptoms.[17]
Others	Intravenous or nebulized magnesium sulfate and helium mixed with oxygen.[29]

Table 3: Maintenance therapies for asthma.

MAINTENANCE THERAPIES	
Inhaled Corticosteroids (ICS)	First-line maintenance agent according to the GINA guidelines.[21] Lowest dose is to be administered to prevent adverse effects such as adrenal suppression and osteoporosis.[17] Commonly used agents are budesonide, fluticasone, mometasone and ciclesonide.[29]
Long-Acting Beta-Adrenergic Agonists (LABA)	Used in addition when dual ICS and SABA therapy is ineffective. Bronchodilation lasts 12 hours longer than SABA.[17] Chauhan et al noted that LABA therapy with ICS improves lung function.[30]
Leukotriene Receptor Antagonists (LTRA)	Used as add-on therapy to ICS and LABA therapies, in case of poor symptomatic control. Agents include montelukast and zafirlukast [17]
Long-Acting Muscarinic Antagonists (LAMA)	Used as an add-on therapy to ICS and LABA. Agents include tiotropium [17]
Biologics	Used as an add-on therapy. Agents include Omalizumab, Dupilumab, Mepolizumab.[17] Saxena et al noted a decrease of 40-50% in annual rate of asthma exacerbation.[31]
5-lipoxygenase inhibitor (5-LOX inhibitor)	It inhibits leukotriene formation, thus reducing airway inflammation. Example: Zileuton[18]

Figure 1: Asthma Management in Age group 0-4 years [18]

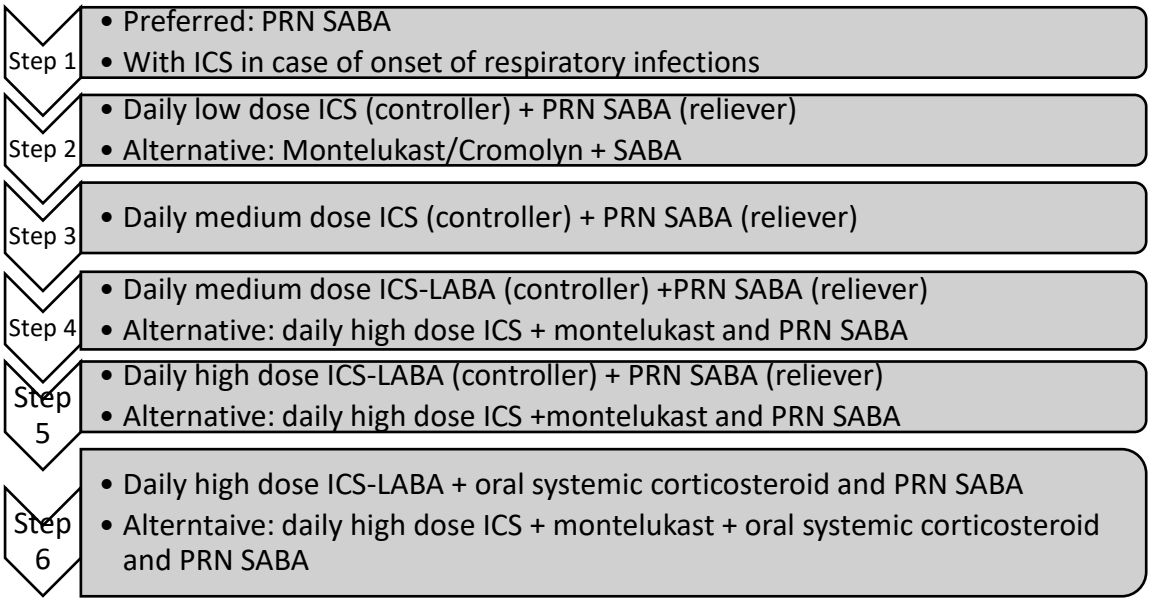
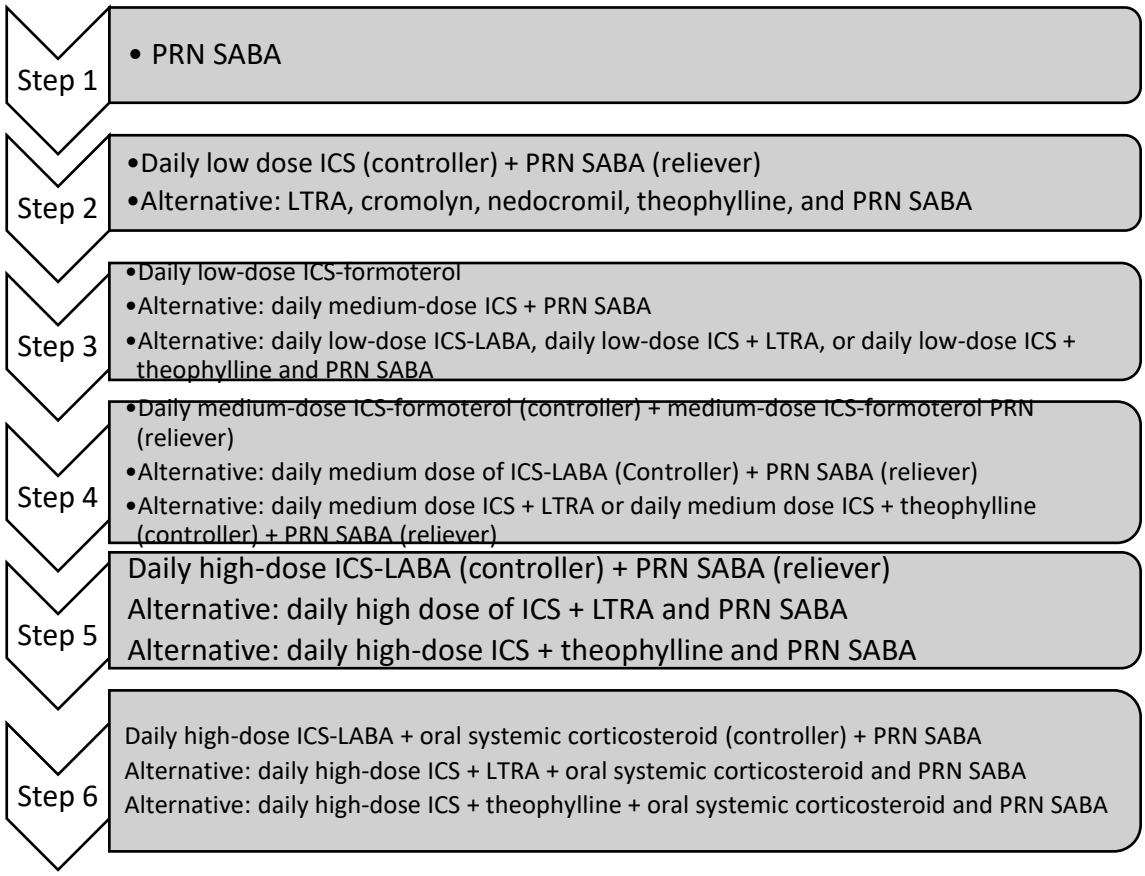
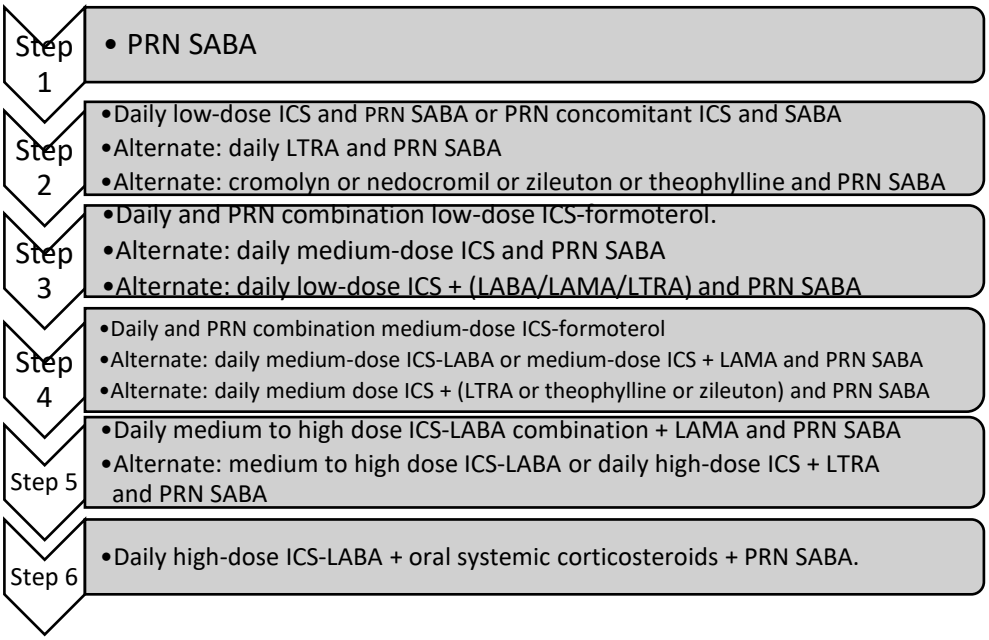


Figure-2: Asthma Management in the Age group 5-11 years [18]



- For steps 2 to 4, for patients ≥ 5 years of age, subcutaneous immunotherapy as an adjunct therapy to the standard treatment for established allergic sensitization and evidence of worsening asthma symptoms following exposure.[18]
- For steps 5 and 6, Omalizumab should be considered; other biologics are not recommended by FDA.[18]

Figure-3: Asthma Management for ages > 12 years [18]



- For steps 2 to 4, subcutaneous immunotherapy is recommended for patients >5 years. [18]
- For steps 5 and 6, biologics can be considered. [18]

GINA recommends dual ICS-SABA treatment for children >5 years. Symptom-driven ICS use is recommended by GINA guidelines, as opposed to daily ICS use for children over 6 years of age.[21]

SMART (Single Maintenance and Reliever Therapy)

This treatment approach consists of treatment with ICS and LABA (formoterol) for daily and reliever therapy. It is recommended for patients ≥ 4 years who do not have any effect with ICS alone. This approach is recommended to reduce exacerbation and reduce the amount of corticosteroid intake. SMART approach should be considered for patients with uncontrolled asthma on ICS-LABA treatment before increasing the dosage.[18] SMART inhalers have demonstrated improved lung function along with reduced need for reliever therapy.[32] Adverse effects commonly seen for the various pharmacological agents include. [18]

Table 4: Adverse effects of pharmacological agents. [18]

DRUGS	ADVERSE EFFECTS
Inhaled beta 2 agonists	Tremors, tachycardia, and palpitations – more commonly seen with initial exposure [33]
Inhaled corticosteroids	Oropharyngeal candidiasis and dysphonia – reduced using spacers devices and rinsing after use [18]
LAMA	Dry mouth, constipation, blurring of vision, and urinary difficulty or retention [18]
Systemic corticosteroids	Vomiting, behavioral changes, sleep disturbance, increased risk of infections, osteoporosis, diabetes, adrenal insufficiency, delayed wound healing, cataracts, aseptic joint necrosis, GI bleeding, and growth suppression [18]
LTRA	Neuropsychiatric ADR- ranges from insomnia to suicidal ideation and hepatoxicity (zafirlukast) [18]
Mast cell stabilisers (cromolyn)	Throat irritation, sneezing, and an unpleasant taste. [18]
Omalizumab	Skin inflammation at the injection site and anaphylaxis [18]

Others

Bronchial thermoplasty is a radiofrequency energy-based bronchoscopic therapy modality for the airways, which reduces airway smooth muscle mass and smooth muscle hypertrophy. Current literature only recommends this modality for adults and not children.[34] Qian et al considered the possibility of pulmonary rehabilitation for children to improve lung function using various techniques such as Buteyko breathing, pursed lip breathing, diaphragmatic breathing training, threshold-pressure inspiratory muscle training, and yoga breathing.[35]

Conclusion

Pediatric asthma is a complex condition that requires the involvement of the patients, caregivers, and the healthcare team to administer medication and prevent any morbidities and mortality in the young patients involved. A comprehensive treatment plan with minimal adverse effects and future repercussions for the child should be considered, which should be revised regularly depending on the response to the therapy.

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Author contributions

The manuscript's original text was written by the initial author. Before the work is forwarded to a journal for publication, each author must provide their final consent. Each co-author contributed to the literature review, the manuscript's editing, and the construction of the table and figures.

Conflict of Interest

The authors declare no conflict of interest, financial or otherwise.

Ethical Approval

Not Applicable

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