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Outpatient Management of Asthma in Children

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Abstract: The principal aims of asthma management in childhood are to obtain symptom control that allows individuals to engage in unrestricted physical activities and to normalize lung function. These aims should be achieved using the fewest possible medications. Ensuring a correct diagnosis is the first priority. The mainstay of asthma management remains pharmacotherapy. Various treatment options are discussed. Asthma monitoring includes the regular assessment of asthma severity and asthma control, which then informs decisions regarding the stepping up or stepping down of therapy. Delivery systems and devices for inhaled therapy are discussed, as are the factors influencing adherence to prescribed treatment.

The role of the pediatric health care provider is to establish a functional partnership with the child and their family in order to minimize the impact of asthma symptoms and exacerbations during childhood.

Keywords: asthma, children, wheeze, management

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Introduction

Asthma is one of the most common chronic diseases in childhood, resulting in significant morbidity and health care expenditure.¹ While asthma deaths are now relatively rare, asthma is one of the most common causes of hospitalization for children in developed countries, and recurrent asthma symptoms greatly reduce the quality of life for both the child and their family.¹ The role of the pediatric health care provider in the outpatient setting is to establish a functional partnership with the child and their carer in order to minimize asthma symptoms and exacerbations and to establish asthma control. As with all chronic diseases, before embarking on a treatment regimen, the clinician must ensure that the diagnosis is correct.

Diagnosis of Asthma

Asthma may be underdiagnosed or overdiagnosed, depending on the presentation and the clinician involved. Asthma is characterized by reversible small airway narrowing that is caused by a combination of bronchoconstriction, airway wall inflammation, and mucus secretion that usually presents with recurrent episodes of wheezing, shortness of breath, chest tightness, and coughing. As asthma is a disease that, for each patient, fluctuates in severity, patients are often asymptomatic in the outpatient setting, making history taking crucial to the diagnosis.

A diagnosis of asthma (described below) is usually made following a combination of history taking, physical examination, and limited special investigations. The symptoms of recurrent wheeze, shortness of breath, and cough are typically worse at night and in the early morning. The astute clinician will be aware that when a child or his or her parent reports wheeze, one should always ensure that the symptom being described is indeed wheeze. Wheezing is often reported by parents in the absence of the medically accepted definition of wheeze.² Symptoms may fluctuate from day to day and may vary from one season to the next. While the vast majority of asthma exacerbations are triggered by viral upper respiratory tract infections (specifically rhinovirus),³ symptoms can also be triggered by exposure to environmental tobacco smoke, exercise, and cold air. Atopic asthma, presenting with a background of eczema, allergic rhinitis, and other allergies can be triggered by exposure to specific allergens such as cat dander

or grass pollen. A first degree relative (especially mother) with confirmed asthma or a personal history of atopy (ie, infantile or current eczema, allergies, or allergic rhinitis) in the child further supports the diagnosis of asthma, although many children with asthma will have none of these supporting features.⁴ The neonatal history is important, as premature birth leading to chronic lung disease of prematurity can predispose children to symptoms mimicking asthma. Table 1 outlines other diseases that may cause symptoms similar to asthma and suggests signs or symptoms that may point towards the diagnosis.

Physical examination during acute asthma may reveal polyphonic wheeze and hyperinflation of the chest, but in the outpatient setting, physical examination often reveals few abnormalities. The presence of eczema would support a diagnosis of asthma, whereas the presence of otitis media or crepitations may point toward an alternative diagnosis. While failure to thrive can occasionally be seen in children with poorly controlled asthma, the finding is unusual and should alert the clinician to exclude other disorders outlined in Table 1. Digital clubbing is not caused by asthma, and, if noted, an alternative diagnosis must be found.

Comorbidities like obesity and obstructive sleep-disordered breathing should be specifically looked for during history taking and examination as will be discussed below. Height and weight should be routinely measured at outpatient visits, especially when inhaled corticosteroids are prescribed.⁵ Measuring growth is essential, as poor linear growth may result from excessive inhaled corticosteroid dosing (leading to adrenocortical insufficiency), poorly controlled asthma, or may alternatively indicate a different or additional diagnosis.

Special investigations, as discussed in the following section, may be of use to confirm the diagnosis of asthma if there is still uncertainty after history taking and physical examination.

Investigations

Spirometry

Spirometry is particularly useful to confirm a diagnosis of asthma. While technically acceptable spirometry is possible, albeit requiring a high level of expertise in pre-school-aged children,⁶ spirometry can usually be reliably performed in children from 6 years of age onwards.

**Table 1.** Differential diagnosis of wheeze children.

Diagnosis	Clinical clues
Mechanical airway obstruction	
Airway foreign body aspiration	Symptoms preceded by a choking episode
Foreign body in oesophagus impinging on airway	Drooling and acute onset of symptoms
Tracheo/bronchomalacia	Symptoms present since birth, that may worsen following inhaled beta-2 agonist
Vocal cord dysfunction	Older children, flattening and notching of inspiratory loops on spirometry
Vascular ring	Symptoms present since birth
Airway obstruction by mass/lymph node (egg. TB)	Wheeze monophonic in nature, night sweats, weight loss
Bronchial disease	
Cystic fibrosis	Failure to thrive, persistent moist cough
Non-cystic fibrosis bronchiectasis	Digital clubbing, persistent moist cough, crepitations on auscultation
Primary ciliary dyskinesia	Runny nose from early infancy, middle ear disease, heterotaxy
Immunological disease	
Anaphylaxis	Acute onset wheeze after exposure to allergen, oedema, blood pressure drop, sudden onset pallor and lethargy in young children
Allergic bronchopulmonary aspergillosis	Index of suspicion required
Other	
Chronic aspiration airway disease	Neurological impairment, recurrent/persistent rattly breathing
Chronic lung disease of prematurity (BPD)	Premature birth
Childhood interstitial lung disease	Failure to thrive, crackles

Spirometrically proven reversible small airway obstruction, characterized by reversible scooping out of the expiratory loops, which improves after inhaled bronchodilator, strongly supports a diagnosis of asthma. An improvement in FEV₁ of $\geq 12\%$ or 200 mL is considered a significant improvement postbronchodilator. As asthma is a fluctuating disease, a normal spirometry result does not exclude asthma.⁷

Spirometry is also useful in alerting the clinician to an alternate diagnosis. For example, in a child with a low forced vital capacity, the clinician should consider restrictive lung disease. Large airway obstruction should be considered when there is flattening of the early part of the expiratory loop or when the inspiratory loop is flattened or notched.

When the diagnosis of asthma is confirmed, spirometry can be useful to monitor asthma control, especially in patients who have a tendency to underreport or underrecognize their asthma symptoms. A significant reduction in FEV₁ in a patient who usually has a normal FEV₁ is a strong indication of poor asthma control.

Bronchial challenge testing

In children where the diagnosis of asthma remains unclear following history, examination, and spirometry, bronchial challenge tests may be helpful.

Bronchial challenge testing has been standardized for use in children using various agents.⁸ Direct challenges make use of agents that directly stimulate airway smooth muscle receptors (histamine, metacholine), whereas indirect challenges (exercise, mannitol) stimulate smooth muscle via indirect pathways that may involve the release of mediators from inflammatory cells. Direct challenge tests have excellent negative predictive value and as such are useful to confidently rule out or exclude a diagnosis of asthma.^{8,9} Indirect challenge tests are less sensitive but more specific^{8,10} and hence are more useful to rule in or confirm asthma as the diagnosis. Exercise challenges are particularly useful to elicit the symptoms that the patient may experience during exercise to support or refute a diagnosis of exercise induced asthma.

Other investigations

A chest X-ray may occasionally be useful to rule out other pathology.

Allergy testing (immunoglobulin E [IgE] levels, radioallergosorbent [RAST] testing, allergy skin prick testing, or blood eosinophil counts) may be useful to support a diagnosis of atopy and to advise about trigger avoidance, as discussed below.

Exhaled nitric oxide is often cited as a marker of eosinophilic airway inflammation and poor



asthma control. However, in children, treatment regimens guided by exhaled nitric oxide levels have not been shown to be of benefit above treatment regimens guided by symptoms alone.^{11,12}

Sputum cell counts, used to differentiate between eosinophilic and neutrophilic airway inflammation, may be of modest benefit when treating adults with asthma,¹³ but benefit has not been proven in children. In addition, as time and cost issues prohibit frequent induced sputum analyses in the outpatient setting, the use of sputum analysis to guide therapy cannot be recommended for pediatric asthma management.

Asthma Severity Versus Asthma Control

The separate concepts of asthma severity and control are used to conceptualize the disease of individual asthma patients. Severity refers to the intrinsic nature of the disease and can be described as the symptom burden in the absence of treatment or as the minimum amount of pharmacotherapy required to gain symptom control.¹⁴ Asthma control refers to the nature of symptoms whilst a patient is on treatment. Hence, a patient with severe asthma can experience few symptoms and therefore have good asthma control with the avoidance of triggers and the use of high doses of inhaled corticosteroids and other drugs. Conversely, a patient with mild to moderate severity asthma may have poor asthma control and a relatively high symptom burden if the preventative medication is not taken or not taken correctly.

Management of Childhood Asthma

The aim of asthma management is to obtain symptom control, optimize the patient's asthma related quality of life,^{5,15–17} and normalize lung function in cases where baseline lung function is abnormal. Children should ideally experience no or minimal asthma-related symptoms, have little need for the use of rescue medications, have very infrequent exacerbations, and have no limitation to their daily activities including sport,⁵ and this should all be achieved using the fewest possible medications.¹⁷

The cornerstone of asthma management is pharmacotherapy, which should always occur simultaneously with the avoidance of asthma triggers and the treatment of comorbidities.

Pharmacotherapy

Short-acting bronchodilators

Inhaled short-acting beta-agonists (eg, salbutamol) should always be readily available for asthma patients for when they experience asthma symptoms. Inhaled beta-agonists are the first-line treatment for relieving symptoms of acute asthma. School-aged children should always carry a short-acting beta-agonist in their school bags and an additional short-acting beta-agonist should be kept on the school premises. As pressurized metered dose inhalers (pMDIs) should be used in conjunction with valved holding chambers, older children and adolescents often prefer taking smaller, unobtrusive dry powder beta-agonist inhalers to school. In such situations, it is important that a pMDI should also be available at the school in case of a severe asthma episode when the child may have difficulty using a dry powder inhaler. Anticholinergics such as ipratropium bromide offer little benefit as an add-on bronchodilator treatment during acute asthma exacerbations and hence have a limited role in treating bronchoconstriction in children.¹⁸ There is no role for bronchodilator syrup in pediatric asthma.

Preventer treatment

Children who experience regular asthma symptoms or exacerbations should be started on preventer treatment in addition to short-acting bronchodilator/reliever treatment. Various options are available, as presented below.

Inhaled corticosteroids

Inhaled corticosteroids form the basis of asthma preventer therapy in childhood. Inhaled corticosteroid use improves asthma symptoms and lung function, and reduces asthma exacerbations and hospitalizations.¹⁹ In children, the greater efficacy of inhaled corticosteroids over cystenyl leukotriene antagonists has been well-documented.^{20,21} Evidence for superiority of one commonly used inhaled corticosteroid over another is scant, and the majority of children who respond to one inhaled corticosteroid will also respond to other inhaled corticosteroids. While there will be rare individuals who respond better to a particular inhaled corticosteroid, the most common reason that children do not respond to their



treatment is that they are either not taking it as prescribed or their device technique is poor.

Inhaled corticosteroids are usually prescribed for regular, daily, or bidaily use. There is some evidence in young children that intermittent high dose use of inhaled corticosteroids (ie, a 2-week course initiated at the start of an exacerbation) is not inferior to daily inhaled corticosteroids and may lead to lower steroid exposure than daily regimens.^{22,23} As discussed in a recent review,²⁴ both the long-term daily use and intermittent use of inhaled corticosteroids in prepubescent children may be associated with a delay in linear growth. The modest delay appears not to be progressive or cumulative but may persist as a reduction in final adult height. The risk versus benefit of inhaled corticosteroids treatment for asthma needs to be considered on a case-by-case basis as uncontrolled asthma is not only associated with significant morbidity but also associated with growth impairment.

Long-acting beta-agonists in combination therapy

Long-acting beta-agonists can be used in combination with inhaled corticosteroids as step-up treatment when symptoms are not controlled by inhaled corticosteroids alone.⁵ The use of long-acting beta-agonists as monotherapy is associated with increased mortality in adults and should therefore also be discouraged in children.^{25,26} The safety data on long-acting beta-agonists in young children, even when used in combination with inhaled corticosteroids, is unclear.²⁷ Long-acting beta-agonists, even in combination with inhaled corticosteroids, should therefore not be used as a first-line treatment in the management of asthma.^{5,27}

Cystenyl leukotriene antagonists

Montelukast has been proven to be effective in the treatment of pediatric asthma and provides a therapeutic alternative for patients with mild persistent asthma, exercise-induced asthma, and aspirin-sensitive asthma.^{5,16,28} It can be particularly helpful for individuals with coexisting allergic rhinitis and other allergies. For moderate to severe persistent asthma, montelukast is inferior to inhaled corticosteroid treatment.^{20,21} The oral administration of montelukast offers an advantage in individual children where inhaler use is problematic. The favourable side effect

profile of montelukast makes it an excellent treatment choice where asthma can be well-controlled without the need for additional treatment. Montelukast can also be used as an add-on therapy to inhaled corticosteroids.²⁹

While the vast majority of children with asthma will achieve good symptom control with the use of inhaled corticosteroids with or without additional long-acting beta-agonists or leukotriene antagonists, there are a small number of children with severe asthma who need to try additional treatment options. These include the following treatments.

Cromones

Nedcromil sodium and sodium cromoglycate can be helpful in the management of individuals with severe exercise induced asthma.^{5,28} The need for 4 times a day dosing limits the use of cromones in clinical practice.

Theophylline

Oral theophylline is a bronchodilator with additional anti-inflammatory properties.³⁰⁻³² The routine use of theophylline is limited by side effects and a narrow therapeutic index. Measurement of plasma theophylline levels is indicated when doses higher than 10 mg/kg per day are prescribed.⁵

Omalizumab

Omalizumab is an anti-IgE antibody that is administered by regular (ie, fortnightly) subcutaneous injections. Omalizumab reduces symptoms and exacerbations and improves lung function as well as quality of life in children with atopic asthma.³³⁻³⁵ The use of omalizumab should be reserved for children where asthma control cannot be maintained by other medications.¹⁷

Treatments rarely considered for use in severe asthma

Methotrexate, cyclosporine, azathioprine, mycophenolate mofetil, anti-TNF alpha, interferon gamma, and mepolizumab (anti-IL-5) are drugs that are very rarely used in asthma that does not respond to conventional therapy. As the potential side effects of these drugs can be severe and evidence for the efficacy of these drugs in pediatric asthma is scant, they are only rarely prescribed by pediatric respiratory specialists running "difficult asthma" clinics.



Prescription of parent-initiated oral corticosteroids for home use

Regular systemic corticosteroids are not routinely used in asthma management in the outpatient setting. The prescription of short courses of oral prednisolone for parents to administer at the start of an asthma exacerbation can be considered. In a robustly designed study of school-aged asthmatic children, parents administered a short course of oral prednisolone or placebo when their children's asthma symptoms flared up.³⁶ Parents were directed as follows: "If from previous experience you suspect this is a more severe attack, or if the symptoms are not getting better in about 6 to 8 hours with regular use of reliever medication, give your child the study medication immediately." Home administered prednisolone use resulted in fewer asthma symptoms, less health resource use, and a reduction in school absenteeism. The authors did conclude that the "modest benefits of this strategy must be balanced against potential side effects of repeated short courses of an oral corticosteroid."³⁶ Parent-initiated oral corticosteroids do not appear to be of benefit for treatment of viral-induced wheeze episodes in preschool-aged children.³⁷

Asthma monitoring

Children with asthma should be monitored regularly to reassess asthma control and fine-tune treatment. Tools to determine asthma control, for example, asthma symptoms, spirometry, and biomarkers have been mentioned above. A distinction between current impairment and future risk needs to be made.¹⁷ Current impairment is usually determined by symptom burden. International guidelines generally describe good asthma control as having ≤ 2 episodes of daytime symptoms per week, ≤ 2 episodes per week where rescue medication is used, ≤ 1 episode per month of nighttime awakenings for asthma symptoms, and no limitation of daily activities.¹⁷

Standardized questionnaires offer objective measures of current impairment. The Asthma Control Questionnaire (ASQ) and the Asthma Control Test (AST) are the two questionnaires that are best validated for use in pediatrics.³⁸ Results from both questionnaires correlate strongly. An advantage of using standardized questionnaires to assess asthma control is that the questionnaires can be administered to both

the parents and the child, as parents often underestimate their children's asthma symptoms.³⁸

Lung function testing offers an objective physiological marker of asthma control. An $FEV_1 < 80\%$ predicted is considered a marker of suboptimal/poor asthma control. Lung function should only be performed and interpreted where the necessary expertise is available.^{6,39}

Home peak expiratory flow measurement, as a marker of airway obstruction and reactivity, has been shown to often be unreliable in children.⁴⁰ However, there may be a role for the use of regular home peak expiratory flow measurements in children as an aid to reduce underperception of symptoms and to increase adherence to prescribed medications.⁴¹

Asthma risk can be estimated by the number of exacerbations per year and side effects of medication.¹⁷ One exacerbation per year can still be considered as low risk, whereas having had two or more exacerbations per year is considered medium to high risk. Children often have few interval symptoms but regular exacerbations. Asthma exacerbations are associated with a decline in lung function, which is accelerated in patients not treated with inhaled corticosteroids.⁴²

Stepping up and stepping down therapy

The stepping up and stepping down of asthma therapy at outpatient visits is based on asthma control,¹⁷ interval symptoms, and risk.

If a patient's asthma is not well controlled and trigger avoidance and adherence to prescribed treatment have been considered and device technique has been checked, then the stepping up of pharmacotherapy should be considered. In a patient being treated with low dose inhaled corticosteroids the following options can be considered: increasing the dose of inhaled corticosteroids, adding a long acting beta-agonist, or adding montelukast. Optimal response to the choice of step-up treatment will vary between individual patients, and asthma control is likely to improve with any of the step-up regimens.²⁹

As asthma should be treated with the minimal amount of treatment that maintains control of symptoms, after control has been achieved, the stepping down of treatment should always be considered after a period (± 3 months), bearing in mind how prone the



individual patient is to experiencing exacerbations.¹⁷ Treatment should be tailor-made for individual patients, that is, after discussion with the child and family, one may choose to keep an asymptomatic child on preventer treatment over the winter if they have previously experienced troubling asthma symptoms during that time of year.

Delivery systems for inhaled therapy

The main delivery devices used to deliver inhaled therapy to the airways in children with asthma are pMDIs with valved holding chambers, dry powder inhalers, and nebulizers. Each delivery method has specific advantages and disadvantages.

pMDIs should always be used with valved holding chambers in children as the use of valved holding chambers greatly improves drug delivery to the airways. Conversely, the use of pMDIs without holding chambers often result in very poor drug delivery in children. They offer the advantage of rapid drug delivery and can be used in very young children. Children as young as 2 years of age can be taught to use the mouthpiece of a holding chamber,⁴³ but guidelines still advocate for the use of a mask on a holding chamber for children under 4 years of age.⁵ As the content of the pMDI is under pressure,⁴⁴ contamination by microbes can be ruled out. Drug delivery via holding chamber can be greatly reduced by the buildup of electrostatic charge over time.⁴⁵ Metal holding chambers and plastic holding chambers made of anti-static polymers are less susceptible to the buildup of electrostatic charge. In Britain and Australia, parents are encouraged to wash plastic holding chambers in a mild detergent solution every 2 weeks in order to reduce electrostatic buildup.^{16,28}

Dry powder inhalers are small and inconspicuous but can only be effectively used in children old enough to generate 30 to 60 litres per minute on inhalation through the inhaler.⁴⁶ Hence dry powder inhalers are usually reserved for use in children older than 6 years of age.⁵

Because of their size and bulkiness, the need to clean regularly, the time taken for drug delivery, and little to no clinical benefit over other delivery systems, nebulizers are not recommended or commonly used for the delivery of asthma preventer medications and should not be seen as first-line delivery devices.¹⁷

Importance of correct technique

Correct device use and inhalation technique is crucial for optimal aerosol drug delivery. Inhalation technique in children is often suboptimal even after instruction.⁴⁷ Device technique should be checked regularly in the outpatient setting, as patients' device technique is known to deteriorate over time.⁴⁸

Basic steps in pMDI-holding chamber use to consider are described in this section.

The pMDI of certain drugs should be shaken just before actuation in order to mix the drug with the propellant.⁴⁹ Drugs like HFA-fluticasone separate from the propellant in the canister soon after shaking.

The time delay between actuation of the pMDI and inhalation through a holding chamber should be minimized as time delay reduces the available dose.⁴⁵ Ensure that the patient's lips form a seal around the mouthpiece and that the patient's teeth are not in front of the mouthpiece opening. Where a facemask is used, ensure a good seal between the mask and the patient's skin.⁵⁰

Single maximal inhalation with breath hold, the preferred inhalation technique in adults, may not be better than tidal breathing/panting through a holding chamber.⁵¹ Children up to the age of 6 years may not be able to perform a single maximal breath on demand.⁵² In younger children, slow tidal breathing should be encouraged. Two to 3 tidal breaths are all that are required to empty most holding chambers.⁵²

Where more than 1 actuation is required, additional actuations should follow inhalation of the initial dose and repeated shaking of the pMDI.⁵³ Rapid repeated actuations in a holding chamber cause aggregation of aerosol particles with reduction in drug delivery to the airways. A review on correct device use for different inhaler devices has recently been published.⁵⁴

Adherence to prescribed treatment

Nonadherence or poor compliance with prescribed treatment is a major reason for suboptimal asthma control that should always be considered in the outpatient setting.⁵⁵ Variation in the level of adherence is extreme in children with asthma.^{56,57} Parental report of adherence only provides health care providers with a very modest degree of insight into their patient's adherence.⁵⁷ Methods for detecting nonadherence



include checking pharmacy records, weighing pMDI canisters, and use of electronic adherence monitors, although such approaches are seldom used in clinical practice. Electronic adherence monitors provide the gold standard for adherence measurement, and certain devices providing reminders to patients to use their medications at preprogrammed intervals appear to improve adherence.⁵⁸

Reasons for nonadherence are complex. Barriers to adherence include concerns about medication side effects and cost, mistrust in the prescribing doctor or the medical system, and beliefs that the patient's asthma is not severe enough to warrant regular treatment.⁵⁹ Adherence tends to be better in children from families with good medication routines whereas family dysfunction is associated with poor adherence.^{60,61} Medication nonadherence is also correlated with lower knowledge about asthma.⁶¹ Socioeconomic status appears to have an influence on adherence, with lower adherence reported in children, but not adolescents, from low-income families.⁶²

Children are dependent on their parents for the administration of their medication. Parents sometimes pass the responsibility of medication administration on to the child before the child is old enough to take the responsibility. In addition to asking about adherence, health care providers should ask about medication routines and who takes responsibility for them.

A recent study demonstrated improved adherence and symptom control in adolescents after an 8-week long school-based intervention program.⁶³ Adherence has also been shown to improve in children when their parents are provided with a written asthma action plan.⁶⁴

Action plans

The outpatient setting is an ideal opportunity to ensure that a patient has an asthma action plan. All asthma patients or their parents should be well-informed on the best way to manage exacerbations. A written action plan provides the necessary information for exacerbation management in an easily accessible format for use in an emergency.⁶⁵ Individualized written action plans are associated with improved asthma outcomes.⁶⁶ For school-aged children, a copy of the action plan should be provided to the school.

Avoidance of triggers

At each consultation, the avoidance of asthma triggers and the patient's home environment and lifestyle should be considered.^{5,15,16} While viral respiratory infection, the most common trigger of asthma exacerbations,^{3,67} cannot easily be avoided, exposure of children to secondary tobacco smoke can be avoided. Appropriate counseling and support regarding smoking cessation should be provided to parents and adolescents where appropriate.

Previous studies have demonstrated that taking atopic children with severe asthma out of their usual environment to a low allergen (high altitude) environment improves asthma control and airway reactivity and reduces airway inflammation.^{68,69} Recent evidence suggests that for the vast majority of children with asthma, benefits of allergen avoidance are small. Hence, while allergy testing may occasionally be helpful for individual patients with atopic asthma, the evidence for house dust mite and pet avoidance strategies as a management strategy of asthma remains weak,⁷⁰ and the avoidance of grass or tree pollen exposure is not usually practically feasible. As food allergens rarely play a role in asthma, dietary changes are not part of routine asthma management.

Acetaminophen use has been associated with the development of asthma as well as asthma symptoms.^{71,72} However, the association is limited to data from epidemiological studies, and acetaminophen has not been demonstrated to have a causative role in asthma. Hence, with current evidence, acetaminophen avoidance cannot be recommended in children with asthma.

Comorbidities associated with poor asthma control

Asthma control with the lowest possible dose of medication is best obtained when comorbidities associated with asthma are managed.

Allergic rhinitis

A strong association exists between asthma control and allergic rhinitis. Allergic rhinitis is common among asthma sufferers, and treatment of the rhinitis has a beneficial effect on asthma control.⁷³ Allergic rhinitis is both underdiagnosed and undertreated in pediatric asthma.⁷⁴ In children with atopic asthma and chronic allergic rhinitis, immunotherapy is a treatment option⁷⁵



especially as the long-term use of nasal steroids in conjunction with inhaled corticosteroids would have a cumulative effect on side effect profile.

Obstructive sleep disordered breathing

Obstructive sleep disordered breathing is common in children with poorly controlled asthma.⁷⁶ Observational data suggest that management of obstructive sleep disordered breathing by adenoidectomy in children with asthma is associated with markedly improved asthma outcomes.⁷⁷ Children with poorly controlled asthma should therefore be assessed for obstructive sleep disordered breathing. The management of sleep disordered breathing in children is discussed in detail elsewhere.⁷⁸

Vitamin D deficiency

Vitamin D plays a complex role in immune regulation, and there are associations between vitamin D and lung function, markers of inflammation, and response to corticosteroids.⁷⁹ Epidemiological and in vitro studies have demonstrated that vitamin D deficiency is associated with increased asthma severity and exacerbations.^{80,81} Vitamin D sufficiency in asthmatic children treated with inhaled corticosteroids is associated with improved lung function.⁸² Therefore, vitamin D levels should be monitored and insufficiency treated in children with asthma.

Avoidance of treatment that is of no benefit or potentially harmful

Treatments that are of no benefit and that may cause harm should be avoided.

Proton pump inhibitors

Untreated gastroesophageal reflux has been postulated to be an aggravating factor in children with asthma. Symptoms of gastroesophageal reflux are common in asthma patients⁸³ and proton pump inhibitors are commonly used to treat these symptoms.⁸⁴ In adults, the use of proton pump inhibitors appears to modestly improve asthma symptoms in patients who have symptoms of gastroesophageal reflux disease.⁸⁵ A high quality randomized controlled trial⁸⁶ performed in children showed no benefit of the use of proton pump inhibitors in the management of children with poor asthma control

in spite of inhaled corticosteroid use. A subgroup of children with proven gastroesophageal reflux (diagnosed by esophageal pH monitoring) did not show any improvement in asthma control in spite of 24 weeks of treatment with a proton pump inhibitor. Notably, the group treated with proton pump inhibitors had a 6-fold increase in activity-related bone fractures. The use of proton pump inhibitors cannot therefore be recommended for the treatment of pediatric asthma.

Alternative medicine

Parents of children with chronic disease often explore alternative medicine options. An awareness of available alternative medicine options is useful for clinicians managing children with asthma. Commonly used treatments include chiropractics, osteopathy, homeopathy, herbal medicines, use of salt rooms, yoga, and breathing exercises, among others. With the exception of breathing exercises, none of the therapies mentioned above have been shown to be of any clinical benefit as asthma treatments in rigorously designed scientific studies.⁸⁷⁻⁸⁹ Alternative treatments tend to be costly and are not without risk.

Breathing exercises have been shown to modestly improve asthma symptoms and reduce preventer use in adults with asthma.⁹⁰ Improved patient engagement in asthma management during the studies and an increased ability to relax during breathing exercises are thought to have played a role in the reduction of symptoms, as physiological markers of disease did not improve in studies where the effect of breathing exercises on asthma were evaluated. There is not enough evidence to recommend breathing exercises for the routine treatment of pediatric asthma.

Asthma Education and Partnership With the Child and Family

In order to achieve optimal health outcome, a functional partnership needs to be established between the doctor and the child-parent unit.¹⁷ The child and/or parent should be empowered to understand the basics of asthma pathophysiology, clinical course, and prognosis. The patient should understand the effect of treatment and the importance of adherence to medication during symptom free periods. Potential treatment side effects should be discussed openly



so that parental concerns can be addressed. Asthma education is a continuous process needing regular repetition, especially when considering the practical aspects of device use.

With a well-functioning doctor-patient partnership the majority of children with asthma can be effectively managed with low dose preventative treatment. Regular review of the basics (ie, inhaler technique, adherence to treatment, trigger avoidance, comorbidities) is the key to providing good clinical care for children with asthma.

Author Contributions

Wrote the first draft of the manuscript: AS. Contributed to the writing of the manuscript: ACM. Jointly developed the structure and arguments for the paper: AS, ACM. Made critical revisions and approved final version: AS, ACM. All authors reviewed and approved of the final manuscript.

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