EXPERT REVIEWS

Management of acute asthma exacerbations in children

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The management of acute asthma exacerbations in children remains controversial and the latest guidelines (Expert Panel Report [EPR]-3 2007 and the Global Initiative of Asthma 2008) leave several questions unanswered. This review summarizes the most up-to-date information on the practical prevention and control of asthma attacks in children, and describes the 20-year experience of a major tertiary asthma clinic with the administration of inhaled corticosteroids in this setting. The following subjects are discussed: the knowledge and skills required by the parents regarding asthma and its treatment, how to prevent or minimize exacerbations in asthmatic children, the drugs used in the treatment of exacerbations and their order of administration, and the steps to follow after discharge from the emergency department or after a severe asthma exacerbation. The efficacy of inhaled corticosteroids in the management of acute asthma exacerbations in children, both at home and in the emergency department, is discussed in detail. The goal of asthma-management programs is to arm parents with the skills and knowledge to prevent, detect and successfully control most exacerbations of asthma in children at home.

Keywords: asthma exacerbation • children • inhaled corticosteroid • management

Exacerbations of asthma, manifested by a temporary worsening of symptoms, form part of the natural history of the disease, although they may also represent a failure of ongoing long-term therapy. Acute asthma accounts for 1.5–2 million visits to the emergency department (ED) per year [1]. In total, 10–20% of patients who present to the ED with acute asthma will require hospitalization [2] and 12–16% of patients discharged from the ED after initial treatment will require additional interventions within 2 weeks [3,4]. The exacerbations present differently in children and adults. The aim of this review is to summarize the most up-to-date practical information on the control and prevention of asthma exacerbations in children, with special consideration of the very young age group. The knowledge and skills required by the parents, the importance of the parent–physician partnership, the preferred drugs for treatment and their order of administration and the steps to take during follow-up are discussed. Findings on the efficacy of inhaled corticosteroids at home and in the ER are reviewed in detail.

What parents should know about asthma

It is essential that the parents of a child with asthma be armed with reliable information on the causes and control of the disease, even before the first visit to the specialist. Physicians should advise parents of the professional online educational discourses available, such as the one provided by our website [101] and by international websites [102,103], which serve as excellent sources of data. For parents without internet access, the discourses are usually available on disk. Parents should also avail themselves of the lectures and counseling services offered by physicians and asthma nurse educators, either individually or in groups. They might also seek out articles and research papers in the field.

Asthma discourses and educational sessions provide background information on the disease, including the anatomy of the lungs, the breathing process, changes that the bronchi undergo during an asthma attack, the relationship between allergic inflammation and bronchoconstriction, and the symptoms of asthma (coughing, wheezing and difficult breathing). They describe the various external and internal triggers of asthma exacerbations, namely house dust mites, pets, cockroaches, cigarette smoke, air pollutants, stress and physical disease, so that parents can take the appropriate measures to prevent exposing their child to them. They teach parents to recognize the early signs of

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asthma exacerbations and to know when to start treatment, and they describe the different drugs available and their protocols of administration. Finally, they emphasize the proper use of inhalers and spacers. On an individual basis, clinicians should be careful to take specific cultural, religious, educational, psychological and economic factors into account, as well as health beliefs and attitudes.

Enhancing parental adherence

Studies have shown that patient information programs alone are insufficiently effective in improving the self-management of asthma, and that simply providing medical information may not make the patient change erroneous habits, beliefs and attitudes [5]. To ensure adherence, parents must be made to understand that 'episodes of coughing and wheezing' are indeed asthma exacerbations and that the treatment the physician has prescribed is appropriate, free of side effects and nonaddictive. This can be carried out only in the setting of a solid and trusting physician–parent partnership, starting from diagnosis. Physicians should assure the parents that they are experts in the field of asthma, that they have at hand the optimal data defining the health status of their child and that their judgment should be followed to achieve the best outcome. A good physician–parent relationship should be maintained at every step of medical care. It is also important that the treatment regimen be kept as simple as possible (minimal number and doses of medication), that the instructions are clear and concise and that the parents are well-instructed in the use of inhalers and devices. The physicians should also provide the parents with a written asthma action plan for regular treatment and for treatment during acute asthma exacerbations, and carefully explain to the parents that, at the first signs of an asthma attack, they are to immediately start treatment, as directed, at home.

Preventing asthma exacerbations

Good management may prevent most asthma exacerbations. The first step is to guide the parents in ways to ensure that their child avoids exposure to the many triggers that can cause an asthma attack:

- Cold viruses: every upper-respiratory tract viral infection in a young asthmatic child can cause an asthma attack. Parents should exert the greatest efforts in preventing their asthmatic child from catching a cold by choosing a school with a small number of children, making sure that the child does not visit friends with a cold or that friends with a cold do not come to play with him/her, and by separating the child from a sibling with a cold, especially if they share the same room. If their asthmatic child wakes up with a cold and manifests the first signs of an asthma attack, the parents must immediately start treatment with anti-asthma drugs;
- Changes in the weather: dry or cold air that enters the lungs can cause or aggravate an asthma attack. Parents should use air conditioners for cooling and heating with caution, because both induce dryness of the air;
- Intense physical activity: this trigger applies more to older children. Physical exertion can lead to shortness of breath and an asthma attack. The risk is increased in cold or dry weather. Bronchodilators taken before or immediately after physical activity can prevent the exacerbation;
- Allergens in the environment: all kinds of substances in the environment, both inside and outside the home, can enter the airways and cause an asthma attack. Parents should try to prevent their child from being exposed to these triggers. The main trigger of asthma attacks inside the house is dust mites, found in most sheets, covers, pillowcases and mattresses. Parents should use bedding made of specific materials and should change and wash their bedding frequently. Other important triggers are cigarette smoke and animal danders. Outside the house, children with asthma may be affected mainly by tree, grass or flower pollens and also by smoke;
- Psychosomatic factors: extreme emotional states can trigger an asthma attack. Parents should learn ways to help their child handle stress more effectively and teach them suitable coping techniques.

Identifying the start of asthma attacks

An asthma exacerbation is defined at our clinic according to the revised Global Initiative for Asthma (GINA) guidelines [6] as a sudden, progressive increase in asthma symptoms: shortness of breath, cough, wheezing and chest tightness, alone or in combination. In our experience, parents who have undergone asthma education are well versed in the early signs of an asthma attack and have learned to use the anti-asthma drugs according to a clear treatment plan will be able to initiate treatment early at home and thereby control most of their child's asthma attacks without the need for ED care or hospitalization. We advise parents to initiate treatment during an upper-respiratory infection with a runny nose combined with more than five to ten episodes of coughing. They are encouraged to compare all events of respiratory infection with previous asthma attacks to become familiar with the appearance of the onset of an attack. Studies by our group showed that, when parents followed these instructions, they were able to control 85–94% of their childrens' attacks at home [7–9].

Treating acute asthma exacerbations

The treatment of acute asthma in the ED consists of oxygen, especially in very young children, accompanied by β_2-agonists and followed by corticosteroids.

Oxygen

Humidified oxygen is administered as the first-line treatment for acute asthma to ease breathing difficulties [10]. In addition, oxygen must always accompany the administration of β-agonists, delivered by air compressors, to offset the further aggravation of hypoxemia by their bronchodilator action and the consequent enhanced perfusion of the relatively poorly ventilated area of the lung (ventilation–perfusion mismatch) [11,12]. Studies have

shown that an initial oxygen saturation of 91% or less in room air is a good predictor of a poor outcome requiring hospitalization in young infants [13], and that patients with an initial saturation of 95% or greater rarely relapse after discharge [14]. Oxygen should be administered by a mask to maintain oxygen saturation at more than 95% [15], or as close as possible to normal values (96–100%) [16].

Bronchodilators

β_2-adrenoceptor agonists are effective bronchodilators with a rapid onset of action [17], and their use in the initial phase of acute asthma is essential. They can be administered alone only in mild cases and only in children without a previous history of acute asthma exacerbation. Otherwise, inhaled β_2-agonists are given together with oral or inhaled corticosteroids. In very young children, or in children with severe obstruction of the airways (i.e., oxygen saturation below 92%), wet nebulization with humidified oxygen is the preferred method of administration, because of the uncertainty of delivery via spacers and inhalers [18]. However, in older children, if the attack is not severe enough to warrant treatment with oxygen, inhalers and spacers may be equally effective [19–24]. One randomized study reported that children treated with an inhaler and spacer had a significantly shorter stay in the ED than children treated with nebulization, in addition to a lesser increase in pulse rate and fewer episodes of vomiting. Furthermore, the results of a Cochrane review including 2066 children and 614 adults from 25 trials in emergency rooms and community settings indicated that metered-dose inhalers (MDIs) used with a spacer yielded outcomes at least as good as those for nebulizer delivery [21]. Starting children on the MDI and spacer in the ED or during hospitalization makes it easier to continue at-home management and long-term prophylaxis; it is also less expensive [22]. At our out-patient clinic, inhaler treatments are given only for the first 2–4 days of our 4- or 8-day protocols (depending on the severity of the attack) (Table 1). We have found this relatively short treatment with inhaled β_2-agonists to be very effective, as described in several of our publications [7–9,25]. The number of treatments should be adjusted according to the individual patient response [21]. Nebulization is performed every 20 min for the first 3 h at a dose of 0.15 mg/kg, provided that the maximum dose does not exceed 10 mg every 1–4 h [26]. The recommended dose for the MDI with holding chamber is four to eight puffs every 20 min for the first 3 h, and then once every 1–4 h, as necessary [26]. Parenteral β_2-agonists may be considered in patients who fail to respond to inhaled or subcutaneous therapy [27].

Subcutaneous epinephrine or terbutaline has been found to have no advantage over inhaled β_2-adrenoceptor agonists, except in uncooperative patients [28]. Continuous nebulization of albuterol may be associated with adverse events, such as muscle cramps, hypokalemia and hyperglycemia [29], and should be considered before institution of parenteral β_2-agonists or mechanical ventilation only in the hospital setting and only in patients at risk of significant obstruction. The 2007 Guidelines for the Diagnosis and Management of Asthma of the Third Expert Panel Report (EPR-3) [26] recommend inhaled ipratropium bromide for use in the ED but not in the hospital, and only in addition to β_2-agonists. The addition of multiple high doses of ipratropium bromide 0.25–0.5 mg nebulizer solution or four-to-eight puffs by MDI has been found to cause additional bronchodilatation [30]. Intravenous magnesium sulfate may be beneficial [31], but should be considered only in children with life-threatening exacerbations being treated with bronchodilators and steroids [26]. The EPR-3 [26] did not recommend the use of methylxantine (Aminophiline®), mucolotic agents, antibiotics, aggressive hydration or chest physical therapy. Theophylline has no additional benefit.

Corticosteroids

Systemic corticosteriods

The early intake of systemic corticosteroids by the intravenous, intramuscular or oral route for acute asthma has been found to reduce hospital admission rates by 60% and the risk of relapse in both children and adults [32–34]. In a recent review, Rachelefsky found oral corticosteroids to be effective for the outpatient treatment of recurrent, acute asthma episodes in children [34]. Both the EPR-3 [26] and GINA [15] guidelines recommended the early use (within 24 h) of systemic corticosteroids 0.5–1.0 mg kg/ day or equivalent in the acute setting in children, and Rowe *et al*., in a meta-analysis of 12 randomized controlled trials, reported that the administration of corticosteroids within 1 h of ED admission was beneficial in patients with severe asthma and those not receiving steroids at the time [32]. In another trial, a short course of 1–2 mg/kg/day corticosteroids in patients with acute asthma exacerbations led to a significant decrease in the number of relapses and in β_2-agonist use, without an apparent increase in side effects [35]. Comparative studies found a single dose of intramuscular corticosteroids in addition to β_2-agonist, to be as effective as oral corticosteroids [32,36]. It significantly reduced the hospital admission rate [36] and prevented relapse and reduced β_2-agonist use at discharge from the ED [32]. There was no difference in the rate of hospitalization between children with severe attacks treated with intravenous or oral methylprednisolone [37].

It is well accepted that, in children, short courses (3–5 days) of systemic corticosteroids administered one- to two-times a year are usually safe. However, at high doses, oral corticosteroids, even when administered intermittently, can cause adverse effects [25,38–43]. The two most severe side effects are impeded height growth and depressed serum cortisol concentration [42]. Others include thrush and a significant state of restlessness, especially with methylprednisolone. Prednisolone is associated with fewer adverse effects, but it is prescribed much less frequently for young children because it is not soluble in water and has a very bad taste [43].

Inhaled corticosteroids

Both the GINA [15] and the EPRP-3 [26] guidelines claimed that too few placebo-controlled studies had been conducted to reach definitive conclusions regarding the effectiveness of inhaled corticosteroids in the management of acute asthma exacerbations, either in adults or children. Since then, however, three reviews

Table 1. Treatment plan for the use of budenoside 200 µg and fluticasone 125 µg inhalers.

At the beginning of asthma attack or when starting preventative treatment		Administer first	Followed by		
		Terbutaline (blue) or Ventalin (green) – opens the airways	*Budenoside 200 µg (brown) or Fluticasone 125 µg (orange) – keeps them open*		
Regular treatment (mild attack) – 4-day protocol	*Enhanced treatment (severe attack) – 8-day protocol*	*Number of puffs to be taken (one after the other)*		*Number of times per day*	*At interval of*
To be taken on day:	*To be taken on day:*				
Day 1	Day 1 and 2	2 (both protocols)	1 (4-day protocol) 2 (8-day protocol)	4	3–4 h
Day 2	Day 3 and 4	2 (both protocols)	1 (4-day protocol) 2 (8-day protocol)	3	4–5 h
Day 3	Day 5 and 6	2 (both protocols)	1 (4-day protocol) 2 (8-day protocol)	3	4–5 h
Day 4	Day 7 and 8	2 (both protocols)	1 (4-day protocol) 2 (8-day protocol)	2	12 h
After the 4th day (regular treatment) or 8th day (enhanced treatment): [ ] Stop treatment or continue as on day 4 or 8 for several additional days [ ] Continue treatment as on day 4 or 8 for a period of __weeks or months [ ] If no attacks occur, reduce treatment to once daily for another __weeks/ months [ ] Visit the clinic for follow-up in __weeks/months, or during uncontrolled attack					
For users of a spacer: Nebuchamber® (metallic) or Aerochamber® (plastic) [ ] With face mask: after each puff keep the mask tight for a period of half a minute [ ] With mouthpiece: after each puff, breathe deeply and slowly in and out three to five-times					
[ ] Bring your spacer and all your inhalers to each follow-up visit [ ] Updated information about asthma can be found at www.volovitz.co.il					

and several additional publications have provided supportive data [9,44–46]. Unfortunately, until now, no drug company or international institute has conducted a large-scale well-controlled study to finally elucidate this issue. In spite of these recommendations, many pediatricians and general practitioners recommend an increase in the dose of inhaled corticosteroids at home during asthma exacerbations [47]. In this review, the accumulating evidence of the effectiveness of inhaled corticosteroids in the management of acute asthma exacerbations in children will be presented [9,44–46].

Inhaled corticosteroids have the important potential advantage of direct delivery to the airways, which substantially reduces the risk of the adverse systemic effects of the oral route [25,41–43,48–51]. Other advantages are an apparently more rapid action of the drug, as documented in both adults and children with severe asthma [52,53], and enhanced responsiveness to concomitant β_2-agonists [54]. Studies have shown that, even at high doses, inhaled budesonide was not associated with a decrease in plasma cortisol concentration, either when fasting at 8 am or 1 h after adrenocorticotropic (ACTH) stimulation; nor did it affect the diurnal variation of serum cortisol [55]. Moreover, 5 years of treatment in young children did not impair growth [56]. De Benedictis *et al.* reported that 10 days' administration of nebulized budesonide 500 µg or fluticasone 250 µg was not associated with hypothalamic–pituitary–adrenal (HPA) axis suppression [57].

Horvath and Wanner [58], and Rhen and Cidlowski [59] attributed the more rapid action of inhaled corticosteroids to their nongenomic effect, as opposed to the action of oral corticosteroids, which involves genomic transcription. However, the effect of inhaled corticosteroids may be more transient: Mendes *et al.* noted that the acute vasoconstriction induced by inhaled corticosteroids lasted only 2 h, even with high doses [60]. The improved clinical response may be explained by the possible direct effect of the inhaled drug on the mucosal blood vessels [60], in addition to its effect on plasma exudation and bronchial secretion [61]. Despite the theoretical advantages of using inhaled corticosteroids to treat asthma exacerbations, their role in the treatment of children is still controversial. Two studies failed to show beneficial effects of inhaled corticosteroids in this setting [62,63]. However, both included children with extremely constricted airways (mean forced expiratory volume in 1 s of 45 or 50–79%, respectively), in whom systemic corticosteroids are clearly preferable. Recently, three evidence-based reviews reported that repeated high doses of inhaled corticosteroids are very effective in controlling acute asthma exacerbations in both adults and children [44–46], and a

Cochrane review suggested that the early use of inhaled corticosteroids reduced hospital admissions and improved pulmonary function compared with placebo [64]. McKean and Ducharme, in an evidence-based review of the literature, suggested that episodic treatment with a high dose of inhaled corticosteroids is beneficial for mild, virally induced wheezing in children [65]. Several other randomized double-blind studies in the emergency setting yielded similar findings when comparing oral prednisolone with various inhaled corticosteroids, such as budesonide [25,66–68], fluticasone [69], flunisolide [70] and dexamethasone [50], administered with various devices, namely nebulizer [50,67,68,70,71], turbohaler [25] or MDI and spacer [66,70]. Good results were also reported in more specific double-blind studies of children with wheezing due to respiratory infections [72–74]. In all studies in which inhaled corticosteroids were found to be effective, the dosage was at least quadrupled [7,9,25,69–71,75]: budesonide 2400 µg via nebulizer [67]; budesonide 2000 µg via nebulizer [68]; budesonide 1600 µg dry powder inhaled [25]; dexamethasone 1.5 mg/kg via nebulizer [71]; budesonide 1200 µg via MDI with spacer [66]; and fluticasone 1000 µg via nebulizer [69]. Recently, De Benedictis *et al*. found that, in children, a short course of nebulized fluticasone had the same effects as a double dose of nebulized budesonide when either drug was added to bronchodilator therapy [57].

Our clinical experience with inhaled corticosteroids

Inhaled budesonide has been used in our out-patient clinic for the treatment of acute exacerbations of asthma in children since 1987. Our clinical experience has been described in various publications [7–9,25,56,76]. We found that by using high starting dosages of budesonide in children aged 1–14 years, parents were able to control 1001 out of 1061 asthma exacerbations at home [7]. In a recent study of treatment with high starting doses of budesonide (1600 µg) or fluticasone, (1000 µg) for 4–8 days, 86% of 237 asthma exacerbations were successfully controlled [9]. In this study, simply doubling the dose in the mildest cases was effective. These results, which contrast with the findings of Garrett *et al*. [77], may be explained by the good adherence to treatment of our patients owing to our extensive asthma education program and our careful instructions to the parents to start treatment immediately at the early signs of an attack.

In another study, we demonstrated that, in children who presented to the ED with moderately severe asthma attacks, treatment with high-dose inhaled corticosteroids conferred similar benefits to oral corticosteroids in all parameters evaluated: spirometry, pulmonary indices, wheezing, accessory muscle use and oxygen saturation [25]. Similar to the systemic route, these effects of the inhaled route were noted already within 1 h of treatment and led to the same symptom score after 4 h [25]. During the first week after discharge, the symptom scores of the children treated with inhaled budesonide improved more quickly than with oral prednisolone [25].

We employ three protocols for the control of asthma exacerbations with inhaled corticosteroids (**Table 1**) [7–9,25,56,76]:

- A 4-day protocol is used for children starting treatment with inhaled corticosteroids and for children with relatively mild exacerbations. We encourage the parents to start the protocol at the first signs of an asthma exacerbation (usually coughing in the early stages of the common cold with runny nose). Children aged younger than 1 year are started at higher doses, using the 8-day protocol;
- An 8-day protocol is used for children who do not respond to treatment with the 4-day protocol and children with moderate-to-severe exacerbations, with more significant cough, dyspnea or wheezing. We advise parents of children aged less than 1 year with severe exacerbations to refer to the ED for oxygen, because the administration of β_2-agonists alone in this age group could worsen the hypoxemia [11];
- An 8-day plus azithromycin or doxycycline protocol is given to children who do not respond to the 8-day protocol, and children in whom infection with an atypical agent is suspected.

We have found that, with the addition of azithromycin to inhaled budesonide or fluticasone, 93–96% of the severest asthma exacerbations can be controlled [9]. Before azithromycin became available, we used doxycycline, with a 94% clinical success rate [78]. After azithromycin became available, we continued to use doxycycline in the absence of a response to azithromycin. We showed that treatment with up to four courses of doxycycline in children aged 2–8 years was not associated with tooth staining [78]. The rationale underlying the addition of these drugs is based on growing evidence of the key role of atypical respiratory pathogens, such as *Chlamydia pneumoniae* and *Mycoplasma pneumoniae*, in the pathogenesis of asthma exacerbations: infection with *M. pneumoniae* was found to be significantly associated with hospitalization for acute exacerbations of asthma [79]. Furthermore, *C. pneumoniae* infections may account for the symptoms of asthma that are poorly controlled by steroids [80]. One study demonstrated a positive effect of macrolides on reducing the number of eosinophils and markers of eosinophilic inflammation in patients with asthma [81]. This was

Box 1. My approach to asthma management in young children.

- If a child has a prolonged cough for more than 3–4 weeks, there is a problem in their lungs
- Cough due to viral-induced bronchitis or asthma exacerbation should be considered and treated in the same way
- To properly control asthma, parents of an asthmatic child should participate in asthma-intervention education
- In young children, it is possible by proper management to achieve good asthma control and quickly prevent most asthma attacks
- Good asthma control means total elimination of all asthma symptoms and asthma exacerbations
- Ideally, asthma attacks should be controlled within 2–4 days
- Babies from the age of 3 months can respond well to inhaled corticosteroids and probably to other anti-asthma drugs.

further supported by studies reporting a clinical benefit of doxycycline in the control of acute and recurrent asthma attacks [82,83], and both anti-inflammatory and anti-infective effects of azithromycin on chronically inflamed airways [84].

The availability of combination drugs, including both inhaled corticosteroids and long acting β_2-agonists (such as Symbicort®) enabled us to also use them in older children during acute asthma exacerbations with similar protocols, resulting in similar success rates.

Finally, before changing from one protocol to the next, we clarified if the initial protocol was strictly followed and if the technique used was correct (i.e., the spacer was intact and the inhaler was filled with the drug).

As mentioned earlier, all protocols include the prior use of inhaled β_2-agonist in the first 2–4 days of treatment (Table 1). After each two puffs of inhaled budesonide or inhaled fluticasone, we asked the parents to give their children a drink in order to prevent the development of mouth thrush.

Optimal control of asthma exacerbation

During the first medical visit of a child with acute asthma exacerbations, the following measures should be addressed:

- Did the parents administer the maintenance drug as prescribed in terms of dosage and times per day?
- Did the parents start treatment at the first signs of asthma exacerbation, as instructed?
- Did the parents follow their individual asthma action plan?
- Was the technique of administration correct?
- Was the spacer well functioning and was the inhaler filled with the drug?

If one of these conditions was not met, the physician should discuss its importance with the parents and provide appropriate instruction and clarification. A follow-up visit should be scheduled within the next few days and the parents should be encouraged to contact the physician if a problem arises in the interim.

At the first follow-up visit after the exacerbation or after discharge from the ED, the following measures should be addressed:

- Is the original asthma action plan still valid or should changes be made?
- Should the preventive treatment be changed in view of the last asthma exacerbation?
- Is the inhaler/spacer being used correctly?
- Have the parents taken measures to avoid another attack, and what should be done in addition?
- Do the parents have the proper instructions and the telephone numbers of the physician or other health provider? It is generally recommended that patients, and especially children, after hospitalization for severe asthma exacerbation or discharge from continuous supervision in the ED be referred to a specialist [15].

In the subsequent follow-up visits, which should be scheduled at regular intervals after a severe exacerbation of asthma [15], the use of prophylactic treatment should be considered if the first attack was followed by a second within a month or less and control is poor. Other factors to take into account in the decision include the patient's age (younger children should be assessed more carefully), the time of the year (prophylactic treatment is usually more necessary in winter) and parental adherence (the more compliant the parents, the greater their success with as-needed treatment).

Role of leukotriene antagonists in acute asthma exacerbations

Leukotriene antagonists have been recommended for use in the treatment of chronic asthma but not in the treatment of acute asthma exacerbations. One study demonstrated that, in preschool-aged children with mild-to-moderate acute asthma, a single montelukast 4-mg tablet provided some additive clinical benefit, starting within the first 90 min, when administered concomitantly with short-acting β_2-agonist bronchodilators [85]. Researchers are currently investigating both whether leukotriene antagonists can be used in the acute setting and what the proper dose and frequency of administration should be.

Conclusion

There is now cumulative evidence that, with appropriate treatment measures, including parental asthma education, inhaled corticosteroids can be used effectively for acute asthma in children, both at home and in the ED. However, large-scale well-designed studies are still needed to validate this practice. For optimal outcomes, parents should undergo in-depth asthma education, including mastery of the manual skill to properly apply inhaler devices. Although there are practical and technical limitations to the use of inhaled corticosteroids in children, when they are available and the child is already using them as maintenance treatment, simply increasing the dose of the inhaled corticosteroids at home according to the accepted protocol can successfully control acute exacerbations. On the basis of the present findings, our vast clinical experience and the many published studies, we suggest that high starting doses of inhaled corticosteroids, either budesonide or fluticasone, administered repetitively with a gradual decrease in dose over a few days are at least as effective as oral corticosteroids and, in many cases, more effective, without the potential adverse effects of oral corticosteroids. Therefore they should be used in the treatment of acute asthma exacerbations in children.

Expert commentary

The management of acute asthma exacerbations in young children has only recently been included in international consensuses, and there are too few large-scale well-designed studies on which to base broad standards. The goal of asthma-management programs is to provide parents with the skills and knowledge to prevent, detect and effectively treat most asthma exacerbations at home. For the last 20 years, we have been treating asthma exacerbations in young children with inhaled corticosteroids, and our experience has been

described in worldwide medical journals and at scientific meetings. On the basis of the many published studies, we suggest that high starting doses of inhaled corticosteroids, either budesonide or fluticasone, administered repetitively with a gradual decrease in dose over a few days, are preferable to systemic corticosteroids for the management of acute asthma exacerbations in children.

Five-year view

Current international guidelines for the management of acute asthma exacerbations in children are insufficient owing to a lack of evidence-based data on many still-unresolved issues. Further studies are needed in the pediatric age group to review traditional concepts, provide new perspectives, and suggest novel approaches.

I believe that, within 5 years, there will be a consensus to change the cuurent accepted definition of asthma in young children from three episodes of wheezing to one episode of wheezing combined with a history of recurrent episodes of coughing or coughing for more than 4 consecutive weeks, provided that all other possible causes of wheezing have been excluded. Furthermore, episodes of wheezing or coughing starting from the age of 3 months (usually virus-induced) will be considered as exacerbations of asthma and will be treated with the effective anti-asthma treatment (i.e., inhaled corticosteroids). Finally, we believe that, in 5 years, it will be widely recognized that there is an effective treatment for childhood asthma exacerbations, and there will be no more cases of primary physicians or asthma experts telling worried mothers that nothing can be done until their child 'outgrows' the illness.

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Key issues

- Effective conventional drug treatment is available for all acute asthma exacerbations.
- Parents should be provided with the skills to prevent most asthma exacerbations in their child. They need to learn to recognize the first signs of asthma exacerbations and to give their child the appropriate treatment in terms of drugs and schedules, using all asthma devices correctly.
- Oxygen is needed to control hypoxia in the most severe asthma exacerbations.
- Inhaled β_2-agonists should always be administered together with oxygen in children with low oxygen saturation, especially very young children.
- Oral corticosteroids are the preferred treatment for severe asthma exacerbations in the presence of severe lung constrictions.
- Inhaled corticosteroids given initially together with inhaled β_2-agonists, at the beginning of an asthma exacerbation, are very effective in controlling acute asthma exacerbations in children.
- There is now cumulative evidence that, when appropriate measures are employed, inhaled corticosteroids can be used effectively and safely in the treatment of acute asthma exacerbations in children, both at home and in the emergency department.
- Asthmatic children should be routinely followed to ensure adherence.

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- • of interest
- •• of considerable interest

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Websites

101 To know more about asthma… www.volovitz.co.il

102 The Global Initiative for Asthma www.ginasthma.com

103 American Academy of Allergy, Asthma and Immunology www.aaaai.org

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