



Inappropriate home albuterol use during an acute asthma exacerbation

Kelly Clayton, MD^{*}; Kathy Monroe, MD^{*}; Teresa Magruder, MD^{*}; William King, DrPH, MPH, RPh^{*,†}; and Kathy Harrington, PhD, MPH^{*}

^{*} University of Alabama at Birmingham

[†] Children's of Alabama, Birmingham

ARTICLE INFO

Article history:

Received for publication July 9, 2012.

Received in revised form August 26, 2012.

Accepted for publication September 18, 2012.

ABSTRACT

Background: Increased asthma morbidity and mortality is associated with inappropriate home self-management skills.

Objectives: To examine the proportion of children presenting to the emergency department (ED) with an acute asthma exacerbation with incorrect home use of their albuterol inhaler and to identify factors associated with improper treatment.

Methods: Caregivers of children with asthma aged 4 to 14 years, presenting to the ED with an asthma exacerbation, participated in the study. Interviewers collected caregiver's perceived severity of the asthma exacerbation and home albuterol use before the ED visit. National Asthma Education and Prevention Program guidelines were used to classify home albuterol use as appropriate or inappropriate.

Results: Home albuterol use for the current asthma exacerbation was categorized as inappropriate (56 [68%]) and appropriate (26 [32%]) for 84 participants. Thirty-nine of the inappropriate group undertreated, with 24 not giving albuterol frequently enough and 15 without albuterol at home. Other reasons for incorrect home albuterol use included: no spacer, overtreating, overreacting, and using a controller medicine for quick relief. Those with appropriate albuterol use were more likely to have their child hospitalized for asthma in the past 48 months ($P=.004$). Caregivers with inappropriate use perceived their child's asthma exacerbation as more severe ($P<.001$) compared with physician rating. Physicians rated asthma severity higher in the appropriate group than the inappropriate group ($P<.001$).

Conclusion: A significant proportion of caregivers incorrectly treat children's asthma exacerbation with albuterol. Despite perceiving their children's asthma exacerbations as more severe, most undertreat with albuterol. Correctly assessing asthma symptom severity and appropriate home albuterol use may be linked to disease experience.

© 2012 American College of Allergy, Asthma & Immunology. Published by Elsevier Inc. All rights reserved.

Introduction

Asthma is the leading cause of chronic disease in childhood. It currently affects more than 7 million children, with 4 million having at least one asthma exacerbation in the prior year.¹ Children of families whose income falls below the poverty level, non-Hispanic black children, and males have increased asthma prevalence when compared with their counterparts.¹ Not only does asthma interfere with children's education, accounting for an estimated 10.5 million missed school days annually in 2008, it also is costly to our health care system.¹ In 2007, there were 640,000 children visiting the emergency department (ED) for an asthma exacerbation, with 157,000 admitted to the hospital, and 185 asthma-related deaths in the United States.¹

According to the National Asthma Education and Prevention Program (NAEPP), the goal of early initiation of home management therapy is to "avoid treatment delays, prevent exacerbations from becoming severe, and add to patients' sense of control over their asthma."² The NAEPP also suggests that caregivers and patients be taught to identify worsening respiratory signs and symptoms and be provided with an asthma action plan (AAP) to help guide an appropriate response to a child's asthma exacerbation. Per the NAEPP guidelines, home treatment involves up to 3 albuterol treatments (20 minutes apart) in the first hour of an attack.^{2,3} If symptoms improve on reassessment, albuterol can be administered every 3 to 4 hours for 24 to 48 hours and the primary care physician (PCP) contacted for further follow-up care. If persistent wheezing, continue albuterol every 2 to 4 hours, administer an oral corticosteroid, and contact the PCP for a same-day appointment. If there is a poor response, worsening of symptoms, or albuterol symptom relief lasting less than 2 hours, urgently seek emergency medical care.^{2,3}

Reprints: Kelly Clayton, MD, 10150 SW 55th Lane, Cooper City, FL 33328; E-mail: kclaytes@juno.com.

Disclosures: Authors have nothing to disclose.

Despite these guidelines, many parents are unable to recognize deteriorating asthma symptoms and to correctly treat the asthma exacerbation with their home β_2 -agonist (albuterol).^{4,5} The objectives of this study were to determine the proportion of parents incorrectly treating their child with albuterol at home before seeking emergency care and to identify factors associated with improper treatment.

Methods

This is a cross-sectional, descriptive study designed to evaluate home management of albuterol therapy during asthma exacerbations that occur before the asthmatic child presents to the ED. Also examined are factors associated with home albuterol use and the caregiver's and PCP's perceptions of the child's asthma exacerbation severity. The study was approved by the University of Alabama at Birmingham's (UAB) Institutional Review Board for Human Use.

Selection and enrollment

The study took place in the ED at Children's of Alabama hospital. Caregivers were eligible to participate in the study if their child was between 4 and 14 years old. The child also needed to have a prior diagnosis of asthma (reported by the caregiver or documented previously in the patient's medical record) and be presenting to the ED for an acute asthma exacerbation (determined by the treating physician). The age of 4 years was chosen to avoid enrollment of children who were wheezing secondary to bronchiolitis. Children at this age are also more likely to carry the diagnosis of asthma. Excluded from the study were non-English-speaking caregivers, children with other chronic diseases (eg, cerebral palsy, bronchopulmonary dysplasia, and cystic fibrosis), and children who required intubation in the ED.

From June 2010 to June 2011, eligible caregivers were approached in the ED and written informed consent was obtained by trained research personnel. Enrollment of the convenience sample occurred on weekend and weekdays, at all hours, when research personnel were present.

Outcome measures

A 40-question asthma survey was developed and revised with the collaboration of UAB's Lung Health Center and the UAB Pediatric Pulmonary Division. The survey recorded demographic limited information, home asthma medication use, caregiver- and PCP-perceived asthma severity, asthma control, and caregiver asthma knowledge. The questionnaire was orally administered by the principal investigator or by trained research assistants while the child was receiving albuterol therapy in the ED. Home albuterol use was measured using a structured interview guide. The caregiver was asked, "Since the current asthma attack, have you given your child any asthma medications?" If yes, the specific medication was either named or identified via a photograph by the caregiver. The caregiver was then asked to report how many puffs or nebulizers of the medication were given with each treatment, how frequently each treatment was being administered, and the total period that the child had been receiving treatments. The specific times that the medications were administered were recorded. Other questions included, "If using a puffer, did you use a spacer?" (a photograph of a holding chamber was provided) and "When was the child's last treatment given at home?" Caregivers were also asked if the PCP was contacted before coming to the ED. They were not asked about the specific advice that was provided by their PCP. Asthma control was measured with the Juniper Asthma Control Questionnaire (6-item).⁶ Perceived asthma severity was based on a Likert scale of 1 (mild) to 10 (very severe). ED attending physicians, fellows, and nurse practitioners evaluating the patient provided the health care asthma severity rating score, independent of the caregiver's rating. In

addition, the caregiver's knowledge of asthma was evaluated with the National Heart, Lung, and Blood Institute's (NHLBI) Asthma IQ Questionnaire, which consisted of 12 true or false items. Laminated visual aids of Likert scales and medication pictures were also used.

Ten surveys were pilot tested, resulting in only minor changes to the wording of the questions. Completed surveys were then reviewed and home management was coded by the principal investigator, with 20% also coded by an independent reviewer, who is a pediatric emergency medicine physician and director of the ED of Children's of Alabama. Home albuterol use was categorized as appropriate or inappropriate.

Definitions

Appropriate home albuterol use was defined as any of the following: (1) 1 to 3 albuterol treatments in the first hour, (2) administering albuterol treatments every 4 hours at home (providing the treatments are effective for 4 hours), or (3) caregiver referring to the child's AAP.^{2–4}

Inappropriate home albuterol use included the following: (1) overtreatment (administering >3 albuterol treatments in the first hour or too frequent albuterol dosing for a prolonged period [<4 hours between treatments for >24 hours]), (2) undertreatment (albuterol dosing intervals too long [>4 hours between treatments]),^{2–4} (3) not using a holding chamber if using an inhaler, (4) using the wrong medication for quick relief, (5) overreacting (no albuterol administered at home, although albuterol available in the home, and child immediately brought to ED or giving a single albuterol treatment without waiting for a response before calling 911 or going to the ED),^{2–4} or (6) no albuterol administered at home because the caregiver did not have albuterol available. Regardless of whether the parent called the PCP's office, if the parent's actions were not aligned with the NAEPP guidelines, home albuterol use was still considered inappropriate.

Statistical analysis

Data were entered into Epi Info (version 7; Centers for Disease Control and Prevention, Atlanta, Georgia) and Excel (version 2007; Microsoft Inc, Redmond, Washington) software programs. Statistical significance was determined by the z test of proportions, χ^2 test, t test of means, and 95% confidence intervals (CIs). A 2-tailed α level of .05 and a power of 0.80 were used to establish appropriate sample size. It was determined that the number needed for adequate power was 21 participants for the appropriate albuterol group and 42 for inappropriate group.

Results

Sociodemographic characteristics

A total of 87 caregivers were approached, with 84 (96.5%) participating in the survey. Three caregivers declined to take the survey secondary to the time of the night. The mean age of the children was 7.7 years (range, 4–14 years), with 69% males and 66% insured by Medicaid. A total of 81% of children were non-Hispanic black, 17% were white, and 2% were of mixed race. Most patients primarily received asthma care from a private PCP (59%), followed by the health department (25%), a subspecialist (11%), and the ED (5%). Fifty patients (61%) were taking long-term controller medications, and 59 (70%) presented to the ED between 7 AM and 7 PM at time of enrollment. Table 1 demonstrates the characteristics of our sample of children presenting to the ED with an acute asthma exacerbation.

Surveys were reviewed and home albuterol use was categorized as appropriate vs inappropriate. Two of the surveys did not have adequate information to be categorized. Twenty percent of the surveys were independently coded, with 100% agreement for

Table 1
Characteristics of the patient population

Characteristic	No. (%) of patients ^a
Age, mean (SD), y	7.7 (2.9)
Sex (n=84)	
Male	58 (69)
Female	26 (31)
Race (n=84)	
Black	68 (81)
White	14 (17)
Other	2 (2)
Insurance	
None	3 (4)
All children	6 (7)
Medicaid	55 (66)
Blue Cross	13 (15)
Other	7 (8)
Time at presentation to ED	
7 AM–7 PM	59 (70)
7 PM–7 AM	25 (30)
Currently taking long-term asthma controller medication (n=82)	
Yes	50 (61)
No	32 (39)

^aData are presented as number (percentage) of patients unless otherwise indicated.

appropriate vs inappropriate categorizations. For the 82 participants, home albuterol use for the asthma exacerbation was categorized as inappropriate for 56 (68%) and appropriate for 26 (32%) (95% CI of the difference, 21%–51%; $z=4.5$, $P<.001$) of the studied population. Of caregivers in the inappropriate group, 43 of 56 (77%) had 1 reason and 13 of 56 (23%) had 2 or more reasons that placed them in this category. Thirty-nine of the inappropriate group was undertreating; of these, 24 were not giving albuterol frequently enough, and 15 did not have albuterol at home. In addition, 17 of the inappropriate group using a metered-dose inhaler (MDI) were not using a holding chamber. Other reasons for incorrect home albuterol use included overtreating (3 patients), overreacting (5 patients), and using a controller medicine for quick relief (6 patients). In addition, most children in the entire study population used an albuterol MDI (52%) but were giving only 2 puffs (63%).

Factors associated with albuterol use

No statistical differences were detected between the 2 home albuterol therapy groups for race, time of presentation to the ED, or primary site of asthma care (private PCP office, health department, subspecialist office, or ED). However, children of parents with appropriate home albuterol use were more likely to have Medicaid than other insurance coverage ($\chi^2=4.8$, $P=.02$) and be taking a long-term controller medication when compared with the inappropriate group (85% vs 53%; $z=2.54$, $P=.01$). The Juniper score, used to measure asthma control in the sample population, demonstrated no difference between the appropriate and inappropriate groups (1.47 vs 1.39; $t=-0.29$, $P=.77$).

No statistical differences were found between the appropriate group and the inappropriate group when examining whether a similar asthma attack (89% vs 71%; $z=1.51$, $P=.13$), ED visit (81% vs 64%; $z=1.13$, $P=.26$), and/or intensive care unit admission (19% vs 7%; $z=1.03$, $P=.30$) was experienced in the past 48 months. However, parents with appropriate home albuterol use were associated with having had their child hospitalized in the past 48 months (95% CI of the difference, 13%–59%; $z=2.8$, $P=.004$). Table 2 compares characteristics of the appropriate vs inappropriate home albuterol groups.

Examining the asthma severity scores in the appropriate group revealed no difference between the caregiver's perceived asthma severity score and the ED physician's score (Mean score, 7.3 vs 6.3;

Table 2
Comparison of characteristics of inappropriate and appropriate albuterol use

Characteristic	No. (%) of patients	
	Appropriate home albuterol use	Inappropriate home albuterol use
Similar asthma attack in past 48 months	23/26 (89)	40/56 (71)
ED asthma visits in past 48 months		
None	2/23 (9)	4/40 (10)
<2	4/23 (17)	5/40 (12)
2–4	8/23 (35)	12/50 (30)
>4	9/23 (39)	19/40 (48)
Asthma hospitalizations in past 48 months ^a	17/23 (74)	16/40 (40)
Asthma ICU admissions in past 48 months	5/23 (22)	4/40 (10)

Abbreviations: ED, emergency department; ICU, intensive care unit.

^a $P=.004$.

$t=1.67$, $P=.10$). On the other hand, caregivers with inappropriate home albuterol use estimated their child's asthma exacerbation as more severe when compared with the ED physicians (6.4 vs 4.2) (95% CI of the difference, 1.5–2.9; $t=5.8$, $P<.001$). Physicians also scored the appropriate group significantly higher than the inappropriate group (6.3 vs 4.2) (95% CI of the difference, 1.1–3.1; $t=4.1$, $P<.001$).

Of caregivers in the inappropriate home albuterol group, 54% reported never receiving an AAP, 36% stated they had been given one, and 9% were unsure. In the appropriate home albuterol group, 50% reported getting an AAP sometime during the child's asthma treatment, whereas 50% did not. Although a lower proportion of caregivers in the inappropriate group had an AAP compared with the appropriate group, the difference did not reach statistical significance (difference, –14%; 95% CI difference, –37% to 9%). A greater proportion of the inappropriate group had called their PCP before presenting to the ED, compared with the appropriate group, although the difference did not reach statistical significance (41% vs 25%) (difference, 16%; 95% CI of the difference, –7% to 39%). The main reasons that the PCP was not called was because caregivers “didn't think there was time” followed by “the PCP was not available.” Both groups had similar scores on the “asthma IQ knowledge questions,” with a mean score of 83% (10/12) of questions correct.

Discussion

The NAEPP asthma guidelines were designed to decrease asthma-related morbidity and mortality. As with previous studies, there is a high rate of nonadherence by caregivers to the asthma guidelines.^{5,7,8} One study, looking specifically at albuterol home management and caregiver response to a mock acute asthma exacerbation, found that 66% of caregivers would appropriately use albuterol at home.⁴ The current study found only 32% of caregivers reported giving home albuterol appropriately in response to an actual asthma exacerbation. The high percentage (68%) of inappropriate home albuterol use may better represent caregiver behavior because it is based on an actual asthma exacerbation rather than a hypothesized one. The immediacy of the data collection to the exacerbation in this study limits potential recall bias.

In the current study, oral administration of the questionnaire helped overcome any literacy barriers. More than half of caregivers with inappropriate home albuterol use were undertreating with albuterol. This finding is interesting because these caregivers perceived their child's asthma severity score as higher when compared with the ED physician's perceived asthma severity score. Yet, only 5% of the inappropriate home albuterol population was overtreating with albuterol. This finding suggests some concern about the use of albuterol at home, especially because most of these parents had albuterol on hand at home. Previous studies have

determined that parents' negative attitudes about daily asthma medications are associated with poor medication adherence.^{9–11} Perhaps these attitudes persist for rescue medications as well.

Overall, the appropriate home albuterol management group was perceived by the ED physicians to have a more severe asthma exacerbation when compared with the inappropriate group. Those with appropriate home albuterol use had children significantly more likely to be hospitalized in the past 48 months and be taking a long-term asthma controller medication. They also scored their child's asthma exacerbation similar to the treating health care professionals. Because this group of caregivers appears to have children with more severe asthma exacerbations, perhaps their more appropriate home management is a result of reinforced exposure to asthma education by health care professionals. However, no significant difference was found between the groups when examining asthma knowledge scores, which is not surprising given the usually weak link between knowledge and behavior.

Multiple studies have demonstrated the effectiveness of albuterol delivery using a holding chamber with an MDI when compared with using an MDI alone.^{12–15} Only half of one study's population regularly used a holding chamber with their MDI.⁵ The current study demonstrated that 66% of the 52 caregivers whose children used a MDI, used a holding chamber when administering albuterol. The higher percentage may reflect social desirability or possibly represent improved asthma education of MDI use by health care professionals.

In addition, the current study found no association between adequate home albuterol treatment and having an AAP. This finding has been demonstrated in multiple additional studies.^{4,7,16} Asthma knowledge based on the NHLBI's Asthma IQ Questionnaire was also not different between the appropriate and inappropriate home albuterol management groups. Just 36% of all caregivers called their PCP before coming to the ED. Most caregivers did not call their PCP because they did not think there was time or because the PMD was not available. These results are similar to those from a study by Scarfone et al, which reported that less than half of parents presenting to the ED with an acute asthma exacerbation attempted to contact their PCP.⁵

Although the number of puffs administered with an albuterol MDI was not included as a criterion for appropriate vs inappropriate home albuterol treatment, 63% of caregivers gave only 2 puffs. Four or more albuterol puffs were given by 27%, 3 puffs by 5%, and 1 puff by 5% of caregivers. The NAEPP guidelines recommend an ED dosing of 4 to 8 puffs and home dosing of 2 to 6 puffs of albuterol for an asthma exacerbation.² With 2 puffs of albuterol being on the low end of home use recommendations, there may be a need to increase awareness of the range of appropriate puffs with albuterol dosing.

This study has several limitations. One potential limitation of this study is response bias because caregivers may have responded to questions with socially desirable answers. Therefore, appropriate home albuterol use may be lower than reported in this study. Another limitation of this study is that parents were also not assessed about their perceived appropriateness of home albuterol treatment or if they were following advice given to them by their PCPs or other health care personnel. However, it seems unlikely that health care professionals would advise home albuterol use not aligned with NAEPP guidelines. Some information, including the number of previous ED visits and hospitalizations and the frequency of albuterol administration, is subject to potential recall bias. The current study examined asthma hospitalizations in the past 48 months and did not examine the specific dates the hospitalization occurred. It may be difficult for parents to remember specific asthma hospitalizations during this long period. In addition, the study

included 4-year-old children in whom prior hospitalizations for "asthma" possibly could have been for other disease processes. Furthermore, this is a single-center study, and the sample excluded non-English-speaking families and included only patients who sought ED care. Therefore, these data may not be generalizable to the population of asthmatic children who do not necessitate ED care or who are non-English-speaking. Our definitions of appropriate and inappropriate were not validated, although they were based on NAEPP guidelines and a prior published study.⁴ We also did not examine oral corticosteroid therapy.

In conclusion, a significant proportion of parents incorrectly treat their child's asthma exacerbation with home albuterol. These caregivers perceived their children's asthma exacerbations as more severe than medically assessed, perhaps reflecting difficulty evaluating the severity of their child's asthma symptoms. Asthma education requires a partnership between physicians and caregivers where reinforcement of the asthma guidelines is key. This study's results suggest that health care professionals develop and implement an asthma educational tool for caregivers, focusing on the identification of worsening asthma symptoms and the proper use of home albuterol.

Acknowledgments

I acknowledge Elizabeth Molony, Cecily Collins, and Rebecca Smith for data collection. I also acknowledge the assistance of Mary Lou Lackey with data entry.

References

- [1] Akinbami L, Moorman J, Liu X. Asthma prevalence, health care use, and mortality: United States, 2005–2009. *Natl Health Stat Rep*. 2011;32:1–16.
- [2] National Asthma Education and Prevention Program. *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma*. Bethesda, MD: National Heart, Lung, and Blood Institute, National Institutes of Health; 2007.
- [3] National Heart, Lung, and Blood Institute. *National Asthma Education and Prevention Program, Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma*. Bethesda, MD: National Institute of Health; 1997.
- [4] Garbutt JM, Freiner D, Highstein GR, et al. Home albuterol use for asthma exacerbations. *Ann Allergy Asthma Immunol*. 2009;102:504–509.
- [5] Scarfone R, Zorc J, Capraro G. Patient Self-management of acute asthma: adherence to national guidelines a decade later. *Pediatrics*. 2001;108:1332–1338.
- [6] Juniper EF, O'Byrne PM, Guyatt GH, Ferrie PJ, King DR. Development and validation of a questionnaire to measure asthma control. *Eur Respir J*. 1999;14:902–907.
- [7] Warman KL, Silver EJ, McCourt MP, Stein REK. How does home management of asthma exacerbations by parents of inner-city children differ from NHLBI guideline recommendations? *Pediatrics*. 1999;103:422–427.
- [8] Leickly FE, Wade SL, Crain E, et al. Self-reported adherence, management behavior, and barriers to care after an emergency department visit by inner-city children with asthma. *Pediatrics*. 1998;101:1–8.
- [9] Conn KM, Halterman JS, Fisher SG, Yoos HL, Chin NP, Szilagyi PG. Parental beliefs about medications and medication adherence among urban children with asthma. *Ambul Pediatr*. 2005;5:306–310.
- [10] Conn KM, Halterman JS, Lynch K, Cabana MD. The impact of parents' medication beliefs on asthma management. *Pediatrics*. 2007;120:e521–e526.
- [11] Orrell-Valente JK, Jarlsberg LG, Rait MA, Thyne SM, Rubash T, Cabana MD. Parents' specific concerns about daily asthma medications for children. *J Asthma*. 2007;44:385–390.
- [12] Brown PH, Blundell G, Greening AP, Crompton GK. Do large volume spacer devices reduce the systemic effects of high dose inhaled corticosteroids? *Thorax*. 1990;45:736–739.
- [13] Lipworth BJ. New perspectives on inhaled drug delivery and systemic bioactivity. *Thorax*. 1995;50:105–110.
- [14] Newman SP, Millar AB, Lennard-Jones TR, Moren F, Clarke SW. Improvement of pressurized aerosol deposition with Nebuhaler spacer device. *Thorax*. 1984;39:935–941.
- [15] Selroos O, Halme M. Effect of a volumetric spacer and mouth rinsing on systemic absorption of inhaled corticosteroids from a metered dose inhaler and dry powder inhaler. *Thorax*. 1991;46:891–894.
- [16] Lefevre F, Piper M, Weiss K, Mark D, Clark N, Aronson N. Do written action plans improve patient outcomes in asthma? an evidence based analysis. *J Fam Pract*. 2002;51:842–848.