

Metered-Dose Inhaler

The Emergency Department Orphan

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Objective: Physicians providing emergency department care to children primarily use nebulizers for the delivery of bronchodilators and these physicians have misconceptions regarding the advantages and disadvantages of using metered-dose inhalers (MDIs) with a spacer (MDI+S) for acute asthma exacerbations.

Design: Self-administered mail survey.

Setting: Emergency department.

Participants: Emergency medicine section members of the American Academy of Pediatrics and Canadian Pediatric Society.

Interventions: Bronchodilator delivery methods in acute pediatric asthma.

Main Outcome Measures: The 2 principal outcomes for bivariate analysis were self-reported nebulizer use in all patients and MDI+S use in patients with mild acute asthma.

Results: Of eligible physicians, 333 (51%) of 567 responded. The majority were dual trained in pediatrics and pediatric emergency medicine (72%) and practiced full time (83%) in an urban (83%) pediatric emergency department (80%). The most commonly cited advantages of MDIs were their cost (33%) and speed of use (28%). The most commonly cited disadvantages were patient or parent dissatisfaction (24%) and relative ease of nebulizer use (23%). Only 10% to 21% of participants used MDIs in the emergency department and reserved this delivery method for children with mild asthma exacerbations. There were no significant associations between selected respondent demographic variables and the use of MDIs.

Conclusions: Misconceptions regarding the efficacy and safety of MDI+S for the treatment of acute asthma exacerbations exist but are limited to a minority of surveyed emergency medicine physicians caring for children. Nebulizers remain the preferred method of routine bronchodilator delivery by physicians providing care to pediatric asthmatics in the emergency department.

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ASTHMA IS the most common chronic disease of childhood, affecting an estimated 4.8 million children in the United States. Its increasing severity throughout the last 3 decades has been well documented by an increase in hospitalizations from 386 000 to 466 000 (1980 to 1994) and deaths from 1.5 to 6.5 per million (1976 to 1995).¹

One area of recent controversy in asthma therapy is the underuse of metered-dose inhalers (MDIs) in adult and pediatric patients.¹⁻⁴ It is well documented that MDIs with an attached spacer device (MDI+S) require less equipment and time to administer, are cheaper, and are more portable than nebulizers. Furthermore, numerous studies in children and adults have demonstrated that MDI+S

are clinically as effective as nebulizers in the delivery of bronchodilators. Clinical equivalence has been proven in many randomized clinical trials using multiple types of spacer devices and bronchodilator medications in children and adults.⁵⁻¹⁴

The nebulizer system of aerosolized medication delivery is generally accepted as the standard of care for children with acute asthma presenting to the emergency department (ED). This occurs despite the equivalent clinical efficacy and added cost and inconvenience of a nebulizer. The hypotheses of this study were that physicians caring for children in the ED primarily use nebulizers for bronchodilator delivery and that these physicians have misconceptions regarding the advantages and disadvantages of MDI+S use in children with acute asthma exacerbations.

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PARTICIPANTS AND METHODS

PARTICIPANTS

We obtained a list of members of the emergency medicine (EM) sections of the American Academy of Pediatrics and the Canadian Pediatric Society. A 15-question survey and self-addressed stamped envelope were mailed to each subject (available from the principal investigator on request). Second and third mailings were sent to those not responding within a month of the previous mailing. Surveys returned by self-identified pediatricians not caring for children in an ED setting were excluded. This survey was piloted by a group of 9 pediatric EM physicians and revised prior to the first mailing.

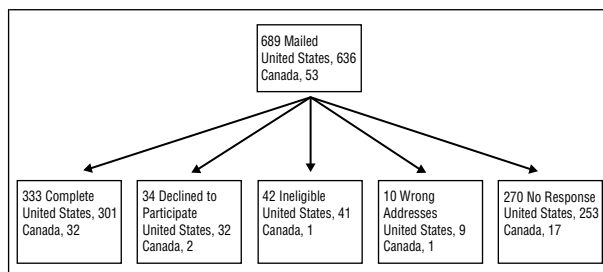
SURVEY INSTRUMENT

The 15-question survey instrument addressed professional characteristics of the respondent and his or her clinical practice, the presence of asthma management guidelines in their EDs, attitudes toward MDI+S use, self-reported patterns of MDI+S and nebulizer use, and information influencing their choice of bronchodilator delivery method. The survey included multiple choice, Likert scale, and open-ended questions.

DATA ENTRY AND ANALYSIS

Data were entered into a Microsoft Excel 97 spreadsheet (Microsoft Corp, Redmond, Wash) and analyzed using Epi Info 6.0¹⁵ and SPSS (Statistical Product and Service Solutions; SPSS Inc, Chicago, Ill) software. Bivariate associations between the independent variables and principal outcomes were analyzed using the χ^2 test. Multivariate analysis was planned to test the associations between principal outcomes and independent variables. The 2 principal outcomes were self-reported nebulizer use in all patients and MDI+S use in patients with mild acute asthma. Respondent-related independent variables included the average number of clinical hours worked per week (≤ 16 hours vs > 16 hours), number of years of postresidency practice (< 5 years, 5-10 years, 10-20 years, and > 20 years), position at his or her primary institution (full-time, part-time, or fellow), residency training (EM vs pediatrics), fellowship training (pediatric EM [PEM] vs non-PEM training), country of practice (United States or Canada), setting of practice (general ED or pediatric ED/pediatric area in a general ED), environment in which the respondent's ED was located (urban or suburban/rural), and training programs offered in the respondent's institution (EM residency, pediatrics residency, or PEM fellowship).

This study was approved by the Boston University (Boston, Mass) institutional review board.



Flowchart of survey responses.

DEMOGRAPHICS

The majority of physicians had training in pediatrics and PEM (72%). They also generally practiced full-time (83%), commonly in an urban (83%) pediatric ED (80%), and for 5 to 20 postresidency years (83%). Information regarding the characteristics of nonresponders was limited to region of practice. Subjects in the Midwest had the highest nonresponse rate of 65% (51/147 physicians) followed by the West (60%, 29/72), the South (49%, 102/202), and the Northeast (47%, 71/134) (**Table 1**).

PERCEIVED ADVANTAGES AND DISADVANTAGES TO MDIs

When asked the open-ended question, "What do you think are the advantages to the use of high-dose MDIs (6-8 puffs per treatment) over nebulizers in the emergency department management of pediatric asthma?" the most commonly cited answers addressed cost, speed, and portability. Eighty-five (33%) of 256 respondents stated that MDIs are cheaper. Seventy-two (28%) felt that MDIs are faster to administer. Twenty-two (8%) felt that MDIs require less staff time to use. Sixty-two respondents (24%) stated that the use of MDIs in the ED allows for an opportunity to teach MDI technique to patients and parents. Forty-one (16%) felt that the portability of MDIs is an advantage to their use, and 77 respondents (21%) gave no response.

When subsequently asked: "What do you think are disadvantages to using high-dose MDIs (6-8 puffs per treatment) over nebulizers in the emergency department management of pediatric asthma?" responses most commonly addressed issues of patient dissatisfaction and inconvenience in administration. Sixty-five (24%) of 272 respondents felt that patients and parents expect nebulized therapy when they arrive in an ED and that the use of MDIs would result in patient and parent dissatisfaction. Sixty-two (23%) felt that nebulizers are easier to administer. Similarly, 51 (19%) felt that MDIs would require more staff supervision, 44 (16%) felt MDIs were too difficult to use in the young, and 30 (11%) felt that children are poorly compliant with MDI medication delivery. Some clinical considerations were also voiced. Twelve percent (32/272) felt that nebulizers were superior to MDIs because they can be administered with supplemental oxygen, and 26 (10%) felt that MDIs are less effective than nebulizers when used in children suffering from severe asthma exacerbations. Sixty-one respondents (16%) gave no response.

RESULTS

Of the 689 subjects contacted, 375 returned surveys. Forty-two respondents not providing emergency care to children were ineligible and excluded from analysis. The overall response rate was 51% (**Figure**).

Table 1. Profile of Respondents*

| Variable | Patients, No. (%) (N = 333) |
|--|--------------------------------|
| Average hours worked per week | |
| 0-16 | 69 (21) |
| >16 | 264 (79) |
| No. of postresidency years in practice | |
| <5 | 33 (10) |
| 5-10 | 150 (45) |
| >10-20 | 125 (38) |
| >20 | 25 (7) |
| Position at primary facility | |
| Full-time | 276 (83) |
| Part-time | 44 (13) |
| Fellow | 10 (3) |
| Other | 3 (1) |
| Respondents' specialty training | |
| EM residency only | 1 (0.3) |
| Pediatrics only | 38 (11) |
| EM residency + PEM fellowship | 10 (3) |
| Pediatrics + PEM fellowship | 238 (72) |
| EM residency + pediatrics | 12 (4) |
| EM residency + pediatrics + PEM fellowship | 31 (9) |
| PEM fellowship only | 3 (1) |
| Country in which respondent practices PEM | |
| United States | 301 (90) |
| Canada | 32 (10) |
| Region in which respondent practices PEM† | |
| Northeastern United States | 63 (19) |
| Midwest United States | 96 (29) |
| Southern United States | 99 (30) |
| Western United States | 43 (13) |
| Setting in which respondent practices PEM | |
| General ED: one ED in which patients of all ages are seen by the same practitioners | 26 (8) |
| Pediatric: an area in a general ED where pediatric patients are seen by practitioners separate from adult patients | 39 (12) |
| Pediatric only: a separate ED where only pediatric patients are seen | 266 (80) |
| Other | 2 (1) |
| Environment in which the ED is located | |
| Urban | 275 (83) |
| Suburban | 53 (16) |
| Rural | 5 (1) |
| Residency/fellowship training offered at the institution where the respondent works | |
| EM | 138 (41) |
| Pediatrics | 251 (75) |
| PEM | 189 (57) |

*EM indicates emergency medicine; PEM, pediatric emergency medicine; and ED, emergency department.

†Northeast: Conn, Me, Mass, NH, NJ, Pa, RI, Vt; Midwest: Ill, Ind, Iowa, Kan, Mich, Minn, Mo, Neb, ND, Ohio, SD, Wis; South: Ala, Ark, Del, DC, Fla, Ga, Ky, La, Md, Miss, NC, Okla, SC, Tenn, Tex, Va, WV; West: Alaska, Ariz, Calif, Colo, Hawaii, Idaho, Mont, Nev, NM, Ore, Utah, Wash, Wyo.

SELF-REPORTED METHOD OF BRONCHODILATOR USE

The majority of physicians deliver bronchodilators by nebulization to all children in the ED. When given a checkbox question asking for which age groups of children (<2 years, 2-5 years, 5-7 years, 7-18 years) they used either nebulizers, MDI+S, or MDI without spacers, 76% of respondents stated that they use nebulizers for all acute

Table 2. "Please Check Off the Method You Most Commonly Use to Deliver Bronchodilator Medication to Children in the Emergency Department Based on Age and Your Definition of Asthma Severity."*

| Delivery Mechanism | Age Group, No. (N = 328) | | | |
|---------------------------------|--------------------------|-------|-------|--------|
| | <2 y | 2-5 y | 5-7 y | 7-18 y |
| Nebulizer use | | | | |
| Mild acute asthma | 0 | 0 | 1 | <1 |
| Moderate-severe acute asthma | 8 | 11 | 15 | 18 |
| Severe acute asthma | 2 | 2 | 4 | 5 |
| All acute asthma | 90 | 87 | 79 | 76 |
| Not used for acute asthma | 0 | 0 | <1 | <1 |
| MDI + S use | | | | |
| Mild acute asthma | 10 | 15 | 20 | 21 |
| Moderate acute asthma | 0 | <1 | 0 | <1 |
| Mild to moderate acute asthma | 3 | 3 | 5 | 6 |
| Moderate to severe asthma | 0 | 0 | <1 | <1 |
| All acute asthma | 1 | 2 | 3 | 4 |
| Not used for acute asthma | 86 | 80 | 72 | 69 |
| MDI without spacer use | | | | |
| Mild acute asthma | 0 | 0 | 0 | 3 |
| Mild to moderate acute asthma | 0 | 0 | 0 | 2 |
| Moderate to severe acute asthma | 0 | <1 | <1 | <1 |
| All acute asthma | <1 | 0 | 0 | <1 |
| Not used for acute asthma | 100 | 100 | 100 | 95 |

*Five respondents left this entire question blank. MDI + S indicates metered-dose inhaler with an attached spacer.

patients with acute asthma between 7 and 18 years old. This proportion increased as the age of the patients decreased. Seventy-nine percent, 87%, and 90% of respondents use nebulizers for children in the 5- to 7-year old, 2- to 5-year old, and younger than 2-year-old age groups, respectively. In contrast, a significant minority of respondents stated that they use MDI+S in selected children. The proportion of respondents using MDI+S in children with mild acute asthma decreased with age. Twenty-one percent, 20%, 15%, and 10% stated that they would selectively use MDI+S in children with mild acute asthma aged 7 to 18 years, 5 to 7 years, 2 to 5 years, and younger than 2 years, respectively. The small minority of respondents (3%) who reported selective MDI without spacer use do so only for those with mild acute asthma in the 7- to 18-year-old age group (**Table 2**).

When asked the open-ended question, "How do you decide which method of bronchodilator delivery you use for any particular child in the emergency department with an asthma exacerbation?" 159 (58%) of 275 respondents stated that they always use nebulized bronchodilators, and 59 (22%) of 275 decide based on the severity of the child's exacerbation. Twenty-five (9%) of 275 reported that they only use the MDI for teaching prior to discharge, 23 (8%) decide based on the age of the patient, and 15 (6%) use their judgment of the patient's ability to cooperate with an MDI to decide (**Table 3**).

ASTHMA PATHWAYS AND MDI+S USE

Of the 19 respondents from 16 institutions who provided a copy of their asthma pathway, 3 specified the MDI+S as an option for bronchodilator delivery in the ED.

Table 3. "How Do You Decide Which Method of Bronchodilator Delivery You Use for Any Particular Child in the Emergency Department With an Asthma Exacerbation?"*

| Response | Patients, No. (%) (N = 275) |
|---|--------------------------------|
| I always use a nebulizer. | 159 (58) |
| I decide based on the severity of the exacerbation. | 59 (22) |
| I use an MDI for teaching prior to discharge. | 25 (9) |
| I decide based on age. | 23 (8) |
| I decide based on the patient's ability to cooperate. | 15 (6) |
| I use the standard practice for the ED I am working in. | 12 (4) |

*Fifty-eight respondents left this question blank. MDI indicates metered-dose inhaler; ED, emergency department.

BIVARIATE ANALYSES

No differences emerged in bivariate analyses of the independent variables and the principle outcomes of nebulizer use for all patients, and MDI+S use for patients presenting with mild acute asthma. Results of a multivariate analysis are not reported due to small sample size.

COMMENT

The results of this survey suggest that the majority of physicians use nebulizers as their primary method of delivering bronchodilators to children in the ED setting. Despite this, the majority of those surveyed do use MDI+S in some capacity in select children in the ED. Additionally, while some are unaware of the benefits of MDIs, including quicker delivery, lower cost, and increased efficacy in medication delivery, most of the physicians surveyed did not cite inaccurate opinions regarding the efficacy of MDIs in the pediatric acute asthma setting.

The data supporting the use of MDI+S in acute asthma are not new. Meta-analyses reviewing adult and pediatric literature conclude that the 2 methods are equally effective.^{16,17} These data have been consistent across multiple prospective studies in adults¹⁶⁻²¹ and children.⁶⁻¹² Leversha et al²² clearly demonstrated the cost-benefit of using MDI+S in the ED. Williams et al⁵ also showed that using MDI+S in the pediatric ED was feasible. The 1997 National Heart Lung and Blood Institute and 1993 British Thoracic Society asthma management guidelines both acknowledged the clinical equivalence of MDI+S and nebulizers.^{23,24} They suggested that MDIs be considered in the ED setting to deliver bronchodilators to children who do not have severe asthma and are able to cooperate. Even this conservative recommendation, however, does not seem to have translated into practice.

Eleven percent of our respondents cited a concern for patient cooperation in MDI medication delivery, and 16% felt the method was too difficult to use in the very young. Clearly, prior to significant improvements in aerosol reservoir technology, MDIs were difficult to use even in cooperative adults and children.^{25,26} The development of valved spacers has allowed medication delivery to occur efficaciously even when delivered via tidal breathing.^{5,6,11,12,22,27} Child and infant studies have also docu-

mented the equivalence of pulmonary medication delivery using MDI+S and nebulizers to deliver radioactively labeled aerosol vehicles.²⁷⁻²⁹

Studies have also demonstrated that MDI+S bronchodilator administration requires less staff time.^{5,12} While it may seem that nebulizers, in practice, require less staff attention, all of the studies comparing these 2 modalities use a facemask with the nebulizer to minimize wasted aerosol. In our opinion, keeping a facemask on an uncooperative young child's face for 10 to 15 minutes requires more effort and supervision than holding a facemask attached to an MDI+S for 3 minutes.

Despite the evidence supporting the use of MDI+S over nebulizers in acute asthma, it does not seem to be the current standard of care in practice. Our attempt to identify populations of pediatric ED physicians who are using MDI+S did not yield any predictive variables by bivariate analysis. Respondent residency or fellowship training, years of practice, and location of practice did not seem to affect how often they used MDI+S in the ED. This, in addition to statements of uniform use of nebulizers, suggests that it is perhaps the culture of the ED and not the individual physician that influences the initial bronchodilator delivery technique used in children. However, it can also be the individual physician who strives to change the culture of the ED.

Changing physician behavior and practicing evidence-based medicine has become an important focus for medicine over the past decade. Evidence-based medicine originates from the ongoing concerns about quality of care, including variation in hospitalization rates, therapeutic interventions, and patient outcomes.³⁰ Despite the overwhelming data suggesting that MDI±S are equivalent and possibly superior to nebulizers, the results from this survey suggest that they are not being used. As we have previously described, physician decisions are governed by 3 domains: evidence, physician experience, and patient factors.³¹ The participants in our survey demonstrated a generally good grasp of the evidence supporting the use of MDIs for acute asthma exacerbations. Additionally, the literature suggests a preference for MDIs by patients and parents in the ED. This, in our opinion, suggests that the largest barrier to the routine use of MDIs is the lack of motivation for physicians to change their practice and the culture of their practice environment. Additional environmental barriers to adoption of this technique, including perceived staff reluctance to change, departmental financial barriers, and barriers at the hospital administration level most likely also contribute to the sluggish adoption of new technologies. Changing physician behaviors is quite difficult. The myriad reviews have suggested that education alone is insufficient, and that reminders, opinion leaders, audit and feedback, and administrative interventions can work in specific situations.³⁰⁻³² While we will need to adopt some of these techniques to encourage the use of MDI+S, motivating physicians to strive for evidence-based practice is ultimately of the utmost importance.

As with any survey, there are limitations of this methodology, including self-reporting bias that may not accurately reflect current practice patterns. However, it is difficult to imagine that the use of MDI+S is greater than reported. Secondly, our response rate was 51%, which

What This Study Adds

Published literature supports the use of MDI+S for the treatment of acute asthma exacerbations in children; however, our anecdotal experience is that they are rarely used in the ED. To our knowledge to date, there is no published literature regarding current practice by physicians caring for children in an ED setting regarding the type(s) of delivery system(s) used for bronchodilator therapy, and attitudes and knowledge toward MDI use for acute asthma exacerbations.

This study defines the current attitudes, knowledge, and use of MDI in the ED for acute asthma exacerbations in children. A majority of physicians caring for pediatric patients with asthma in the emergency department do not use MDIs despite evidence in the literature supporting their use. This study demonstrates the underutilization of evidence-based decisions regarding bronchodilator delivery methods in the ED and will hopefully raise awareness and help to catalyze change of behavior in this area.

may limit generalizability. We have few data on nonresponders, although there is no reason to think that MDI use is greater in nonresponders.

In conclusion, we found that many ED physicians are familiar with the benefits of MDIs. However, a majority do not use them. No differences in MDI+S and nebulizer use patterns were noted based on respondent demographics. External factors may be primarily responsible for the observed underuse of MDI+S in the ED setting among children. Further research is needed to explore ED culture and systems barriers to MDI+S use.

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