Teaching Time for Metered-Dose Inhalers in the Emergency Setting*

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Objectives: In some acute-care settings, practitioners are reluctant to institute bronchodilator therapy with metered-dose inhalers (MDIs) as standard management. Such therapy requires that personnel ensure optimal use of these devices. We prospectively evaluated the time required to teach patients correct inhaler use for the emergency treatment of asthma and COPD, and patient factors associated with duration of teaching.

Design: MDI arm within a single-center randomized clinical trial comparing bronchodilator administration by MDI with a delivery enhancement device (MDI/DED) vs delivery by wet nebulizer.

Setting: All subjects were treated for asthma or COPD exacerbations at the respiratory acute-care day hospital of the Montreal Chest Institute, immediately after presentation to our emergency department. Inhaler-use education was provided according to a predetermined protocol.

Measurements: Subjects’ baseline characteristics were obtained from medical charts, spirometry, and questionnaires; satisfaction was evaluated by questionnaire. All inhaler-use education was observed and timed.

Results: Sixty-one patients with asthma (median age, 46 years) and 32 patients with COPD (median age, 68.5 years) were randomized to treatment by MDI/DED. Mean FEV\textsubscript{1} (percent predicted) was 63.5% for patients with asthma and 39.5% for patients with COPD. Five patients could not complete MDI teaching and therefore received subsequent treatment by wet nebulization. For the 88 other patients, the median teaching time was 6.5 min. Shorter teaching-time requirements were independently associated with higher initial arterial oxygen saturation, home DED use after previous MDI instruction, and a single initial bronchodilator treatment by wet nebulization. Most subjects expressed satisfaction with MDI/DED teaching and treatment.

Conclusions: Successful MDI/DED teaching followed by self-medication is feasible in the emergency setting, based on a simple protocol. A single bronchodilator dose administered by wet nebulization may facilitate subsequent MDI teaching.

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Key words: asthma; COPD; delivery enhancement device; emergency department; metered-dose inhaler; teaching time

Abbreviations: DED = delivery enhancement device; ED = emergency department; IQR = interquartile range; MDI = metered-dose inhaler; MDI/DED = metered-dose inhaler with a delivery enhancement device; \textit{SpO}_2 = oxyhemoglobin saturation

Several reports have documented spirometric and clinical outcomes after emergency department (ED) treatment of acute asthma exacerbations with bronchodilators administered by metered-dose inhaler (MDI) with a delivery enhancement device (DED) [MDI/DED].\textsuperscript{1–3} Randomized, parallel-group trials have demonstrated equivalent outcomes when compared with traditional wet nebulization both in children and adults.\textsuperscript{1,2} There is less evidence regarding MDI/DED use for acutely ill patients with COPD.\textsuperscript{3}

Successful MDI/DED therapy requires proper technique. Surveys among patients with stable asthma and patients with stable COPD have repeatedly shown that inhaler technique is frequently suboptimal, despite the longstanding and widespread
use of these devices. Indeed, patients with poor adherence and/or poor medication technique are overrepresented among ED users. Hence, emergency bronchodilator therapy with an MDI requires immediate teaching and supervision for this treatment modality to be effective. In the acute-care setting, patient self-medication with MDI devices has been associated with substantial savings in inhalation therapist time and cost. These savings have prompted many EDs to adopt MDIs as the standard mode of bronchodilator administration.

However, the standard use of MDI therapy places additional demands on ED personnel, who must ensure optimal technique for medication delivery. As part of a randomized controlled trial among patients with asthma and patients with COPD, the primary objective of the present study was to measure the teaching time that was in fact necessary for successful MDI/DED use at our acute-care facility, based on demonstrated mastery, according to a predefined protocol. We investigated patient factors associated with duration of teaching time. We also evaluated patient satisfaction.

**Materials and Methods**

**Design**

We conducted a randomized, open-label, parallel-group controlled trial to compare bronchodilator delivery methods (MDI/DED vs wet nebulization) for the treatment of acute exacerbations of asthma or COPD. Patients were recruited at the Montreal Chest Institute from April 1, 1998, through November 30, 1999. Subjects were randomized to the two treatment arms in a 1:1 ratio, with stratification by primary diagnosis (asthma vs COPD). Subjects randomized to the MDI/DED arm form the basis for this report.

**Setting**

Subjects received teaching and treatment at our respiratory-care day hospital, an acute-care unit that provides ambulatory treatment of respiratory disease (primarily asthma and COPD) over a duration ≥1 day. At the Montreal Chest Institute, patients are immediately referred to our day hospital for initiation of treatment after a brief medical assessment in our ED or walk-in clinic. All acutely ill patients with asthma or COPD, whose hospital treatment involves more than a single supervised bronchodilator dose, are rapidly moved to the day hospital; the only exception is with patients who are so severely ill that they require immediate inpatient or ICU hospitalization. Where necessary, patients can be transferred subsequently from the day hospital to our inpatient unit or ICU.

**Subjects**

All patients referred to the day hospital for treatment for worsened respiratory symptoms were assessed for eligibility. Inclusion criteria included the following: (1) an established diagnosis of asthma or COPD; (2) referral to the day hospital for treatment of acutely worsened respiratory symptoms, (3) a medical order for inhaled bronchodilator therapy, (4) age ≥18 years, and (5) the ability to communicate in French or English.

Patients were excluded if one or more of the following were present: (1) severe respiratory distress and/or respiratory failure (respiratory rate ≥40/min, and/or oxyhemoglobin saturation \(\text{SpO}_2<90\%\) with the fraction of inspired oxygen \(\geq 35\%\), and/or arterial blood pH <7.3); (2) unstable cardiac disease (left ventricular failure, unstable angina, uncontrolled arrhythmia); (3) major neurologic or psychiatric condition; (4) malignancy, either untreated or treated within the preceding 6 months; (5) pregnancy; (6) residence at an extended-care facility; (7) supervised use of bronchodilator at any health-care facility, within the preceding 24 h; (8) history of hypersensitivity or adverse reaction to bronchodilator medication; (9) prior enrollment in the study; or (10) refusal or inability to provide informed consent.

To receive the classification of COPD, subjects had to be ≥40 years old, with a smoking history of ≥10 pack-years. Their best recorded FEV\(_1\) during the preceding year had to be ≤70% predicted.

All potentially eligible subjects were identified in the Montreal Chest Institute ED, outpatient clinic, and the day hospital by the triage or receiving nurse in consultation with the research team. Potential subjects were then approached and screened by the research assistants. Basic demographic data were kept in nonnominal form for all patients who refused or were excluded, and reasons for refusal or ineligibility were noted.

**Study Protocol**

Patients were permitted a single dose of nebulized bronchodilator before recruitment if judged necessary by the treating physician. After randomization to MDI/DED, subjects received standardized one-on-one teaching from one of three day hospital baccalaureate nurses, based on a simple and clear protocol (Table 1). The nurses demonstrated the inhalation technique, using a placebo inhaler with the Aerocochamber device (Trudell Medical International; London, ON). The teaching session also included brief instruction for the care and maintenance of the device. The nurses had received formal training in MDI/DED coaching before the initiation of this study.

Once subjects demonstrated suitable technique, they received all subsequent treatments by MDI/DED. Treating physicians selected the bronchodilator(s) used and the frequency of their administration; however, standard doses were used (Table 2). Subjects could cross over to wet nebulization in the event of adverse effects or unsatisfactory response to treatment, based on their own or their treating physician’s judgment.

All participants provided written informed consent at the time of recruitment. This study was approved by the research ethics committee of the Montreal Chest Institute Research Center.

**Measurements**

Baseline clinical and demographic data were obtained from subjects’ hospital charts and by questionnaires administered by research staff. Spirometric measurements were obtained by research assistants immediately after recruitment, using a desktop spirometer (Vitalograph Compact, model C; Vitalograph; Kansas City, MO) according to the American Thoracic Society guidelines. The regression equations of Knudson et al were used for calculation of predicted values.

For each subject, all MDI teaching was directly observed and timed by the research assistants, beginning with the placebo demonstration by the nurse and ending with the subject’s self-administration of \(\beta_2\)-agonist by MDI. On discharge from the
day hospital, patients completed a brief, self-administered satisfaction questionnaire. This included four statements about bronchodilator treatment and teaching; for each statement, subjects indicated their degree of agreement on a 5-point Likert scale.

**Statistical Analysis**

Data from subjects who were randomized to the MDI/DED arm and received training and treatment were included in teaching-time analyses. Subjects who withdrew or who crossed over to treatment by wet nebulization before completing MDI teaching were reported as such; teaching time could not be calculated for these subjects.

All statistical analyses were conducted with software (Stata version 7.0; Stata Corporation; College Station, TX). Participants’ baseline characteristics and teaching time requirements were described by mean ± SD or by medians and interquartile ranges (IQRs), stratified by primary diagnosis. Univariate and multivariate linear regression analyses evaluated factors potentially associated with teaching duration. In addition to the prespecified variables of age, gender, diagnosis, FEV₁ percent predicted, and Borg scale score, only the variables with p values < 0.20 on univariate analysis were retained in the multivariate model. Because the distribution of the dependent variable (teaching duration) was slightly skewed to the right, we used bootstrapping methods (1,000 bootstrap samples) to construct confidence intervals for confirmation. Other linear regression model assumptions were verified, as recommended.

**RESULTS**

**Recruitment**

Patient recruitment is summarized in Figure 1. Of 460 patients screened, 216 patients were found to be ineligible. The most frequent reasons for ineligibility included administration of two or more supervised bronchodilator treatments before screening (n = 52), an inability to communicate in French or English (n = 40), and the presence of unstable cardiovascular disease (n = 34). Among 57 patients who refused to participate, the major reasons cited were “too tired” (n = 14), “reluctant to fill the diary cards” (n = 12), and “prefer wet nebulization” (n = 10).

Of 61 patients with asthma who were randomized to MDI/DED treatment, 2 patients switched to wet nebulization before MDI teaching began: 1 patient because of a rapidly worsening respiratory condition, and 1 patient because of a vagal episode after baseline spirometry. Two other patients with asthma could not complete the initial MDI teaching session because of severe dyspnea and severe cough, respectively. The four patients with asthma were older (mean [SD] age, 60.3 [9.5] years vs 50.1 [17.8] years) and had lower FEV₁ values (mean [SD] FEV₁ percent predicted, 47.7% [26.3%] vs 64.2% [22.4%]) than those who completed MDI/DED teaching, respectively. Of 32 patients with COPD randomized to MDI/DED, 1 patient crossed over to wet nebulization because of worsening dyspnea after the first MDI treatment. Therefore, 57 patients with asthma and 31 patients with COPD (95% of subjects randomized to MDI/DED) completed MDI teaching according to protocol.

**Baseline Characteristics**

Subjects’ baseline characteristics are summarized in Table 3. On average, subjects with COPD were older than those with asthma and had lower FEV₁ values and oxygen saturation at study entry. Three patients with COPD were treated with supplemental oxygen at the day hospital. Forty-nine (80%) patients with asthma and 25 patients (78%) with COPD
received a bronchodilator treatment at the hospital, an average of 90 min before randomization. Of these, all except three patients with asthma and one patient with COPD received this rescue treatment by wet nebulization. Sixty-one patients (66%) reported previous instruction in MDI use; 43% of the patients with asthma and 63% of the patients with COPD reported DED use at home (always, most of the time, or sometimes).

Duration of Teaching

Median total teaching time was 6.2 min for patients with asthma (IQR, 4.3 to 9.2 min) and 8.5 min (IQR, 5.1 to 11.0 min) for patients with COPD. Only two patients with asthma and four patients with COPD required additional coaching after the second supervised MDI treatment. Among patients with asthma or with COPD who reported no previous MDI instruction, median total teaching time was 8.4 min (IQR, 5.9 to 11.3 min) and 9.9 min (IQR, 5.1 to 11.0 min), respectively.

Following adjustment for age, gender, primary diagnosis, baseline Borg score, and baseline FEV$_1$ (as percent predicted), the following were independently associated with reduced total teaching-time requirements: higher oxygen saturation at recruitment, previous MDI instruction and DED use at home, and single bronchodilator treatment before randomization (Table 4). Confidence intervals from this final model and those obtained by the bootstrap technique were consistent (data not shown). The use of a single rescue dose of bronchodilator before randomization accounted for a 2-min reduction in teaching time, on average. Initial oxygen saturation

Table 3—Baseline Characteristics of Study Subjects

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Asthma (n = 61)</th>
<th>COPD (n = 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age, yr (IQR)</td>
<td>46 (36-65)</td>
<td>68.5 (62-74.5)</td>
</tr>
<tr>
<td>Female gender, No. (%)</td>
<td>35 (57.4)</td>
<td>13 (40.6)</td>
</tr>
<tr>
<td>Formal education, mean (SD), yr</td>
<td>12.7 (4.7)</td>
<td>11.3 (3.8)</td>
</tr>
<tr>
<td>Received one dose of bronchodilator, No. (%)</td>
<td>49 (80.3)</td>
<td>25 (78.1)</td>
</tr>
<tr>
<td>Mean FEV$_1$, % predicted at entry (n = 92), (SD)</td>
<td>63.5 (23.3)</td>
<td>39.5 (14.3)</td>
</tr>
<tr>
<td>Best FEV$_1$ recorded in previous year, % predicted (n = 58),* (SD)</td>
<td>68.8 (22.2)</td>
<td>46.6 (14.1)</td>
</tr>
<tr>
<td>Mean modified Borg scale score (n = 92), (SD)</td>
<td>3.7 (2.2)</td>
<td>3.7 (2.0)</td>
</tr>
<tr>
<td>Mean SpO$_2$ at entry (n = 88), (SD)</td>
<td>96.1 (2.5)</td>
<td>93.7 (2.8)</td>
</tr>
<tr>
<td>Previous MDI instruction, No. (%)</td>
<td>40 (65.6)</td>
<td>21 (65.6)</td>
</tr>
<tr>
<td>DED use (always/most of the time/sometimes),† No. (%)</td>
<td>26 (42.6)</td>
<td>20 (62.5)</td>
</tr>
<tr>
<td>Previous MDI instruction and using DED,‡ No. (%)</td>
<td>23 (37.7)</td>
<td>17 (53.1)</td>
</tr>
<tr>
<td>Inhaled corticosteroid use during the previous week, No. (%)</td>
<td>45 (73.8)</td>
<td>21 (65.6)</td>
</tr>
<tr>
<td>Oral corticosteroid use during the previous week, No. (%)</td>
<td>14 (23.0)</td>
<td>8 (25.0)</td>
</tr>
</tbody>
</table>

*Based on 38 asthma patients and 20 COPD patients with documented spirometry within the preceding year.
†Frequency of DED use was asked in the question, “How often do you now use the DED (spacer) with your puffer?”
‡An aggregated variable from previous MDI instruction and DED use.

Figure 1. Flow diagram of study subjects. *Six subjects were found to have been erroneously recruited and were withdrawn immediately after randomization. The reasons for exclusion included misdiagnosis of asthma or COPD exacerbation (n = 3), undisclosed comorbidity (n = 2), and concomitant enrollment in another trial (n = 1). WN = wet nebulization; Tx = treatment; DH = day hospital.
was inversely related to teaching duration, whereas years of formal education were unrelated to duration of teaching time. Three of the 61 patients with asthma (5%) and 4 of 32 subjects with COPD (13%) required inpatient hospitalization because of persistent respiratory symptoms; these patients include 2 patients with asthma who did not complete the MDI teaching and were treated using wet nebulization. For purposes of comparison among participants randomized to receive treatment by wet nebulization, the proportion of patients hospitalized were 3 of 56 for patients with asthma (5%) and 5 of 32 for patients with COPD (16%). These proportions are consistent with the usual frequency of transfers to acute-care wards in our patient population. Most patients expressed satisfaction with MDI/DED coaching and treatment (Table 5).

**DISCUSSION**

In this prospective, randomized study of adults with acute airflow obstruction, 88 of 93 subjects were successfully trained to use MDI/DED therapy for emergency management. Teaching and supervision of MDI/DED use were based on a straightforward protocol. In most cases, the training time required of health-care personnel was < 10 min.

On average, less teaching was required for subjects who reported both previous MDI instruction and ongoing DED use at home, as well as for those with higher initial oxygen saturation and for those who had already received a rescue dose of a bronchodilator. Most subjects reported that they were satisfied with MDI/DED coaching and treatment.

This study has several strengths. The randomized design removed potential physician or investigator bias toward treatment allocation. Most eligible patients (77%) agreed to take part in the study, whereas only 4% of eligible patients refused because of a preference for wet nebulization. This suggests that our results can likely be generalized to the target population of patients with moderate acute airways obstruction. Teaching time was prospectively measured for every subject. Although coaching was one-on-one, it followed a standard protocol. Subjects were coached by respiratory nurses with formal training in inhaler teaching, a role that is also well suited to respiratory therapists and to trained ED personnel.

<table>
<thead>
<tr>
<th>Statements</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Indifferent</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>The MDI/DED was easy to use</td>
<td>67 (76)</td>
<td>16 (18)</td>
<td>2 (2)</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>The MDI/DED helped me feel better</td>
<td>62 (70)</td>
<td>19 (22)</td>
<td>2 (2)</td>
<td>6 (7)</td>
<td>3 (3)</td>
<td></td>
</tr>
<tr>
<td>I would like to be treated by MDI/DED in the</td>
<td>54 (61)</td>
<td>18 (20)</td>
<td>7 (8)</td>
<td>3 (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>event of a future visit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The teaching I received satisfied me</td>
<td>75 (85)</td>
<td>9 (10)</td>
<td></td>
<td></td>
<td></td>
<td>4 (5)</td>
</tr>
</tbody>
</table>

*Data are presented as No. %.

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**Table 4—Univariate and Multivariate Association Between Baseline Characteristics and Teaching Time**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unadjusted*</th>
<th>95% Confidence Interval</th>
<th>Adjusted†</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, per 10-yr increase</td>
<td>35.0</td>
<td>6.8 to 63.3</td>
<td>26.7</td>
<td>5.5 to 55.8</td>
</tr>
<tr>
<td>Gender, female vs male</td>
<td>3.0</td>
<td>98.7 to 104.6</td>
<td>15.8</td>
<td>80.0 to 111.7</td>
</tr>
<tr>
<td>Diagnosis, COPD vs asthma</td>
<td>109.4</td>
<td>5.7 to 213.2</td>
<td>47.5</td>
<td>83.1 to 178.0</td>
</tr>
<tr>
<td>FEV1, % predicted, per 1% increase</td>
<td>1.9</td>
<td>4.1 to 0.3</td>
<td>1.7</td>
<td>1.0 to 4.4</td>
</tr>
<tr>
<td>Borg scale, per 1 score increase</td>
<td>0.9</td>
<td>23.4 to 25.3</td>
<td>3.8</td>
<td>26.9 to 19.3</td>
</tr>
<tr>
<td>SpO2, per 1% increase</td>
<td>37.5</td>
<td>55.4 to 19.5</td>
<td>34.6</td>
<td>54.7 to 14.4</td>
</tr>
<tr>
<td>Previous MDI instruction, yes vs no</td>
<td>129.1</td>
<td>232.7 to 25.6</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>DED use</td>
<td>88.7</td>
<td>188.6 to 11.1</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Always/monthly/sometimes vs rarely/never</td>
<td>120.5</td>
<td>219.8 to 21.2</td>
<td>144.9</td>
<td>240.7 to 49.0</td>
</tr>
<tr>
<td>MDI instructed and DED use, yes vs no</td>
<td>102.2</td>
<td>233.7 to 19.3</td>
<td>133.4</td>
<td>253.3 to 13.5</td>
</tr>
<tr>
<td>Bronchodilator treatment before recruitment, yes vs no</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Total differs (from n = 82 to n = 88) due to missing values.  
†Adjusted for other variables in the Table, including the combined previous MDI instruction and DED use variables.  
§Statistical significance (p < 0.05).
personnel. The use of a valved holding chamber promoted ease of use as well as bronchodilator delivery.18–20

Because of the setting and the eligibility criteria, most subjects had moderate acute airflow obstruction. A single bronchodilator treatment (most often given by wet nebulization) was permitted before randomization; in fact, >75% of subjects received this treatment. This occurred because bronchodilator administration by wet nebulizer was standard practice in our facility, and it was considered unethical to delay or alter treatment before study recruitment. In fact, our findings suggest that this practice may facilitate subsequent MDI teaching and treatment.

Subjects were taught by one of three trained nurses who were permanently assigned to our respiratory day hospital. We were not able to evaluate differences between nurses with respect to teaching. However, nurse assignments reflected date and time of arrival and were not related to patient characteristics.

All subjects were recruited in a specialty hospital setting. Hence, all subjects had previously used MDI devices at home, and two thirds reported previous instruction in their use. It is likely that teaching time requirements would be greater among patients with more limited experience—particularly among those with little previous access to suitable care.

Indeed, Gray and colleagues5 reported that extensive instruction in MDI required an average of 17 min among healthy volunteers and patients with stable respiratory disease (mean age, 70 years), most of whom had no previous inhaler experience. Chafin and colleagues22 reported that MDI/DED instruction required approximately 20 min among healthy university students. In contrast, among a group of previously treated patients with asthma, the mean instruction time in an ED was 8.3 min (SD, 5.8 min).8 The only identified predictor of teaching time was previous mastery of MDI technique, based on a seven-step checklist for correct inhaler use. Age was controlled in the analysis, but the mean age was not reported. The present study, conducted among a mixed group, with respect to prior MDI instruction and DED use, extends similar findings to patients with COPD as well as patients with asthma.

Asthma education programs remain relatively uncommon in acute-care facilities; in 1998, only 12 of 77 participating EDs (16%) in the Multi-Center Airway Research Collaboration reported formal educational programs targeting patients with asthma.22 Respondents to the same survey considered that instruction in proper inhaler technique as well as use of spacer represented the highest priority for ED-based asthma education. Our study suggests that the time required of personnel on a per-patient basis is modest and falls within targets identified by the survey respondents: 15 min for respiratory therapists, or 5 to 10 min for ED nurses. Therefore, personnel time should not be perceived as an obstacle to more widespread teaching and use of MDI devices in the acute-care setting, although there are clearly associated start-up costs in terms of staff training.

As in other reports, we documented the importance of previous MDI training. Indeed, the time required to ensure successful MDI use in the acute-care setting would almost certainly be even less than that reported here if MDI/DED technique were routinely reviewed during both follow-up and emergency visits. We conclude that the supervised use of MDIs based on a simple teaching protocol is not only safe and effective in the acute care of obstructive airways disease, it is also well within the capacity of many patients and most emergency facilities.

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