

Instruction of Hospitalized Patients by Respiratory Therapists on Metered-Dose Inhaler Use Leads to Decrease in Patient Errors

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BACKGROUND: Hospitalized patients have been shown to make several errors in using metered-dose inhalers (MDIs), which can lead to poor medication delivery. **METHODS:** This study was designed to look at the potential benefit of a respiratory therapist (RT) giving instruction on the use of MDIs to hospitalized patients with obstructive lung disease. A baseline group of 58 patients was observed by a physician while performing 2 actuations of their MDI and the number of errors they committed, based on the National Institutes of Health's recommended 8 steps for proper MDI use, was recorded. After a program of MDI instruction (which included encouragement to use a spacer) by an RT was performed, a second group of hospitalized patients was again observed by a physician to determine if their error rate was reduced. **RESULTS:** The baseline error rate was 6.72 (out of 15 possible) errors per patient, and improved to 2.43 errors per patient after RT-provided instruction ($p < 0.001$). This improvement was still significant after controlling for an increased use of spacers in the post-instruction group of patients (27.6% and 91.7% spacer use before and after education). **CONCLUSIONS:** Instruction of hospitalized patients with obstructive lung disease by an RT improves their correct use of MDIs and increases their use of spacers while in the hospital. *Key words:* metered-dose inhaler, education, respiratory therapist, spacer, obstructive lung disease. [Respir Care 2005;50(8):1040–1045].

Introduction

There have been numerous studies in the past describing the misuse of metered-dose inhalers (MDIs) in patients prescribed inhaled medications,^{1–3} and potential methods to improve the use of MDIs.^{4–6} Unfortunately, methods such as the education of hospital personnel, videotaped instruction for patients, and written instruction for patients^{5–7} have not proven to be beneficial, and the rate of

misuse remains unacceptably high. The misuse of MDIs can have important consequences, such as decreased efficacy, increased adverse effects, and increased cost generated from unnecessary use.^{8,9}

When MDIs with spacers are compared to nebulizer treatments for delivering bronchodilators, the clinical outcomes are similar, even in the acute setting.¹⁰ Considering the additional cost and personnel needed to administer nebulizer treatments, there are definite advantages in using MDIs. When correctly used, MDIs have been shown to deposit around 10–20% of medication to the targeted air-

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CPT Won S Song MD MC USA presented a version of this report at the Army chapter meeting of the annual meeting of the American College of Physicians, held November 12–15, 2003, in San Antonio, Texas.

The opinions expressed herein are not to be construed as official or as reflecting the policy of the Department of the Army or the Department of Defense.

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ways, which is similar to other delivery systems.¹¹ However, if the MDI is misused by the hospitalized patient, then the amount of delivery of the medication will decrease and the clinical result may be compromised.⁸

In general, health-care providers have poor knowledge regarding the proper use of MDIs.¹² However, out of all health-care providers, it has been shown that respiratory therapists (RTs) have the most knowledge regarding the proper technique of administering an MDI.¹³ In addition, one-to-one teaching with inpatients has been shown to provide significant benefit.⁴ This study was designed to see if education by an experienced RT would improve the correct use of MDIs by inpatients. Our hypothesis was that hospitalized patients who received one-to-one teaching by an RT would demonstrate better technique in the use of their MDIs.

Methods

Adult (over age 18) inpatients at Madigan Army Medical Center who had been prescribed MDIs were observed for their proficiency in the use of MDIs. Computerized medication lists on the hospital wards (excluding intensive care units) were reviewed to identify patients who had been prescribed bronchodilator MDIs for obstructive lung disease. These patients (Group 1) were not consecutive and were chosen mainly at the convenience of the investigator to observe the patients. An initial baseline group of patients was observed over a period of 3 months by an investigator (JM) who was a physician not involved in the patients' care. The patients were asked to take 2 puffs of their inhaler, and their technique was evaluated using 8 steps described as the proper use of MDI. The investigator did not provide any further instruction, teaching, or correction during the observation. Patients were also asked about previous experience with the use of MDIs, previous instruction, and the diagnosis for which they were using the MDI. Patients were excluded if they were not available on the ward, already discharged, unwilling to sign informed consent, or who had obvious mental-status changes.

The 8 steps are based on the recommendations of the National Institutes of Health review committee for the treatment of asthma.¹⁴ The patient must shake the canister prior to each actuation. The patient should then place the canister in an upright position within 4 cm of the opening of the mouth. A slow breath should be initiated prior to one actuation of the MDI (within the first third of inhalation). With patients using a spacer, the slow breath should be initiated after actuation. The breath should be continued slowly until total lung capacity is reached. The patient should hold his or her breath for at least 4 seconds. Although 10 seconds is actually recommended in the National Institutes of Health publication, we have found that

Table 1. Correct Use of a Metered-Dose Inhaler, With and Without a Spacer

MDI Without Spacer (8 steps)

1. Shake canister
2. Hold canister upright at opening of mouth
3. Begin a slow breath
4. Actuate the MDI once
5. Continue slow breath
6. Inhale to total lung capacity
7. Hold breath for at least 4 seconds
8. Wait at least 30 seconds before next actuation

MDI With Spacer (7 steps)

1. Shake canister
2. Hold canister upright with spacer in mouth
3. Actuate the MDI once
4. Take a slow breath
5. Inhale to total lung capacity
6. Hold breath for at least 4 seconds
7. Wait at least 30 seconds before next actuation

MDI = metered-dose inhaler

hospitalized patients are often too dyspneic to hold their breath for a full 10 seconds. Finally, the patient should wait at least 30 seconds between the first and second actuations. Again, the National Institutes of Health publication recommends 60 seconds between actuations, but we found that patients tended to rush their demonstration to the physician and so accepted waiting at least 30 seconds. Since the patients using a spacer do not need to begin a slow breath prior to actuation, they have only 7 steps per actuation. Since all patients were observed for 2 actuations, the total number of possible errors per patient was 15 if not using a spacer and 13 if using a spacer. Waiting 30 seconds between actuations occurs only once for 2 inhalations (Table 1).

After the initial observation period, a second group of different adult hospitalized patients who were prescribed bronchodilator MDIs by their physicians for obstructive lung disease were provided with teaching and bedside instruction on proper inhaler use by an RT. The patients were not consecutive and were chosen mainly at the convenience of when the RT had time to teach them. The patients were again identified by reviewing the medication lists of the non-intensive-care inpatients. All instruction was provided by a single RT (NR), who would usually spend between 5 min and 10 min with each patient. The RT would use the patient's prescribed MDI if available, or a demonstrator MDI if it was not available. All patients were encouraged to use a spacer with their MDI, and instruction was usually provided with a spacer (Aerochamber Plus, Monaghan Medical Corporation, Plattsburgh, New York), unless the patient refused. Patients were educated

on the reported benefits of using a spacer. Patients were also instructed regarding timing the actuation of the MDI with breathing, taking a slow breath (avoiding a whistling sound from the spacer, which indicates the breath is too fast), holding their breath for 10 seconds after full inhalation if they could, and waiting 60 seconds in between actuations. Instructions regarding cleaning of the spacer were also conveyed. Again, patients who were not available on the wards, already discharged, or with obvious mental-status changes were excluded. Patients who could not perform the task despite multiple attempts at teaching were also excluded.

A list of instructed patients was e-mailed to another investigator (WS), who, again, was a physician not involved in the care of these patients. The instructed group of patients was observed by this investigator to determine their proficiency with MDI use (Group 2) over a period of 3 months. Most patients were observed between 4 and 24 hours after receiving instruction by the RT. Because of inconvenient timing, the patient not available on the ward, patient unwilling to sign consent, or the patient already discharged, not all the instructed patients were included in Group 2.

Because of military deployment, the physician who observed the baseline Group 1 was not the same as the physician who observed the post-instruction Group 2. However, both physicians concomitantly observed 8 patients in Group 2 and scored the rate of patient errors independently, to ensure good correlation between investigators. The rate of errors was compared between the baseline and post-instruction groups. Subgroup analysis was performed on patients who were or were not using spacers in Group 1 and in Group 2. Statistical differences were determined using Student's *t* test, Fisher's exact test, and the chi-square test. A *p* of < 0.05 was considered significant. Assuming a baseline error rate of 75% (percent of patients making at least one error), we would need 58 subjects in each group to give an 80% power to detect a drop in the error rate to 50%. Therefore, the goal number of patients in each group was 60.

Results

There were 58 patients (31 men, 27 women) in the pre-instruction group (Group 1), with a mean age of 67.6 years (range 24–87 y) and 60 patients (39 men, 21 women) in the post-instruction group (Group 2), with a mean age of 67.9 years (range 33–86 y). A total of 60 patients were observed in Group 1 by the physician investigator (JM), but recorded data were incomplete for 2 patients, and they were excluded. A total of 74 different patients were provided with instruction by the RT (NR). Two patients could not perform proper MDI use even after multiple attempts at education. They could not perform inhalation and breath-

Table 2. Baseline Clinical Characteristics

	Group 1*	Group 2	p (Group 1 vs Group 2)†
Number of patients	58	60	NA
Mean age and age range (y)	67.6 (24–87)	67.9 (33–86)	0.91
Male (<i>n</i> and %)	31 (53.4)	39 (65.0)	0.20
COPD (<i>n</i> and %)	39 (67.2)	46 (76.6)	0.25
Asthma (<i>n</i> and %)	8 (13.8)	9 (15.0)	0.85
Previous instruction by physician (<i>n</i> and %)	24 (41.4)	21 (35.0)	0.48
Previous instruction by nurse (<i>n</i> and %)	15 (25.9)	11 (18.3)	0.32
No previous instruction (<i>n</i> and %)	15 (25.9)	9 (15.0)	0.14
Never used MDI before (<i>n</i> and %)	4 (6.9)	7 (11.7)	0.37
Used a spacer (<i>n</i> and %)	16 (27.6)	55 (91.7)	< 0.00

*Group 1 are patients without instruction, and Group 2 are different patients observed after instruction.

†Calculated via chi-square test, except for age, which was via Student's *t* test.

NA = not applicable

COPD = chronic obstructive pulmonary disease

MDI = metered-dose inhaler

hold properly. These patients were excluded and their physicians were contacted in order to change their medication order to a nebulizer. Group 2 consisted of 60 instructed patients who the investigator (WS) was able to observe using their MDI, 4–24 hours after instruction. No data are available on the 12 instructed patients who were not observed. Spacer devices were used by 16 patients (27.6%) in the pre-instruction group and 55 patients (91.7%) in the post-instruction group (*p* < 0.0001). Otherwise, the 2 groups were very similar (Table 2).

Baseline data collected from 58 patients revealed that the average number of errors per patient in Group 1 was 6.72. After the instruction by an RT, the error rate in Group 2 was to 2.43, a 63.8% difference in errors per patient, compared with Group 1 (*p* < 0.001). Almost all steps improved significantly after instruction with all patients, as well as in the subgroups using a spacer or not using a spacer (Table 3). Steps that did not improve significantly were shaking the canister and waiting at least 30 seconds between inhalations. Shaking the canister before the second inhalation was worse than before the first (shook canister before first inhalation: 86.2% in Group 1, 88.3% in Group 2; shook canister before second inhalation: 56.9% in Group 1, 65.0% in Group 2). Of the total steps available to perform correctly in Group 1 (838), 447 (53.4%) were performed correctly; in Group 2 (790), 644 (81.5%) were performed correctly (*p* < 0.0001, see Table 3). Fifty-five out of 58 patients (94.8%) in Group 1 made at least one error, while 45 out of 60 patients (75.0%) in Group 2 made at least one error (*p* = 0.0027). The persistent high rate of

MDI INSTRUCTION OF HOSPITALIZED PATIENTS BY RESPIRATORY THERAPISTS

Table 3. Number of Correct Steps by Patients Using MDIs Without Instruction (Group 1) and by a Different Group of Patients After Instruction (Group 2)

MDI Steps	Group 1						Group 2								
	With Spacer	Correct (%)	Without Spacer	Correct (%)	Total	Correct (%)	With Spacer	Correct (%)	<i>p</i> *	Without Spacer	Correct (%)	<i>p</i> †	Total	Correct (%)	<i>p</i> *
Shake canister‡	21	65.6	62	73.8	83	71.6	82	74.5	0.320	10	100.0	0.1098	92	76.7	0.3696
Hold canister upright‡	28	87.5	62	73.8	90	77.6	108	98.2	0.008	2	20.0	0.0014	110	91.7	0.0026
Begin a slow breath‡§	NA	NA	21	25.0	21	25.0	NA	NA	NA	8	80.0	0.0011	8	80.0	0.0004
Actuate the inhaler‡	24	75.0	73	86.9	97	83.6	107	97.3	< 0.0001	10	100.0	0.6001	117	97.5	0.0002
Continue the slow breath‡	11	34.4	41	48.8	52	44.8	96	87.3	< 0.0001	10	100.0	0.0016	106	88.3	< 0.0001
Inhale to total lung capacity‡	15	46.9	39	46.4	54	46.6	104	94.5	< 0.001	7	70.0	0.1937	111	92.5	< 0.0001
Hold breath for at least 4 s‡	12	37.5	24	28.6	36	31.0	72	65.5	0.005	6	60.0	0.0693	78	65.0	< 0.0001
Wait 30 s‡	3	9.4	11	13.1	14	12.1	20	18.2	0.185	2	20.0	0.6070	22	18.3	0.1395
Total of Subgroups and Groups	With Spacer	Correct (%)	Without Spacer	Correct (%)	Total	Correct (%)	With Spacer	Correct (%)	<i>p</i> *	Without Spacer	Correct (%)	<i>p</i> *	Total	Correct (%)	<i>p</i> *
Total patients	16	NA	42	NA	58	NA	55	NA	NA	5	NA	NA	60	NA	NA
Total steps	208	NA	630	NA	838	NA	715	NA	NA	75	NA	NA	790	NA	NA
Total steps correct	114	54.81	333	52.86	447	53.34	589	82.38	< 0.0001	55	73.33	0.0008	644	81.52	< 0.0001

Sub-groups are divided into those with a spacer, those without a spacer, and the total. Each observation of a patient's inhaler technique is of 2 inhalations, and the same step from each inhalation is combined in this table. The values are the number of correctly performed steps.

**p* for difference between Group 1 and Group 2 determined by chi-square test.

†*p* for difference between Group 1 and Group 2 determined by Fisher's exact test.

‡Step done twice for each patient

§Step done only by patients not using spacer

¶Step done only once by each patient

MDI = metered-dose inhaler

NA = not applicable

imperfect use in instructed patients relates mostly to not waiting at least 30 seconds between inhalations, but also to failure to breath-hold at least 4 seconds and not shaking the canister before the second actuation. The most dramatic improvements with instruction were in taking a slow breath prior to actuation in patients not using a spacer, continuing (without spacer) or taking (with spacer) a slow breath after actuation, taking a full breath to total lung capacity and breath-holding for at least 4 seconds after inhalation (see Table 3).

A subgroup analysis was performed, since the vast majority of patients in the post-instruction group used spacer devices. When spacer devices were used, the average number of errors per patient decreased in both groups (5.9 in Group 1 and 2.29 in Group 2), but the decrease in the post-education error rate remained statistically significant ($p < 0.001$). The decrease in error rate coincides with the decrease in total possible errors when using a spacer (13 steps vs 15 steps). The most frequent error remained failure to wait at least 30 seconds between inhalations, in both groups.

The 2 observers (JM and WS) had the same interpretation (correct vs incorrect) for 100 out of 104 observations in 8 patients observed simultaneously, for a correlation of 96.2%. All 4 mismatched observations were of different steps, so no systematic difference of observation was evident.

Discussion

As in previous studies, the misuse of MDIs is evident among hospitalized patients; however, there is definite improvement in technique following instruction by an RT. Despite enhanced performance with spacer use in both groups, there is still a significant improvement after education is provided by an RT. The RT also convinced a number of patients to use a spacer. A previous study of elderly patients who were instructed as inpatients in an elderly care ward revealed improved use of MDIs after one-to-one teaching by a registered nurse on 4 separate occasions.⁴ The question of whether an RT would have any benefit above and beyond a trained registered nurse is unknown. Unfortunately, many nurses have been shown to have important deficiencies in the proper use of MDIs^{2,11,15} and would require further training in order to become proficient instructors. The question of whether additional training would be beneficial was addressed by Thompson et al.^{5,6} Unfortunately, additional education, in the form of in-services, to nurses and house staff did not benefit proper patient MDI use.⁵ Based on our experience, the only way to ensure that hospitalized patients are using their MDIs correctly is to give them one-to-one instruction by someone who knows how to use the MDI. The benefit of using an RT to do this is that RTs usually already have this skill from their training and experience.¹³

Several biases are readily evident in this study. The nature of the study required that observers would be unblinded and that the evaluation of patients would be subjective. To decrease this bias, a limited number of simple steps were used to document the correct technique. Another bias is introduced by having different observers evaluate the pre-instruction and post-instruction groups. In comparing the results of 8 patients in Group 2, who were simultaneously but independently observed by both physicians, there was no significant difference in the evaluation of these patients (96.2% correlation).

Because of limited time available to the investigators and the RT, who all had other clinical duties while this investigation was being performed, not all eligible patients were observed or instructed. No data are available on patients not observed or instructed, so there could be a hidden bias, since the patients were selected based on the time available to observe or teach them.

To decrease variability, only one RT educated patients, although the use of a respiratory therapy team could be more efficient and productive. The study would have had more real-life validity if a team had been available to teach all patients prescribed an MDI, and if a random sample of these instructed patients had been observed. Because of military deployments and unavailability of staff, this was not possible. We intend on using the results of this study to justify hiring actions to make such a team available.

The obvious increase in spacer use and decreased number of required steps did not seem to eliminate the benefit of education, and the improved rate of spacer use can be claimed as another benefit of respiratory therapy consultation. Two patients were excluded from observation in Group 2 because the RT deemed them unable to perform the required steps. One could see this as falsely improving the correct use in the post-instruction group, but we feel this is yet another benefit of respiratory therapy consultation. Physicians may be unaware that their patients are not capable of performing the necessary steps to use an MDI, and identifying these patients to provide alternative therapies is appropriate. The amount of time between instruction and testing was not standardized, but was between 4 and 24 hours. Since patients were observed within one day of instruction, one could rightly argue that only short-term memory is being tested and that there may be no long-term benefit. Our major concern for the genesis of this study was that hospitalized patients were being prescribed medication that they were probably not benefiting from in many cases, because of improper MDI use. We have attempted multiple interventions^{5,6} to try to combat this problem, to no avail, until this study was performed. Since our average length of hospital stay is less than 3 days, we feel that the instruction provided by an RT would improve MDI use among our hospitalized patients.

The effects/benefits of improving MDI use were not evaluated in this study. It has been shown that an intensive program that includes instruction in proper use of MDIs leads to decreased length of hospitalization and fewer readmissions to the hospital, among asthmatic patients.¹⁶ In the future, use of alternative devices (eg, dry powder inhalers) to administer medications previously dispensed via MDI may prove to be highly beneficial, as problematic steps that require specific timing and coordination (initiating a slow breath prior to actuating an MDI and actuating the MDI during the inhalation) would be eliminated.¹⁷ The need for proper and continued instruction will still be tantamount in the proper dispensing of these inhaled medications, regardless of how simple the directions may appear to clinicians.

Conclusions

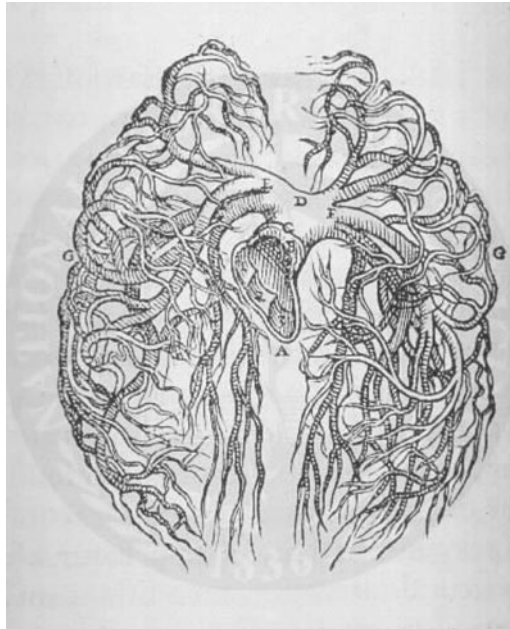
The results of this study support the use of RTs for instructing patients who use MDIs. This would lead to a significant decrease in the rate of errors, which in turn would lead to improved delivery of medications and symptom control.^{8,16}

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MDI INSTRUCTION OF HOSPITALIZED PATIENTS BY RESPIRATORY THERAPISTS

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Venous circulation of the lungs
Andreas Vesalius. *De humani corporis fabrica*
Ex officina Joannis Oporini; 1543
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