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## ORIGINAL RESEARCH

## Improving Metered Dose Inhaler Technique in the Emergency Department: A Prospective Study

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### ABSTRACT

**Objective:** To determine if improvement in patients' metered dose inhaler (MDI) technique could be achieved in the emergency department (ED) with the use of a simple illustrated instruction sheet. **Methods:** Prospective evaluation of a convenience sample of patients with asthma or COPD. Patients were first subjectively and objectively evaluated on their usual MDI technique, then were given an illustrated instruction sheet to study for 5 minutes. There was no verbal coaching prior to the post-test. A post-test evaluation was then performed. Results were compared using paired Student *t* test. **Results:** A total of 115 patients were enrolled. Mean age was 34.9±13.1 years, and mean years using MDI was 5.7±3.8. Subjective improvement in technique was reported by 110 patients (96%) with a mean pre-test

score of 7.4±1.5 and post-test score of 9.2±1.1 ( $p<0.0001$ , 10 point scale). Objective improvement was achieved in 113 patients (98%) with a mean pre-test score of 3.9±1.3 and post-test score of 5.8±1.0 ( $p<0.0001$ , 7 point scale), corresponding to a 30% improvement in technique (95% CI: 22,39). Forty-four patients (38%) reported never having been shown proper MDI technique by a health care professional, and 112 patients (97%) found the instruction sheet helpful. **Conclusions:** Rapid objective and subjective improvement of MDI technique from both patients' and physicians' perspective is possible in the ED with the use of an illustrated instruction sheet, and requires minimal effort from the treating emergency physician.

Key words: asthma, metered dose inhaler, emergency department, education

### INTRODUCTION

The incidence of asthma continues to increase in the developed world, and patients with acute and chronic asthma exacerbation who have been prescribed metered dose inhaler (MDI) medications commonly present to the emergency department (ED).<sup>1</sup> Furthermore, despite pharmacological advances, it remains the only treatable disease of the western world with increasing morbidity.<sup>2</sup> One theory for this increasing morbidity is patients' improper technique in the use of MDI and lack of instruction by health care workers. It has been recognized in several studies that both patients and physicians have had little training in the proper use of MDIs, and patients may not be fully benefiting from their MDI usage.<sup>3-7</sup> In theory, EDs may not be the best place for educating patients on the proper use of their MDIs, as EDs tend to be impersonal, noisy, and overcrowded. Furthermore, present day emergency physicians have little time to spend on patient education, as they are usually caring for many patients at the same time.<sup>8</sup> The possible benefits of proper MDI use include increased drug delivery, decreased sick days and ED visits, and improved patient compliance and relations with health care staff. We developed a rapid instruction protocol utilizing an illustrated sheet where instruction could be achieved in 5 minutes with limited time input from the emergency physician and without any verbal coaching

**Figure 1. The prospective data collection instrument.**

*MDI Data Sheet*

Patient Stamp

Instructor?: ML JR

Verbal instruction given?: Yes No

Pretest: Patient (subjective): \_\_\_\_\_ Scale (0 - 10)      Posttest: Patient (subjective): \_\_\_\_\_ Scale (0 - 10)

Physician (objective): \_\_\_\_\_      Physician (objective): \_\_\_\_\_  
 Scale (0 - 7)      Scale (0 - 7)

Step

1 Cap off/Shake \_\_\_\_\_

2 Hold upright \_\_\_\_\_

3 Exhale to RV \_\_\_\_\_

4 Depress MDI with inhalation \_\_\_\_\_

5 Steady deep inhalation \_\_\_\_\_

6 Hold breath 5+ seconds \_\_\_\_\_

7 Wait > 20 seconds for next \_\_\_\_\_

Age: \_\_\_\_\_ Race: \_\_\_\_\_ Language: \_\_\_\_\_


Gender: \_\_\_\_\_ Employed: \_\_\_\_\_ Education: \_\_\_\_\_

Years using MDI: \_\_\_\_\_ Disease: \_\_\_\_\_ Years with disease: \_\_\_\_\_

Which Rx?: \_\_\_\_\_ Use Spacer?: \_\_\_\_\_

Ever been shown?: \_\_\_\_\_ By whom?: \_\_\_\_\_ Did that help?: \_\_\_\_\_

Know how much left in MDI?: \_\_\_\_\_ Did this demo help?: \_\_\_\_\_



condition necessitating the use of an MDI, such as asthma, reactive airway disease, or chronic obstructive pulmonary disease (COPD). Other inclusion criteria included understanding of written English, ability to clearly visualize the instruction sheet, and age greater than or equal to 18.

**Study Protocol.** A convenience sample of patients was enrolled in the study by two of the study investigators (JR, ML). Informed consent was obtained, and an objective pre-test using the patient's own MDI, or one provided to the patient at discharge, was performed with no coaching or other input from the emergency physician to the patient. Seven critical steps were scored during the pre-test: (1) Cap off/Shake; (2) Hold upright; (3) Exhale to residual volume; (4) Depress MDI with inhalation; (5) Steady, deep inhalation; (6) Hold breath 5+ seconds; (7) Wait >20 seconds before repeating. The seven steps were identified and previously validated from several studies and educational tools concerning proper MDI technique.<sup>9-11</sup> The data collection instrument used for this purpose is demonstrated in Figure 1, which also included patients' demographics, medical and medication history.

involved. To test its feasibility we conducted a prospective study in a busy university ED.

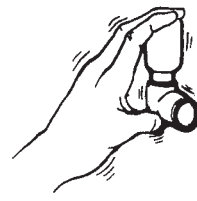
**METHODS**

**Study Design.** This prospective study was conducted over a one-year period at an urban university hospital ED with an annual census of 65,000 patient visits. This ED serves a surrounding population of approximately 2 million, and serves as the public, or county, hospital for this region as well as a Level I Trauma Center. This study was approved by the hospital's human subjects review committee.

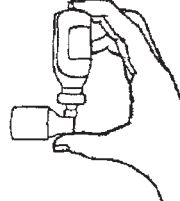
**Study Population.** Patients were eligible for the study if they presented with any medical

**Figure 2. The patient instruction sheet given after the pre-test.**


SAVE YOUR LUNGS - USE YOUR INHALER CORRECTLY




REMOVE CAP AND SHAKE CANISTER



HOLD UPRIGHT




BLOW OUT ALL THE AIR FROM YOUR LUNGS




PLACE MOUTHPIECE ONE INCH FROM YOUR MOUTH

*(or... you can wrap your lips around the canister if you prefer)*



INHALE SLOWLY AND DEEPLY WHILE PRESSING DOWN ON THE CANISTER



HOLD YOUR BREATH 5 - 10 SECONDS  
WAIT 20 SECONDS UNTIL YOUR NEXT PUFF

**Table 1. Interrater reliability between the two study investigators (JR, ML) for the first 20 patients enrolled.**

Pre-Test Step	Agreement (%)	Expected (%)	Kappa	Z
1	100	90.5	1	4.47
2	100	90.5	1	4.47
3	95	78	0.78	3.55
4	95	78	0.78	3.55
5	80	48	0.62	2.98
6	80	62.5	0.47	2.09
7	100	52	1	4.47
<b>Post-Test</b>				
Post-Test Step	Agreement (%)	Expected (%)	Kappa	Z
1	95	78	0.78	3.55
2	100	90.5	1	4.47
3	85	53	0.68	3.06
4	95	78	0.77	3.55
5	75	62	0.34	2.08
6	80	62.5	0.47	2.09
7	100	50	1	4.47
<b>Overall</b>	90.71	50	0.81	12.24

Kappa values greater than 0.75 represent excellent agreement beyond chance, between 0.40 and 0.75 represent fair agreement, and values below 0.40 represent poor agreement.

After the pre-test, patients were given an illustrated instruction sheet conceived and developed by the authors (Figure 2) to study for a period of 5 minutes, with no verbal input from the emergency physician. After 5 minutes, a post-test was performed using the same 7 critical steps as the pre-test, and patients' performances were reevaluated and recorded on the data collection instrument. Subjects were not allowed to look at the instruction sheet during the post-test. In addition, there was a subjective questionnaire for the study participants regarding their perception of MDI technique before and after the study, prior education for MDI use, how to determine remaining volume in an MDI, and whether or not the instruction sheet was useful in improving their MDI technique.

**Data Analysis.** Differences in participants' performance before and after instruction were analyzed using the paired Student t-test. Since the test was administered by just two of the investigators, interrater reliability was measured using the kappa statistic for both the pre- and post-testing on the first

20 patients of the study. Statistical significance is assumed at a level of  $p < 0.05$ , and 95% confidence intervals (CI) are included where appropriate. Data are reported as mean  $\pm$  standard deviation or standard error of the mean (SEM).

## RESULTS

There were 115 patients enrolled in the study, and none refused to complete the study once begun. Mean age of the study participants was  $34.9 \pm 13.1$  years. There were 56 females (49%) and 59 males (51%). Forty-four were white (38%), 36 black (31%), 19 Asian (17%), and 16

Hispanic (14%). Additional demographic information collected includes employment status, with 62 (54%) employed at the time of the study and 53 (46%) unemployed. With regard to level of education, 81 (70%) had high school or equivalent, 23 (20%) had a college degree, 11 (10%) had grade school or less, and none had a post-graduate degree.

There were 71 study participants (62%) who reported having been taught proper MDI technique prior to the study by pharmacists ( $n=37$ ), physicians ( $n=30$ ), and respiratory therapists ( $n=4$ ). Fifty-five subjects (48%) reported regular use of a spacer, and only 10 (9%) knew how to determine when their MDI was empty. Mean years using MDIs for the entire study group was  $5.7 \pm 3.8$  years. One hundred three (90%) had a medical history of asthma, and 12 (10%) had COPD. There were no patients in the study who had *de novo* diagnoses of asthma or COPD made at the time of the study.

Interrater reliability was determined between the two investigators responsible for administering the pre- and

**Table 2. Objective improvement for each step of the pre- and post-test.**

Step	Pre-Test %±SEM	Post-Test %±SEM	Improvement % (95% CI)	P-value
1	80.9±4.1	95.8±2.1	14.9 (9.8, 20.1)	0.0001
2	100	100	0	~
3	25.5±4.5	81.9±3.9	56.4 (50.3, 62.2)	<0.0001
4	84.0±3.8	91.5±2.9	7.5 (2.4, 12.1)	0.02
5	54.3±5.2	90.4±3.1	36.1 (30.2, 42.6)	<0.0001
6	32.9±4.9	80.9±4.1	48 (41.4, 55.1)	<0.0001
7	20.2±4.2	48.9±5.2	28.7 (21.8, 35.3)	<0.0001

physicians are often *de facto* primary care providers, as many patients now utilize the ED as an alternative to seeking out a primary care physician for various reasons.<sup>8</sup> Present-day emergency physicians have little time to devote to patient education, as they are often juggling multiple tasks while simultaneously providing care to several acutely ill and

post-tests and survey. The first 20 patients enrolled in the study were included for this phase, and results are shown in Table 1. Overall agreement was 90.7% for both the pre- and post-test, with a kappa of 0.81.

One hundred thirteen patients (98%) had objective improvement in one or more steps of their MDI technique upon completion of the study. The mean total pre-test score was 3.9±1.3, and mean post-test score was 5.8±1.0 (maximum score of 7), an overall improvement of 30% (95% CI: 22,39, p<0.001). The improvement for each step is demonstrated in Table 2. The greatest technical improvement was for step three, which was 56.4% (95% CI: 50,62, p<0.001); this was followed by step six, which was 48% (95% CI: 41,55, P < 0.001). Subjective improvement was noted by 110 patients (96%), with a mean pre-test score of 7.4±1.5, and mean post-test score of 9.2±1.1 (maximum score of 10). This represented an overall improvement of 20% (95% CI: 13,28, p<0.001). Forty-four patients (38%) reported never having been shown proper MDI technique by a health care professional, and 112 patients (97%) found the instruction sheet helpful.

## DISCUSSION

The efficacy of any medication delivered via MDI is highly dependent on proper technique, and health care providers who prescribe these medications should have the basic knowledge of MDI use.<sup>12,13</sup> Furthermore, if their patients demonstrate limited knowledge about MDIs and/or improper technique, practitioners should also be willing to correct this deficiency. Emergency

injured patients.

We chose to develop and evaluate an educational tool that kept emergency physicians' time input to a minimum. We know of no other prospective studies that utilized only an instruction sheet and required no verbal coaching or demonstration of technique by the health care provider. In one of the few studies conducted in the ED, Shrestha and associates used verbal individualized instruction to achieve improvement in patients' MDI technique, but concluded the amount of time required for instruction was directly proportional to the number of steps missed and may not be feasible for the ED setting.<sup>14</sup>

In a single-blind prospective study, Verver and associates were able to document improvement in MDI technique for 48 patients over a two-week period with verbal instruction and videotaping.<sup>15</sup> This type of instruction, although effective, would not only be inappropriate for the ED from both a time and equipment perspective, but also for patient confidentiality issues. Rydman and colleagues, in their prospective study at the Asthma Clinic of Cook County Hospital in Chicago, compared two instructional methods: verbal instruction with demonstration versus written instruction only.<sup>16</sup> Both educational tools resulted in equivalent statistical improvement, and the authors concluded written instruction alone may be sufficient for patient education in MDI technique. This would seem to confirm the results of our study, which involved only written instructions with no demonstration or verbal coaching.

In a large prospective study in Spain, 349 patients were instructed on proper MDI technique by physicians, nurses, and respiratory therapists.<sup>17</sup> The authors then reevaluated the subjects after 2 and 8 months to determine retention, and demonstrated that improvement in MDI technique was long-term. The patient population in the ED makes both long- and short-term follow-up difficult, if not impossible, and evokes confidentiality issues as well. Computer technology and the Internet have evolved over the past decade, and provide educational opportunities for both patient and practitioner. Erickson and colleagues compared training of pharmacists in MDI technique between a traditional lecture and a web-based tutorial, and found both were equally effective in improving MDI technique.<sup>18</sup> Although a web-based educational tool has many advantages, it would unfortunately be impractical for use by the emergency physician, as it would require the use of computers within the ED, or that ED patients have access to the Internet after discharge.

It has been well documented from past studies that health care workers have limited knowledge of MDI technique, and that few have received formal training in its proper use.<sup>4,5</sup> We considered an individualized training session for the patient by the emergency physician, but felt this would be impractical from the time required, which might negatively impact patient flow in the ED. Chafin and associates utilized a brief discussion and demonstration as an educational tool for medical students and noted significant improvement in MDI technique as a result.<sup>19</sup> We did not study emergency physicians' prior knowledge of MDI use and their technique.

Inadequate literacy is a barrier to asthma knowledge and treatment for many patients presenting to the ED.<sup>20</sup> For this purpose, we devised an instruction sheet that was more visual than verbal, although the ability to read English was one of the inclusion criteria.

The actual demonstration of MDI technique by the patient may be one of the keys to success in this and prior studies. Kamps and co-workers demonstrated that pediatric patients improved their MDI technique more reliably when patients themselves demonstrated

their technique.<sup>21</sup> Although we did not include children, one of the main features of our study was to observe patients' MDI technique, which improved appreciably after they studied the instruction sheet for just 5 minutes. In our study, the steps which showed the most improvement in MDI technique were three and six, which corresponded to exhaling completely to residual volume prior to drug delivery and holding one's breath at least 5 seconds, respectively. These are probably the most important steps with regard to maximum drug delivery, and prior studies have also identified these particular steps as the most difficult for elderly, adolescent, and pediatric patients to perform correctly.<sup>22-24</sup>

## LIMITATIONS AND FUTURE QUESTIONS

This prospective study had several limitations. First, it measured a convenience sample of patients, and different outcomes may have resulted if there were a consecutive sample of patients. There were two unblinded study investigators involved in the consent and administration of the test, and there may have been some bias with regard to data collection as a result. This was one of the main reasons interrater reliability was measured for the first 20 patients.<sup>25</sup> The instruction sheet was only printed in English, and many patients who lacked the ability to read English were unable to participate in the study. The instruction sheet also required the ability to visualize it clearly to acquire the graphical teaching; thus patients with restrictions on their vision were also unable to participate in the study. This may have also ultimately affected our results. We did not conduct follow-up studies to determine patients' retention of proper MDI technique, which may have deteriorated after the initial tutorial. Future questions involve the creation of an instruction sheet in other languages, and the possibility of verbal coaching for those patients with vision impairment.

Finally, the use of spacers to improve MDI delivery has been advocated but was not included in this study. Most ED patients are unfamiliar with spacers and do not carry them because of the added bulk and complexity. A future study might compare spacer versus non-spacer training in the ED and effect on

medication delivery, and patient satisfaction within the ED setting.

## CONCLUSION

Rapid objective and subjective improvement of MDI technique from both the patients' and physicians' perspective is possible in the ED with the use of an illustrated instruction sheet, and requires minimal effort from the treating emergency physician.

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