ORIGINAL RESEARCH

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

John R. Richards, MD
Michael J. Luskin, MD
Irina N. Krivoshto
Robert W. Derlet, MD

From the Division of Emergency Medicine
University of California, Davis Medical Center,
Sacramento, California

Correspondence:
John R. Richards, MD
Division of Emergency Medicine
University of California, Davis Medical Center
2315 Stockton Boulevard
Sacramento, CA 95817
Phone: (916) 734-1537
Fax: (916) 734-7950
Email: jrrichards@ucdavis.edu

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).\(^1\) Furthermore, despite pharmacological advances, it remains the only treatable disease of the western world with increasing morbidity.\(^2\) 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.\(^3\)\(^-\)\(^7\) 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.\(^8\) 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.
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 1 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 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. The data collection instrument used for this purpose is demonstrated in Figure 1, which also included patients’ demographics, medical and medication history.

---

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

**Figure 2. The patient instruction sheet given after the pre-test.**
Table 1. Interrater reliability between the two study investigators (JR, ML) for the first 20 patients enrolled.

| Step  | Agreement (%) | Expected (%) | Kappa | Z   |
|-------|---------------|--------------|-------|-----|
| Pre-Test |               |              |       |     |
| 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|
| Post-Test |               |              |       |     |
| 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|
| Overall | 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 ± 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±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±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
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. Furthermore, if their patients demonstrate limited knowledge about MDIs and/or improper technique, practitioners should also be willing to correct this deficiency. Emergency 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. 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 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.

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. 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. 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. 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. 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. 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. 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. 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. 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.

**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. 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.

**REFERENCES**

1. Mannino DM, Homa DM, Pertowski CA, et al. Surveillance for asthma: United States 1960-1995. **MMWR Morb Mortal Wkly Rep** 1998;47:1-28.

2. Woolcock AJ, Peat JK. Evidence for the increase in asthma worldwide. In: CIBA Foundation symposium 206: The rising trends in asthma, Chichester, UK: John Wiley & Sons, 1997, pp 123-125.

3. Tan NC, Ng CJ, Goh S, Lee CE. Assessment of metered dose inhaler technique in family health service patients in Singapore. **Singapore Med J** 1999;40:465-467.

4. O’Donnell J, Birkinshaw R, Burke V, Driscoll PA. The ability of A&E personnel to demonstrate inhaler technique. **J Accid Emerg Med** 1997;14:163-164.

5. Jones JS, Holstege CP, Rickse R, White L, Bergquist T. Metered-dose inhalers: do emergency health care providers know what to teach? **Ann Emerg Med** 1995;26:308-311.

6. DeBlaquiere P, Christensen DB, Carter WB, Martin TR. Use and misuse of metered dose inhalers by patients with chronic lung disease. **Am Rev Respir Dis** 1989;140:910-916.

7. Plaza V, Sanchis J. Medical personnel and patient skill in the use of metered dose inhalers: a multicentric study. **Respiration** 1998;65:195-198.

8. Derlet RW, Richards JR, Kravitz RL. Frequent overcrowding in U.S. emergency departments. **Acad Emerg Med** 2001;8:151-155.

9. Murphy S. Guidelines for the diagnosis and management of asthma. Bethesda, MD: National Institutes of Health, National Heart, Lung, and Blood Institute; 1997. Report 97-4051.

10. Grainger JR. Correct use of aerosol inhalers. **CMAJ** 1977;116:584-585.

11. Newman SP, Pavia D, Clarke SW. Simple instructions for using pressurized aerosol bronchodilators. **JR Soc Med** 1980;73:776-779.

12. Lindgren S, Bake B, Larsson S. Clinical consequences of inadequate inhalation technique in asthma therapy. **Eur J Respir Dis** 1987;70:93-98.

13. Giraud V, Roche N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. **Eur Respir J** 2002;19:246-251.

14. Shrestha M, Parupia H, Andrews B, Kim SW, Martin MS, Park DI, Gee E. Metered-dose inhaler technique of patients in an urban ED: prevalence of incorrect technique and attempt at education. **Am J Emerg Med** 1996;14:380-384.

15. Verver S, Poelman M, Bogels A, Chisholm SL, Dekker FW. Effects of instruction by practice assistants on inhaler technique and respiratory symptoms of patients. A controlled randomized videotaped intervention study. **Fam Pract** 1996;13:35-40.

16. Rydman RJ, Sonenthal K, Tadimeti L, Butki N, McDermott MF. Evaluating the outcome of two teaching methods of breath actuated inhaler in an inner city asthma clinic. **J Med Syst** 1999;23:349-356.

17. Giner J, Macian V, Hernandez C, et al. Multicenter prospective study of respiratory patient education and instruction in the use of inhalers (EDEN study). **Arch Bronconeumol** 2002;38:300-305.

18. Erickson SR, Chang A, Johnson CE, Gruppen LD. Lecture versus web tutorial for pharmacy students’ learning of MDI technique. **Ann Pharmacother** 2003;37:500-505.

19. Chafin CC, Tolley E, Demirkan K, Burbeck J, Self TH. Effect of a brief educational intervention on medical students’ use of asthma devices. **J Asthma** 2000;37:585-588.

20. Williams MV, Baker DW, Honig EG, Lee TM, Nowlan A. Inadequate literacy is a barrier to asthma knowledge and self-care. **Chest** 1998;114:1008-1015.

21. Kamps AW, Brand PL, Roorda RJ. Determinants of correct inhalation technique in children attending a hospital-based asthma clinic. **Acta Paediatr** 2002;91:159-163.
22. Van Beerendonk I, Mesters I, Mudde AN, Tan TD. Assessment of the inhalation technique in outpatients with asthma or chronic obstructive pulmonary disease using a metered-dose inhaler or dry powder device. *J Asthma* 1998;35:273-279.

23. Gray SL, Williams DM, Pulliam CC, Sirgo MA, Bishop AL, Donohue JF. Characteristics predicting incorrect metered-dose inhaler technique in older subjects. *Arch Intern Med* 1996;156:984-988.

24. Scarfone RJ, Capraro GA, Zorc JJ, Zhao H. Demonstrated use of metered-dose inhalers and peak flow meters by children and adolescents with acute asthma exacerbations. *Arch Pediatr Adolesc Med* 2002;156:378-383.

25. Gray SL, Nance AC, Williams DM, Pulliam CC. Assessment of interrater and intrarater reliability in the evaluation of metered-dose inhaler technique. *Chest* 1994;105:710-714.