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Competence in metered-dose inhaler technique among healthcare workers of three general hospitals in Mexico: it is not good after all these years

Abstract

Introduction: Inhaled medication is the cornerstone of pharmacological treatment for chronic respiratory diseases. Therefore, it is important to use a metered-dose inhaler (MDI) correctly to get the appropriate dosage and benefit from the drug. Health-care workers (HCW) are responsible for teaching the correct MDI technique. Unfortunately, numerous studies consistently show that HCW have poor MDI technique. This study aimed to evaluate the current knowledge of MDI technique in HCW working in three general hospitals.

Material and methods: A hospital-based, cross-sectional descriptive study was conducted in three general hospitals in Aguascalientes, México. Three surveyors simultaneously scored through a 14 dichotomic questions list as bad, regular, good, and very good MDI technique. Data were analyzed with SPSS version 16. Statistical analyses were performed using chi-square test or unpaired t-tests. An analysis of one-way ANOVA was used for comparison of three independent general hospitals. Values of $p < 0.05$ were considered to indicate statistical significance.

Results: A total of 244 HCWs were surveyed: 78.3% were nurses whereas 21.3% were physicians. The inter-observer concordance analysis among observers was 0.97. We observed that 32.4% (79) performed a bad technique, 51.6% (126) a regular technique, 13.5% (33) a good one, and 2.5% HCW (6) a very good technique. No difference between gender, labor category, schedule, service, age, seniority, and education degree between the three hospitals was observed. The most common mistakes were "insufficient expiration prior to activation of the device", and "the distance the inhaler was placed for inhalation" (83 and 84% respectively).

Conclusion: We observed that a high percentage of HCW do not follow the MDI technique correctly, being this percentage even higher than the reported in other studies. These observations suggest the urgent need to establish frequent training programs for the correct use of MDI.

Key words: metered-dose inhaler, inhalation devices, inhaler technique, health-care workers, physicians

Adv Respir Med. 2021; 89: 8–14

Introduction

Since the inhalation of vapor of black henbane was known thanks to the papyrus of Ebers an ancient Egyptian (1,554 BC), inhalation therapy has been widely used worldwide and it was until 1829 that Schneider and Waltz developed a system called "hidroconion" to pulverize and atomize liquids [1]. This appliance was used as an inhaler since then [2]. The word aerosol was first introduced by Whitlaw, Grey, and Patterson in 1932 to define the suspension of tiny liquid or solid particles in the air [2]. Controlled-dose inhalers were the primary means for treating respiratory diseases, such as asthma and COPD, both of which have a significant prevalence worldwide [3].

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DOI: 10.5603/ARM.a2021.0027
Received: 27.07.2020

ISSN 2451–4934

The pressurized metered-dose inhaler (MDI) was introduced in 1956 becoming one of the commonest delivery systems for the introduction of drugs into airways. The MDI with a good inhaler technique and adequate adherence are important for delivering the correct doses during treatment. Concerning technique, specific steps and good coordination are necessary for the proper use of this device. A less than optimal technique is commonly observed in respiratory patients and can result in decreased drug delivery and potentially reducing efficacy [4].

Health-care workers (HCW) play a pivotal role in imparting the correct steps in MDI technique. However, several studies have found that among HCW a suboptimal knowledge and skills on the MDI technique are not uncommon [5]. Thus, it is important HCW know the basic steps of the MDI technique because inhaled medications are the mainstay of bronchial disease therapy and their successful use requires both practical skills and theoretic knowledge, in order to obtain the maximum benefit of these inhalers. It is evident that if HCW are unable to apply the MDI technique correctly [6–9], educating patients for its use would be ineffective [10, 11].

Blaiss *et al.* [12] have mentioned that many patients cannot use de MDI correctly, which compromises the treatment of patients with obstructive diseases. There is no doubt that patients actively participate in using the MDI, however, physicians and nurses also participate in administrating drugs using this device, mostly when patients are hospitalized, thus, it is very important HCW know the correct technique while using MDI [2]. The objective of this study was to evaluate the current knowledge of MDI technique in HCW working in three general hospitals, of Aguascalientes, México

Material and methods

An interview hospital-based cross-sectional survey was conducted to evaluate HCW competence on the MDI technique. The protocol was approved by scientific and ethics committees with approval number 2HTM-12/09. It was done in three different general hospitals (GH); two of them, "Tercer milenio" and a "Private Hospital" (PH) are located in the city of Aguascalientes, México, and the other in the municipality of "Rincón de Romos", located approximately 40 km (25 mi) north of this city.

The GH "Tercer Milenio" (GHTM) has 52 beds, and it counts with 108 physicians, 160 nurses, whereas the GH "Rincón de Romos" (GHRR) has 30 beds and their personnel includes 70 physicians and 133 nurses, both of them are considered a second-level unit. The third hospital is a private unit, has a 30-bed capacity, and its personnel is compound by 138 nurses; however, no fixed physicians exist there. Written consent has been obtained from each participant. Evaluation (data collection) tool was adapted from the American Thoracic Society: "Using Your Metered Dose Inhaler (MDI), fact sheet", and checked for suitability to score the competency of use of MDIs by health care workers [13].

Three surveyors who obtained special training on the MDI technique, simultaneously and in an independent manner scored for each of the interviewers through a 14 dichotomic (right or wrong) questions list. Each question corresponds to each one of the steps of the correct technique of MDI [14], with special attention to the essential steps (step 5, 6, 10, and 11) [15], Table 1. Adequacy of the MDI technique was scored according to the number of "right" answers as bad (0–3), regular (4–7), good (8–10), and very good (> 10). For the evaluation, we excluded physicians and nurses older than 65 years old, students, and residents, as well as HCW out of duty because of vacations and or illnesses, as well as those who refused to participate in the study.

Statistical significance for comparison of the categorical variable between groups was determined by the chi-square test or Fisher exact test; for ordinal continuous and non-normal numeric variables between two groups, a two-tailed Student's t-test or Mann-Whitney U test were used. Furthermore, an analysis of one-way ANOVA was used for the comparison of three independent groups (GHTM, HGRR & PH). Statistical significance was considered when $p < 0.05$. Finally, for an inter-observer agreement, we used Fleiss' Kappa Test [16] and interpreted it according to Viera, and Garrett, 2005 [17]. Data entry was done using Epi Info v6 and data, transferred to SPSS version 16, and analyzed with InerSTAT-a v1.3 (Instituto Nacional de Enfermedades Respiratorias, México).

Results

A total of 244 HCW from three regional hospitals were approached and consented to participate in the study: 124 (50.8%) were from GHTM, 65 (26.6%) from GHRR, and 55 (22.5%) were from the private hospital. Among all the surveyed, 173 (70.9%) were female and 71 (29.1%) were

Table 1. Percentage of wrong answers of HCW respondents to demonstrate each step of the metered-dose inhaler technique

	Item	GHTM [%]	GHRR [%]	PH [%]	Total [%]	P
1.	Wash hands technique before using MDI	100	100	100	100	NS
2.	Shake the MDI 10–15 times before puff.	90	52	62	68	< 0.001*
3.	Verify if the mouthpiece is clean	95	94	96	95	NS
4.	Puffing MDI before to expelled drug	95	92	96	94	NS
5.**	Breathe out all of the way before activating MDI	77	86	85	83	NS
6.**	Hold the mouthpiece 2.5 to 5 cm (1 to 2 inches) from the mouth	89	77	85	84	NS
7.	Half-open mouth	85	72	80	79	NS
8.	Placement of the mouthpiece down	3	9	2	6	NS
9.	Inhaling immediately after puff	18	22	9	16	NS
10.**	Breathe in slowly and deeply through the mouth and actuate the MDI once	76	65	53	65	< 0.05*
11.**	Hold breath for 10–20 seconds after inhaling MDI	69	60	55	61	NS
12.	Activating MDI one time for each puff	15	32	9	19	< 0.05***
13.	Exhale & wait one minute before the second dose	73	63	33	56	< 0.001*
14.	If a second puff is necessary, wait 30 seconds, shake and actuate the MDI again	57	63	56	59	NS

P-values from ANOVA analysis. *Comparison among GHTM *vs* PH; **Essential step of the metered-dose inhaler technique; ***Comparison among GHRR *vs* PH. NS — not statistically significant; GHTM — General Hospital Tercer Milenio; GHRR — General Hospital Rincón de Romos; PH — private hospital

male. The mean age was 33.4 ± 10.8 years old and, the average seniority was 10.5 ± 9.1 years.

From the total population, a greater proportion of surveyed were nurses 191 (78.3%), whereas only 53 (21.7%) correspond to physicians. The most common nurse degree was nursing technicians (61%), whereas physicians, 49% were primary care physicians and the rest were different types of medical specialists.

One hundred sixty-four surveyed (67.2%) worked in one institution, 75 surveyed (30.7%) in two and, 5 surveyed (2%) in three. Most surveyed worked in the morning whereas a lower amount of them worked in the afternoon (Table 2).

The main services where surveyed labored were: 27% in the Internal medicine service, 22% in an adult emergency room and, 12% in the pediatric emergency room (Table 3). The inter-observer concordance analysis among observers showed a kappa index of 0.97.

The survey analysis showed that bad and regular performances were the frequent action carried out. Thus, among all HCW surveyed, it was observed that 79 (32.4%) performed a bad technique, 126 (51.6%) a regular technique, while only 33 (13.5%) and 6 (2.5%) of all surveyed performed a good or very good technique, respectively. A comparison of correct performance with the site of work did not show a statistically significant difference in all steps.

Table 2. Health-care workers distribution according to schedule and hospital

Schedule	GHTM n = 124 [%]	GHRR n =65 [%]	PH n = 55 [%]	All n = 244 [%]
Morning	44 (35%)	25 (38%)	14 (25%)	83 (34%)
Afternoon	35 (28%)	10 (15%)	15 (27%)	60 (25%)
Night A	21 (17%)	16 (25%)	16 (29%)	53 (22%)
Night B	24 (19%)	14 (22%)	10 (18%)	48 (20%)

GHTM — General Hospital Tercer Milenio; GHRR — General Hospital Rincón de Romos; PH — private hospital

Among the different steps for the correct use of MDI some steps are considered critical for a good deposition of inhaled drugs, thus the most common critical mistakes in the technique exhibited by all the surveyed were: step 5: "insufficient expiration prior to activation of the device" and step 6: "the distance the inhaler was placed for inhalation" (83 and 84% respectively), step 10: "the lack of slow and deep inhalation" (65%) and, step 11: "the maintenance of inspiration shorter than 10 seconds after the activation of the MDI" (61%) (Table 1). It is important to emphasize that

Table 3. Health-care worker's distribution according to hospital and service they labor

Clinical service	GHTM n = 124	GHRR n = 65	PH n = 55	All n = 244
Internal medicine	22 (18%)	20 (31%)	24 (43%)	66 (27%)
Pediatric	16 (13%)	6 (9%)	7 (12%)	29 (12%)
Out patient	12 (10%)	6 (9%)	0	18 (7%)
Surgery	11 (9%)	1 (2%)	0	12 (5%)
Adult outpatient service	12 (10%)	4 (6%)	0	16 (6%)
Adult ER	28 (22%)	15 (23%)	10 (20%)	53 (22%)
Pediatric ER	8 (6%)	0	0	8 (3%)
UCIP	4 (3%)	5 (8%)	3 (5%)	12 (5%)
UTIA	7 (6%)	5 (8%)	7 (13%)	19 (8%)
Supervision	4 (3%)	3 (5%)	4 (7%)	11 (5%)

GHTM — General Hospital Tercer Milenio; GHRR — General Hospital Rincón de Romos; PH — private hospital; ER — emergency room; UCIP — Pediatric Intensive Care Unit; UTIA — Adult Intensive Care Unit

these steps are critical to the correct use of MDI, particularly step 6; therefore if 84% of surveyed subjects did not perform this step correctly, we may consider that a very high percentage of HCW have a bad practice.

Next, we analyzed the performance between all surveyed concerning the type of profession. It was found that among all 53 physicians, 20 (37.7%) developed a bad technique, 25 (47.2%) a regular, 7 (13.2%) a good one, and just 1 (1.9%) a very good technique. In the case of all 191 nurses, the technique was bad in 58 (30.4%), in 101 (52.9%) was regular, in 27 (14.1%) was good and only 5 (2.6%) performed a very good procedure (Figure 1).

When comparing mistakes in technique by the hospital, we found that GHTM in comparison with PH had a greater percentage of mistakes, denoted by step 2: "agitation of the MDI" (90 *vs* 62, $p < 0.001$), step 10: "slow and deep inhalation" (76 *vs* 53%, $p < 0.05$), and step 13: "waiting a minute between each puff" (73 vs 33%, $p<0.001$). In contrast, the GHRR had a greater frequency of mistakes in step 12: "Activating MDI one time for each puff" (32 *vs* 9%, $p < 0.05$) than PH. There were no further differences in other steps between the three hospitals, neither among the frequency of each step with the different variables like physicians *vs* nurse, gender, labor category, schedule, service, age, seniority, and education degree ($p > 0.05$).

Discussion

The results of this survey showed that a very poor MDI technique is frequent in health care workers from three general hospitals from Aguascalientes, Mexico.

Several studies have been shown that HCW [18], and even patients [19] do not know the correct technique of applying MDI, this problem is greater in elderly patients [20]. This situation seems to be originated by the lack of teaching this technique by experts (pulmonary specialists, pulmonary therapists) to HCW, besides the common belief that "this technique is easy and well-performed by everybody".

In this survey, the high percentage of HCW that do not apply the MDI technique correctly is even higher than the reported in other studies. Therefore, while in our study we found that only 14% of HCW performed a good and a very good technique, Plaza V *et al*. [21], found that only 14.2% of physicians had adequate knowledge of MDI technique, regarding medical specialty. Furthermore, Riduan and Ismail [22] evaluated 41 physicians who worked at a hospital in Malaysia and reported that 48.9% of them used the MDI technique correctly. However, in this same study, they observed that outpatient physicians performed a worse technique in comparison with inpatient care physicians. O`Donnell *et al*. [23] developed a study including nurses and physicians laboring in an Accident and Emergency (A&E) Department, but even though 22 (88%) physicians knew the "Thoracic British Society guidelines for applying MDI", only 10 (40%) performed the technique properly. In another study, Resnick *et al*. [24] observed that only 26% (38 pediatricians) developed a correct MDI technique. Besides, when 83 third grade pharmacy students

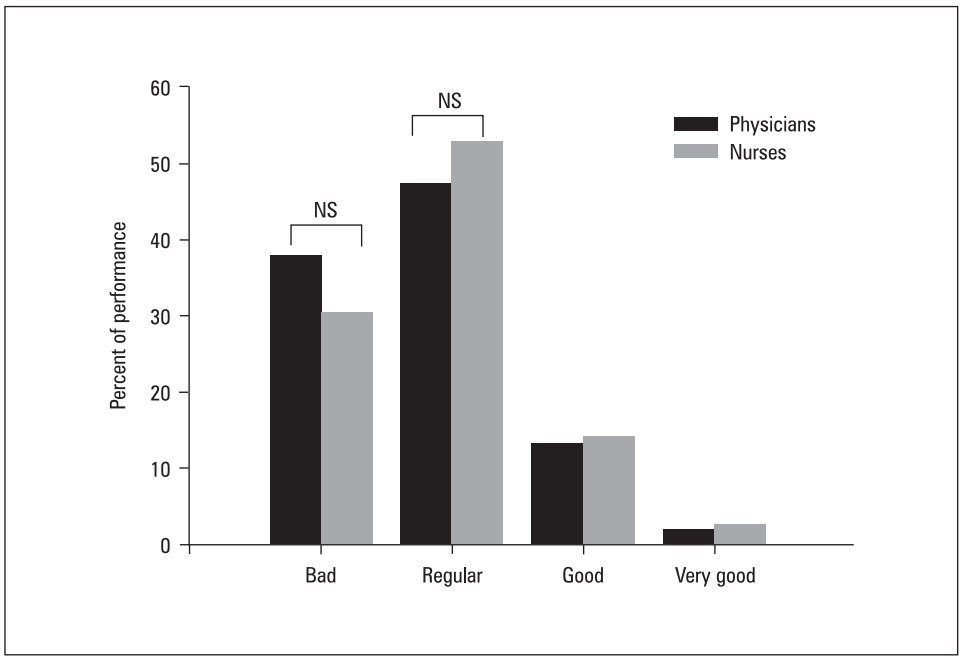

Figure 1. Distribution of studied HCW and percent of performance score of meter-dose inhaler technique. NS — not significant value for this X^2 test

were asked to perform the MDI technique after 20 minutes of listening to the correct technique, there was no difference among males and females in using the MDI [25].

In our study, we observed that more than half of surveyed failed in step 11 " to maintain a deep breath after MDI was activated", being this results similar to those found by Riduan [22]. Besides, other recurrent mistakes were also found like: "not washing hands before using MDI (100%)", "not verifying if mouthpiece was clean (95%), breathing out before activating MDI" (83%), "incorrect distance between mouth and MDI" (84%) and not performing "deep and slow inspiration after activating MDI" (65%). In contrast, Larsen *et al*. [26] found in 501 patients that the most common errors were "expiration before activating MDI", and the "lack of coordination of inspiration and activation of MDI, whereas, Sotomayor *et al*. [27] in Chile, found that the most common errors in physicians and nurses were: not "waiting for 60 seconds between each puff" (33.3% and 56.7%, respectively), not "doing it slowly and deeply" (13.4% and 30% respectively), and not "agitating MDI before using it" (60% physicians and 26.7% nurses). It can be observed that these different studies report similarities of the errors of the steps of the MDI technique.

Lastly, in our study, we also observed that the frequency of errors in the MDI technique was not influenced by different factors such as labor category, seniority, clinical service, age, nor labor schedule. Similar observations were reported by Chafin *et al*. [25] with pharmacy students and by Van Beerendonk *et al*. [28] in a study done with patients, where they did not find differences among genders.

In this survey, despite the involvement of all the responders, none of them were able to perform all steps of the MDI technique correctly, which will be reflected in the patients that will not have adequate instruction. It is also well known that only 8–20% of the drug reaches bronchial airways when MDI is used correctly, thus when the MDI technique is not properly applied, the amount of drug delivered into the lungs is lower than it should be producing worse disease outcomes [4, 29–31]. Therefore, for the proper administration of drugs using MDI, each one of the different steps of the MDI technique must be performed correctly. An incorrect MDI use due to poor education of patients leads to poor control of respiratory diseases and an increased in emergency department visits [32].

Conclusion

Several studies have been published regarding MDI technique worldwide, and in all of them have encouraged different levels of HCW to spread MDI technique to others, however, after all these studies and all these years, the problem continues, being this problem greater in HCW laboring in Mexican institutions than

those reported in other countries. Our study demonstrated that HCW of three general hospitals from Aguascalientes, Mexico, do not follow the MDI technique correctly and consequently the optimal biological dose in patients might not be achieved. These observations suggest the urgent need to establish frequent training programs for the correct use of MDI, which also must include general practitioners, pharmacists, and health educators. Special attention should be given to correct the errors in the essential steps of the inhaler technique. Associations, higher education, governmental and non-governmental organizations should take part in resolving the problem. The proper use of the technique by health care workers will bring enormous benefits to patients affected with pulmonary diseases being easier to control. Limitations of the study are that most nurses and physicians are not exclusively involved with respiratory patients such as respiratory therapists and patient's relatives.

Acknowledgments

We thank Georgina Diaz Herrera for her helpful advice during the preparation of this work.

Conflict of interest

None declared.

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