

Patterns of use of dry powder inhalers versus pressurized metered-dose inhalers devices in adult patients with chronic obstructive pulmonary disease or asthma: An observational comparative study

Wijdan H Ramadan¹ and Aline T Sarkis²

Abstract

Numerous patients with chronic obstructive pulmonary disease (COPD) and asthma do not use inhaler devices properly, which can contribute to poor disease control. The objective of this study is to assess the technical and safety use of dry powder inhalers (DPIs) versus pressurized metered-dose inhalers (MDIs) in adult patients with COPD or asthma in Lebanon. A concurrent, prospective comparative observational study was conducted at one hospital and 15 community pharmacies in Lebanon. Over a period of 18 months, 246 questionnaires were filled. Patients included were adults with COPD or asthma. Answers were entered into the Statistical Package for Social Sciences software and excel sheet. T-test and correlation were used to analyze the results; 67.8% and 38.4% of those using DPIs and MDIs, respectively, performed the exact technical steps adequately ($p = 0.003$, relative risk: 2.134, 95% confidence interval: 0.910–4.842). When compared to MDI, a higher percentage of DPI users found their devices easy to use. Moreover, 81.4% of the MDI users found difficulty in coordinating between pressing the canister and inhaling. Rates of exacerbations were significantly higher in MDIs vs. DPI users (59.4% vs. 21.7%). Overall, 44.31% of patients did not receive education from their healthcare professionals about the devices. A significant number of COPD/asthma adult patients do not use their devices properly. Even though DPIs were significantly easier to use, proper education on the technical use of all types of inhalers is needed.

Keywords

Inhalers, MDI, DPI, COPD, asthma

Date received: 2 June 2016; accepted: 9 December 2016

Introduction

Asthma and chronic obstructive pulmonary disease (COPD) are chronic respiratory diseases (CRDs) of the airways and the lungs.¹ According to the American Thoracic Society, CRDs are responsible for around 7% of deaths worldwide; they are a major burden on public health services and are a cause of diminished quality of life and loss of productivity.² In Lebanon, and despite limited data, one study was able to determine the prevalence of COPD as 9.7%.³ In addition, and as

¹ Department of Pharmacy Practice, School of Pharmacy, Lebanese American University, Byblos, Lebanon

² School of Pharmacy, Lebanese American University, Byblos, Lebanon

Corresponding author:

Wijdan H Ramadan, Department of Pharmacy Practice, School of Pharmacy, Lebanese American University, P.O. Box: 36-F 53, Byblos, Lebanon.

Email: wramadan@lau.edu.lb



Creative Commons CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-Non Commercial 3.0 License (<http://www.creativecommons.org/licenses/by-nc/3.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

estimated by the World Health Organization, by 2030, COPD will be the third leading cause of death around the world.⁴ Since respiratory diseases affect a considerable percentage of the population worldwide and because of the increasing risk of morbidity and mortality, more efforts should be made in order to increase prevention and optimize treatment of such diseases. One way is to improve the use of inhaler devices and appropriately train and educate patients.^{5,6}

Pressurized metered dose inhalers (MDIs) and dry powder inhalers (DPIs) are the most commonly used inhaler devices. MDIs, developed in the mid-1950s,⁷ deliver a fixed drug dose from a pressurized canister requiring coordination between inhalation and actuation. Around two decades later,⁸ DPIs were introduced to the market as a more convenient alternative to MDIs since they deliver the drug in a powder form and do not require coordination. Although inhalers are highly effective in reducing the burden and risk of asthma and COPD, many patients do not use them properly. Multiple studies have shown that a significant percentage (up to 94%) of patients fail to complete at least one step correctly.^{9–14} This poor adherence contributes to uncontrolled symptoms,^{15,16} low drug deposition in the lungs,^{14,17} impaired quality of life, flare-ups, urgent doctor visits, and loss of life.¹⁸ There are multiple factors related to incorrect inhalation technique, the most reported include old age,^{12,13,16,19–23} low education level,^{11,13,19,22,23} lack of prior instructions,^{12,13,16,19,20,22,23} and the use of multiple devices.^{12,21}

As for device type, data is inconsistent in favoring one type over the other. Multiple trials have shown more errors with the use of MDIs than with DPIs.^{9,13,23–25} A large French observational study of 3811 patients showed that errors were higher in patients using pressurized MDIs (76%) versus DPIs (49–55%). Critical errors compromising treatment efficacy were highest for Turbuhaler (32%) followed by MDIs (28%) and finally by Aerolizer, Autohaler, or Diskus (11–12%).²⁴ Furthermore, few studies favored specific DPIs over the others such as Diskhaler,^{10,21} Handihaler,¹¹ or Diskus.^{23,25} On the other hand, a recent retrospective multicenter study reviewed medical registries of COPD patients on fixed-dose combinations of inhaled corticosteroids and long-acting β_2 agonists. After adjustment for confounding factors, results showed that patients using DPIs (vs. MDIs) were less likely to adhere to treatment.²⁶ Another large multicenter study found no significant difference in inadequate inhalation technique

between DPIs (17% for Aerolizer, 23% for Turbuhaler, and 24% for Diskus) and MDIs without a spacer (24%).²⁷ The “Device Selection and Outcomes of aerosol therapy: evidence-based guidelines,” published by CHEST (2005), concluded that devices used for the delivery of bronchodilators and inhaled corticosteroids do not differ in efficacy. However, the randomized controlled trials included are of limited quality (design and duration) where patients are carefully selected and well trained thus not reflecting reality and effectiveness.²⁸

Accordingly, it is necessary for healthcare professionals to understand the administration difficulties faced by patients in order to prescribe the preferred and most appropriate device for each individual and emphasize on the important steps for administration. Healthcare professionals identify poor adherence with inhalers as a major barrier to the delivery of effective asthma and COPD care, yet practical adherence interventions are lacking.

Because of the conflicting data worldwide and the limited data in Lebanon, this study was conducted in order to assess the technical and safety use of DPI (all types such as Diskhaler, Accuhaler, Turbuhaler, and Handihaler) vs. pressurized MDI devices in adult patients with COPD or asthma in Lebanon.

Methods

Setting and design

A concurrent, prospective comparative observational study was conducted at one teaching hospital and 15 community pharmacies in Lebanon in Beirut and Byblos area over a period of 18 months. Patients, with COPD or asthma using MDIs and/or DPI devices, visiting the community pharmacies to purchase such products or being hospitalized due to pulmonary diseases and discharged on such devices were asked if they were willing to participate in the study. Two structured questionnaires (one for MDIs and one for DPIs) were prepared by the investigators in order to conduct the survey. This study was approved by the Lebanese American University (LAU) Institutional Review Board and a waiver of consent was obtained from the patients before filling out the questionnaire.

Inclusion/exclusion criteria

Adult patients (at the age of 18 years or older), from both genders, suffering from COPD or asthma and using medications delivered through MDIs and/or

DPIs were included. Patients receiving pulmonary medications through nebulizers or soft mist inhalers only were excluded.

Sources of data

The investigators, with the help of LAU pharmacy students, interviewed pulmonary hospitalized patients and/or patients entering the community pharmacies from 9:00 am till 4:00 pm. The investigators included community and clinical pharmacists (all of which are preceptors to the LAU students and some are professors as well). All of them were trained prior to the initiation of the study. Pharmacy students helping the investigators were completing their fifth and sixth year of pharmacy. They were well trained as well prior to initiation of the study and were supervised by their preceptors. Students were paired in two at each pharmacy/hospital. Both students along with the investigators assessed patients and filled the questionnaires. The tool for assessment consisted of two well-structured questionnaires, where the patients, with the assistance of the investigators, filled the questions with the appropriate answers.

One questionnaire targeted patients using DPIs users, whereas the second targeted those using MDIs. Each questionnaire is divided into three sections. The first section consists of patient's demographics, the second section includes information about the administration techniques and the different steps required for using DPIs or MDIs, and the last section marks data about ease of use, safety, and patients' preference (Tables 1 and 2). At the end of data collection, a total of 246 questionnaires were filled; 123 for DPIs and 123 for MDIs. The questions were converted to endpoints in order to meet the objective of the study.

The primary endpoint was the correct application of the administration techniques. The responses for both devices were converted to either "proper" or "improper." The secondary endpoints were the ease and safety of use as well as patients' preference. Each one was analyzed based on the answers to the corresponding questions.

A correlation was conducted to analyze the relationship between ease of use and age; the ease of use and the time of diagnosis; the ease of dose inhalation and exacerbation of symptoms; and gargling after taking a corticosteroid inhalation and side effects. Three categories were developed for the ease of use: difficult, moderate, and easy; two categories for age: all ages (18–60 years) and age >60 years; two

categories for time of diagnosis: <1 year, and >1 year; three categories for the ease of dose inhalation: difficult, moderate, and easy; three categories for exacerbation of symptoms: no exacerbation, less frequent (1 episode in 6 months), more frequent (>1 episode in 6 months); three categories for gargling: no gargling, sometimes, after each dose; and three categories for side effects: no side effects, oral thrush and hoarseness of voice, and other side effects.

Statistical analysis

Data was processed and analyzed through the application of two software: The Statistical Package for Social Sciences (SPSS, version 19, Chicago, IL, USA) and Microsoft Excel. Responses were tabulated and cross-tabulated. Percentages, *p*-values, relative risk (RR), and 95% confidence interval (CI) were calculated. *T*-test and binary correlation were applied in order to analyze the results.

Results

A total of 246 patients were surveyed, out of which 123 were using DPIs and 123 were using MDIs; 37 patients (15%) were on both DPIs and MDIs at the same time. Demographic information is shown in Table 3.

The primary endpoint involved the correct application of the administration techniques of all types of inhalers. Only 19.5 and 26.3% of MDI users, respectively, prime and shake the inhaler before taking the dose. High percentages of both groups position the head and the mouth piece properly while using the inhalers and exhale appropriately after inhaling the dose. However, no significant difference is revealed between the two groups. A higher percentage of DPI users (67.8%) performed the exact technical steps (administration techniques) adequately and properly, as compared to MDI users (38.4%) ($p = 0.003$, RR: 2.134, 95% CI: 0.910–4.842). The percentages of appropriateness for all administration techniques with *p*-values are shown in Table 4; a *t*-test was conducted to test the significance level of difference on administration techniques between DPIs and MDIs: DPI users, as compared to MDI users, had a significant higher percentage of appropriateness on the way of holding the inhaler (100% vs. 73.9%) and the type of inhalation while taking the dose (83.7% vs. 61.2%).

The common unapplied (not applied correctly) steps, after being calculated from Table 4, among DPI

Table 1. DPI questionnaire.

I. Demographics	
A. Age	D. Time of diagnosis
1. 18–30 years	1. <1 month
2. 31–40 years	2. 1 month–1 year
3. 41–60 years	3. 1–5 years
4. >60 years	4. 6–10 years
	5. >10 years
B. Gender	E. Primary pulmonary diagnosis
1. Female	1. Asthma
2. Male	2. COPD
	3. Other pulmonary disease
C. Educational level	F. Patient-perceived severity of pulmonary disease
1. No school	1. Mild
2. High school graduate or less	2. Moderate
3. Some college	3. Severe
4. College graduate	
5. Postgraduate studies	
2. Administration techniques	
G. How do you breathe just before using your inhaler?	
1. Inhale	
2. Exhale	
3. Breath in and out	
H. How do you tilt your head while using your inhaler?	
1. Tilt head forward	
2. Keep head level	
3. Tilt head backward	
I. How do you hold your inhaler while using it?	
1. Horizontal	
2. Vertical	
J. How do you position the mouthpiece?	
1. In your mouth (lips around it)	
2. 1–2 inches from your lips with mouth open	
K. Do you load the dose (capsule) inside the device (inhaler). (If yes, specify if correct; specify the type of inhaler)	
1. Yes	
2. No	
L. How do you inhale while taking the dose?	
1. Inhale slowly and deeply	
2. Inhale quickly	
M. How do you breathe after taking the dose?	
1. Breath out immediately	
2. Hold your breath for about 5 to 10 seconds before exhaling	
N. How do you exhale after inhaling the medicine?	
1. Exhale slowly	
2. Exhale quickly	

(continued)

Table 1. (continued)

2. Administration techniques

O. If your directions are to take "2 puffs" for your dose, how do you manage?

1. Press the inhaler twice (load two doses) before inhalation
2. Press the inhaler once (load one dose) and inhale, and then wait about a minute before doing it again
3. Press the inhaler once (load one dose) and inhale, and then press it again (load another dose) for the very next breath

P. Do you gargle with water after taking a corticosteroid inhalation?

1. No
2. Sometimes
3. Yes

3. Ease of use, safety, and patients' preference

Ease of use

Q. How easy it is to use the device?

1. Difficult
2. Moderate
3. Easy

R. How easy it is to inhale the dose?

1. Difficult
2. Moderate
3. Easy

S. What is the most difficult step in using the inhaler?

T. How comfortable would you feel using an inhaler without counseling?

1. Not comfortable
2. Relatively comfortable

U. Did you receive any counseling from a healthcare professional about the device (Inhaler)?

1. No
2. Yes

Safety

V. Number of exacerbation of symptoms:

1. No exacerbation
2. Less frequent (1 episode in 6 months)
3. More frequent (>1 episode in 6 months)

W. Type of side effects you developed during therapy:

1. No side effects
2. Oral thrush and hoarseness of voice
3. Other side effects

Patients' preference

X. Patients on MDIs and DPIs (at the same time): Was it more convenient when shifting to or using DPIs?

1. No
2. Yes

Table 2. MDI questionnaire.

I. Demographics	
A. Age	D. Time of diagnosis
1. 18–30 years	1. <1 month
2. 31–40 years	2. 1 month–1 year
3. 41–60 years	3. 1–5 years
4. >60 years	4. 6–10 years
	5. >10 years
B. Gender	E. Primary pulmonary diagnosis
1. Female	1. Asthma
2. Male	2. COPD
	3. Other pulmonary disease
C. Educational level	F. Patient-perceived severity of pulmonary disease
1. No school	1. Mild
2. High school graduate or less	2. Moderate
3. Some college	3. Severe
4. College graduate	
5. Post-graduate studies	
2. Administration techniques	
G. If you are using a new inhaler, do you prime it?	
1. No	
2. Yes	
H. Before using your inhaler, do you shake it?	
1. No	
2. Yes	
I. How do you breathe just before using your inhaler?	
1. Inhale	
2. Exhale	
3. Breath in and out	
J. How do you tilt your head while using your inhaler?	
1. Tilt head forward	
2. Keep head level	
3. Tilt head backward	
K. How do you hold your inhaler while using it?	
1. Upright (canister up)	
2. Down (canister down)	
L. How do you position the mouthpiece?	
1. In your mouth (lips around it)	
2. 1–2 inches from your lips with mouth open	
M. When pushing down the canister for a dose, when do you take a breath?	
1. Begin to breathe in while pushing down the canister and continue breathing in	
2. Push down the canister, and then take a breath	
3. Take a breath, and then push down the canister	

(continued)

Table 2. (continued)**2. Administration techniques****N. How do you inhale while taking the dose?**

1. Inhale slowly and deeply
2. Inhale quickly

O. How do you breathe after taking the dose?

1. Breath out immediately
2. Hold your breath for about 5 to 10 seconds before exhaling

P. How do you exhale after inhaling the medicine?

1. Exhale slowly
2. Exhale quickly

Q. If your directions are to take “2 puffs” for your dose, how do you manage?

1. Push down the canister twice while taking a breath
2. Push down the canister once, and then wait about a minute before doing it again
3. Push down the canister once, and then push it down again for the very next breath

R. Do you gargle with water after taking a corticosteroid inhalation?

1. No
2. Sometimes
3. Yes after each dose

3. Ease of use, safety, and patients’ preference*Ease of use*

- S. How easy it is to use the device?
4. Difficult
5. Moderate
6. Easy

T. How easy it is to inhale the dose?

4. Difficult
5. Moderate
6. Easy

U. What is the most difficult step in using the inhaler?**V. How comfortable would you feel using an inhaler without counseling?**

1. Not comfortable
2. Relatively comfortable

W. Did you receive any counseling from a healthcare professional about the device?

3. No
4. Yes

Safety

- X. Number of exacerbation of symptoms:
 4. No exacerbation
 5. Less frequent (1 episode in 6 months)
 6. More frequent (>1 episode in 6 months)

(continued)

Table 2. (continued)**3. Ease of use, safety, and patients' preference****Y. Type of side effects you developed during therapy:**

1. No side effects
2. Oral thrush and hoarseness of voice
3. Other side effects

Patients' preference**Z. Patients on MDIs and DPs (at the same time): Was it more convenient when shifting to or using DPs?**

1. No
2. Yes

Z'. Do you prefer shifting to DPs when it is at the same cost as MDIs?

1. No
2. Yes

DPIs: dry powder inhalers; MDIs: metered-dose inhalers; COPD: chronic obstructive pulmonary disease.

Table 3. Baseline demographic percentages.

	DPI (N = 123)	MDI (N = 123)
Age		
18–30 years	10.4%	14.3%
31–40 years	33.6%	32.8%
41–60 years	34.2%	30.7%
>60 years	21.8%	22.2%
Gender		
Male	32.2%	40.8%
Female	67.8%	59.2%
Educational level		
No school	0.0%	0.0%
High school graduate or less	14.6%	11.5%
Some college	36.2%	37.6%
University graduate	41.8%	45.2%
Postgraduate studies	7.4%	5.7%
Primary pulmonary diagnosis		
Asthma	31.5%	42.5%
Chronic obstructive pulmonary disease	64.9%	52.2%
Other pulmonary disease	3.6%	5.3%
Time of diagnosis		
<1 month	3.2%	9.7%
1 month–1 year	15.8%	25.3%
1–5 years	47.2%	36.1%
6–10 years	21.4%	19.8%
>10 years	12.4%	9.1%
Patient-perceived severity of pulmonary disease		
Mild	25.7%	33.4%
Moderate	58.7%	52.9%
Severe	15.6%	13.7%

DPI: dry powder inhaler; MDI: metered-dose inhaler.

users vs. MDI users were exhaling before taking the dose (56.7% vs. 67.3% of patients do not apply it correctly; $p = 0.07$), holding breath for few seconds after taking the dose (78.4% vs. 47.8% of patients do not apply it correctly; $p = 0.01$), waiting around 1 min between two consecutive doses (48.6% vs. 52.8% of patients do not apply it correctly; $p = 0.08$), and gargling after taking a corticosteroid inhalation (52.7% vs. 51.2% of patients do not apply it correctly; $p = 0.1$).

A secondary endpoint was the ease of use of the inhalers. A higher percentage of DPI users (87.3%) found the devices easy to use compared to 56.7% of the MDI users group who said their devices are easy to use ($p = 0.001$, RR: 2.031, 95% CI: 1.187–3.453). The majority of DPI users (94.8%) found it easy to inhale the dose vs. 53.6% of MDI users ($p = 0.001$, RR: 2.321, 95% CI: 1.075–3.835). Most of MDI users (81.4%) found difficulty in coordinating between pressing the canister and inhaling, whereas 15.8 and 23.7% of DPI users, respectively, considered loading the dose or loading the capsule inside the device (for DPs) and holding the breath after taking the dose as the most difficult steps. Out of 246 patients of both groups, 109 patients (44.31%) mentioned that they did not receive the required education or counseling from the healthcare professionals (pharmacists or physicians) about the devices. When asked how comfortable would you feel using an inhaler without counseling, 48.47% of DPI users and 41.51% of MDI users, respectively, answered as relatively comfortable.

Table 4. Administration techniques.

Percentage of appropriateness (correct use) of the administration techniques comparison between DPIs and MDIs users

Administration techniques ^a	a	b	c	d	e	f	g	h	i	j	k	l	m
DPIs			43.3%	86.2%	100%	100%		100%	83.7%	21.6%	98.1%	51.4%	47.3%
MDIs	19.5%	26.3%	32.7%	81.7%	73.9%	97%	52%		61.2%	52.2%	95.4%	47.2%	48.8%
p-Value			0.07	0.09	0.03	0.1			0.04	0.01	0.1	0.08	0.1

DPIs: dry powder inhalers; MDIs: metered-dose inhalers

^aa: Priming the inhaler (for MDI); b: shaking the inhaler (for MDI); c: exhaling before taking the dose (for both MDI and DPI); d: the way of positioning/tilting the head while using the inhaler (for both MDI and DPI); e: the way of holding the inhaler (for both MDI and DPI); f: the way of positioning the mouth piece (for both MDI and DPI); g: coordinating between pressing the canister and inhaling (for MDI); h: loading the dose or loading the capsule inside the device (for DPIs); i: type of inhalation while taking the dose (for both MDI and DPI); j: holding breath after taking the dose (for both MDI and DPI); k: type of exhaling after inhaling the dose (for both MDI and DPI); l: waiting around 1 minute between two consecutive inhalations (for both MDI and DPI); m: gargling after taking a corticosteroid inhalation (for both MDI and DPI).

Table 5. Correlations.

I. Correlation between ease of use and age			
Type	All patients	DPI users	MDI users
Correlation	-0.81	-0.74	-0.88
p-Value	0.01	0.02	0.01
II. Correlation between ease of use and time of diagnosis			
Type	All patients	DPI users	MDI users
Correlation	0.92	0.83	0.73
p-Value	0.001	0.03	0.04
III. Correlation between ease of dose inhalation and exacerbation of symptoms			
Type	All patients	DPI users	MDI users
Correlation	-0.16	-0.28	-0.12
p-Value	0.1	0.09	0.1
IV. Correlation between gargling after taking a corticosteroid inhalation and side effects			
Type	All patients	DPI users	MDI users
Correlation	-0.79	-0.87	-0.82
p-Value	0.02	0.01	0.03

DPIs: dry powder inhalers; MDIs: metered-dose inhalers.

Ease of use was allied with the age group, mainly for patients who are above 60 years of age; and with the time of diagnosis. There was a significant negative correlation between ease of use and age for all patients (Table 5; section I). For patients using DPIs and diagnosed with COPD or asthma for more than 1 year, 73.27% found it easy to use vs. 46.34% in the MDI users. For all patients (Table 5; section II), there

was a significant positive correlation between ease of use and time of diagnosis.

Safety of use was another secondary endpoint. A statistically significant difference was shown between the two groups in the incidence of exacerbation of symptoms. A much higher percentage (59.4%) of MDI users showed exacerbation of symptoms during therapy compared to only 21.7% of DPI users ($p = 0.002$, RR: 2.765, 95% CI: 1.184–6.846). As for the side effects developed during therapy, a statistically significant difference was also notified between the two groups ($p = 0.01$, RR: 2.32, 95% CI: 0.657–1.875) where 49.7 and 16.8% of DPI and MDI users, respectively, developed oral thrush. Ease-of-dose inhalation was stratified by the exacerbation of symptoms. However, there was no significant relationship between them for all patients, DPI users, and MDI users (Table 5; section III). When studying the relationship between gargling after taking a corticosteroid inhalation and side effects, it was noticed that there was a significant negative correlation between them (Table 5; Section IV).

Touching another secondary endpoint that measured patients' preferences, 78.7% of patients using DPIs and MDIs together found it more convenient shifting to or using DPIs instead of MDIs; and 81.9% of the MDI users would like to shift to a DPI if it has the same cost.

Discussion

The study shows significantly higher adequate and proper administration technique with DPI users (67.8%) vs. MDI users (38.4%). These results are consistent with multiple studies in the literature.^{9,13,23–25} Regarding specific steps, DPI users

were significantly better at holding the inhaler appropriately (100% vs. 73.9%) and inhaling correctly while taking the dose (83.7% vs. 61.2%). These findings can also be explained by the less complex administration of DPIs (no coordination needed). Common errors for both DPIs and MDIs were exhaling before the dose, holding breath after the dose (fewer errors with MDIs), waiting between two consecutive doses and finally gargling after a corticosteroid dose. Previous data have shown that common error for both types of inhalers was to exhale before taking the dose.^{23,29} Lavorini et al. summarized data from 18 studies performed in patients with asthma and COPD exhibiting specific errors in DPIs technique. Exhaling before taking the dose is by far the most common error observed (12–77%) followed by failure in holding the breath after the dose (0–73%).¹⁴ In this study and for MDIs specifically, patients ranked low in performing the following steps: priming the inhaler (19.5%), shaking the inhaler (26.3%), and coordinating between pressing the canister and inhaling (52%). About 81.4% of MDI users identify coordinating between pressing the canister and inhaling as the most difficult step. On the other hand, 15.8 and 23.7% DPI users, respectively, considered loading the dose and holding the breath after taking the dose as the most difficult steps. A higher percentage of DPIs users found their device easy to use and the inhalation easy to take when compared to MDIs.

Melani et al. investigated the misuse of inhalers in 1644 patients with COPD and asthma. Most common errors seen with MDIs use were failure to exhale before the dose, coordinate between pressing on the canister and inhaling, and hold breath followed by failure to shake the inhaler.¹⁹ This study also found, independent of the inhaler type, a strong association between inhaler misuse and older age and lack of instructions.¹⁹

Our data shows a statistically significant negative correlation between ease of use and age, a positive correlation between ease of use and time of diagnosis, and finally a negative correlation between gargling after taking corticosteroid inhalation and side effects. This confirms once again that the older age is associated with the misuse of inhaler thus special attention to this age group is needed during counseling; moreover, patients will increase their risks of developing some side effects such as oral thrush when they don't gargle after inhaling a corticosteroid dose. As mentioned previously, lack of prior instructions is one of the major risk factors for inadequate inhalation

technique.^{12,13,16,19,20,22,23} Our study revealed that a significant percentage (44.31%) of patients did not receive the required education or counseling from their healthcare provider. This provides a major area for improvement and highlights once again the importance of appropriate education. Overall patients preferred DPIs. When asked, most patients on both types of inhalers preferred switching all of their devices to DPIs. After explaining the concept of DPIs (devices containing powdered medications where coordination between pressing on the canister and inhalation is not required) to patients on MDIs, most patients preferred shifting to DPIs if they were at the same cost.

There are multiple ways to improve inhalation technique. Re-education seems to be one of the most important ones. A series of studies were conducted between 1982 and 2000 to assess pressurized MDI use after reading inhaler package inset and/or receiving instructions.^{30–32} The percentage of patients able to use the inhaler appropriately declined throughout the years suggesting the need for re-education in order to maintain and ensure the adequate use of inhalers. In other words, previous ability to correctly use a pressurized MDI is not indicative of correct use during subsequent testing thus continuous re-evaluation is a must.³⁰ Another way to enhance and reinforce correct inhalation technique is the use of multimedia methods. One study showed that the use of multimedia improved patient's inhalation technique when compared to the use of the patient information leaflet.³³ According to a recent study, multimedia counseling was as effective and time efficient as conventional counseling in MDIs education.³⁴ In addition, van der Palen et al. showed that the use of video instructions cause an improvement in inhaler techniques when compared to the control group and to those receiving personal instructions. The combination of multimedia and personal instructions is suggested as well.³⁵ Finally, the use spacer devices or holding chambers with pressurized MDIs facilitate the coordination between actuation and inhalation and reduce the impaction of large particles in the oropharynx.³⁶

Healthcare professionals should tailor the device choice to patients' needs, preferences, and ability. For example, MDIs are preferred in those with spontaneous breathing, appropriate coordination, and poor inspiratory flow. For those with poor coordination but adequate inspiratory flow, a DPI, an MDI with spacer, or a breath-actuated MDI are preferred. As for those with poor coordination and poor inspiratory flow, a pressurized MDI with a spacer is the

most efficient option.³⁶ Future research should be targeted toward finding the optimal device for each specific patient population.

There are some limitations to our study. First, an equal weight was given to each of the essential steps although some are more critical than others. This might overestimate the prevalence of the incorrect use of inhaler devices. On the other hand, one error in a critical step might counteract the entire effect and consequently influence the outcome. Second, results were reported by more than one observer thus inter-observer variability cannot be ignored. Finally, our study neither measured compliance nor its relationship with the adequate use of inhaler devices.

Conclusion

In conclusion, the study showed a significant percentage of adult patients with COPD/asthma that do not use MDIs/ DPIs appropriately in the Lebanese community. However, proper administration technique was significantly higher in patients using DPIs. Also, it showed a high percentage of patients not receiving the needed education about their devices. Accordingly, it is very important for healthcare professionals to appropriately train their patients in order to gain the maximal benefits expected from the devices and to prevent exacerbations and worsening of symptoms.

Author note

Duration of the study was 18 months. Data collection type is prospective patient interview—questionnaires. Data collection places are community pharmacies and one hospital in Lebanon.

Acknowledgement

The authors gratefully acknowledge the assistance of Hamzeh Ramadan, PhD, in applying the statistical tests and reviewing the statistical analysis; Aline Milane, PharmD, PhD, in participating in the development of the questionnaires; and the LAU pharmacy students in collecting data and filling the questionnaires.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. World Health Organization. Chronic respiratory diseases. <http://www.who.int/respiratory/en/> (accessed 23 October 2015).
2. American Thoracic Society. The global burden of lung disease. <http://foundation.thoracic.org/news/the-global-burden-of-lung-disease.php> (accessed 23 October 2015).
3. Waked M, Khayat G and Salameh P. Chronic obstructive pulmonary disease prevalence in Lebanon: a cross-sectional descriptive study. *Clin Epidemiol* 2011; 3: 315–323.
4. World Health Organization. Chronic Obstructive Pulmonary Disease (COPD). <http://www.who.int/respiratory/copd/en/> (accessed 23 October 2015).
5. National Heart, Lung, and Blood Institute (US). Education for a partnership in asthma care. Expert panel report 3: guidelines for the diagnosis and management of asthma. Bethesda, MD: National Asthma Education and Prevention Program (NAEPP), August 2007.
6. Global Initiative for Chronic Obstructive Lung Disease (GOLD). *Global strategy for the diagnosis, management, and prevention of COPD*. January 2015. <http://www.goldcopd.org> (accessed 23 October 2015).
7. Freedman T. Medihaler therapy for bronchial asthma: a new type of aerosol therapy. *Postgrad Med J* 1956; 20: 667–673.
8. Bell JH, Hartley PS and Cox JSG. Dry powder aerosols: I. A new powder inhalation device. *J Pharm Sci*. 1971; 60: 1559–1564.
9. Souza ML, Meneghini AC, Ferraz E, et al. Knowledge of and technique for using inhalation devices among asthma patients and COPD patients. *J Bras Pneumol* 2009; 35(9): 824–831.
10. Hesselink AE, Penninx BW, Wijnhoven HA, et al. Determinants of an incorrect inhalation technique in patients with asthma or COPD. *Scan J Prim Health Care* 2001; 19: 255–260.
11. Pothirat C, Chaiwong W, Phetsuk N, et al. Evaluating inhaler use technique in COPD patients. *Int J Chron Obstruct Pulmon Dis* 2015; 10: 1291–1298.
12. Rootmensen GN, van Keimpema ARJ, Jansen HM, et al. Predictors of incorrect inhalation technique in patients with asthma or COPD: a study using a validated videotaped scoring method. *J Aerosol Med Pulm Drug Deliv* 2010; 23(5): 323–328.
13. Arora P, Kumar L, Vohra V, et al. Evaluating the technique of using inhalation device in COPD and bronchial asthma patients. *Respir Med* 2014; 108(7): 992–998.

14. Lavorini F, Magnan A, Dubus JC, et al. Effect of incorrect use of dry powder inhalers on management of patients with asthma and COPD. *Respir Med* 2008; 102(4): 593–604.
15. Levy ML, Hardwell A, McKnight E, et al. Asthma patients' inability to use a pressurized metered-dose inhaler (pMDI) correctly correlates with poor asthma control as defined by the Global Initiative for Asthma (GINA) strategy: a retrospective analysis. *Prim Care Respir J* 2013; 22(4): 406–411.
16. Giraud V and Roche N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. *Eur Respir J* 2002; 19: 246–251.
17. Cochrane MG, Bala MV, Downs KE, et al. Inhaled corticosteroids for asthma therapy. Patient compliance, devices and inhalation technique. *Chest* 2000; 117: 542–550.
18. Foster JM, Usherwood T, Smith L, et al. Inhaler reminders improve adherence with controller treatment in primary care patients with asthma. *J Allergy Clin Immunol* 2014; 134(6): 1260–1268.
19. Melani AS, Bonavia M, Cilenti V, et al. Inhaler mis-handling remains common in real life and is associated with reduced disease control. *Respir Med* 2011; 105(6): 930–938.
20. Wieshamer S and Dreyhaupt J. Dry powder inhalers: which factors determine the frequency of handling errors? *Respiration* 2008; 75: 18–25.
21. van der Palen J, Klein JJ, Kerkhoff AH, et al. Inhalation technique of 166 adult asthmatics prior to and following a self-management program. *J Asthma* 1999; 36: 441–447.
22. Sestini P, Cappiello V, Aliani M, et al. Prescription bias and factors associated with improper use of inhalers. *J Aerosol Med* 2006; 19(2): 127–136.
23. Lee SM, Chang Y-S, Kim C-W, et al. Skills in handling Turbuhaler, Diskus, and pressurized Metered-Dose Inhaler in Korean asthmatic patients. *Allergy Asthma Immunol Res* 2011; 3(1): 46–52.
24. Molimard M, Rahersion C, Lignot S, et al. Assessment of handling of inhaler devices in real life: an observational study in 3811 patients in primary care. *J Aerosol Med* 2003; 16: 249–254.
25. Khassawneh BY, Al-Ali MK, Alzoubi KH, et al. Handling of inhaler devices in actual pulmonary practice: metered-dose inhaler versus dry powder inhalers. *Respir Care* 2008; 53(3): 324–328.
26. Darbà J, Ramírez G, Sicras A, et al. The importance of inhaler devices: the choice of inhaler device may lead to suboptimal adherence in COPD patients. *Int J Chron Obstruct Pulmon Dis* 2015; 10: 2335–2345.
27. Melani AS, Zanchetta D, Barbato N, et al. Inhalation technique and variables associated with misuse of conventional metered-dose inhalers and newer dry powder inhalers in experienced adults. *Ann Allergy Asthma Immunol* 2004; 93(5): 439–446.
28. Dolovich MB, Ahrens RC, Hess DR, et al. Device selection and outcomes of aerosol therapy: evidence-based guidelines: American College of Chest Physicians/American College of Asthma, Allergy, And Immunology. *Chest* 2005; 127(1): 335–371.
29. Self TH, Pinner NA, Sowell RS, et al. Does it really matter what volume to exhale before using asthma inhalation devices? *J Asthma* 2009; 46(3): 212–216.
30. Crompton GK. Problems patients have using pressurized aerosol inhalers. *Eur J Respir Dis Suppl* 1982; 119: 101–114.
31. Crompton G and Duncan J. Clinical assessment of a new breathactivated inhaler. *The Practitioner* 1989; 233: 268–269.
32. Lenny J, Innes JA and Crompton GK. Inappropriate inhaler use: assessment of use and patient preference of seven inhalation devices. *Respir Med* 2000; 94: 496–500.
33. Savage I and Goodyer L. Providing information on metered dose inhaler technique: is multimedia as effective as print? *Fam Pract* 2003; 20(5): 552–557.
34. King TL, Kho EK, Tiong YH, et al. Comparison of effectiveness and time-efficiency between multimedia and conventional counseling on metered-dose inhaler technique education. *Singapore Med J* 2015; 56(2): 103–108.
35. van der Palen J, Klein JJ, Kerkhoff AH, et al. Evaluation of the long-term effectiveness of three instruction modes for inhaling medicines. *Patient Educ Couns* 1997; 32(1 Suppl): S87–S95.
36. Broeders ME, Sanchis J, Levy ML, et al. The ADMIT series-issues in inhalation therapy. 2. Improving technique and clinical effectiveness. *Prim Care Respir J* 2009; 18: 76–82.