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A SYSTEMIC REVIEW:ERRORS IN INHALER USE INTRODUCTION

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Abstract
Inhalation therapy is the cornerstone of successful management of obstructive airway diseases (OADs) such as asthma and chronic obstructive pulmonary disease (COPD) due to its two-fold benefits – drug delivery to the target organ, and less systemic exposure with minimal adverse effects on other organs.Different types of inhaler devices such as pressurized metered-dose inhalers (pMDIs) with or without spacers, dry powder inhalers (DPIs), breath-actuated inhalers (BAIs) and nebulizers are available, which provide the physician and the patient the opportunity to select/use a device based on the ability of patients and preference of patient and physicians. Despite this, most physicians report poor inhaler technique and non-adherence to inhaler devices among their patients, which can result in a high economic burden on healthcare cost and utilization, both directly and indirectly, involving exacerbations, increased hospitalizations/hospital visits, poor quality of life and increased morbidity and mortality[31]

Most respiratory diseases whether obstructive or restrictive or both requires inhalers as main stay of treatment.

Problems with the use of inhalers were noted shortly after the launch of MDI in 1960s and even persisted despite elaborate initiatives to reduce them [6-11]. Differenttypes of inhaler devices are being used in management of COPD and BA, and other respiratory diseases.It has been observed that 90% patients show incorrect technique with all the devices. The largest study on inhaler technique was done by Mollimard et al. in over 3800 outpatients. (4) It showed that approximately 50% of the subject at least one error when using a DPI. A greater proportion, 76%, madeat least one error with MDI.Previous studies have reported a high rate of inadequate inhalation technique varying from 77.5% to 89.2% depending upon the type of inhalers used, the patient profile, and the method they are using (4,6).

Ensuring that patients use their inhalers correctly remains a significant challenge today. This write-up aims to review the errors associated with inhaler use and offer potential solutions.

Essential Inhalation Maneuver Steps

The correct inhalation maneuvers technique should be according to the device being used.

1. **ForMetered dose inhaler (MDI) and breath-actuated metered dose inhaler (BAMDI)-**

a. Prepare the device:by uncapping,Shakingand Holding the inhaler. (Canister vertical and mouthpiece horizontal) in case of BAMDI raise the valve lever.
b. Breathe out completely.
c. Place teeth and lips around the mouthpiece and fire the device while beginning a slow inhalation.
d. Breathe in slowly and deeply, without stopping.
e. Hold the breath for 5 to 10 seconds or as long as possible.

2. **Metered dose inhaler (MDI) and InhalationChamber (IC)-**

a. Prepare the device: by uncapping,shaking the inhaler while holding it vertically with mouthpiece on the bottom, and connect it to the chamber.
b. Exhale gently and then place teeth and lips around the chambers mouthpiece to form a seal.
c. 3)fire the MDI and take 4 to 5 slow breaths, inhaling from the chamber; hold the last breath for 5 to 10 seconds or as long as possible.

3. **Dry powder inhaler (DPI)-**

a. Prepare the device by uncappingand loading the inhaler.
b. Turn away from the inhaler and breathe out completely.
c. Placeteeth and lips around the mouthpiece to make a seal.
d. Breathe in with one brisk, deep inhalation.
e. hold the breath for 5 to 10 seconds or as long as possible.

These all above mentioned steps should be correctly followed while taking inhalers for proper dispensing of drug and symptom control.

The list of steps for the different devices is based on the early descriptions ofNewman et al[12]and Dolovich et al [13]and later endorsed by the recommendationsof international bodies [1,2,14]. The open mouth technique was alsoaccepted. BAMDI=breath-actuated MDI; DPI=dry powder inhaler; MDI=metered-dose inhaler; MDI +IC = MDI with inhalation chamber.Tidal breaths (4-5) in small children. A single, long deep expirationoutside the chamber and long deep inspiration (small chambers) orseveral tidal breaths in older children or adults using large chambers werealso accepted.

ERRORS IN INHALER TECHNIQUE

Inspite of providing proper training and repetitive checking of inhaler techniques, a very few take them correctly especially in developing countries like India. Various studies have been done regarding proper and improper uses on inhaler techniques and the results were not very encouraging. Systemic review of errors in inhaler use extracted from144 articles reporting a total number of 54,354 subjects performing 59,584 observed list of technique showed that most common MDI errors were in coordination (45%; 95% CI, 41%-49%), speed and/or depth of inspiration (44%; 40%-47%), and no post-inhalation breath-hold (46%; 42%-49%). Frequent DPI errors were incorrect preparation in 29% (26%-33%), no full expiration before inhalation in 46%, and no post-inhalation breath-hold in 37% (33%-40%). The overall prevalence of correct technique was 31% (28%-35%); of acceptable, 41% (36%-47%); and of poor, 31% (27%-36%).[30]Given the fact that children amounted to 44.7% of the subjectstested with MDI+IC devices, we analyzed the results ofChildren and adults separately, finding lower errorFrequencies in children. They were better from adults in preparing the device, better exhaling and sealing of chamber outlet with lips and actuate, 4-5 slow deep breaths and breath holding. According to a study of 140 done at department of pulmonary medicine, King George's medical university (KGMU), 71.8% patients were using inhalers

incorrectly. Most common faults were not fully exhaling before start of inspiration(25.43%), not shaking device exclusively for MDIs(16.76%),not able to hold breath after full inhalation (15.03%) , and not pressing the button just after inspiration starts (14.45%)[20].Another study of 109 patients done at KGMU ,who were prescribed inhaled therapy , 30 (27.5%) patients discontinued or feared using inhalers because of various reasons[21].A study done at L.R.S. Institute of TB and Respiratory Diseases ByPiyushArora et al showed that among 300 patients, 82.3% made one or more error whereas only 17.7% were using the device properly without any error. Maximum error observed in those using MDI (94.3%), followed by DPI (82.3%) and MDI with spacer (78%) while users of Nebulizers (70%) committed least number of errors while using it. (22) A study done by a tertiary care hospital in India "In total of 105 patients, the patients doing all steps correctly are 16.12% among the DPI users, 6% among MDI users and 20.8% among spacer users [23]. According to a study By Gupta and Gupta rotahalers were used less frequently (12.1%) compared to MDIs (35.1%). But the technique of using Rota-halers was satisfactory in 88.2% of patients as compared to those using MDIs(32.3%).[17]The study by Bedi[10]observed that majority of patients refused inhaler therapy because they are difficult to use (50.4%), difficult to carry(48.6%), habit forming(41.9%), last resort(38.2%), and social stigma (36.6%)[20].

A multicentric observational study conducted a comparison of a novel breath- actuated inhaler, with a pressurized metered dose inhaler (pMDI) in patients with COPD, asthma, and healthy volunteers. The findings indicated that BAI is an easy-to-use and easy-to-handle inhaler, demonstrating a significantly lower number of errors and shorter training time compared to the pMDI. Most participants expressed a preference for BAI over pMDI and found it more satisfactory and easier to use. 88.5% patients chose BAI and 6.1% chose pMDI. Overall, the study suggests that BAI offers better usability and handling, which can lead to improved treatment adherence and outcomes in patients with respiratory conditions.[31]Another multicentricstudy enrolled 490 patients with documented diagnoses of asthma who were treatment-naive or uncontrolled due to poor inhaler technique associated with a previous device. found that using the BAI significantly improved asthma control and lung function in patients with asthma. Patients were given BAI and followed for 12 weeks. The proportion of well-controlled responders increased from 39.9% at week 4 to 77.1% at week 12, demonstrating significant improvement in asthma control. Most patients preferred the BAI inhaler over their previous devices due to its usability, portability, and satisfaction. 91% of patients preferred the BAI over their previous inhaler devices. Overall, the study suggests that BAI offers an effective and patient-preferred option for asthma management, providing significant clinical benefits in real-world settings.[32]

Different types of devices are available having differentformulations and inhalation techniques and each device has different drug delivery system and require skill, hand-and mouth co-ordination. It has been noticed that patients make lots of error while using inhalers despite of repeated explanation about their correct usage. This remains a greater challenge since last 4 decades how to improve patient techniques. However, the incorrect techniques that have been observed with various devices are listed below.

1.Metered dose inhaler (MDI) with spacer and common errors associated.

- Patient tends to forget to exhale before starting inhalation process.
- Failure to ensure a tight seal when mouthpiece is inserted into spacer.
- Failure to hold spacer with inhaler in upright position.
- Failure to seal lips around mouthpiece.
- Problem in dispensing the dose into the spacer.
- Improper inhalation technique.
- Inhalation through nose.
- Not holding breath after whole process of inhalation.
- Coordination.
- Preparation.

2. Dry powder inhaler (DPI) and common errors associated.

- Failure to exhale before inhalation process.
- Not inhaling deep enough.
- Improper handling of device.
- Poor seal around mouthpiece.
- Problem in breath holding after inhalation.
- Inhalation is not forceful from the start.
- Improper hand and mouth coordination

3. Problems associated with MDIs.

- Patients tends to forget to exhale before starting inhalation process.
- Patient tends to forget shaking of device before inhalation.
- Holding inhaler upright and shake them well.
- Not able to form good seal around inhaler.
- Not holding breath after inhaling the drug.

4. Problems associated with Breath actuated-metered dose inhaler (BAMDI.)

- Preparation.
- Full exhalation.
- Breathe in and actuate.
- Slow deep breath.
- Breath-hold.

According to a meta-analysis done by Joaquin Sanchis, MD et al he extracted data from 144 articles reporting on a total number of 54,354 subjects performing 59,584 observed tests of technique ,he observed following common problems associated with various inhalers.

TABLE 1 Distribution of the Most Frequent Errors Made With Inhalers

Inhaler (No. of Tests)	Step	Mean Percentage (95% CI)	Period (No. of Groups)	Mean Percentage (95%CI)
MDI (23,720)	Preparation	30 (24-36)	I (n = 5)	19 (11-29)
			II (n=13)	34 (27-41)
	Full expiration	48 (43-53)	I (n = 11)	43(34-52)
			II (n=40)	49(43-55)
	Coordination	45(41-49)	I (n = 35)	43(38-49)
			II (n=38)	46(40-53)
	Slow deep breath	44(40-47)	I (n=21)	46(36-56)
			II (n=40)	42(39-46)
	Breath-hold	46 (42-49)	I (n=27)	46(38-53)
			II (n=42)	45(41-50)
BAMDI (10,833)	Preparation	ID		…..
				…..
	Full exhalation	32 (27-38)		…...
	Breathe in and actuate	ID		……
	Slow deep breath	33(27-39)		……
	Breath-hold	39(35-43)		

MDI+IC (2,432)	Prepare, shake, and connect chamber	33(25-41)	Child (n=11)	31(23-41)
			Adult(n=9)	34(20-50)
	Exhale and seal chamber outlet with lips	34(20-50)	Child (n=8)	21(8-38)
			Adult(n=8)	49(31-67)
	Actuate, 4-5 slow deep breaths, and breath-hold	38(30-45)	Child (n=11)	31(23-41)
			Adult(n=12)	44(33-54)
DPI(21,497)	Preparation	29(26-33)	I (n=20)	25(19-30)
			II (n=49)	30(25-35)
	Full expiration	46(42-50)	I (n=18)	52(46-58)
			II (n=58)	44(39-49)
	Inhale with lips on mouthpiece	18(11-25)	I (n=8)	18(11-27)
			II (n=1)	ID
	Brisk, accelerated deep breath	22(19-25)	I (n=21)	19(13-25)
			II (n=41)	23(19-27)
	Breath-hold	37(33-40)	I (n=19)	37(27-47)
			II (n=50)	36(32-40)

Error frequencies with the MDI, BAMDI, and MDI+IC devices were all 30%. Errors with the MDI+IC are given for all subjects and both periods together but separately for children and adult subjects. Errors with the MDI alone and the DPI are given by period. DPI errors tended to be somewhat lower than MDI errors in the first period; in the second period, the error frequencies were still higher for the MDI, although the tendency was less dear. ID insufficient
data. See Table 1 legend for expansion of other abbreviations.
*MDI: period 1, 1975-1995; period II, 1996-2014. DPI: period 1, 1990-2002; period II, 2003-2014.
According to a meta-analysis they had expected that adding holdingchambers would reduce MDI errors substantially, but theysaw no evidence that this is the case. Inhalation chambers differ in shape and volume, and most of them—but not all—are valved. Chambers are usedpreferably for small children, the elderly, or physically ormentally disabled adults. It was also expected that DPIswould perform better and were surprised that their error rates were only slightly lower than MDI rates. More than one-third of patients using a DPI made errors—particularly in dose preparation,expiration, and inspiration—that would drastically reduce the delivery of drug to the lung[15, 8]. In a study it was seen that prescribers do not properly educate their patients about techniques due to lack of time and this is one of the reason for poorly controlled COPD and asthma.

According to a study done in All India institute of medical sciences Delhi, patient using MDI were included in the study.Inhalertechnique first evaluated at baseline using a standard checklist of recommended steps and scores were given for each step correctly performed. Those who could not perform all step were given training intervention. The patients were assigned to two groups of educational intervention, one group was trained by providing written material given step wise instructions while the other group was given actual physical training using a placebo device. The technique was re-evaluated and scored following each individual session, and continued till the patient achieved a full score, or for maximum of 3 sessions, whichever occupied earlier.Median

score was calculated after each session and was compared between two groups. Each patient was followed up after two months and they re-evaluated the same way.117 patients were included in the study (59 in written group and 57 in practical group). At baseline, only 1 of the subjects could perform all the steps of inhaler usage correctly, theoverall median score of whole groups was 3.

Changes in the frequencies of incorrect Inhaler use over time have not been assessed properly. Most authors emphasize the same strategies Careful instruction[25,26].Observation of inhalationTechnique, and individual matching of inhaler and patient. Training is facilitated by demonstration[25,27]and repeated tuition, [9,17,4]as well as by videoinstructions, computer assistance, and written material. Our data suggest that either these measures are insufficient, or training recommendations generally arenot implemented.The studies mentioned above clearly suggest that there has been a very little improvement in patient's inhaler technique despite best training and retraining sessions which needs to be address seriously and More research is required identify new and/or better approaches.

There are number of factors which impact use of inhalers. Problem arises from prescription of device,patient's technique and at the level of health care professional.

Advancing age remains a greater challenge for physicians as to what device to prescribe and for patients to use it correctly.It has been seen that about 76% of patients using inhalers commit errors in inhaler use[5-7]it has also been seen that most of the patients learn inhaler technique by physicians and pharmacist(about 98%,) 2 to 3% by themselves and about 48% by nursing staff[(8)].As inhaled therapy has been recommended as first line of therapy for diseases like COPD and asthma, its acceptance is less in India as compared to developed countries.
In the data provided in a study one mistake was committed by each patient that is about 94.2% [9].A study done in Spain showed that there was not proper training provided by physician or staff due to lack of knowledge [10]. Patients can be educated either by demonstrating proper technique or by printed text material, when both were compared demonstration was better and effective method [11,12]. Educatingpatients about these disease like asthma and type of medication required also helps towards patient compliance towards therapy [13,14]. Usage of different devices as inhaler medications has become a challenge in India considering theireducational and socio-economic status.Urban population committed less mistakes as when compared to rural population.Proper training and education are important for delivery devices and inhalation therapy.

The type of device should be prescribed according to patient's situation, preference, and cost. Correction of faulty inhaler technique and subsequent assessment leads to control of disease.In a study it was estimated that 11% of patients follow –up assessment and education on their inhalertechnique. [15]. Pharmacists in the community can provide training in correcting inhaler techniques.(16)repeated follow of patient and demonstration of inhaler technique using standard check –list reduces errors, this is one of the reason for poorly controlled COPD and asthma .A large body of evidence from randomized clinical trials has shown that the patients inhaler technique can be improved by education from health professional[17-19] or other person trained in correct technique. Switching the inhaler device affects care, as inhalers differ in design (particularly DPIs) and device has unique required steps and inhaler technique. Regular training sessions should be provided at each visit and patients should be encouraged to bring their inhalers to provide a demonstration of competence of inhaler technique. Customized patient-friendly treatment that anticipates and accommodates usual behavior and address conscious and unconscious medications beliefs is more likely to achieve the desired goals of disease control [42]. Patient education is crucial in proper use of delivery devices. The choice of device needs to be prescribed according to patient needs situation, and preference. Education interventions to reduce inhaler technique errors, improve health care professional inhaler knowledge and skills, improving patient inhaler knowledge and skills are very important steps that can improve patient's technique finally relief in symptoms.

Conclusion

Incorrect inhaler use in patients with asthma and COPD is unacceptably high outside clinical trials and does not seem to have improved over the past 40 years. This may be a major obstacle for achieving good asthma ,copd control.New approaches to handling this important problem should be explored. To facilitate comparisons of results,future studies should be based on generally accepted techniques.

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