

Assessment of inhalation technique among asthmatic children and their carers at the Kenyatta National Hospital, Kenya

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Abstract

The aim of this study was to evaluate the correctness of use of pressurised metered-dose inhalers and spacer devices and to determine the common errors in the inhalation technique and factors associated with incorrect technique. The descriptive cross-sectional survey took place in the Kenyatta National Hospital, Nairobi, Kenya. Eighty-two asthmatic children aged 6 months to 12 years (median age 45 months, 56% males) on inhaler medications and their carers were recruited into the study and assessed for correctness of inhalation technique.

Of the 82 subjects, only 37 (45.1%) performed all the essential steps of the inhalation technique correctly. The commonest errors were failure to take adequate breaths after actuation of inhaler (45%) and not shaking the inhaler before use (18%). The characteristics of correct and incorrect users are mainly similar.

It was concluded that the majority (55%) of asthmatic children and their carers do not perform the inhalation technique correctly.

Introduction

The evolution of inhalation therapy can be traced to India 4000 years ago. However, contemporary inhalation therapy began in the 19th century industrial revolution with the invention of the glass bulb nebuliser. Since then, inhaler technology has evolved with refinements in nebuliser technology and the invention of a portable inhalation device, the pressurised metered-dose inhaler (pMDI). Recently, modifications in the pMDI itself with auxiliary devices (spacers) and the development of new inhaler systems, dry powder inhalers (DPIs) and the breath-actuated metered-dose inhaler (BA-MDI), have helped in overcoming some of the difficulties associated with MDI use.¹

Inhaled corticosteroids (ICS) are the first-line medications for asthma control at all ages. Inhaled therapy using a pressurised metered-dose inhaler with attached spacer (pMDI+S) is the preferred method for delivering asthma medication for acute attacks and chronic prophylaxis in all ages. Good quality aerosols, good inhaler technique, close follow-up of patients, and education of parents and patients on the importance of treatment adherence, are prerequisites for treatment effectiveness.^{2,3}

The global initiative for asthma has come up with recommendations for the types of inhaler devices to use in various categories of children based mainly on efficacy of drug delivery, cost effectiveness, safety, ease of use and convenience. In these guidelines, children below 4 years are effectively managed by using pMDI plus spacer with face mask; those aged 4 to 6 years, pMDI plus spacer with mouthpiece; while those above 6 years can use BA-MDIs or DPIs or pMDI plus spacer with mouthpiece.² It should, however be emphasised that the choice of inhalation device should always be individualised according to the ability of the child. Studies have shown that low-cost bottle spacers and commercially produced spacers produce equivalent responses when used to deliver bronchodilator in young children with acute lower airway obstruction.⁴

At the Kenyatta National Hospital (KNH), asthma management has been far below the international recommendations. Laigong et al found that less than half of the inpatients and only one-fifth of outpatients were getting appropriate care for acute asthma as per the internationally accepted guidelines,⁵ while Ngeta et al found that only 0.5% of asthmatic children were on inhaled controller medication.⁶ These two studies were done before the start of a regular paediatrics chest clinic which began in April 2008. More recently, most children on long-term follow-up at KNH with moderate to severe asthma have been started on inhaler medications and are now on regular follow-up at the paediatrics chest clinic.

Inhalation technique

Using an inhaler correctly is difficult for children and many may use their devices incorrectly even after instruction for correct use. Furthermore, studies have shown that correct inhalation technique, if not repeatedly practised, deteriorates over time.⁷ Most mistakes are committed by patients whose only source of information consists of the contents of the package insert. Training in application

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plus demonstration and subsequent exercise reduces the error ratio to a minimal level.⁸ This has also been shown in studies done among subjects who get frequent instructions and demonstrations during clinic visits.⁹

Patients on pMDI without spacer devices are more likely to make mistakes in the inhalation therapy than those using spacer devices.¹⁰ Among common errors noted in the inhalation technique in previous studies include: not shaking the inhaler, not applying the puff at the start of inspiration, and failure to hold the breath after inhalation.⁸

Studies have shown that poor inhalation technique is associated with poor lung deposition of the aerosols which in turn is associated with poor asthma control. There is also an increased rate of oropharyngeal and gastrointestinal deposition of the drug particles which is associated with untoward side-effects like oropharyngeal candidiasis, especially for those on ICS.^{11,12} However, there are no studies to quantify the measured benefits of appropriate technique in terms of better effectiveness in asthma control.

Poor asthma control means frequent use of reliever medications, frequent emergency visits and hospitalisations and missed school days for the child and working days for the carer, all of which could have serious financial implications on the family. There are no studies done to quantify the increased cost of treatment due to inappropriate inhaler technique.

The essential steps for assessment of inhalation technique in children varies in different studies.¹³ Removal of the cap of the inhaler and connecting it to the spacer (where necessary) is essential in preparing the inhaler for use. Shaking of the inhaler before use is important for ensuring uniform mixing of the contents of the canister as they tend to settle in layers over time.¹⁴ A good seal at the mouthpiece ensures that there is very little loss of the inhaler into the air and so is the formation of a good seal on the face with the face mask covering both mouth and nose. Breath counts are considered essential since, in young children, it is important for maximising the amount of medication inhaled.

There are different breathing techniques for optimal delivery of the medication: tidal breathing, slow and deep breaths, or taking one deep breath and holding for 10 seconds. These have been demonstrated to be equivalent in school-age children,¹⁵ although data are limited. Hansen and Pedersen¹⁶ demonstrated that in children, response to bronchodilators was not affected by breath holding and tilting the head. Among those using a spacer with mouthpiece, multiple or single-breath techniques can be used but the former is recommended for children in clinical settings, since most of them cannot hold their breath. In vitro studies have shown that single or multiple puffs of the inhaler have produced similar effects.¹⁷

This study was to evaluate the correctness of use of pressurised metered-dose inhalers and spacer devices among asthmatic children aged 6 months to 12 years.

Methods

This descriptive cross-sectional study was carried out at Kenyatta National hospital (KNH) between February and May 2009. Ethical approval was obtained from the Ethical Review Committee of KNH.

A total of 82 eligible asthmatic children (aged 6 months to 12 years) on inhaler medications were recruited at the paediatrics chest clinic and paediatrics emergency unit of KNH. The children and their carers were interviewed using a structured questionnaire and asked to demonstrate their inhalation technique using a placebo inhaler and corresponding spacer device, if any. The technique was scored on a standardised checklist (see Box 1 below). Correct technique was judged to be the performance of all the essential steps (see Box 2), while incorrect technique was considered to be any missed or wrongly performed steps.

Box 1: Steps to assess pMDI[†] with spacer device technique (standardised checklist)

1. Remove cap of the pMDI^{*}
2. Shake the pMDI^{*}
3. Hold pMDI upright and connect to spacer device[†]
4. Extend neck to sniffing position[†]
5. Breathe in slowly and deeply then breathe out slowly and completely[†]
- 6a. Place mouthpiece of holding chamber between teeth and lips and form a seal[†]
- 6b. Connect face mask to mouth piece of holding chamber and form a seal covering mouth and nose then allow established breathing.[†]
7. After actuation take 7–10 deep breaths (by mouth)[‡]

References

- * Essential steps of correct inhalation technique.
- † Only for older children who do not require a face mask.
- ‡ Only for children using spacer with a face mask.

Box 2: Essential steps to assess pMDI

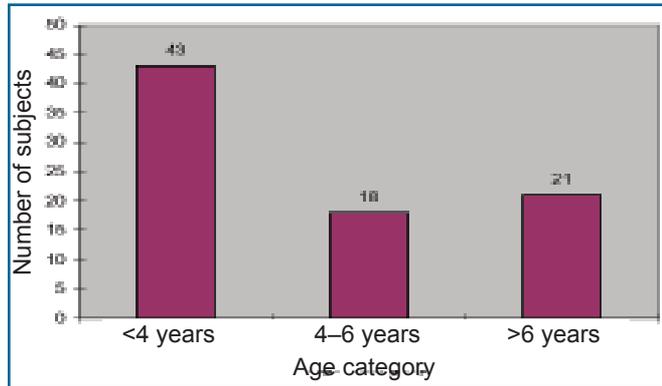
1. Remove cap of the inhaler
 2. Shake inhaler
 3. Breathe out gently
 4. Put mouthpiece in mouth and as you breathe in, which should be slow and deep, press canister down and continue to inhale steadily and deeply
 5. Hold breath for 10 seconds or as long as is comfortable.
- NB For another dose, repeat steps 1–4

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 17.0 and were presented as number or percentage where appropriate. Correlates of inhalation technique were explored using the Chi square test, Student's t-test and odds ratio. A p value of <0.05 was considered significant.

Results

Of the 82 subjects recruited, 46 (56%) were male. The median age was 45 months (range 9–155). The age distribution of subjects is shown in Figure 1. Inhaler medications

Figure 1 Distribution of children studied by age (n=82). Table 2 Errors in performance of inhalation technique



Steps	Number with incorrect technique (%)	Number tested
Removal of pMDI cap	0 (0%)	82
Shaking of pMDI	15 (18)	82
Connecting pMDI to spacer	5 (6%)	76
Use of spacer mouthpiece	4 (19%)	21
Use of face mask	7 (12)	55
Counting the breaths	34 (45)	76

Table 1 Characteristics of study population (n=82)

Characteristics	Number (n)	(%) or range
Sex: male	46	56.1
female	36	43.9
Median age of children (months)	45	9–155
Person administering inhaler medication:		
self	8	9.8
carer	74	90.2
Residence:		
rural	10	12.2
urban	72	87.8
Carers level of education:		
primary/below	29	35.4
secondary/above	53	64.6
Per capita monthly income:		
<2000Ksh	25	30.5
>2000Ksh	57	69.5
Median duration of inhaler use (months)	7	2–72
Median duration since diagnosed asthma (months)	13	1–82
Spacer used		
– zerostat	62	75.6
– able	6	7.3
– volumatic	5	6.1
– modified juice bottle	1	1.2
– aerochamber	2	2.4
– no spacer used	6	7.3

were administered by the carers in 74 (90%) subjects. Seventy-six subjects (93%) were using spacer devices (most commonly Zerostat, 76%) and of these, 55 (72%) were using an accompanying face mask (see Table 1)

Of the 82 subjects, only 37 (45%) performed all the essential steps of the inhalation technique correctly. Seventy-seven (93%) of the subjects had been trained on inhalation technique with a doctor being reported as the trainer in 35 (45%). Of the five who had not been trained, three had learnt how to use inhaler medications by reading the package insert. None of the five subjects who had not received training on the inhalation technique performed it correctly.

Table 3 correlates of correct and incorrect use of inhaler medications

Characteristics	Correct users (n=37)	Incorrect users (n=45)	Odds ratio (95% CI)	Pvalue
Median age (months)	51 (9–155)	40 (9–135)		0.096
Median duration of inhaler use (months)	7.5 (2–72)	6 (4–36)		0.129
Per capita monthly income:				
<2000Ksh	10 (40%)	15 (60%)	0.74 (0.26–2.13)	0.503
>2000Ksh	27 (47.4%)	30 (52.6%)		
Carer level of education:				
Primary/below	9 (31%)	20 (69%)	0.42 (0.14–1.15)	0.058
Secondary/above	28 (52.8%)	25 (47.2%)		
Trained on inhaler use?				
Yes	37 (48.1%)	40 (51.9%)		0.121
No	0 (0%)	5 (100%)		
Trainer of technique				
Doctor	21 (55.3%)	17 (44.7%)	1.00	0.402
Nurse	14 (45.2%)	17 (54.8%)	1.53 (0.50–4.70)	
Pharmacist	2 (15.4%)	11 (84.6%)	7.33 (1.22–56.57)	

Discussion

This study showed that a majority of children on inhaler medications and their carers were not able to perform the inhalation technique correctly. The possible reasons for this could be that the subjects were not adequately trained in the first place or perhaps their training was done once and no subsequent reviews have been made, or maybe they were trained on a different set of steps all together. The content of the training is however not within the scope of this study. This emphasises the need to review the technique at every visit or contact the patient has with the health worker since this has been shown to reduce the error ratio to a bare minimum.⁸

The most common error in the inhalation technique in this study (see Table 2) was failure to take adequate breaths after actuation of the pMDI followed by failure to shake the inhaler before use. This contrasts with a similar study done in India which showed the commonest error to be failure to shake the inhaler before use.⁹ In a review of 20 articles, the four main errors in the use of pMDI (with or without spacer) in both adult and paediatric patients were, in decreasing order of frequency: improper hand-lung synchronisation (27%); improper breath holding after inhalation (26%); too rapid inspiration (19%); and inadequate shaking of inhaler (13%).¹⁸ Studies evaluating inhalation technique in children are limited. Kamps et al¹⁹ demonstrated that out of 200 children with asthma using pMDI with spacer, 78.5% performed all essential steps correctly. His study showed that the most common error was not shaking the inhaler (19.6%). This study also did not find any difference in socio-demographic characteristics between correct and incorrect users of the metered-dose inhaler with spacer.¹⁹

Based on this study, socioeconomic status of the child or carer seems not to have an influence on correct or incorrect performance of the technique. This has also been found in other studies.^{9,13,19}

The fact that all the subjects who had not been trained on inhalation technique performed it incorrectly further emphasises the need for training as opposed to access to package inserts which they had. Among patients who had been trained on inhalation technique, incorrect performers were more likely to have been trained by the pharmacists as compared with either doctors or nurses. These findings may be explained by the possibility that the type of training offered by the pharmacists, in the first place, differs from that offered by either doctors or nurses.

The limitation of this study was that it was not able to make firm conclusions on the correlates of correct and incorrect technique due to the small sample size.

This study recommends that all carers of asthmatic children on inhaler medications, and older children, should be trained on appropriate inhalation technique. Further studies should be done on the knowledge, attitude, and practice of health workers regarding the use of inhaler medications and accompanying devices.

Acknowledgements

We would like to express our sincere appreciation to the following: the staff at the paediatrics chest clinic and the records department at the KNH for helping us contact and recruit the booked subjects; Mr Mwaura of NARESA for helping us with data analysis; GlaxoSmithKline Limited for their material support with the necessary devices needed for the assessment and demonstration of the inhalation technique, and the members of the Department of Paediatrics, University of Nairobi for their comments. Finally, we wish to thank all the children and their carers for voluntarily agreeing to participate in this study.

References

1. Grossman J. The evolution of inhaler technology. *J Asthma* 1994; 31(1): 55-64.
2. GINA Report: Global strategy for asthma management and prevention. Updated 2008. Available from www.ginasthma.org.
3. Zar HJ, Asmus MJ, Weinberg EG. A 500 ml plastic bottle: an effective spacer for children with asthma. *Paediatr Allergy Immunol* 2002; 13(3): 217-22.
4. Zar HJ, Streun S, Levin M, Weinberg EG, Swingler GH. Randomised controlled trial of the efficacy of MDI with bottle spacer for bronchodilator treatment in acute lower airway obstruction. *Arch Dis Child* 2007; 92: 142-6.
5. Laigong PK, Wamalwa D, et al. Acute asthma care in children seen at Kenyatta National Hospital: a comparison with international standards. MMed dissertation, Department of Paediatrics and Child Health, University of Nairobi, 2006.
6. Ngeta C, Obimbo E, et al. Prevalence of use of controller medications among asthmatic children in Kenyatta National Hospital. MMed dissertation, Department of Paediatrics and Child Health, University of Nairobi, 2006.
7. Brand PL. Key issues in inhalation therapy in children. *Current Med Res Opin* 2005; 21 Suppl 4: 527-32.
8. Petro W, Gebert P, Lauber B. Analysis of causes of incorrect use of dose aerosols. *Pneumologie* 1994; 48(3): 192-6.
9. Walia M, Paul L, Satyavani A, et al. Assessment of inhalation technique and determinants of incorrect performance among children with asthma. *Paediatr pulmonol* 2006; 41: 1082-7.
10. Golpe GR, Mateos CA, Soto FI. Inadequate technique in the use of inhalers in patients seen at pneumology clinic. *An Med Interna* 2001; 18(2): 69-73.
11. Newman SP. Spacer devices for metered dose inhalers. *Clin Pharmacokinet* 2004; 43(6): 349-60.
12. Giraud V, Roche N. Misuse of corticosteroid metered dose inhaler is associated with decreased asthma stability. *Eur Respir J* 2002; 19(2): 246-51.
13. 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: 378-83.
14. Fink JB. Metered-dose inhalers, dry powder inhalers and transitions. *Resp Care* 2000; 45: 623-35.
15. Gleeson JG, Price JF. Nebuhaler technique. *Br J Dis Chest* 1988; 82: 172-2.
16. Hansen OR, Pedersen S. Optimal inhalation technique with terbutaline Turbuhaler. *Eur Respir J* 1989; 2: 637-9.
17. Rau JL, Restrepo RD, Deshpande V. Inhalation of single vs. multiple metered-dose bronchodilator actuations from reservoir devices: an in vitro study. *Chest* 1996; 109(4): 969-74.
18. McFadden ER. Improper patient techniques with metered dose inhalers: clinical consequences and solutions to misuse. *J Allergy Clin Immunol* 1995; 96: 278-83.
19. Kamps AW, Brand PL, Roorda RJ. Determinants of correct inhalation technique in children attending a hospital-based asthma clinic. *Acta Paediatr* 2002; 91(2): 159-63.