

Errors in Inhalation Technique and Efficiency in Inhaler Use in Asthmatic Children

S. PEDERSEN, L. FROST and T. ARNFRED

Allergy Unit, Dept. of Pediatrics, and Dept. of Clinical Chemistry, Aalborg Hospital, Aalborg, Denmark

256 asthmatic children receiving regular inhalation therapy demonstrated how they used their inhalers. Pulmonary function measurements (PFM) were made before and after the demonstrations, and errors in technique were recorded. 242 children had reversible airway obstruction on the day of study. In only 109 (45 %) did the inhalation result in an increase in $FEV_1 \geq 15$ % (efficient technique). An efficient inhalation technique was found in 46 % of children who demonstrated a pressurized aerosol, 59 % who demonstrated a tube spacer aerosol and 46 % who demonstrated a rotahaler, and the frequency of efficient technique varied from 17 % to 84 % between six different groups of instructors. 87 % of children controlled and 25 % not controlled with PFM at the time of prescription had an efficient technique. Children under 6 years had a more inefficient and a more faulty technique than older children, but otherwise age did not influence the result. Neither was time since instruction of any importance for efficiency or number of errors. The errors recorded that seem to influence efficiency most were: coordination problems, rapid inspirations, ceasing to inspire when the aerosol was fired, and inhalation through the nose. The results emphasize the paramount importance of clear instructions and control of inhalation technique *at the time the treatment is prescribed*.

Key words: inhaler use; children; asthma; inhalation technique.

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As inhalation therapy offers the advantages of small dosage, infrequent systemic side effects, and a rapid onset of action, its use has become increasingly widespread in the day-to-day management of asthmatic patients. However, correct use of an inhaler is much more difficult than swallowing a tablet, and it has been shown that many adult patients use their inhalers incorrectly (2, 3, 6, 7, 11). Unfortunately, only little specific information is available about the problems that *children* experience when trying to use their inhalers and about the influence of these problems on the airway response to a bronchodilator.

We performed this study in an attempt to clarify some of these questions. In addition, we have tried to evaluate the influence of some of the factors which we anticipated might be of importance for the outcome of inhalation therapy in children.

PATIENTS AND METHODS

The 267 asthmatic children with perennial asthma who attended the out-patient clinic during a 4-month period were asked to participate. Eleven refused, thus the study comprised 256 children (172 boys and 84 girls aged 4-16 years (mean 9.7 years) (Fig. 1). Of these, 132 demonstrated a pressurized aerosol (PA), 85 an aerosol with a tube spacer (TS), and 39 a rotahaler (RO).

To be included in the study the children had to be receiving inhalation therapy on a regular basis with the inhaler that was originally prescribed when treatment was started. Inhalation therapy was always suspended for 12 h and oral bronchodilators for 24 h before the study. Informed consent was obtained from all children and their parents.

The children were familiar with pulmonary function measurements before the study began.

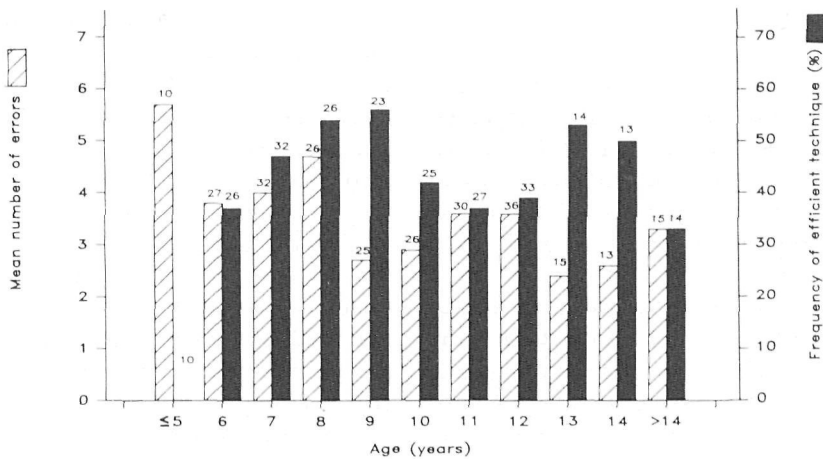


Fig. 1. Mean number of errors in inhalation technique (▨) and frequency of efficient inhaler use (■) in various age groups of asthmatic children demonstrating their inhaler use. The figures above the columns indicate the number of children in each group.

Forced expiratory volume in 1 s (FEV_1) was measured with a dry wedge spirometer (Vitalograph) and the best of three measurements was used for analysis.

On the day of study the procedure was as follows: After the initial pulmonary function measurement the children were asked to demonstrate their use of the type of bronchodilator inhaler they normally used at home, and the following recordings were made:

- 1) whether the parents helped the child with the inhalation,
- 2) whether the child received treatment at home with only one type of inhaler or with combinations of aerosol devices, e.g. beclomethasone with a conventional aerosol and a β_2 -agonist with a tube spacer aerosol,
- 3) who had instructed the child in the use of the inhaler (general practitioners, hospital nurses, hospital doctors, or instructors at the pediatric allergy unit),
- 4) whether the inhalation technique had been controlled at the time of prescription by the aid of pulmonary function measurements (PFM) before and after treatment with a β_2 -agonist,
- 5) time interval since last control of inhalation technique,
- 6) errors in inhalation technique (Table 3).

PFM was repeated 10 min after the demonstration. If FEV_1 at that time showed an increase $\geq 15\%$ the inhalation technique was assessed as "efficient" regardless of the number of errors, and no further recordings were made. If the improvement in FEV_1 was $< 15\%$ in spite of an apparent acceptable inhalation technique the child repeated the demonstration, but with the nose closed with a nose clip during inhalation. If this resulted in an increase in $FEV_1 \geq 15\%$ the assessment was "inspiration through the nose" and no further recordings were made.

Finally, to ensure that a 15% increase in FEV_1 could be obtained at the time of study, all children who had not yet shown an increase in $FEV_1 \geq 15\%$ were treated with a total of three puffs of terbutaline given with a 750 ml spacer (Nebuhaler®). If this treatment did not result in an improvement in $FEV_1 \geq 15\%$ the assessment was "not reversible".

Pulmonary function measurements were only evaluated in children who had reversible asthma and a pretreatment $FEV_1 \leq 85\%$ of the predicted value on the day of study.

When a child was unable to load the capsule into the RO, the investigator loaded and the child continued the demonstration.

If the capsule did not break when the RO was twisted the child was given a new capsule only if the child itself discovered the mistake.

Statistics

Chi-square tests without correction for continuity were used to compare frequencies. Adjoining classes of data were pooled if the number in a class was too small. It was assumed that there was no difference and expected values were calculated by use of the observed values of the other variables. $P > 0.05$ was considered not significant.

When frequencies in various groups were compared, the influence of other variables affecting the result was always taken into account by adjusting the rates for these factors before making the comparison. When such adjustments were made, only results from subgroups consisting of five or more patients were used for analysis. Values adjusted in this way are given as "standardized" (stand.).

RESULTS

In 109 children (43 %) the demonstration of inhalation technique resulted in an increase in $FEV_1 \geq 15\%$ (efficient inhalation technique) and in 133 (52 %) the increase in FEV_1 was $< 15\%$ (inefficient inhalation technique). Fourteen patients (5 %) did not have reversible asthma on the day of study.

Influence of age

TS aerosols were used more often by younger and PA aerosols more often by older children ($P < 0.05$).

The occurrence of efficient technique and the mean number of errors in the various age groups are shown in Fig. 1. No statistically significant *systematic* variation with age was found, either when the results from all inhalers were grouped together or taken separately. However, a comparison of the results from children under 6 years with those from the rest of the children showed a significantly lower frequency of efficient technique (0 % vs. 47 %) and a higher mean number of errors (5.9 vs. 3.3) in the younger age group ($P < 0.01$ for both variables).

When the frequency of each single error was studied separately, only nasal inhalation varied systematically with age. This error was more common in younger than in older children ($P < 0.01$).

Eighteen of 95 children aged 5–8 years were helped by their parents. This was not adjusted for when the influence of age was evaluated.

Type of inhaler used

The frequency of efficient technique and the mean number of errors in the three inhaler groups are given in Table 1; the TS group was significantly better than the others on both variables. Coordination problems, rapid inhalations and ceasing to inspire when the aerosol particles reached the soft palate, were more common after PA than after TS demonstrations (Table 2).

There was no difference in the occurrence of

Table 1

Frequency of efficient inhalation technique and standardized mean number of errors in asthmatic children ≥ 6 years who were taught inhaler use by six different instructors

Instr.	Percent with PFM	Frequency of efficient technique (%)				No. of errors
		PA	TS	RO	Mean	Mean
1	54	43 (28)	81 (21)	60 (5)	61	2.7
2	28	35 (31)	50 (10)	56 (9)	44	3.4
3	82	100 (5)	83 (18)	70 (10)	84	1.6
4	2	14 (35)	14 (7)	29 (7)	17	4.4
5	32	27 (11)	54 (13)	17 (6)	33	3.1
6	12	56 (9)	71 (7)	– (0)	63	3.1
	$P < 0.01$				$P < 0.01$	$P < 0.01$
Mean		46	59	46	$P < 0.01$	
Mean No. of errors		3.3	2.6	3.3	$P < 0.01$	

PA = pressurized aerosol, TS = tube spacer aerosol, RO = rotahaler. The number of children in each group is given in parenthesis. PFM = control of inhalation technique by means of pulmonary function measurement at the time of instruction.

efficient inhalation technique or number of errors between the 159 children treated with only one type of inhaler (49 % with efficient technique and mean number of errors 3.1) and the 97 children treated with combinations of the three inhalers (50 % with efficient technique and mean number of errors 3.2).

Importance of instruction

The efficiency in inhalation technique and the number of errors greatly depended on the person who had taught the child the use of the inhaler (Table 1). The instructor with the best results more often used pulmonary function measurements to control technique before prescribing, and used TS aerosols more frequently than did the less successful instructors (this was adjusted for when the comparison was made).

Pulmonary function measurement (PFM)

Eighty-eight children had had their inhalation technique controlled by pulmonary function measurements, and inhaled therapy had not been prescribed until the child was able to use the inhaler efficiently. The mean number of errors in these children was 2.3 and 87 % used

their aerosols efficiently. In contrast, the inhaler was used efficiently by only 25 % of the 168 children not controlled by PFM and their mean number of errors was 3.5 ($P < 0.01$ for both variables).

Time since instruction

No systemic variation in time interval since instruction was observed, either when the results of all inhalers were pooled or when the results of each inhaler, or the frequency of each single error, were studied separately (Fig. 2).

Errors and increase in FEV₁

There was a statistically significant negative correlation between the number of errors and the increase in FEV₁ ($r = -0.56$; $P < 0.01$), and, on average, the 109 children with an efficient technique made significantly fewer errors (mean = 1.9) than the 133 children with an inefficient technique (mean = 4.6) ($P < 0.01$). Coordination problems, ceasing to inspire when firing the aerosol, and inhalation through the nose, seemed to be more important than other errors for the increase in FEV₁ (Table 3).

Table 2

Frequency of the most common mistakes observed in 256 children demonstrating their use of an inhaler

	PA (n = 132)	TS (n = 85)	RO (n = 39)
Forgetting to shake the canister	49 %	34 %	-
Forgetting to exhale before firing	45 %	51 %	62 %
Neck flexed during inhalation	12 %	14 %	13 %
Coordination problems	55 % *	17 % *	3 %
Fast inhalation	67 % *	28 % *	-
Breath-holding ≤ 7 s	42 %	39 %	49 %
Stop of inspiration when firing aerosol	38 % *	6 % *	-
Inspiration through the nose	24 %	32 %	-
Submaximal inspiration	23 %	19 %	41 %
Unable to load capsule into the RO	-	-	15 %
Turning RO after loading the capsule**	-	-	46 %
RO-capsule did not break***	-	-	15 %
RO-capsule not completely emptied	-	-	36 %
Help from the parents	5 %	6 %	10 %

* $P < 0.01$.

** Powder not correctly distributed in the capsules, or some powder had fallen out of the RO before inhalation.

*** Half of the children discovered the mistake themselves.

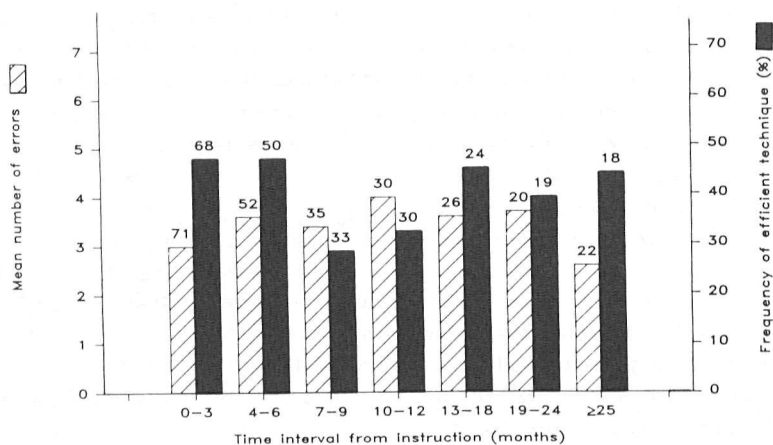


Fig. 2. Variation in mean number of errors in inhalation technique (▨) and frequency of efficient inhaler use (■) with time interval since instruction in 256 asthmatic children demonstrating their inhaler use. The figures above the columns indicate the number of children in each group.

DISCUSSION

It appeared that children and adults experience the same problems in the use of inhalers (2, 3, 6, 7, 11). However, considering the association between regular inhaler use, which was prescribed in all children, and correct technique (3), the problems seemed more pronounced in children (3). The present study not only evaluated and quantified errors in inhalation technique, but also gave information about various factors which influence the success of inhalation therapy.

Table 3

Frequency of observed errors in inhalation technique in asthmatic children with efficient inhalation technique ($n = 91$) and inefficient inhalation technique ($n = 114$). 123 children used a pressurized aerosol and 82 used a pressurized aerosol with a tube spacer

	Efficient %	Inefficient %
Forgetting to shake the canister	30*	54*
Forgetting to exhale before firing	35*	66*
Neck flexed during inhalation	8	17
Coordination problems	16*	58*
Fast inhalation	31*	68*
Breath-holding ≤ 7 s	30**	52**
Stop of inhalation when firing aerosol	2*	46*
Inspiration through the nose	5*	46*
Submaximal inspiration	27*	62*

* $P < 0.01$; ** $P < 0.05$.

which influence the success of inhalation therapy.

The quality of the initial instruction was found to be of paramount importance for the outcome of child inhalation therapy. This is in accordance with the results of Self (10) but in contrast to the findings of Epstein (3). Epstein, however, did not make an evaluation of the staff's teaching competence in order to ensure that differences between the instructors really did exist.

The poor results in many children indicated that, too often, inadequate effort is made to instruct the child, or that the instructors are incompetent, as suggested in a recent paper (1). Unfortunately, the number of initial instructional visits was not recorded, but it is our experience that many children need two or three follow-up visits before they have learned and remembered the correct use of the inhaler (9).

Only in children under 6 years was age apparently an obstacle to successful inhaler use. In general, the pattern of errors in this age group was the same as in older children, only the number of errors was greater. Therefore, to improve results, these children need better tuition with particular attention to nasal inspiration, a problem which seems to be more common in the younger age groups (9).

It has been suggested that patient compliance might be improved if only one device is used for the inhalation of *all* drugs prescribed (2). As it is undoubtedly more convenient for the patient to use only one kind of inhaler, combinations of inhalers should be avoided. However, when combinations cannot be avoided, our results showed that effective inhaler use could be maintained.

The better results in the TS group were in agreement with earlier findings in children suffering from acute bronchoconstriction (8). However, the poor results in children demonstrating the rotahaler were surprising since this device was designed to make inhaled therapy more simple. This finding may have been influenced by the fact that the RO was rather new in Denmark at the time of study, and, consequently, the instructors may not have been so familiar with it. This emphasizes that the simplicity of an inhaler is no substitute for careful tuition by experienced instructors. Finally, we do not know the reasons for choosing a PA, a TS or an RO, and it is possible that some selection process at the time of prescribing may have influenced the results.

The use of pulmonary function measurements at the time of instruction is likely to reflect the enthusiasm of the instructor, and the better results in children with PFM may largely be ascribed to the fact that instructors using PFM normally gave repeated and more careful instruction than those who did not. However, coordination problems, ceasing to inspire when firing the aerosol, and inspiration through the nose, are not always obvious by observation alone, and sometimes these errors will not be noticed if PFM is not done to control the technique (4, 9). Finally, PFM may have some learning value.

In adults the importance of repeated tuition and regular checks of inhaler use at follow-up clinics has been stressed (2, 5). This was not supported by the findings in the present study. The results were not influenced at all by the time interval since last tuition. It was more a question of "once learned never forgotten" – provided the inhaler is used regularly.

The study did not allow a more detailed

evaluation of the influence of the various errors on bronchodilation. Many children had an efficient technique in spite of several errors, and only ceasing to inhale when the aerosol was actuated, coordination problems, and inspiration through the nose after firing the aerosol into the mouth, were almost invariably accompanied by a reduced increase in FEV₁.

Conclusion

Many asthmatic children use their inhalers inefficiently because they have not been thoroughly instructed at the time of prescription. Most children over 5 years can be taught effective use of an inhaler provided careful tuition is given, and the best result is achieved when instruction is combined with control of pulmonary function to demonstrate an effective use of the inhaler. Once an efficient technique has been learned it is rarely forgotten. For many children, a pressurized aerosol with a tube spacer seems easier to use.

REFERENCES

1. Burton, A. J.: Asthma inhalation devices: what do we know? *Br. Med. J.* 288, 1650–1651, 1984.
2. Crompton, G. K.: Problems patients have using pressurized aerosol inhalers. *Eur. J. Respir. Dis.* 63, Suppl. 119, 101–104, 1982.
3. Epstein, S. W., Manning, C. P. R., Ashley, M. J., et al.: Survey of the clinical use of pressurized aerosol inhalers. *Can. Med. Assoc.* 120, 813–816, 1979.
4. Lee, H. S.: Proper aerosol inhalation technique for delivery of asthma medications. *Clin. Pediatr.* 22, 440–443, 1983.
5. Newman, S. P.: The correct use of inhalers. In Clark, T. J. H. (ed.): *Steroids in asthma. A reappraisal in the light of inhalation therapy*, pp. 210–226. ADIS Press, Auckland, 1983.
6. Orzech, J., Gayraud, P., Grimaud, C., et al.: Patient error in use of bronchodilator metered aerosols. *Br. Med. J.* 1, 76, 1976.
7. Paterson, I. C. & Crompton, G. K.: Use of pressurized aerosols by asthmatic patients. *Br. Med. J.* 1, 76–77, 1976.
8. Pedersen, S.: Aerosol treatment of bronchoconstriction in children, with or without a tube spacer. *N. Engl. J. Med.* 308, 1328–1330, 1983.
9. Pedersen, S. & Østergaard, P. A.: Nasal inhalation as a cause of inefficient pulmonary aerosol inhalation technique in children. *Allergy* 38, 191–194, 1983.

10. Self, T. H., Brooks, J. B., Lieberman, P., et al.: The value of demonstration and role of the pharmacist in teaching the correct use of pressurised bronchodilators. *Can. Med. Assoc. J.* 128, 129-131, 1983.
11. Shim, C. & Williams, M. H.: The adequacy of inhalation of aerosol from canister nebulizer. *Am. J. Med.* 69, 891-894, 1980.

Address:

Søren Pedersen
Hobrovej 13
DK-9000 Aalborg
Denmark

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