

Nasal Inhalation as a Cause of Inefficient Pulmonary Aerosol Inhalation Technique in Children

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In order to evaluate whether children can be taught the efficient use of a pressurized terbutaline aerosol with a tube spacer 71 children were given careful instruction in aerosol inhalation technique according to the manufacturer's instructions. Inhalation technique was assessed as being efficient when a child achieved an increase of more than 19% in FEV₁ 10 min after taking two puffs of terbutaline (each puff = 0.25 mg). After instruction about 37% of children aged 5-7 years and about 80% of children over 7 years were efficient in inhalation technique. Inhalation through the nose after actuation into the mouth accounted for about 50% of treatment failures, with the problem being more frequent in the younger age group. When this error was corrected about 83% of the children were efficient in the technique. Coordination problems and too rapid inspiration after actuation were also common errors. The findings stress the importance of checking all children's inhalation technique before prescribing inhalation therapy. Careful instruction was not enough. The possibility of nasal inhaling should be borne in mind when looking for causes of treatment failure.

Key words: children; errors in inhalation technique; nasal inhalation; pressurized aerosols.

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It is widely accepted that inhalation of a β_2 -agonist from a pressurized aerosol is preferable to oral therapy in the treatment of asthma (4). The efficiency of such treatment is highly dependent upon the inhalation technique, and it has been shown that many adults use their aerosols incorrectly and therefore fail to benefit sufficiently from the treatment (6). Therefore, attention has been called to the most common problems that patients experience when they use aerosols (1, 2, 6) so that these problems can be pointed out when patients are taught aerosol inhalation technique.

In the treatment of asthmatic children we have observed a problem which has not been mentioned as a major one in previous papers dealing with adults' inhalation technique: actuation into the mouth followed by inspiration through the nose with no air being drawn in

through the mouth. It has been our impression that this problem is rather common in children, and therefore the aims of the present study have been:

- 1) To estimate the occurrence of inhalation through the nose after actuation into the mouth as a cause of aerosol therapy failure.
- 2) To evaluate whether children themselves, after careful tuition, are capable of efficiently using a conventional pressurized terbutaline aerosol with a tube spacer.

MATERIAL AND METHODS

The investigation was carried out prospectively so that patients who were taught aerosol inhalation technique in the department during 1 year participated consecutively, i.e. 43 boys and 28 girls aged 5 to 14 years (median 8 years) (Fig.

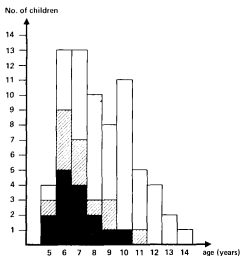


Fig. 1. Assessment of inhalation technique in 71 asthmatic children who were taught aerosol inhalation technique. □ = efficient technique, ▨ = inefficient technique, ■ = nasal inhalation as a cause of inefficient technique. Efficient technique means that aerosol treatment was followed by an increase in $FEV_1 \geq 20\%$.

1). All children had shown an increase in forced expiratory volume in 1 s (FEV_1) of more than 20% after a nebulizer (Pari) treatment with salbutamol. None of the children suffered from nasal stenosis on the study days. Informed consent was obtained from the children themselves and their parents before the child entered the trial.

The children and the parents were carefully informed in the use of the aerosol according to the manufacturer's instructions with special emphasis on the importance of a 10-sec breath-holding pause after inhalation. The child then tried a placebo aerosol a few times until the inhalation technique seemed correct, and 1 week later the child demonstrated his inhalation technique using a terbutaline aerosol.

FEV_1 was measured before, and 10 min after the terbutaline treatment. An increase in $FEV_1 \geq 20\%$ was considered an indication of efficient aerosol inhalation technique, whereas an increase of $<20\%$ indicated inefficient technique.

A pressurized terbutaline-sulphate aerosol with a tube extension (10×3.2 cm) was used in all cases. The children took a total of two puffs. The puffs were taken 1 min apart and each puff

delivered 0.25 mg terbutaline. On all occasions the children administered the spray without help from adults. During the inhalations obvious errors in the technique were registered, but they were not pointed out to the patients until the investigation was over.

The following schedule was used:

Day 1: All 71 children took part. The procedure was as described above.

Day 2: All children who on Day 1 had inefficient inhalation technique participated. The procedure was as on Day 1 except that the child kept his nose closed with his fingers during inhalation and no instructions in aerosol technique were given. If again inefficient inhalation technique was observed no further control was made.

Day 3: All children who showed inefficient inhalation technique on Day 1 and efficient inhalation technique on Day 2 participated. The procedure was as on Day 1 except that no instructions in aerosol technique were given.

The following assessments were used:

$FEV_1 \geq 20\%$ on Day 1: efficient inhalation technique.

$FEV_1 < 20\%$ on Days 1 and 2: inefficient inhalation technique.

$FEV_1 < 20\%$ on Days 1 and 3 but $FEV_1 \geq 20\%$ on Day 2: this was considered to indicate that nasal inhalation was a cause of therapy failure.

$FEV_1 \geq 20\%$ on Days 2 and 3 but $FEV_1 < 20\%$ on Day 1: this was considered inconclusive regarding nasal inhalation, and as an expression of efficient inhalation technique.

Measurements of FEV_1 were made on a dry wedge spirometer (Vitalograph®). The best of three measurements was chosen for study. Before the study all children were familiar with pulmonary function measurements.

On days of control of aerosol inhalation technique pretreatment FEV_1 was less than 70% of the predicted value. When a child participated on more than 1 day, control took place at the same time of the day and pretreatment FEV_1 varied less than 10% on the different days. On

Table 1

Pretreatment FEV₁ and increase in FEV₁ (median range) in 71 children who took two puffs of terbutaline with 1 min between each puff (each puff = 0.25 mg) from a pressurized aerosol with a tube spacer

	Increase in FEV ₁ ≥ 20 %	No. of patients	Pretreatment FEV ₁ (% pred.)	Increase in FEV ₁ (%)	Assessment
Day 1	+	40	64.5 (61.4-69.0)	24.0 (20.7-34.4)	Efficient technique
	-	31 retested on Day 2	65.3 (58.9-68.7)	8.7 (0-16.0)	
Day 2	+	19 retested on Day 3	66.4 (63.0-68.0)	25.1 (21.6-30.1)	Inefficient technique
	-	12	64.8 (61.1-66.1)	7.9 (0-17.9)	
Day 3	+	4	64.4 (63.1-68.2)	21.5 (20.0-32.4)	Efficient technique
	-	15	64.6 (63.0-68.1)	5.2 (0-14.8)	Nasal inhalation

Day 1 and Day 3: ordinary inhalation. Day 2: inhalation with obstructed nose.

Table 2

Assessment of errors in inhalation technique observed in 71 children treated with a pressurized terbutaline aerosol with a tube spacer. 15 children who inhaled through the nose after actuation into the mouth are assessed separately. Assessment of efficient or inefficient technique depended on whether or not an increase in FEV₁ ≥ 20 % was seen after terbutaline treatment

Assessment	No. of patients	Canister not shaken	Neck flexed during inhalation	Rapid inhalation	Actuation before inspiration	Actuation during expiration	Actuation at end of inspiration
Efficient	44	2	2	9	14	0	0
Inefficient	12	1	1	6	4	4	3
Nasal inhalation*	15	1 (0)	0 (1)	3 (4)	5 (5)	0 (0)	0 (0)

* Day 2 (nose closed).

control days no medications had been taken for 24 h prior to the terbutaline treatment.

RESULTS

The time interval from Day 1 to Day 2 varied from 1 to 7 days (median 7 days) and from Day 2 to Day 3 from 1 to 14 days (median 7 days). The longest interval between Day 1 and 3 was 14 days.

The FEV₁ measurements, numbers of children participating on the 3 days and their distribution in the groups "efficient inhalation technique", "inefficient inhalation technique" and "nasal inhalation" are given in Table 1. On Day 1 efficient technique was seen in 40 chil-

dren (56.3%) while 31 children (43.7%) showed inefficient technique. Twelve children (16.9%) showed inefficient technique on both Day 1 and Day 2. Fifteen children (21.1%) only showed efficient inhalation technique when their nose was closed during inhalation. Four children (5.6%) showed efficient technique on Days 2 and 3 but not on Day 1.

There was no statistically significant difference between the pretreatment FEV₁ values of children with inefficient and children with efficient technique on any of the 3 test days (Wilcoxon's rank sum test).

The results in relation to the children's age are given in Fig. 1. About 37% of the children aged 5-7 years and about 80% of the children

over 7 years had an efficient inhalation technique after careful instruction in the use of the aerosol. In the younger age group inhalation through the nose accounted for 11 of 19 cases of treatment failure, and after correcting this problem about 70% of the children in this age group were able to benefit satisfactorily from their inhalations. In only six of the 15 cases of nasal inhalation was this suspected on the basis of the observations made during the inhalation. Other errors in technique are given in Table 2.

DISCUSSION

A 20% increase in FEV_1 as a measure of efficient inhalation technique is an objective but arbitrary measure, and this fact should be taken into account when the results are evaluated. In addition, we did not include a placebo treated control group, and therefore do not know the placebo effect of treatment. However, despite these factors some conclusions can be drawn from the study.

The results point out a problem, so far unnoticed, which children experience when they use their aerosols. Inhaling through the nose may be the cause of treatment failure in children when the drug is given by inhalation, and in cases of ineffective symptom control in a child who seems to have a satisfactory inhalation technique the possibility of nasal inhaling should always be considered. It is our experience that such a policy has often improved symptoms and reduced the number of daily doses of medicine in asthmatic children with badly controlled symptoms. The problem of nasal inhaling occurred with such frequency that we find that it should be mentioned in the standardised instructions given out by the pharmaceutical companies.

The fact that many children benefited from the treatment even if their technique was not optimal may have been due to a breath-holding pause of more than 8 s by all children. This has been shown to increase bronchodilation considerably (5). Furthermore, actuation a few seconds before inspiration does not reduce the bronchodilating effect when a tube spacer is used (3, 8).

When they were not suffering from acute bronchoconstriction most children older than 5 years could be taught to use a pressurized aerosol with a tube extension efficiently without help from the adults. However, the results stress the importance of checking all children's inhalation technique before prescribing inhalation therapy. If this is not done, a very high percentage of the children will not benefit satisfactorily from the drugs prescribed.

The frequency of efficient technique was higher than we had expected from the results of studies in adults (1, 2, 7). This may be because the technique was tested immediately after very careful instructions. No follow-up was undertaken.

The fact that four of 19 children showed efficient technique on Day 3 and not on Day 1, even if the procedure was the same on the 2 days, may have been due to the inaccuracy of a 20% increase in FEV_1 as a measure of efficient technique, or that the children recognized their technical problem after the test on Day 2. All four children were more than 8 years old.

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