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# Acoustic rhinometry in small children*

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SUMMARY

***Objectives:*** *To study how acoustic rhinometry succeeds in a sample of small children of one to six years of age and to evaluate reasons for failed recordings.*
***Methods:*** *Twenty-six healthy children one to six years of age were invited to the Helsinki University Hospital, Department of Otorhinolaryngology for clinical examination and measurements with acoustic rhinometry.*
***Results:*** *Three children of ten refused recordings in the age group of one to two years. The children's nose adaptor was too small for three of seven children in the age group of three to four years. The anatomical nose adaptor and the adult nose tube were suitable for children between five to six years of age.*
***Conclusions:*** *Acoustic rhinometry is well tolerated and usually well accepted in small children. The recordings succeeded in most children. However, lack of adequate equipment hinders measurements in part of the children.*

*Key words: acoustic rhinometry, child, nasal volume, nasal airway*

## INTRODUCTION

The most common causes of impaired nasal breathing in small children are adenoid and tonsillar hypertrophy, upper respiratory tract infections and allergic rhinitis. In clinical practice the assessment of nasal patency and treatment results in small children is mainly based on reports of the parents and clinical examination. Experience of objective methods in evaluation of nasal airway is still scant.

In 1989, a new method called acoustic rhinometry (ARM) was introduced for assessment of nasal geometry. ARM measures cross-sectional areas and volume of the nasal cavity, and helps to define objectively the dimensions and pathology of the nasal passage [1,2]. The method involves measurements of acoustic reflections from the nasal cavity. A sound pulse produced by a spark in a sound tube enters nasal cavity via a nosepiece. The method is non-invasive, requires little cooperation of the subject, and has been recommended to be used even in small children [1-3].

Standard operating procedures, and calibration checks as well as trained operators enhance the accuracy and reproducibility of measurements of ARM [2]. Conical nosepieces may allow the nostril to change position thereby deforming the nasal valve region in adults and children. Fisher et al. recommend the use of anatomical nosepieces which limit the deformity of the nasal valve [4]. Errors may be due to change of position of the sound tube [5]. The test should be recorded during mouth breathing or in the cessation phase of respiration [4,6].

Although ARM has been used in clinical trials of adults, to date only a few studies have evaluated its use in small children [7-14].

The purpose of the present study was to investigate how the measurements of ARM succeed in a sample of healthy children of one to six years of age.

## MATERIALS AND METHODS

*Subjects*

Twenty-six children were examined in the Department of Otorhinolaryngology Helsinki University Central Hospital. All children were healthy and had no nasal symptoms at the time of measurements or during the preceding two weeks. None of the children had received nasal medication. Height, weight and head circumference were recorded at the time of evaluation. In otorhinolaryngological examination none had marked septum deviation or turbinate hypertrophy. No craniofacial abnormalities were observed. All children were of Finnish origin. The study was approved by the local Ethics Committee, Helsinki University Central Hospital and informed consents were given by the guardians.

*Acoustic Rhinometry*

ARM was performed using A1/2 Acoustic Rhinometer; G.M. Instruments Ltd. One otorhinolaryngologist performed all measurements (KL).

The device was calibrated prior to the measurements of each child. The children were tested after twenty minutes of arrival, a period of acclimatization in the test room temperature and humidity according to the current recommendations [2]. The measurements were performed in a seated position and a

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Figure 1. In the anatomical nosepiece the end of the adapter was shaped to fit into the nostrils of right and left side separately. For the younger children the symmetrical rounded nose adaptor was used.

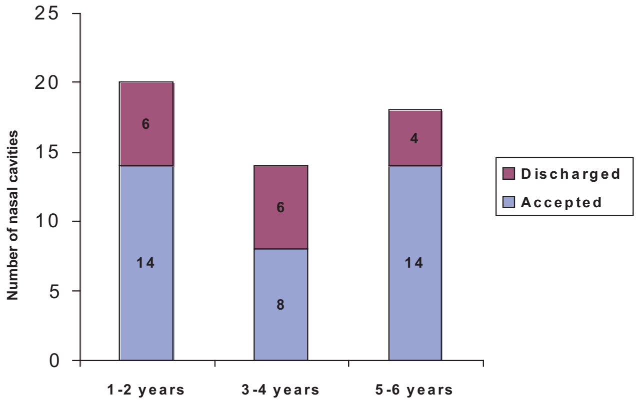


Figure 2. The number (n) of accepted and discharged acoustic rhinometric curves of a single nasal cavity in different age groups. Both baseline and decongested measurements succeeded in accepted recordings of a nasal cavity.

nurse assisted to keep the angle of the nosepiece and the wave tube constant.

We used two different types of nosepieces. In order to obtain adequate seal for the children of five to six years of age we used the smallest anatomical contoured nosepiece provided by the manufacturer for the adult sound wave tube. The end of the adapter is shaped to fit into the nostrils of right and left side separately (11.5 mm inner diameter, length 60 mm). Symmetrical rounded nose adaptor with application of sealing gel to prevent sound loss was applied for the smaller children (6 mm inner diameter, length 45 mm). (Figure 1).

The children were asked to sit still, not to speak and to breathe orally or to hold their breath. Each measurement was repeated at least three times. After each measurement, the nasal adaptor was removed from the nostril and reconnected, and a new measurement was then obtained. The measurements were considered acceptable when the coefficient of variation was less than 10% [(3)]. We selected rhinometric curves visually and a curve with a significant deviation in the nasal volume of one of the curves in relation to the others was discharged. The mean value of the remaining curves was calculated. The minimal nasal cross-sectional area (MCA, $cm^2$) and its distance (cm) from the nostrils were recorded. ARM volumes were measured at distances of 0-5 cm (VOL 0-5) and 1-4 cm (VOL 1-4) from the nostrils before and 10 minutes after decongestion (one spray, 0.07 ml per nostril, Otrivin®, xylometazoline 0,5 mg/ml).

## RESULTS

Twenty-six children, 13 girls and 13 boys participated in this study. The median age was 47.5 months (range, 12 to 82 months) and further patient characteristics are seen in Table 1. The adenoid had been removed in seven (27%) children for recurrent respiratory infections and otitis media with effusion (OME) and one child had undergone adenotonsillectomy for cyclic fever.

Figure 2 shows the amount of discharged and accepted curves of the fifty-two nasal cavities in different age groups. Succeeded recordings of a nasal cavity included acceptance of both measurements: before and after decongestion of the nasal mucosa. In the youngest group (one to two years of age) three children refused the recordings, but the remaining seven children were successfully measured. In the middle age group (three to four years of age) the rounded nozzles were too small for some of the children and sound leakage occurred which was seen as deviating curves in three children (six nasal cavities). In this age group none of the children refused the recording. In the oldest age group (five to six years of age) the measurements of four nasal cavities were discharged for a technical problem. Figure 3 shows the number of children with accepted baseline curves of both nasal passages.

The results of ARM measurements in different age groups are presented in Table 2 and Figure 4 shows the mean nasal volume at distance 1-4 cm from the nostril in different age groups. Nasal volumes of the decongested mucosa showed an increasing trend from younger to older age groups.

Table 1. Height, weight and head circumference in each age group. The data represent mean with standard deviation in parentheses.

| Age groups | 1-2 years<br>(12-35 months)<br>(n=10) | 3-4 years<br>(36-59 months)<br>(n=7) | 5-6 years<br>(60-82 months)<br>(n=9) |
|---|---|---|---|
| Height (cm) | 92 (9.2) | 104 (5.7) | 118 (7.1) |
| Weight (kg) | 14.6 (2.0) | 16.7 (2.0) | 22.7 (8.7) |
| Head circumference (cm) | 49 (2.6) | 49 (1.0) | 51 (1.3) |

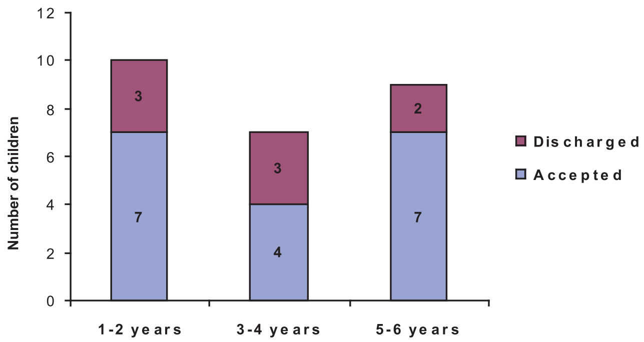


Figure 3. Number of children with accepted baseline curves.

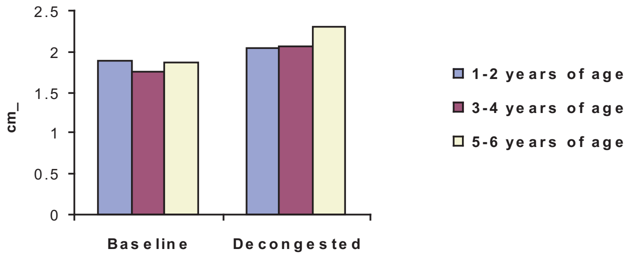


Figure 4. Mean unilateral nasal volume (1-4 cm; $cm^2$) before and after decongestion in different age groups.

Table 2. Mean values of nasal volumes (VOL, $cm^2$) and minimal cross-sectional area (MCA, $cm^2$) and its distance from the nostrils (DCA, cm) for the different age groups before and after decongestion of nasal mucosa. The values represent the results of a single cavity measurement, n= number of nasal cavities. Standard deviation is shown in parentheses.

| | 1-2 years (n=14) | 3-4 years (n=8) | 5-6 years (n=14) |
|---|---|---|---|
| Baseline | | | |
| VOL 0-5 | 3.22 (1.3) | 3.05 (0.7) | 3.21 (0.7) |
| VOL 1-4 | 1.88 (0.8) | 1.75 (0.4) | 1.86 (0.4) |
| MCA | 0.32 (0.1) | 0.36 (0.1) | 0.40 (0.1) |
| DCA | 1.03 (0.2) | 1.12 (0.2) | 1.05 (0.4) |
| Decongested | | | |
| VOL 0-5 | 3.38 (1.2) | 3.34 (0.7) | 3.65 (0.7) |
| VOL 1-4 | 2.04 (0.8) | 2.07 (0.5) | 2.31 (0.6) |
| MCA | 0.37 (0.2) | 0.31 (0.05) | 0.38 (0.1) |
| DCA | 0.84 (0.2) | 0.89 (0.2) | 0.80 (0.2) |

## DISCUSSION

The overall success rate of ARM was over 60%, being the highest (78%) among the children from five to six years of age and from one to two years of age (70%). The most problematic age group was children between three to four years of age. While the anatomic adult nosepiece fitted well in children over five years, which is consistent with a previous report [3] and the symmetrical rounded nose adaptor fitted well in children less than two years of age, neither of these nosepieces was optimal for children between three to four years of age. The main reason for the failure was leakage between nosepiece and nostril despite use of a rim gel which has been shown to improve the connection between the adaptor and the nostril [15]. Our children tolerated ARM measurements well. This is consistent with earlier results by Riechelmann in 45 preschool children between three to six years of age [9]. Compliance of ARM has also been reported in 20 children between seven to sixteen years of age. Two children refused measurements before introduction of the device [16]. In the present study compliance was also found quite good in smaller children of preschool age.

Until now, the experience of ARM among small children is scant although ARM has been used to demonstrate changes in the volume the nasopharynx and nasal cavities before and after adenoidectomy in children of two to sixteen years of age [7-10, 14]. In addition, the method has been found to be suitable for the evaluation of septal deviations and surgical success in school-age children [11], in young adults and children with asthma and perennial allergic rhinitis [12, 17-19] and in diagnosis of congenital choanal malformations in neonates [13].

Riechelmann and his co-workers have reported a mean baseline cross-sectional area of 0.34 $cm^2$ and its distance from the nostrils of 0.66 cm in healthy children between three and six years. MCA does not differ from our results. However, the distance of MCA is higher in the present study [20]. This maybe due to differences in equipment used [21]. Millqvist et al. studied about 80 children younger than 10 years of age were studied without nasal decongestion. These children were healthy and without nasal symptoms [21]. MCA of the narrowest side of the nose was 0.42 $cm^2$ in males and 0.46 $cm^2$ in females. These areas were larger than in our study. The different results could be explained by the age of children. Nasal volumes of the decongested mucosa showed increasing trend with age of our children.

There is no uniform agreement among experts about which variables should be used in ARM to describe nasal cavity dimensions in children. In infants the volume estimate has been recommended to be restricted to the anterior 4 cm[3], and in order to reduce the potential influence of different position and size of the nose adapter, the first 1 cm should be excluded [22]. Due to the rather wide age range in this study we recorded nasal volumes 0-5 cm and 1-4 cm from the nostrils.

In conclusion, we have shown that acoustic rhinometry is well tolerated and usually well accepted in small children. The recordings succeeded in most children. However, lack of adequate equipment induces artefacts and also hinders measurements in part of the children.

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