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Nasal airway resistance in the newborn

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SUMMARY

The present study aimed to provide normative data for nasal airway resistance in the newborn. Anterior rhinomanometry was performed on 17 full term Caucasian infants aged 1 to 4 days, birthweight 3100 to 4150 g. No sedation or decongestion was performed. Average unilateral nasal resistance was 4.86 kPa/l/s (SD=2.41) at a pressure threshold of 75 Pa. Average nasal resistance calculated from the right and left side recordings was 2.14 kPa/l/s (SD=0.77). This corresponds to 21.8 cm H_2O/l/s (SD=7.9). The nasal resistance of the newborn thus is approximately 10 times that of the adult.

INTRODUCTION

Obstruction of the upper airway in the infant can lead to apneic episodes (Cohen and Henderson-Smart, 1986; Gauda et al., 1987) and obstructive sleep apnea (Brouillette et al., 1982), and it is also considered a possible factor in the etiology of SIDS (Kelly and Shannon, 1982; Hunt and Brouillette, 1987). In considering the mechanisms of these conditions, attention must be directed to each of the nasal, pharyngeal, laryngeal and tracheal compartments of the upper airway (Harding, 1986). The present study is concerned with one such factor, namely the nasal resistance in full term newborns.

It is generally known that newborns are obligate nose breathers, and that the ability to oral breathing develops during the first months of life. This condition has been attributed to the anatomical characteristics of the pharynx in the newborn (Moss, 1965; Bartlett, 1986), and also to an assumed neurological immaturity (Bartlett, 1986; Miller et al., 1986). Recent evidence suggests that mechanical occlusion of the nostrils in sleeping normal infants results in arousal and temporary oral breathing (Miller et al., 1985; Rodenstein et al., 1987), whereas this mechanism is less efficient in siblings of SIDS (Harper et al., 1981; Newman et al., 1986). Although normative data are valuable as a basis for assessment of adverse situations, only little information is available about the nasal airway resistance in the newborn. Data for the nasal airway resistance in the newborn therefore seem required.

SUBJECTS

Subjects were selected from the maternity ward of the Copenhagen Hvidovre Hospital. The criteria for selection were: 1) birth weight > 3000 g, 2) no congenital malformations, 3) clinically normal nasal airways, 4) no stridor.

The recording schedule was designed to comprise two sessions per week with an interval of one or two days to permit duplicate recordings of each child. The project comprised 16 recording sessions.

The recordings were made during the child's normal sleep. No sedation or decongestant was given. Usable bilateral recordings were obtained from 17 subjects (9M, 8F). Duplicate recordings were obtained from 10 subjects. Of these, two were recorded on the same day, six on two successive days, and two with an interval of two days.

Mean age at the first recording was 1.9 days, modal age was 2 days, and the age range 1–4 days. The mean birth weight was 3532 g with a range from 3100 to 4150 g.

METHODS

Active rhinomanometric recording of nasal airway resistance is based on the simultaneous recording of airflow through the nose and pressure drop over the nose during normal respiration. In adults, nasal airway resistance can be determined either by anterior or by posterior rhinomanometry. In both procedures, airflow is recorded by a pneumotach inserted in a mask covering the nose. In posterior rhinomanometry, retronasal pressure is recorded by a tube inserted in the mouth. This method is dependent upon patient cooperation because the soft palate must be in a lifted position during the recording. In anterior rhinomanometry, airway resistance is assessed for one nasal half at a time. Retronasal pressure is recorded via the opposite nasal half, a pressure recording tube being attached with an airtight adhesive tape to the nostril (Solow and Greve, 1980). This method does not require active cooperation from the patient. On the other hand, total nasal airway resistance must then be calculated from the separate recordings of the two nasal halves.

The present study of nasal airway resistance in the newborn was based on anterior rhinomanometry. Nasal Respiratory Resistance was determined with a Mercury NR6 Rhinomanometer connected to a BBC microcomputer (Figure 1). The program calculates $NAR = \Delta p / \dot{V}$ for desired flow or pressure thresholds for each respiratory cycle. The values are given in kPa/l/s according to the committee on standardization in rhinomanometry (Clement, 1984). In the present study a pressure threshold of 75 Pascal was used because some children did not reach a threshold of 150 Pascal during normal breathing. While the transnasal pressure drop of the infant does not differ much from that of the adult, the respiratory airflow is much smaller in the infant. Therefore, instead of the normal flowhead provided with the rhinomanometer (F 100L, max. rating

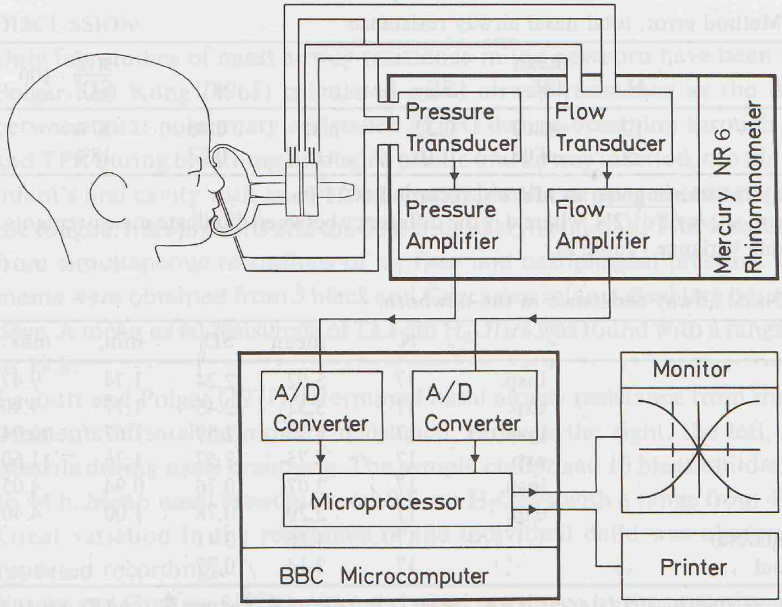

Figure 1. Flow diagram for anterior rhinomanometry.

100 l/ min) an infant flowhead (F 10L, max. rating 10 l/min) was used, and the computer program was modified accordingly. The equipment was calibrated before each session.

Total nasal resistance was calculated according to the formula for resistances coupled in parallel as $NAR_{tot} = (R_R * R_L)/(R_R + R_L)$, where R_R and R_L are the recorded values for the right and left nostrils.

Flow was recorded by the flowhead fitted into a Lærdal® mask covering nose and mouth. Care was taken not to distort the nasal airway with the mask. Pressure was recorded by fixing to each nostril in turn a Leucoflex® adhesive tape fitted with a 1.9 mm catheter connected to the rhinomanometer (Solow and Greve, 1980; Broms et al., 1982) By this method distorsion of the nostril is avoided.

Inspiratory and expiratory resistance values were assessed separately for each nostril. The program calculates the resistance as the mean of four successive respiratory cycles.

METHOD ERROR

Method errors were assessed from the duplicate measurements of 10 children (Table 1). Since the resistances of the two nasal halves oscillate synchronously but inversely due to the nasal cycle (Stoksted, 1952), assessment of the method error was based on the calculated values for total nasal resistance. No significant differences were found between the two sets of measurements. The method

Table 1. Method error, total nasal airway resistance.

	N	mean diff.	SE	p	s(i)	$\frac{s(i)^2}{SD^2} \cdot 100$
inspiration	10	−0.02	0.22	n.s.	0.46	37%
expiration	9	−0.08	0.16	n.s.	0.33	18%

Nasal airway resistance given in kPa/l/s, recorded at 75 Pa.
Method error, $s(i) = \sqrt{\Sigma d^2/2N}$, where d is the difference between duplicate measurements.
SD^2 = sample variance (Table 2).

Table 2. Nasal airway resistance in the newborn.

		N	mean	SD	min.	max.
right side	insp.	17	5.02	2.24	1.74	9.47
	exp.	17	5.31	2.45	1.77	9.40
left side	insp.	17	4.36	2.39	1.67	10.94
	exp.	17	4.75	2.57	1.76	11.60
total nasal	insp.	17	2.07	0.76	0.94	4.05
	exp.	17	2.20	0.78	1.00	4.40
average unilateral		17	4.86	2.41		
average nasal		17	2.14	0.77		

Total nasal resistance calculated as $NAR_{tot} = (R_R * R_L)/(R_R + R_L)$ where R_R and R_L are the measurements for right and left nasal halves determined by anterior rhinomanometry. Measurements given in kPa/l/s recorded at 75 Pa.

error, s(i), represents the standard deviation of an individual measurement based on four recordings. For inspiration the method error was 0.46 kPa/l/s, and for expiration 0.33 kPa/l/s. The corresponding variances constitute 37% and 18%, respectively, of the variance in nasal airway resistance determined from the total sample (Table 2). A large part of this variance was due to a large difference in the measurements from one subject. When this subject was excluded the method errors were 0.28 kPa/l/s for inspiration and 0.29 kPa/l/s for expiration. These values constituted 12% and 13% of the corresponding total variances.

RESULTS

The survey statistics are given in Table 2. The average respiratory resistance of the right and left nasal half ranged from 4.36 kPa/l/s for left side inspiration to 5.31 kPa/l/s for right side expiration. The means for right and left side and for inspiration and expiration did not differ significantly from each other, and were pooled to provide a value for average unilateral resistance. This was found to be 4.86 kPa/l/s with a standard deviation of 2.41 kPa/l/s.

The total nasal respiratory resistance was calculated from the unilateral recordings for each subject. Average values of 2.07 and 2.20 kPa/l/s were found for inspiration and expiration. The values did not differ at the 5% level of significance and were pooled to give an average total NAR of 2.14 kPa/l/s with a standard deviation of 0.77 kPa/l/s.

DISCUSSION

Only few studies of nasal airway resistance in the newborn have been reported. Polgar and Kong (1965) calculated nasal airway resistance as the difference between total pulmonary resistance (TPR) during breathing through the nose and TPR during breathing through a plastic oral airway inserted into the newborn infant's oral cavity with an opening situated in the air space between the root of the tongue, the epiglottis and the posterior pharyngeal wall. TPR was determined from simultaneous recordings of air flow and oesophageal pressure. Measurements were obtained from 5 black and Caucasian infants aged two hours to three days. A mean nasal resistance of 12.1 cm H_2O/l/s was found with a range from 5.6 to 19.9.

Lacourt and Polgar (1971) determined nasal airway resistance from three measurements of total pulmonary resistance: through the right, the left, and both nostrils during nasal breathing. The sample comprised 10 black children aged 10 to 44 h. Mean nasal resistance was 9.5 cm H_2O/l/s with a range from 4.2 to 17.7. Great variation in the resistance of the individual child was observed during repeated recordings.

Stocks and Godfrey (1978) measured nasal resistance by the posterior method in 30 Caucasian and 13 black infants aged 0.3 to 51.6 weeks postnatally. Mean ages were 12.2 w and 3.7 w in the two groups. The children were sedated before measurement. The oral pressure sensing tube was inserted through a modified dummy pacifier, protruding through its end. In the Caucasian group, mean nasal resistance was 14.0 cm H_2O/l/s with a range from 3.7 to 23.9. In the black group mean nasal resistance was 8.8 cm H_2O/l/s with a range from 4.5 to 12.7.

The method used for measurement of nasal resistance in the present study differs from those used in previous studies in that the children were not sedated during the procedure, and no invasive techniques were used. The reason for this difference in approach was that the method was devised with a view to possible subsequent screening applications in large samples. The recordings were easy to perform when the child was sleeping quietly.

The normative data previously reported for nasal resistance in the newborn were 12.1, 14.0 and 8.8 H_2O/l/s. This corresponds to values of 1.19, 1.37 and 0.86 kPa/l/s. The data obtained in the present study are somewhat higher, 2.14 kPa/l/s. Similarly, the standard deviation and the maximum values were larger in this study than in previous studies. Stocks and Godfrey (1978) thus report a maximum value corresponding to 2.25 kPa/l/s, whereas maximum values of 4.05 and 4.40 were found in this study. The reason for the lower values obtained by Polgar and Kong (1965) and Lacourt and Polgar (1971) is probably that the samples comprised black children. Stocks and Godfrey (1978) found lower nasal resistance in black than in Caucasian infants and ascribed this to differences in nasal anatomy. The Stocks and Godfrey (1978) study did not examine only newborns but included children up to 52 weeks of age. Their average resistance values therefore would be expected to underestimate nasal resistance in the newborn. However, from their regression equation of nasal resistance on thoracic gas volume a nasal resistance of 1.82 kPa/l/s would be expected for a newborn thoracic gas volume of 50 ml. This resistance is only moderately lower than that found in the present study.

It is well known that from birth to adulthood nasal respiratory resistance is markedly reduced while the airflow increases, corresponding to the growth in respiratory capacity (Saito and Nishihata, 1981; Parker et al., 1989). For adults, norm values of about 0.2 kPa/l/s are reported (Eichler, 1988). The present study thus shows that the average nasal airway resistance of the newborn is about 10 times larger than that of the adult.

The method error, i.e. the standard deviation of the individual measurement was 0.46 kPa/l/s in inspiration and 0.33 kPa/l/s in expiration. A large intraindividual variability in nasal resistance measurements is reported by most authors and is probably a characteristic of this physiological parameter. The biological variability of this parameter, however, is also large, the extreme values varying from 5% to 200% of the mean. Detection of high or extremely high nasal resistance in the newborn therefore seems feasible with the non-invasive anterior rhinomanometric technique used in the present study.

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