Effect of nasogastric tubes on nasal resistance during infancy

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SUMMARY Nasal resistance (Rn) and total airways resistance (RAW) during nose breathing were measured in two groups of preterm infants. One group had been fed by nasogastric tube during the neonatal period, while the other had received only orogastric or bottle feeds. There were no significant differences in either Rn or RAW between the two groups, which suggests that for these infants a history of nasogastric tube feeding had no adverse effect on subsequent respiratory function. The acute effects of the nasogastric tube (NGT) were assessed by measuring Rn and RAW with and without the NGT *in situ*. A significant increase in both Rn and RAW occurred when the NGT was *in situ*, particularly in white infants, and when the NGT was passed through the larger of the two nostrils.

Nasogastric tube (NGT) feeding is commonly used for preterm infants although little is known about either the acute or long-term effect this may have on nasal resistance (Rn). Previous work has shown that approximately half the total airways resistance (RAW) in white infants is due to the resistance of the nasal passages.¹ Consequently, as most neonates are obligatory nose breathers, any form of nasal obstruction could have significant effects on the overall function of the respiratory system.

This study was carried out to determine whether NGT feeding had any adverse effect on subsequent Rn or RAW, and to measure the effect on airflow resistance of an NGT *in situ*.

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Subjects

Long-term effects of the NGT. Measurements of resting Rn were made in 16 preterm infants (10 white, 6 black) who had been fed via an NGT for varying periods of time (NGT group), and in 10 preterm infants (6 white, 4 black) who had been fed only orogastrically or by bottle (oral group). Details of the infants are summarised in Table 1. Concurrent measurements of thoracic gas volume (TGV) and RAW were made in 20 of these infants.

There was no history of cardiopulmonary disease in any of the infants in the oral group, whereas 4 of the NGT infants had suffered from respiratory distress syndrome during the early neonatal period. However, since none of these infants had received nasotracheal intubation and all had regained entirely normal lung function by the time of testing, they were included in the study group.

Table 1 Summary of long-term effects of nasogastric tube feeding on respiratory function. (Mean values $\pm$ SEM)

	White babies		Black babies	
	NGT (n = 10)	Oral (n = 6)	NGT (n = 6)	Oral (n = 4)
Gestational age (weeks)	31.5 $\pm$ 0.8	32.3 $\pm$ 1.1	32.6 $\pm$ 0.6	33.0 $\pm$ 1.6
Postnatal age (days)	32.5 $\pm$ 5.8	25.0 $\pm$ 7.4	29.4 $\pm$ 5.0	11.5 $\pm$ 4.2
Body weight at time of testing (kg)	2.01 $\pm$ 0.07	2.11 $\pm$ 0.06	1.84 $\pm$ 0.07	2.04 $\pm$ 0.18
Duration of NGT feeding (days)	27.6 $\pm$ 5.3	—	18.9 $\pm$ 3.6	—
Nasal resistance (kPa/l per second)	1.89 $\pm$ 0.10	1.88 $\pm$ 0.15	0.90 $\pm$ 0.08	1.04 $\pm$ 0.12
Nasal resistance as a % total airways resistance	50.7 $\pm$ 2.4 (n = 8)	48.6 $\pm$ 3.7 (n = 4)	28.7 $\pm$ 3.3	34.0 (n = 2)
Specific airways conductance during nose breathing (kPa/s)	3.8 $\pm$ 0.1 (n = 8)	3.5 $\pm$ 0.1 (n = 4)	4.7 $\pm$ 0.3	5.2 (n = 2)

Value of resistance expressed in kPa/l per second and should be multiplied by a factor of 10, to obtain resistance in cmH₂O/l per second, whereas specific conductance should be divided by 10 to obtain values in cmH₂O/s.

Acute effects of the NGT. Attempts to measure Rn with and without a feeding catheter (FG 5) *in situ* were made in 21 infants, but satisfactory results were obtained in only 7 infants due to the prolonged nature of the test, and the disturbance caused to the infant by passing the NGT. Of these infants, 4 had previously only been fed orally, while the remaining 3 had received NGT feeds (Table 2).

This study was approved by the District Ethical Committee and informed parental consent was obtained before it started.

Method

All measurements were performed 30–60 minutes postprandially, and the infants were lightly sedated with chloral hydrate syrup (50 mg/kg)

Long-term effects. Rn was measured using an adaptation of the posterior rhinomanometric method which has been described;¹ changes in transnasal pressure are measured, using a small mouth balloon positioned in the posterior buccal cavity, and are related to simultaneous changes in the rate of air flow measured with a pneumotachograph attached to a face mask.

Whenever possible, concurrent measurements of TGV and RAW were made, using an adaption of the plethysmographic technique which has been described.^{2–3} As infants breathe naturally through their noses, and rarely resort to mouth breathing, total RAW in infants comprises both nasal resistance and the resistance of the airways below the nasopharynx, thus giving an assessment of the overall function of the respiratory system.

Acute effects. The acute effects of the NGT were assessed by measuring resting Rn, and then attempting to repeat the measurements with a feeding catheter (FG 5) passed through each nostril in turn, with a final measurement being made after

the catheter had been removed altogether. However many infants were disturbed by this procedure, especially since satisfactory and reproducible values of resting Rn could take more than an hour to obtain, and take even longer with the NGT *in situ*. Consequently reliable measurements of Rn with the NGT *in situ* were obtained in 7 infants, only 2 of whom co-operated at every stage of the tests.

It had been hoped to assess the acute effects of the NGT on total RAW in the same 7 infants but this proved to be impossible for practical reasons. However measurements of RAW with and without the NGT *in situ* were made in 4 infants.

Results

Long-term effects. Resting values of Rn were significantly higher in white infants than in their black counterparts ($P < 0.001$), and it was therefore necessary to analyse their results separately. Within

Fig. 1 Nasal resistance (Rn) plotted against body weight in preterm infants, showing the significantly higher values of Rn in white than in black infants, but the absence of any effect of previous nasogastric tube feeding on Rn within each racial group.

Table 2 Acute effects of the nasogastric tube on nasal resistance in preterm infants

Case	Body weight (kg)	Previous feeding	Rn before NGT passed (kPa/l per second)	Change in Rn from preintubation value (kPa/l per second)		
				NGT in smaller nostril	NGT in larger nostril	NGT removed
White infants						
1	2.0	Oral	1.81	+1.76 (+97)	+2.75 (+152)	—
2	2.1	Oral	1.63	+1.70 (+104)	+2.55 (+156)	+0.06 (+4)
3	1.9	NGT	1.96	—	+2.44 (+124)	—
4	2.2	Oral	2.65	—	+3.20 (+121)	−0.11 (−4)
Black infants						
5	1.6	NGT	0.95	+0.53 (+55)	—	—
6	1.8	NGT	1.00	+0.44 (+44)	—	—
7	1.7	Oral	1.34	+0.69 (+51)	+1.3 (+97)	−0.03 (−2)

Oral, fed by orogastric tube or bottle, or both; NGT, nasogastric tube feeding.

1 kPa = 10 cmH₂O pressure.

Percentages are given in parentheses.

each racial group there was no significant difference between the NGT and oral groups with respect to resting Rn (Table 1, Fig. 1). There was a tendency for Rn to decrease with increasing body weight in the white infants ($r = -0.5$), but this relationship was not significant in the small range of infants studied ($P = 0.06$), and was not apparent in the black infants.

In each infant, Rn was calculated as a percentage of total RAW (where RAW represents the sum of the resistances of both the nasal passages and the airways below the nasopharynx). Once again, there was a significant difference ($P < 0.001$) between the white infants in whom Rn represented $50.0 \pm 6.8\%$ (SD) of total RAW, and the black infants in whom Rn contributed a mean of only $30.5 \pm 6.9\%$ (SD); whereas differences in previous feeding had no significant effects (Fig. 2, Table 1).

Finally, in order to obtain an assessment of overall airways calibre, corrected for differences in lung size, specific airways conductance (SGAW) was calculated by dividing airways conductance ($GAW = 1/RAW$) by the infant's TGV. Within each racial group, SGAW was found to be unaffected by previous NGT feeding (Table 1).

Acute effects. In all the infants in whom it was possible to measure Rn with the NGT *in situ*, it was found to be easier to pass the NGT through one of the nostrils (designated the larger); this was the right nostril in 5 infants and the left in the remaining 2.

When the NGT was passed through the smaller nostril, mean Rn increased by 101% in white infants and by 50% in black ones, whereas when it was placed in the larger nostril, the increase in Rn was considerably greater, being 138% in the white

infants and 97% in a black infant (Table 2, Fig. 3). Resting levels of Rn were considerably lower in the black infants and the presence of the NGT caused a much smaller rise in Rn (both in absolute terms and percentage increase). In the 3 infants in whom it was possible to repeat the measurements after the NGT had been removed (Cases 2, 4, and 7, Table 2), Rn was found to be very similar to the original basal value.

The acute effects of the NGT on total airways resistance in 4 white preterm infants are shown in Fig. 4. Mean RAW rose by 49.5% when the NGT was in the larger nostril, and by 32.5% when it was in the smaller one.

Fig. 3 Acute effects of the nasogastric tube on nasal resistance. Individual infants are represented by different symbols; open symbols representing white infants, and closed symbols black ones.

Fig. 2 Nasal resistance as a percentage of total airways resistance during nose breathing in each of the study groups. The mean $\pm$ SEM is shown for each group, except the black oral group as airways resistance was only measured in 2 infants.

Fig. 4 Acute effects of the nasogastric tube on total airways resistance in white preterm infants. Individual infants are represented by different symbols.

Discussion

Long-term effects. Anatomical differences in nasal structure probably explain the higher Rn found in white than in black infants, which was also found in a previous study.¹ Differences in Rn between black and white infants have been shown to be responsible for the lower RAW and higher SGAW during nose breathing in black infants (Table 1), with no evidence of any racial differences in the calibre of the lower airways.¹

Rn was found to represent approximately 50% of total RAW in the white preterm infants, irrespective of feeding history, which is very similar both to the values reported for infants during the first year of life,¹ and to those given for adults,⁴⁻⁵ suggesting that this relationship remains relatively constant throughout life.

Thus comparison of resting results between the NGT and oral groups of babies showed no great differences with respect to any of the parameters measured, suggesting that for these infants, previous NGT feeding did not appear to have had an adverse effect on subsequent Rn or RAW.

Acute effects. During the course of this study it was noted that one nostril always appeared to be larger than the other, and that the greatest increase in Rn occurred when the NGT was passed through the larger nostril. This was presumably due to the fact that when the larger nostril was obstructed by the NGT, the infant was forced to breathe through the smaller nostril whose resistance would be considerably greater. Since this effect was noted whether the infant had been fed orally or nasogastrically, the discrepancy in nostril size cannot be attributed to possible effects of previous NGT feeding. A pronounced difference in the calibre of the 2 nasal passages has been reported both in infants⁶ and adults.⁷ In addition, Lacourt and Polgar⁶ noted cyclic variations in the calibre of the 2 nostrils.

If the overall calibre of the nostrils was greater in black infants, as the resting values of Rn suggest, the presence of the NGT would cause relatively less obstruction and hence a smaller increase in Rn than in white infants, as indeed was found.

In all the infants in whom it was possible to measure Rn or RAW after the NGT had been removed, very similar values to the original basal measurements were found. However, on one occasion the presence of the NGT caused a considerable degree of nasal secretion, which persisted after removal of the tube. Unfortunately it was not possible to measure nasal resistance in this infant as he became distressed and snuffly, but this observation does suggest that on occasions, the NGT may cause not only a degree of

physical obstruction but irritation to the nasal mucosa resulting in increased secretions.

The experiments performed to assess the effects of the NGT on total RAW showed that there was a significant increase in RAW when the NGT was *in situ*, this effect being more pronounced when the NGT was in the larger nostril (Table 3, Fig. 4). However, whereas mean Rn increased by 1.7 kPa/l per second (17 cmH₂O/l per second) when the NGT was in the smaller nostril, and by 2.7 kPa/l per second (27 cmH₂O/l per second) when the tube was in the larger nostril, the corresponding mean changes in RAW were only 1.3 and 1.9 kPa/l per second (13 and 19 cmH₂O/l per second) respectively. Whether this discrepancy can be attributed to the fact that the effects of the NGT on Rn and RAW were assessed in different groups of babies and that the numbers were somewhat limited, or to a degree of experimental error is not known. It is unlikely that the relatively smaller increase in RAW was due to the infant partly changing to mouth breathing in an attempt to overcome the obstruction when the NGT was *in situ* as most preterm infants are unable to mouth breathe even if both nostrils are completely obstructed, unless they cry. All these measurements were taken during quiet breathing. In addition had the infants succeeded in mouth breathing when the NGT was *in situ*, one would have expected to see a fall in RAW below the resting values, instead of the significant increase that was measured.

It is possible that some form of compensatory reflex action in the airways below the nasopharynx could have occurred in response to the partial nasal obstruction. Rattenborg⁸ suggested that total RAW could be kept relatively constant in the presence of various external resistances by altering the position of the larynx, but this function of the larynx could not be confirmed by Spann and Hyatt⁹ and is at variance with results obtained from this laboratory where it was shown that if variable resistances were added to the rebreathing apparatus, the measured RAW (apparatus plus infant) rose by almost identical increments.²

Lacourt and Polgar⁶ found that whereas resting values of Rp (pulmonary resistance) remained relatively constant throughout the day, Rn varied considerably. Consequently, they concluded that the resistance below the nasopharynx must have been changing inversely and simultaneously with the changes in Rn, presumably due to some compensatory reflex phenomenon. However, the technique that they used for measuring Rn involved occluding alternate nostrils and depended on the patency of one nostril being totally unaffected (either mechanically or reflexly) by the occlusion of the other, an assumption which is unlikely to be valid

according to the work of Brown,⁷ and which may explain the pronounced variability of R_n in the presence of consistent values of R_p , an observation which has not been confirmed in this laboratory.

Widdicombe¹⁰ showed that stimulation of epipharyngeal receptors by a jet of air and other stimuli could lead to significant bronchodilatation, although others have found that in some instances different types of mechanical stimulation of the nasopharynx can induce bronchoconstriction.¹¹ Obviously further work is needed to elucidate the effects of such reflexes in infants.

However, if such a compensatory reflex exists in infants, the results of the present study suggest that it is not strong enough to negate the effects of nasal obstruction, and that the presence of an NGT will cause a significant increase in total RAW, at least in white preterm infants.

In the past some studies of pulmonary resistance (R_p = airways plus tissue resistance), using the oesophageal balloon technique, have been performed with the catheter passed through the nostril.¹²⁻¹⁴ However, since the presence of any tube is likely to cause an increase in R_p —the extent of which will vary according to the size and race of the infant, the dimensions of the catheter, and the choice of nostril—such measurements of lung mechanics should obviously be performed with the catheter passed orally.

In conclusion, while nasogastric feeding may often be the most convenient and suitable method of feeding small preterm infants and does not appear to have any adverse effect on their subsequent respiratory function, a considerable degree of nasal obstruction can occur while the tube is *in situ*. Efforts should therefore be made to use the smallest feeding tube possible, to pass it through the smaller of the two nostrils (providing this does not necessitate undue force), to ensure that the opposite nostril remains completely unobstructed and, wherever possible, to avoid NGT feeding in infants who are already suffering from respiratory distress.

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