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Studies of transnasal pressure and airflow values in a Japanese population

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SUMMARY

The proportions of subjects who attained transnasal pressure and flow values of different magnitudes during spontaneous nasal breathing at rest were determined. Several co-ordinate points on transnasal pressure: flow curves generated by 77 (34 M, 43 F) healthy Japanese subjects aged 15–65 years were examined. By posterior rhinomanometry the proportion approximated 100% at Brom's radii R_1 and R_2 and 80–90% at 0.25 l/sec flow and at 0.5 cm H_2O (50 Pa) pressure when both nasal cavities were patent. When one nasal cavity was occluded the results were 100% at radius R_1 and 80–90% at radius R_2 and 0.5 cm H_2O (50 Pa) pressure. By anterior rhinomanometry, the proportion approximated 100% at radius R_1 and 0.5 cm H_2O (50 Pa) pressure and was quite high at radius R_2 and 1.0 cm H_2O (100 Pa) pressure. Pressure and flow are more representative at points where the pressure: flow curve includes the turbulent flow component than at radius R_1 and 0.5 cm H_2O (50 Pa) pressure. Calculation of total nasal resistance from unilateral resistances at 1.0 cm H_2O (100 Pa) appears a suitable compromise and this point is recommended for a Japanese population.

INTRODUCTION

Rhinomanometry is now accepted widely in centers of otorhinolaryngology as an objective method for evaluating nasal patency. As described by Kern (1981) and Clement (1984), nasal patency is quantified in terms of nasal resistance. It is determined from measurements of transnasal pressure (P) and nasal airflow ($\dot{V}$) ($NR = P/\dot{V}$). This relationship is not linear, thus the calculated value of nasal resistance is dependent upon the chosen co-ordinate points on the pressure-flow curves. Several different co-ordinate points have been cited in the literature (Hasegawa et al., 1971; Hasegawa and Kern, 1977; McCaffrey and Kern, 1979; Cole et al., 1980; Solow and Greve, 1980; Hasegawa, 1982; Broms et al., 1982; Clement, 1984). Those are peak flow rate, mean nasal resistance (sampled every 20 m/sec), 0.1 l/sec, 0.2 l/sec, 0.25 l/sec, 1.0 cm H_2O (approximate 100 Pa), 1.5 cm H_2O (approximate 150 Pa), and radii R_1, R_2 and R_3 of the polar co-ordinate system of Broms et al.

In subjects with a high degree of nasal patency, transnasal pressure often does not attain 1.0 cm H_2O in quiet breathing. By contrast, nasal airflow often does not attain 0.5 l/sec in subjects with decreased nasal patency. Nasal airflow reflects also the tidal volumes of examinees, in general, subjects with large lung capacity breathe through the nose more deeply than those with small lung capacity. Therefore, the proportion of subjects who achieve pressures or flow values near the extremities of the pressure-flow curve in quiet breathing differ among various kinds of patients with nasal disorders. Proportions may differ also between normal populations of caucacian, oriental and black peoples. The aim of this study is to investigate the proportion of subjects who attain different given pressures or flow rates in a Japanese population.

SUBJECTS AND METHODS

Subjects

Seventy-seven Japanese volunteers (15–65 years of age: 34 male, 43 female) were examined in this study. None had recent nasal symptoms or pathologic findings.

Methods

Nasal resistance was measured by a Nihon-Koden rhinorheograph MPR 1100. Transnasal pressure and nasal airflow were displayed as a pressure-flow curve on an oscilloscope and nasal resistance was computed from digitized data. Nasal resistance was determined by both anterior rhinomanometry with nozzles and posterior rhinomanometry with a mask. Resistances were computed at the following points:

0.5 cm H_2O, 1.0 cm H_2O, 1.5 cm H_2O, 0.25 l/sec, 0.5 l/sec, and radii R_1, R_2, and R_3 (Broms et al., 1982). Unilateral nasal resistance (UNR) was determined both by anterior rhinomanometry and by posterior rhinomanometry, in the latter case one nostril was blocked by a cotton plug lubricated with vaseline. Total nasal resistance (TNR) was determined by posterior rhinomanometry.

RESULTS

The rates at which given pressures or flow values were attained are shown in

Table 1. The rates for attaining given pressures or flow values by posterior rhinomanometry (total nasal resistance).

	male		female	
	insp.	exp.	insp.	exp.
P(0.5)	91.2%	88.2%	86.0%	81.4%
P(1.0)	58.8%	41.2%	51.2%	34.9%
P(1.5)	26.5%	23.5%	20.9%	20.9%
$\dot{V}$(0.25)	94.1%	88.2%	90.7%	81.4%
$\dot{V}$(0.5)	52.9%	41.2%	27.9%	25.6%
R_1	100.0%	100.0%	100.0%	100.0%
R_2	100.0%	97.1%	100.0%	88.4%
R_3	88.2%	85.3%	83.7%	74.4%

Table 2. The rates for attaining given pressures or flow values by posterior rhinomanometry (unilateral nasal resistance).

	male		female	
	insp.	exp.	insp.	exp.
$P(0.5)$	97.1%	97.1%	97.7%	96.5%
$P(1.0)$	72.1%	67.6%	83.7%	76.7%
$P(1.5)$	51.5%	50.0%	48.8%	37.2%
$\dot{V}(0.25)$	80.5%	82.4%	66.3%	48.8%
$\dot{V}(0.5)$	38.2%	27.9%	17.4%	14.0%
R_1	100.0%	100.0%	100.0%	100.0%
R_2	100.0%	100.0%	88.4%	82.6%
R_3	83.8%	75.0%	65.1%	59.3%

Table 3. The rates for attaining given pressures or flow values by anterior rhinomanometry (unilateral nasal resistance).

	male		female	
	insp.	exp.	insp.	exp.
$P(0.5)$	100.0%	100.0%	98.8%	98.8%
$P(1.0)$	94.1%	91.2%	88.4%	81.4%
$P(1.5)$	80.9%	70.6%	65.1%	54.7%
$\dot{V}(0.25)$	72.1%	57.4%	33.7%	20.9%
$\dot{V}(0.5)$	5.9%	5.9%	2.3%	1.2%
R_1	100.0%	100.0%	100.0%	97.7%
R_2	97.1%	97.1%	87.2%	75.6%
R_3	80.9%	70.6%	58.1%	39.5%

Tables 1, 2, and 3. The rates at radii R_1 and R_2 approached 100% and at 0.25 l/sec flow and 0.5 cm H_2O pressure they approached 80–90% for total nasal resistance by posterior rhinomanometry. By the same method the rate for radius R_1 was 100%, radius R_2 and 0.5 cm H_2O were 80–90% for unilateral nasal resistance. By anterior rhinomanometry unilateral pressure and flow values were attained in almost 100% of subjects at radius R_1 and 0.5 cm H_2O and readily at radius R_2 and 1.0 cm H_2O. Female rates at the designated points were less than those of males.

DISCUSSION

As shown in Tables 1, 2, and 3, the proportion of subjects attaining given transnasal pressures or flow values are variable and differ between males and females. Female rates at the designated points were less than those of males. Radius R_1 and 0.5 cm H_2O pressure are readily attained by anterior or posterior rhinomanometry. But these points mainly reflect laminar airflow and the magnitudes of nasal resistance differences are small when measured in this portion of the curve. Co-ordinate points are preferable at portions where the curve is composed of both laminar and turbulent airflows, indeed where most of the respiratory airflow occurs, and radius R_1 or 0.5 cm H_2O do not meet this requirement. The flow rate, 0.25 l/sec, is also readily detectable particularly by posterior rhinomanometry (Table 1), but poorly by anterior rhinomanometry (Table 3). This flow rate is less adequate for determining unilateral nasal resistance. In breathing through the nose, nasal airflows in each side are different due to the degrees of nasal patency and since pressure difference between the nasopharynx and the anterior naris is the same in both sides it seems more suitable to determine the resistance at the same point of pressure than at the same point of airflow. Anterior rhinomanometry with a mask is advocated as a standard method for measuring nasal resistance by International Standardization Committee on Rhinomanometry (ISCR) (Clement, 1984). Radius R_2 or 1.0 cm H_2O (100 Pa) are preferable points for measurement of unilateral nasal resistance by anterior rhinomanometry, because they are attained by a large proportion of subjects and reflect both laminar and turbulent airflows.

Calculation of total nasal resistance from unilateral nasal resistance is somewhat more complicated at the point of radius R_2 than at the point of 1.0 cm H_2O, and 1.0 cm H_2O seems preferable to radius R_2 for a Japanese population and probably for other oriental populations. To calculate total nasal resistance from the separate unilateral nasal resistances the following formula is generally accepted:

$$\frac{1}{\text{TNR}} = \frac{1}{\text{right UNR}} + \frac{1}{\text{left UNR}}$$

This calculation can be performed quite easily by computer and displayed on an oscilloscope.

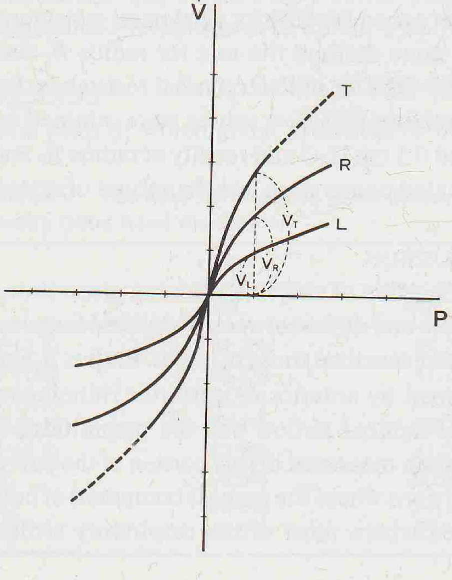

Figure 1.
The pressure-flow curve of total nasal resistance can be derived from a combination of right and left unilateral pressure-flow curves.
($\dot{V}_T = \dot{V}_R + \dot{V}_L$)

The proportion of subjects who attained a transnasal pressure of 1.5 cm H_2O was low by comparison with rates for radius R_2 and 1.0 cm H_2O. It is not recommended for measuring nasal resistance in a Japanese population.
As Tables 1 and 3 show, the rates for 1.0 cm H_2O are different in unilateral and bilateral nasal breathing. This is due to the different work of nasal breathing in the two situations. Unilateral nasal breathing requires more work to maintain adequate tidal volumes and a larger transnasal pressure difference is generated. Bilateral nasal breathing requires less transnasal pressure difference, thus 1.5 cm H_2O is attained infrequently (Tables 1 and 3).
The dotted line of the pressure-flow curve T (Figure 1) is derived from computation, not from spontaneous resting nasal breathing. The solid lines represent the pressure-flow curves as obtained during rhinomanometric assessment.

RÉSUMÉ

On a déterminé les proportions des sujets qui ont atteint des valeurs de pression et d'écoulement de diverses amplitudes au cours de respiration nasale spontanée au repos. On a examiné plusieurs points de coordonnés sur les courbes de pression/écoulement produites par 77 (34 M, 43 F) sujets japonais sains âgés de 15 à 65 ans. Mesurée par rhinomanométrie postérieure, la proportion était proche de 100% aux rayons R_1 et R_2 de Broms et de 80 à 90% à un écoulement de 0,25 l/s et à une pression de 0,5 cm H_2O (50 Pa) lorsque les deux fosses nasales étaient libres. Lorsqu'une fosse nasale était occluse, les résultats étaient 100% au rayon R_1 et de 80 à 90% au rayon R_2 et à 0,5 cm H_2O (50 Pa). Mesurée par rhinomanométrie antérieure, la proportion était proche de 100% au rayon R_1 et à 0,5 cm H_2O (50 Pa) et était vraiment élévée au rayon R_2 et à une pression de 1 cm H_2O (100 Pa). La pression et l'écoulement sont plus représentatifs aux points où la courbe pression/écoulement contient un élément d'écoulement turbulent qu'au rayon R_1 et à une pression de 0,5 cm H_2O (50 Pa). Le calcul de la résistance nasale totale à partir des résistances unilatérales à 1 cm H_2O (100 Pa) semble être un compromis qui convient et ce point est recommandé pour une population japonaise.

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