Rhinology, 29, 287-294, 1991

An international comparison of rhinomanometry between Canada and Japan

Kensei Naito[1], Shigenobu Iwata[1], Philip Cole[2], John Fraschetti[2] and Donna Humphrey[2]

[1] Dept. of O.R.L., Fujita Health University, School of Medicine, Aichi, Japan
[2] Dept. of O.R.L., Airflow Laboratory, University of Toronto, Canada

SUMMARY

International discussions concerning rhinomanometry have been held but no numerical comparisons have been reported. In an attempt to make international comparisons between different rhinomanometric results, nasal resistances were measured by active posterior rhinomanometry with a head-out body plethysmograph produced in Canada and by active posterior and anterior methods with a Japanese commercial rhinomanometer, and the results were compared.

No significant differences were found between measurements obtained from the two types of equipment. It is believed that this study is the first project of international comparison of rhinomanometry.

INTRODUCTION

Rhinomanometry is well established as a useful clinical method for objective assessment of nasal patency. In recent years most workers in this field have employed pneumotachographic systems to determine nasal airflow ($\dot{V}$) which is measured simultaneously with transnasal differential pressure (ΔP). Nasal patency is represented as a ratio between nasal airflow and transnasal differential pressure:

$$\text{R(resistance)} = \frac{\Delta P}{\dot{V}}$$

or

$$\text{C(conductance)} = \frac{\dot{V}}{\Delta P}$$

But, since there are several different methods of expressing and evaluating nasal resistances from pressure and flow studies, it is difficult to compare results between individual workers. Although, an international committee has been set up to recommend standardized methods of measurement and expression or rhinomanometric results (Kern, 1977, 1981; Clement, 1984), quantitative international comparison of equipment and methods has not been published.

In this communication we have attempted to compare measured values in the same subjects by two different types of equipment which are a head-out body plethysmograph produced in Toronto and employed in several centres and a Japanese commercial rhinomanometer (Rhinorheograph MPR-2100).

MATERIALS AND METHODS

Thirty two adult subjects (aged 18–74 with a mean age of 34 years; 19 males and 13 females; two Blacks, four Orientals and 26 Caucasians) referred to the Nasal Airflow Laboratory in Toronto for objective assessment of nasal stuffiness, were employed for the study.

Nasal resistances were measured before and/or after decongestion (0.1% xylometazoline hydrochloride nasal spray) of the nasal mucosa by two types of equipment produced in different countries.

1. Head-out displacement type body plethysmograph (Cole and Havas, 1987): respiratory airflow was detected by a head-out body plethysmograph. Transnasal differential pressures were obtained by a fine catheter (8F infant feeding tube)

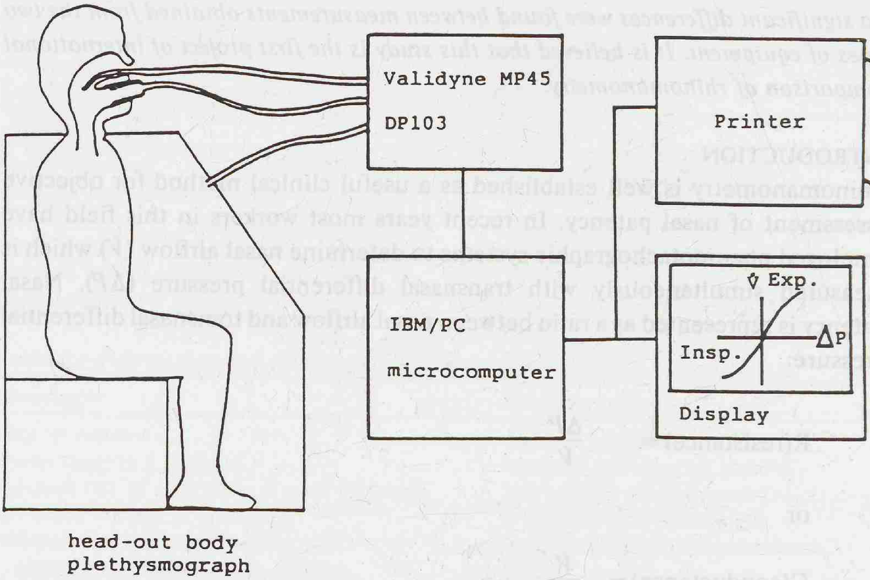

Figure 1. Diagram of the head-out body plethysmographic system in Toronto, Canada.

inserted through one nasal cavity to the nasopharynx. Pressure and airflow signals were sensed by reluctance transducers (Validyne MP45 and DP103). Time averaged nasal resistance, nasal resistance at ΔP100Pa and resistance at peak pressure or peak flow were calculated by an IMB/PC microcomputer program. The rhinomanometric system (Figure 1) was designed by Cole and his colleagues in Toronto, Canada (Cole et al., 1980, 1987, 1988; Naito et al., 1989a, 1989b).

2. Rhinorheograph MPR-2100: this commercial rhinomanometer (Figure 2) produced in Japan (manufactured by Nihon-Kohden Co., Ltd.) was transported to the Airflow Laboratory in Toronto by courtesy of Department of Otolaryngology, Fujita Health University and Nihon-Kohden Co., Ltd. for the mutual comparison of the results. Active posterior rhinomanometry with an anaesthetic mask and active anterior rhinomanometry with either an anaesthetic mask or a nasal nozzle can be performed with this equipment. Nasal resistance at ΔP50Pa, ΔP75Pa, ΔP100Pa, ΔP150Pa and peak pressure points on the pressure/flow curve can be detected. Total nasal resistance by active anterior rhinomanometry is calculated from a modified Ohm's law for parallel resistors as follows (Naito et al., 1990a):

$$R_t = 0.9\ [R_r \times R_l\ (R_r + R_l)]^{0.92}$$

(R_t: calculated total nasal resistance, R_r: measured resistance on the right side, R_l: measured resistance on the left side)

Unilateral and bilateral resistances at the peak pressure point were compared as follows:

1. Active posterior rhinomanometry with the head-out body plethysmograph and active posterior rhinomanometry using an anaesthetic mask with the Rhinorheograph MPR-2100.

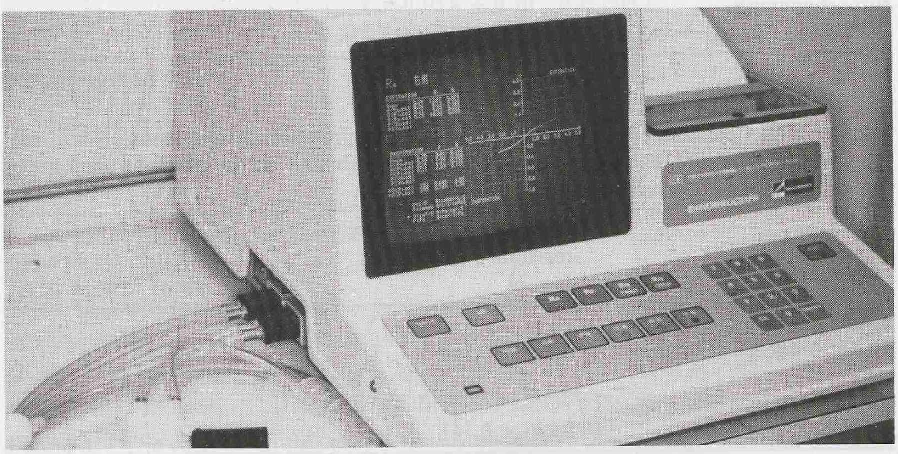

Figure 2. Rhinorheograph MPR-2100 manufactured by Nihon-Kohden Co., Ltd. in Japan.

2. Active posterior rhinomanometry with the head-out body plethysmograph and active anterior rhinomanometry using a nasal nozzle with the Rhinorheograph MPR-2100.

RESULTS

Firstly, results obtained from the two types of equipment by means of artificial breathing machine were compared. No significant differences were found in 24 artificial constant breaths as shown in Table 1.

Clinical resistances on inspiration are shown in Tables 2 and 3, and in Figures 3 and 4. Wilcoxon signed rank test was employed for analysis of relationship between values of nasal resistance obtained from the active posterior method with the head-out body plethysmograph and with the Rhinorheograph MPR-2100 using the mask. We were able to analyze 34 paired measurements. No significant differences were found (Table 2). On the other hand, in Wilcoxon singed rank test between 50 paired measurements, values obtained from the head-out body plethysmograph were higher than those from the active anterior method using the nasal nozzle with the Rhinorheograph MPR-2100 with significant ($p<0.05$) as shown in Table 3.

Table 1. Comparison of artificial breathing resistance at peak pressure between the head-out body plethysmograph (Canada) and Rhinorheograph MPR-2100 (Japan).

	resistance ($Pa/cm^3/s$) n = 24	Wilcoxon signed rank test
the head-out body plethysmograph (Canada)	0.201 ± 0.016	N.S.
rhinorheograph MPR-2100 (Japan)	0.198 ± 0.015	

(N.S.: not significant)

Table 2. Comparison of nasal resistances at peak pressure between posterior rhinomanometry with the head-out body plethysmograph and posterior rhinomanometry (anaesthetic mask) with Rhinorheograph MPR-2100.

	inspiratory nasal resistance ($Pa/cm^3/s$) n = 34	Wilcoxon signed rank test
the head-out body plethysmograph (Canada)	0.275 ± 0.150	N.S.
rhinorheograph MPR-2100 (Japan)	0.295 ± 0.141	

(N.S.: not significant)

Table 3. Comparison of nasal resistances at peak pressure between posterior rhinomanometry with the head-out body plethysmograph and anterior rhinomanometry (nasal nozzle) with Rhinorheograph HPR-2100

	inspiratory nasal resistance (Pa/cm/s) n = 50	Wilcoxon signed rank test
the head-out body plethysmograph (Canada)	0.351 ± 0.221	$P < 0.05$
rhinorheograph MPR-2100 (Japan)	0.290 ± 0.185	

The resistance obtained from the head-out body plethysmograph on the X axis and those from Rhinorheograph MPR-2100 with mask on the Y axis were plotted and the distribution of coordinate points is demonstrated in Figure 3.

The correlation line was as follows:

$$Y = 1.03X + 0.70 \ (r = 0.763, \ p < 0.001)$$

Plots of 50 measurements showed the correlation of resistance values from the head-out body plethysmograph and Rhinorheograph MPR-2100 with nozzle to be as follows (Figure 4):

$$Y = 0.95X + 0.58 \ (r = 0.619, \ p < 0.001)$$

The slopes of both correlation lines did not depart from the line of identity.

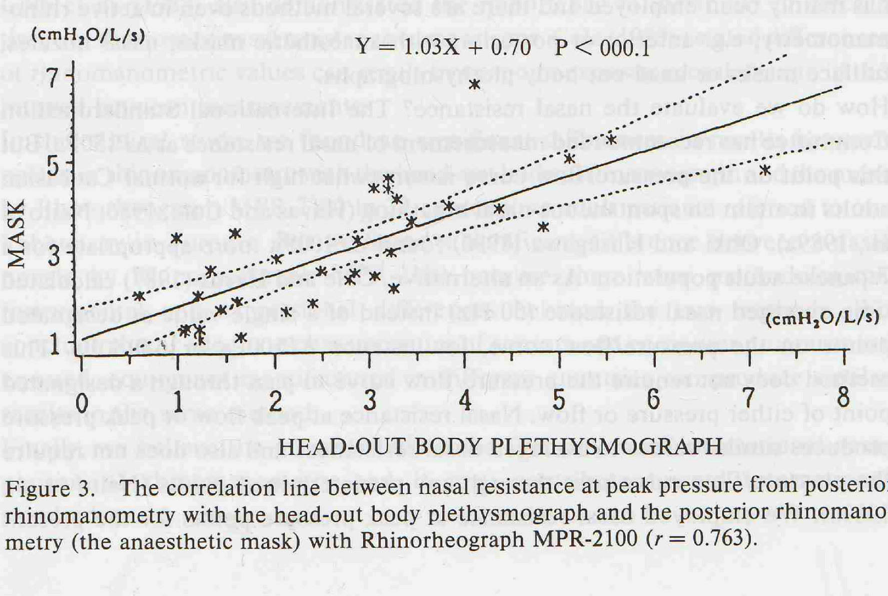

Figure 3. The correlation line between nasal resistance at peak pressure from posterior rhinomanometry with the head-out body plethysmograph and the posterior rhinomanometry (the anaesthetic mask) with Rhinorheograph MPR-2100 ($r = 0.763$).

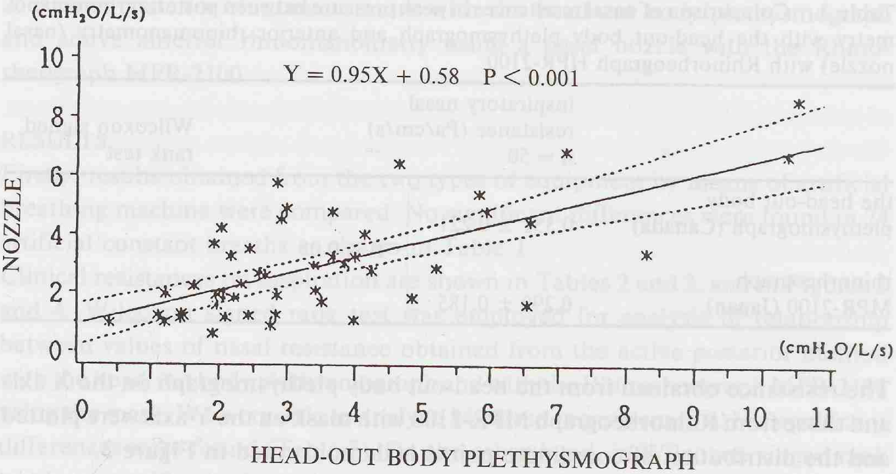

Figure 4. The correlation line between nasal resistance at peak pressure from posterior rhinomanometry with the head-out body plethysmograph and the anterior rhinomanometry (the nasal nozzle) with Rhinorheograph MPR-2100 ($r = 0.619$).

DISCUSSION

Rhinomanometry, which provides an objective assessment of nasal patency, is well developed but still problems remain. Some rhinologists accept the International Standardization Committee recommendations that have been made in an attempt to resolve those problems. However, we are unable to find any reports regarding an actual international project of comparing results.

How do you measure nasal resistance? In recent years, active rhinomanometry has mainly been employed and there are several methods even in active rhinomanometry, e.g. anterior or posterior; with anaesthetic masks, nasal nozzles, fullface masks or head-out body plethysmographs.

How do we evaluate the nasal resistance? The International Standardization Committee has recommended measurement of nasal resistance at ΔP150Pa. But this point on the pressure/flow curve is somewhat high for normal Caucasian adults to attain on spontaneous nasal breathing (Havas and Cole, 1986; Naito et al., 1989a). Ohki and Hasegawa (1986) found ΔP100Pa more appropriate for a Japanese adult population. As an alternative, Cole and Havas (1987) calculated time averaged nasal resistance (50 Hz) instead of a single value at designated points on the pressure/flow curve, for instance ΔP100Pa or ΔP150Pa. This method does not require the pressure/flow curve to pass through a designated point of either pressure or flow. Nasal resistance at peak flow or peak pressure produces similar values to averaged nasal resistances and also does not require the pressure/flow curve pass through any predetermined points (Naito et al., 1989a). We employed nasal resistance at peak pressure points for the present study since the Rhinorheograph MPR-2100 does not have a time averaging program in it.

Basically, the flow and differential pressure sensors of the two instruments employed for the investigation have equivalent characteristics as shown in Table 1. Thus any differences between results from the two rhinomanometric techniques are methodological. Some investigators have reported comparisons between several different types of rhinomanometry, but the studies were neither interinstitutional nor international (Dvoracek et al., 1985; Unno et al., 1986; Cole and Havas, 1987; Jones et al., 1987; Cole et al., 1988, 1989b; Cordts et al., 1989).

In active anterior rhinomanometry we can measure only unilateral resistance since postnasal pressure is obtained from an occluded nostril instead of the oro- or nasopharynx. Thus total nasal resistance in active anterior rhinomanometry can be derived from the Ohm's law for parallel resistors for obtaining calculated total nasal resistance can be applied reliably only to the decongested nose (Cole et al., 1988). For application of Ohm's law equation to achieve a more exact value for total nasal resistance under any conditions, Naito et al. (1990a) modified the equation as shown in the paragraph of Materials and Methods of this paper. Several kinds of masks and a nasal nozzle can also affect nasal resistance to airflow and its coefficient of variation even in the decongested nose (Cole et al., 1988). Influence of the nasal nozzle can be minimized by careful use (Naito et al., 1990b) and we employed a nasal nozzle in the active anterior method with Rhinorheograph MPR-2100 in the present study. Since Cole et al. (1989b) demonstrated the convenience of obtaining postnasal pressure through the fine catheter (8F infant feeding tube) over the peroral wide tube, we employed this method in this study.

Cole et al. (1988) also demonstrated the importance of instability of erectile tissue of the nose to nasal resistance comparisons. Cole (1989a) stated differences of rhinomanometric values can result from spontaneous mucosal change in the interval between measurements.

In this clinical study, we found no significant differences in results between posterior rhinomanometry with the head-out body plethysmograph and the mask by Rhinorheograph MPR-2100 in 32 consecutive adult patients referred to our Laboratory in Toronto. But we found a significant difference between a nasal nozzle by Rhinorheograph MPR-2100 because there were methodological, instrumental and expressional differences between the two methods. We conclude that if adequate characteristics of sensors and computer programs are ensured, equipment manufactured in different countries can produce similar results in the same method.

Finally, we believe the present study is the first project of international comparison of rhinomanometry and it may contribute toward international standardization.

REFERENCES

1. Clement PAR. Committee report on standardization of rhinomanometry. Rhinology 1984; 22: 151-155.
2. Cole P, Fastag O, Niinimaa V. Computer-aided rhinometry. Acta Otolaryngol (Stockh) 1980; 90: 139-142.
3. Cole P, Havas T. Nasal resistance to respiratory airflow. A plethysmographic alternative to the face mask. Rhinology 1987; 25: 159-166.
4. Cole P, Naito K, Chaban R, Ayiomamitis A. Unilateral and bilateral nasal resistance. Rhinology 1988; 26: 209-216.
5. Cole P. Stability of nasal airflow resistance. Clin Otolaryngol 1989a; 14: 177-182.
6. Cole P, Ayiomamitis A, Ohki M. Anterior and posterior rhinomanometry. Rhinology 1989b; 27: 257-262.
7. Dvoracek JE, Hillis A, Rossing RG. Comparison of sequential anterior and posterior rhinomanometry. J Allergy Clin Immunol 1985; 76: 577-582.
8. Gordts F, Clement PAR, Derde MP. Nasal provocation with histamine. A comparison of the determination of the threshold of reactivity by three methods of rhinomanometry. Rhinology 1989; 27: 263-269.
9. Havas TE, Cole P. Resistance to respiratory airflow of the nasal passages. Comparisons between different common methods of calculation. Rhinology 1986; 24: 163-173.
10. Jones AS, Lancer JM, Stevens JC, Beckingham E. Rhinomanometry. Do the anterior and posterior methods give equivalent results? Clin Otolaryngol 1987; 12: 109-114.
11. Kern EB. Standardization of rhinomanometry. Rhinology 1977; 15: 115-119.
12. Kern EB. Committee report on standardization of rhinomanometry. Rhinology 1984; 22: 151-155.
13. Naito K, Cole P, Chaban R, Humphrey D. Computer averaged nasal resistance. Rhinology 1989a; 27: 45-52.
14. Naito K, Cole P, Fraschetti J, Humphrey D. Nasal patency. Subjecteve and objective. Am J Rhinol 1989b; 3: 93-97.
15. Naito K, Cole P, Humphrey D. Unilateral and bilateral nasal resistances: a supplement. Rhinology 1990a; 28: 91-95.
16. Naito K, Iwata S, Kato R. The influence of face masks and a nozzle on nasal airflow. J Otolaryngol Jpn 1990b; 93: 393-397.
17. Ohki M, Hasegawa M. Studies of transnasal pressure and airflow values in a Japanese population. Rhinology 1986; 24: 277-282.
18. Unno T, Naitoh Y, Sakamoto N, Holikawa H. Nasal resistance measured by anterior rhinomanometry. Rhinology 1986; 24: 48-55.

Kensei Naito, M.D.
Dept. of Otolaryngology
Fujita Health University, School of Medicine
1-98 Kutsukake Toyoake, Aichi
470-11 Japan