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New aerodynamic aspects of nasal patency*

Kensei Naito, Yuka Kondo, Eitarou Ohoka, Mayumi Komori, Masahiro Takeuchi, Shigenobu Iwata

Department of Otolaryngology, Fujita Health University School of Medicine, Aichi, Japan

SUMMARY *In considering possible aerodynamic indicators of subjective nasal stuffiness, we measured nasal resistance, acceleration change of nasal airflow, and alteration of differential pressure and compared those with the degree of severity of sensation of nasal obstruction in 75 patients. The acceleration change of airflow and alteration of differential pressure are presented as an equation: $y=ax^2+bx+c$, in which "a" represents the approximate shape of the curve. Nasal resistance, on either inspiration or expiration, and coefficient "a" of acceleration change the rapid phase from inspiration to expiration correlated well with subjective nasal patency, while coefficient "a" of acceleration change the rapid phase from expiration to inspiration and alteration of differential pressure either the rapid phase from inspiration to expiration or from expiration to inspiration did not correlate well with perception of nasal blockage. It seems that measurement of respiratory acceleration of airflow of quiet nasal breathing is a useful indicator of subjective nasal patency.*

Key words: rhinomanometry, nasal patency, nasal airflow acceleration

INTRODUCTION

It is not unusual to find a patient complaining of nasal obstruction with normal values of nasal resistance or, conversely, a symptomless patient with increased nasal resistance. There have been many reports of the discrepancy between perception of nasal patency and nasal resistance to airflow (Naito et al., 1988; Jones et al., 1989; Eccles et al., 1990; Naito et al., 1991a). The discrepancy puzzles both clinicians and patients. To investigate the problem we previously assessed acceleration of nasal airflow (l/s^2) from the start of inspiration or expiration to respective peak flow points in Canadian subjects, and the inspiratory acceleration of nasal airflow appeared to be an indicator of the severity of subjective nasal stuffiness (Naito et al., 1989). Furthermore, we felt that aerodynamic studies of the total cycle of resting breathing through the nose might be important, especially acceleration of airflow or rate of alteration of differential transnasal pressure (cm H_2O/s). The segments of the cycle of particular interest were from commencement of the rapid phase after the stable phase on inspiration to the peak flow point on expiration and also from commencement of the rapid phase after the stable phase on expiration to the peak flow point on inspiration as shown in Figure 1. We have surmised that nasal airflow acceleration changes or alteration of differential transnasal pressure during these phases of the cycle might well relate with perception of nasal patency.

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In this study, acceleration change of nasal airflow and alteration of differential pressure during the phases were measured and compaired with subjective nasal obstruction.

PATIENTS AND METHODS

Patients

Seventy-five Japanese patients with nasal disease visiting our institute (aged 5 to 66, with a mean age of 35.3 years; 53 men and 22 women) were investigated in the study.

Assessment of sensation of unilateral nasal stuffiness

A table was constructed with five categories of the sensation of unilateral nasal breathing as follows: 0: free air passage; 1: slight obstruction; 2: moderate obstruction; 3: considerable obstruction; 4: complete obstruction. Patients selected the number that they felt appropriate immediately before each measurement of nasal patency.

Measurement of objective nasal patency

Unilateral nasal airflow and differential transnasal pressures were detected by active anterior rhinomanometry with a Rhinorheograph MPR-1100 manufactured by Nihon Kohden Co., Ltd. using a nasal nozzle. Airflow (in l/s or cm^3/s) and differential pressure (in cm H_2O or Pa) signals were sensed and their electrical analogues were digitized at 30 Hz by a micro-

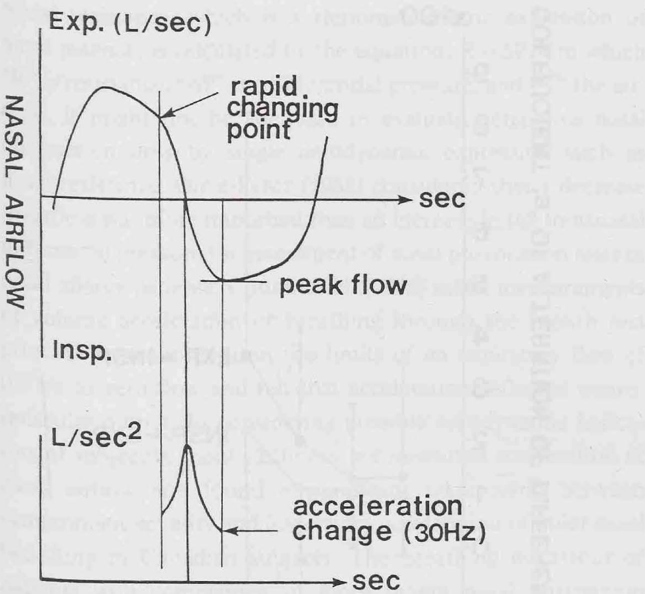

Figure 1. Acceleration change (30 Hz) of nasal airflow the duration from commencement of rapid phase after stable phase on expiration to peak flow point on inspiration can be represented as consecutive correlation cureve and the curve is expressed an approximate equation as $y=ax^2+bx+c$. Coefficient "a" of the equation approximately shows the salient of the correlation curve. Alteration of differential transnasal pressure were obtained from similar method of acceleration change.

computer. Digitized values were stored in the computer memory, and respiratory variables including resistance, acceleration and alteration of differential pressure, were computed on completion of each chosen sequence of breaths by means of the computer program named NI-101 (Naito et al., 1993). Acceleration change of airflow and alteration of differential pressure (30 Hz) during the above-mentioned phases can be described as an equation: $y=ax^2+bx+c$, in which "a" represents an approximate salient of the correlation curve as shown in Figure 1. The processed data can be displayed on the screen of a TV monitor and printed out as shown in Figure 2. Nasal resistance, acceleration change of airflow and alteration of differential pressure were compared with the sensation of nasal stuffiness. The Chi-square test was employed for statistical analysis in the study.

RESULTS

A significant relationship was found between symptomatic severity and nasal resistance on either inspiration or expiration ($p < 0.005$) as shown in Figure 3. A significant relationship was found between symptomatic severity and coefficient "a" of acceleration change the duration from inspiration to expiration ($p < 0.05$) as shown in Figure 4, while no significant relationships were found between grading of subjective stuffiness and coefficient "a" of acceleration change during the period from expiration to inspiration. No significant relationships were found between grading of subjective nasal stuffiness and coefficient "a" of alteration of transnasal differential pressure either the duration from expiration to inspiration or from inspiration to expiration (Figure 5).

DISCUSSION

Rhinomanometry is a well-established method for evaluation of objective nasal patency. But it still has some problems that need to be resolved. An inconsistency between nasal resistance and the sensational severity of nasal stuffiness of which the patient complains is one of these problems (Naito et al., 1988; Jones et al., 1989; Eccles et al., 1990; Naito et al., 1991a).

Eccles and Jones (1983) have investigated nasal resistance and sensation of nasal patency before and after 5-min exposure to menthol vapour and found that menthol inhalation had no consistent effect on nasal resistance, but a majority of subjects

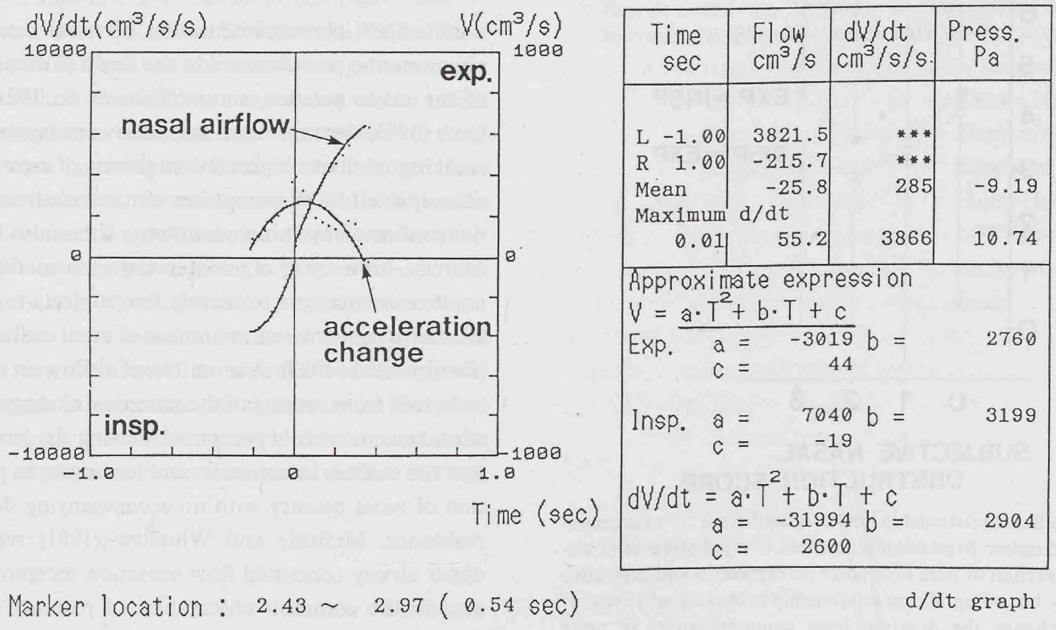

Figure 2. A processed data by the computer programme named NI-101 can be displayed on TV monitor and printed out. The equation $y=ax^2+bx+c$ of acceleration change and coefficient "a" are demonstrated on the right side of the screen. Alteration of pressure also can be demonstrated according to similar method.

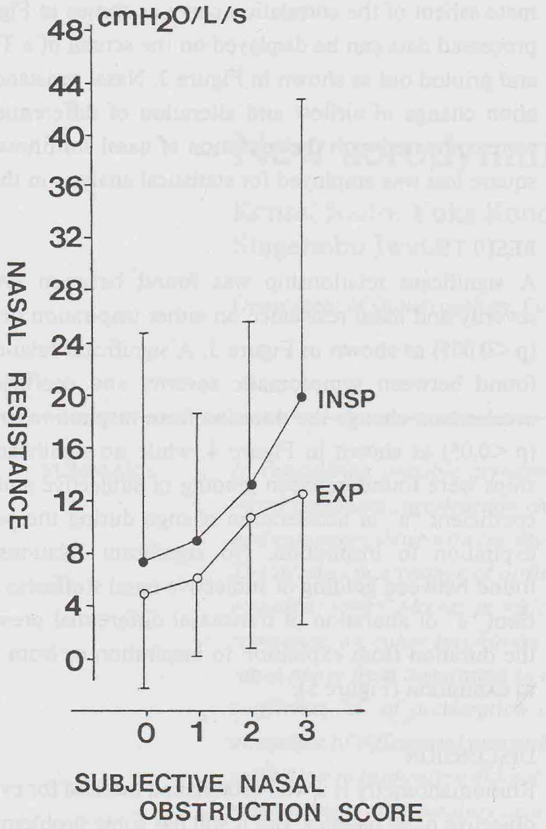

Figure 3. Significant relationships between nasal resistance and subjective nasal obstruction on either inspiration or expiration was found by means of the Chi-square test in 150 measurements.

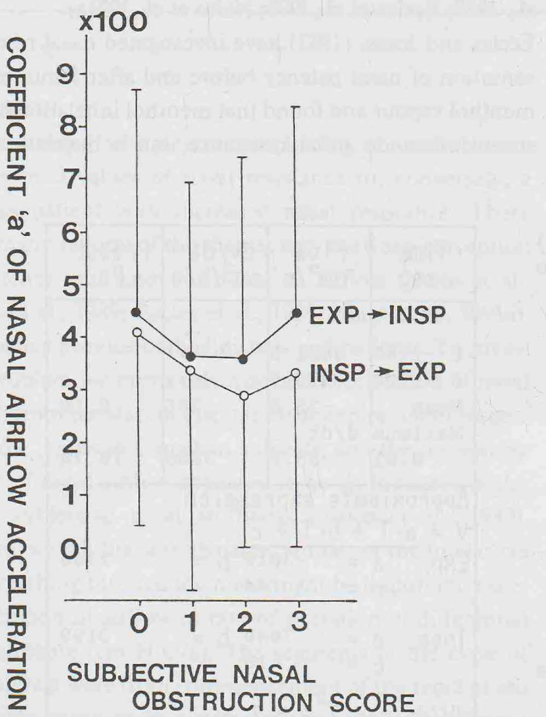

Figure 4. A significant relationship between coefficient "a" of acceleration change the duration from commencement of rapid phase after stable phase on inspiration to peak flow point on expiration and subjective nasal obstruction, but no significant relationship between coefficient "a" of acceleration change the duration from commencement of rapid phase after stable phase on expiration to peak flow point on inspiration and subjective nasal obstruction were found by means of the Chi-square test in 150 measurements.

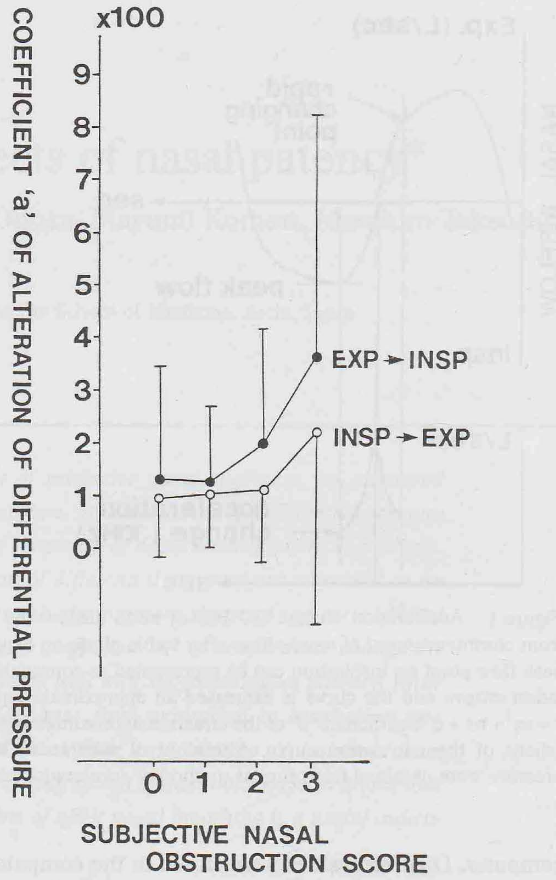

Figure 5. No significant relationship between coefficient "a" of alteration of pressure the duration from commencement of rapid phase after stable phase on inspiration to peak flow point on expiration and subjective nasal obstruction and between coefficient "a" of alteration of pressure the duration from commencement of rapid phase after stable phase on expiration to peak flow point on inspiration and subjective nasal obstruction were found by means of the Chi-square test in 150 measurements.

reported an increased sensation of nasal patency. A similar phenomenon was observed in the study of menthol stimulation of the major palatine nerve (Naito et al., 1991c). In contrast, Urch (1986) demonstrated that passive exposure of young non-smoking adults to high concentrations of cigarette smoke was accompanied by the sensation of nasal obstruction, which was not confirmed by rhinomanometry. It has also been noted that exercise on a cycle ergometer causes a marked reduction in nasal resistance; yet, relatively few subjects reported any cold sensation or increased awareness of nasal airflow after exercise (Burrow et al., 1983). A sensation of airflow on nasal inspiration is derived from cooling of the mucosa. Inhaling menthol vapour stimulates nasal cold receptors, causing the brain to mis-interpret the sensory information and leading to an increased sensation of nasal patency with no accompanying decrease in nasal resistance. McBride and Whitelaw (1981) reported that the upper airway contained flow sensation receptors, which might explain the common observation of patients with respiratory disease or even normal people that warm, humid air made them breathless while cool air brought relief, and stimulation of the receptors produced a marked influence on respiration.

Nasal resistance, which is a rhinomanometric expression of nasal patency, is calculated by the equation: $R=\Delta P/\dot{V}$ in which "R" is resistance, "ΔP" the differential pressure, and "$\dot{V}$" the airflow. It might not be adequate to evaluate perceptive nasal obstruction only by single aerodynamic expression such as nasal resistance. Olive-Pérez (1988) considered that a decrease in airflow was more important than an increase in the transnasal differential pressure for assessment of nasal provocation tests in nasal allergy patients. Cotten et al. (1988) made measurements of volume acceleration of breathing through the mouth just prior to inspiration within the limits of an expiratory flow of 0.2 l/s to zero flow and felt that acceleration reflected neuromuscular output. In considering possible aerodynamic indicators of subjective nasal stuffiness, we measured acceleration of nasal airflow and found a significant relationship between symptomatic severity and inspiratory acceleration of quiet nasal breathing in Canadian subjects. The breathing behaviour of patients who complained of more severe nasal obstruction showed lower inspiratory acceleration of airflow (Naito et al., 1989). Also Eccles et al. (1989) have shown that changes in breathing pattern can alter the nasal sensation of airflow.

In the present study, we investigated inspiratory and expiratory objective aerodynamic features other than resistance and their relationship with the perception of nasal blockage in Japanese subjects. The present study showed results different from our previous study of Canadian subjects (Naito et al., 1989). In brief, nasal resistance on either inspiration or expiration and coefficient "a" of acceleration change the duration from inspiration to expiration correlated well with subjective nasal patency, while coefficient "a" of acceleration change the duration from expiration to inspiration and alteration of differential pressure, either the duration from inspiration to expiration or from expiration to inspiration, did not correlate well with perception of nasal blockage in Japanese subjects. We compared rhinomanometric results from both Japanese and Canadian equipment and no significant differences were observed (Naito et al., 1991b). Thus, the differences of the results in the two investigations might result from the method of acceleration expression and/or racial, cultural, and educational differences in perception of nasal obstruction between Japanese and Canadian individuals. As a reason of the inconsistency, we must consider furthermore the diffences of environmental conditions, for example ambient air temperature and humidity, between the both countries.

It seems, therefore, that measurement of respiratory acceleration of nasal airflow is a useful indicator of subjective nasal obstruction and can be applied to complement the clinical objective evaluation of subjective nasal patency in Canadian and Japanese subjects, and further attempts should be made to develop suitable expressions of acceleration of airflow through the nose.

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