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# Unilateral and bilateral nasal resistances: A supplement

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SUMMARY

*Three hundred and thirty-four measurements of bilateral and unilateral nasal resistance (at $\Delta P$ 1.0 cm $H_2O$ and by time averaging) in 233 adults were carried out by posterior rhinomanometry with a head-out body plethysmograph. Total nasal resistances, calculated by the equation of Ohm's Law for parallel resistors from measured unilateral resistances, were compared with measured total nasal resistances.*

*The time averaged total nasal resistances calculated by use of Ohm's Law for parallel resistors were closer to direct measurements than resistances at $\Delta P$ 1.0 cm $H_2O$ calculated from the same equation. We attempted to fit calculated total nasal resistance with direct measurements by modification of the equation of Ohm's Law for parallel resistors to $T=0.96[R\times L/(R+L)]^{0.92}$ in the time averaged nasal resistance and $T=1.07[R\times L/(R+L)]^{0.77}$ in resistance at $\Delta P$ 1.0 cm $H_2O$ (T: total nasal resistance, R: nasal resistance on the right side, L: nasal resistance on the left side). Calculated total nasal resistances from the above equations agreed closely with direct measurements.*

## INTRODUCTION

Active anterior rhinomanometry using an anaesthetic face mask is probably more commonly employed than active posterior rhinomanometry because of occasional failure in obtaining the oropharyngeal pressure in the latter method. Unilateral nasal resistance, but not total resistance, can be measured by active anterior rhinomanometry and total nasal resistance can be derived from the Ohm's Law equation for parallel resistors as follows (Kern, 1977):

$$1/T=1/R+1/L \text{ or } T=R\times L/(R+L) \tag{1}$$

(T: total nasal resistance, R: nasal resistance on the right side, L: nasal resistance on the left side).

Calculated total nasal resistances often differ somewhat from actual measurements. Cole et al. (1988) pointed out that resistive variations associated with mucovascular instability and with use of a face-mask contributed substantially to differences between the results of anterior and posterior rhinomanometric assessment of total nasal resistance.

In this communication, we have attempted to arithmetically fit calculated total nasal resistance from equation (1) with measured total nasal resistance, and have derived equations which achieve closer agreement between both total nasal resistance methods under all conditions which had prevailed during measurements.

## MATERIALS AND METHODS

### *Subjects*

Nasal resistances in 233 adult patients (aged 15–81, with a mean age of 37, 159 males and 64 females), referred to our nasal airflow laboratory in Toronto, were measured by posterior rhinomanometry with a head-out body plethysmograph before and/or after decongestion of the nasal mucosa.

### *Nasal resistance*

Respiratory nasal airflow was detected by a head-out displacement body plethysmograph, while concomitant transnasal pressure was measured through a fine pernasal tube (8F infant feeding tube) to the nasopharynx (Cole and Harvas, 1987).

Time averaged nasal resistances (Cole, 1980; Naito et al., 1988) and inspiratory nasal resistances at $\Delta P$ 1.0 cm $H_2O$ ($\fallingdotseq$100 Pa), on the transnasal pressure/flow curve, were employed. Total nasal resistances calculated by equation (1) from the separately measured unilateral resistances were compared with direct measurements of total nasal resistance.

## RESULTS

In 334 measurements, regression of time averaging total nasal resistances from equation (1) on measured total nasal resistances was $Y = 0.92X - 0.04$ ($p < 0.01$), when calculated resistances were plotted on the logarithmic X axis and measured resistances were plotted on the logarithmic Y axis. The regression line was very close to the line of identity whether the mucosa of the nasal turbinates was decongested or not. On the other hand, the regression of calculated total nasal resistances at $\Delta P$ 1.0 cm $H_2O$ from equation (1) on measured resistances was $Y = 0.77X - 0.07$ ($p < 0.01$) on the logarithmic coordinates and the line departed from the line of identity (Figure 1).

From these regressions, we were able to derive the following equations to fit calculated total nasal resistance with actual measured total nasal resistance arithmetically.

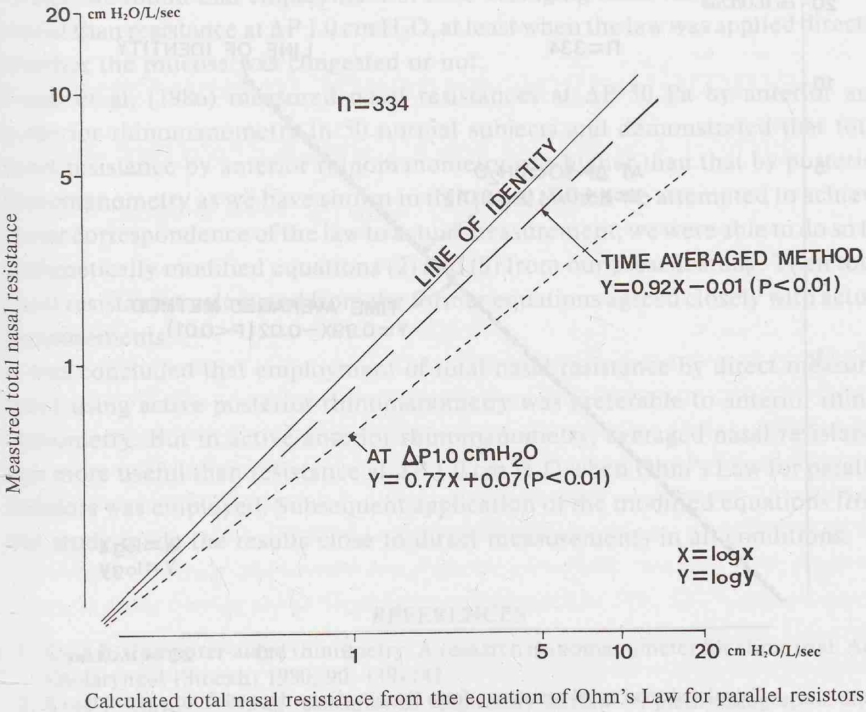


Figure 1. Regression of total nasal resistance (at ΔP 1.0 cm $H_2O$ and by time averaged) calculated from Ohm's Law for parallel resistors on measured total nasal resistance on the logarithmic coordinates.

In the time averaging nasal resistance:

$$T = 0.96[R \times L/(R+L)]^{0.92} \quad (2)$$

In nasal resistance at the point of ΔP 1.0 cm $H_2O$:

$$T = 1.07[R \times L/(R+L)]^{0.77} \quad (3)$$

Total nasal resistances calculated from equation (2) or (3) were compared with measured total nasal resistances as shown in Figure 2 respectively. The slopes of the both regressions were equal to unity on the logarithmic coordinates with a statistical significance ($p < 0.01$).

DISCUSSION

Ohm's Law for parallel resistors is widely employed to calculate total nasal airflow resistance by measurements obtained from each nasal cavity separately. The law is applied to constant direct electric current for parallel resistors. But airflow through the nose is not constant, and furthermore the nasal cavity is not a simple cylinder but a complicated conduit. Physiological differences of airflow

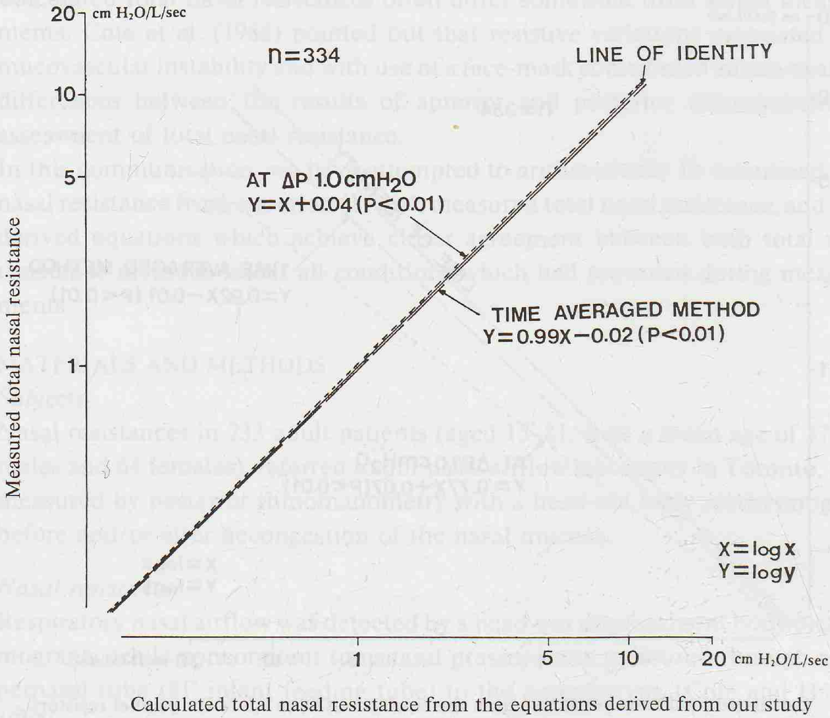


Figure 2. Regression of total nasal resistance calculated from our modified equations of Ohm's Law for parallel resistors on measured total nasal resistance on the logarithmic coordinates.

and differential pressure between unilateral and bilateral breathing through the nose even at rest cannot be ignored. Fundamentally, application of the law to nasal airflow resistance may be questioned.

Only when total nasal resistance is calculated without the influence of mucovascular instability and/or distortion of either the facial tissue or the anterior nasal region generally caused by use of nasal masks and nozzles, calculated total nasal resistance coincides with direct measurement at a transnasal pressure of 1.0 cm $H_2O$ (Cole et al., 1988). But, we have to measure nasal resistance under various conditions. How should we deal with calculated total nasal resistance under conditions of mucovascular instability (Hasegawa et al., 1979; Stoksted, 1952; Haight and Cole, 1984) or with masks or nozzles (Cole et al., 1988)? Shortening the interval between measurements and decongestion or, alternatively, averaging a large number of results minimized the difference between calculated resistance from equation (1) and direct measurement (Jones et al., 1987).

Firstly, we found that employment of time averaging nasal resistance was more useful than resistance at $\Delta P$ 1.0 cm $H_2O$, at least when the law was applied directly whether the mucosa was congested or not.

Unno et al. (1986) measured nasal resistances at $\Delta P$ 50 Pa by anterior and posterior rhinomanometry in 50 normal subjects and demonstrated that total nasal resistance by anterior rhinomanometry was higher than that by posterior rhinomanometry as we have shown in this paper. When we attempted to achieve closer correspondence of the law to actual measurement, we were able to do so by arithmetically modified equations (2) and (3) from our present study. Then total nasal resistances calculated from the former equations agreed closely with actual measurements.

It was concluded that employment of total nasal resistance by direct measurement using active posterior rhinomanometry was preferable to anterior rhinomanometry. But in active anterior rhinomanometry, averaged nasal resistance was more useful than resistance at $\Delta P$ 1.0 cm $H_2O$ when Ohm's Law for parallel resistors was employed. Subsequent application of the modified equations from our study made the results close to direct measurements in all conditions.

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