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Assessing degree of nasal patency by measuring peak expiratory flow rate through the nose

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Peak expiratory flow rate through the nose (PEFR_n) can be measured with a Wright peak flow meter. A function of PEFR_n, provisionally called blockage index (BI), is described which correlates closely with nasal airway resistance (NAR) but is independent of total expiratory effort. The method is sensitive, and the apparatus is robust and easily transported.

Quantitative determination of nasal patency or obstruction is of great importance in assessing the status and progress of patients with allergic rhinitis, especially when evaluating new or experimental forms of therapy. The nasal airway resistance (NAR), which is defined as the quotient between the transnasal pressure difference and the nasal airflow ($dP/\dot{V}$), can be measured directly and indirectly by a wide variety of methods, which have been well reviewed by Solomon and associates¹ and by Ingelstedt, Jonson, and Rundcrantz.² NAR is a direct measure of the degree of nasal obstruction, but since airflow through the nose is invariably turbulent rather than laminar,³ the NAR also varies, exponentially, with nasal airflow.⁴ At high flow rates the NAR, as defined ($dP/\dot{V}$), is a poor index of true nasal resistance ($\Delta dP/\Delta \dot{V}$).⁵ It follows that measurements of NAR must be made during quiet breathing, at a specified flow rate (in our laboratory, 0.4 L. per second). Connell⁶ has described

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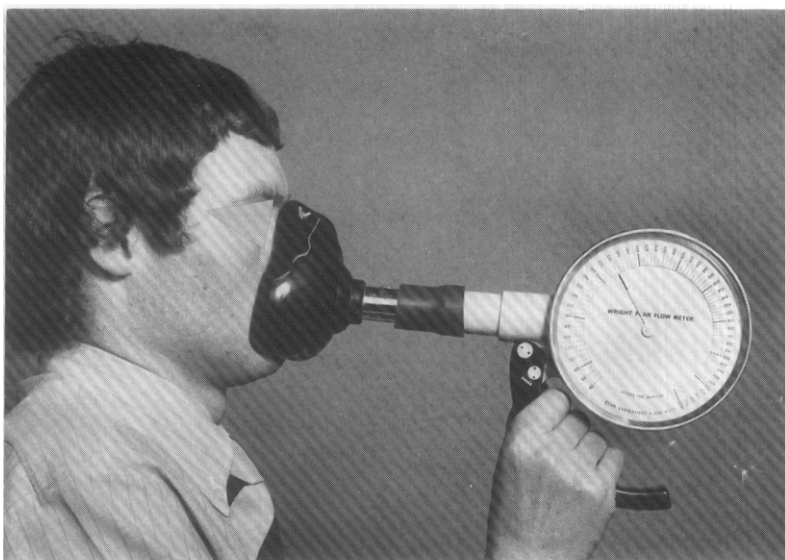


FIG. 1. Measuring the peak expiratory flow rate through the nose ($PEFR_n$).

an apparatus with which to measure the "effective cross-sectional nasal airway," a measurement that is largely independent of nasal flow rate. Both his apparatus and ours, however, are bulky and difficult to transport, and cannot be adapted readily for routine use at the bedside or in the outpatient clinic. We felt that a measurement of peak expiratory flow rate through the nose ($PEFR_n$) would answer both objections. Although $PEFR_n$ is obviously dependent on the subject's total expiratory effort (which varies considerably), we will describe a function of $PEFR_n$, provisionally called blockage index (BI), which is independent of total expiratory effort but which correlates closely with NAR.

MATERIALS AND METHODS

NAR was measured at a flow rate of 0.4 L. per second in 10 healthy volunteers, using a modification of the apparatus described by Solomon and associates.¹ This machine has been described previously.⁴ Total expiratory effort ($PEFR$ through the mouth, i.e., $PEFR_o$) was assessed using a Wright peak flow meter with a standard mouthpiece. The best of six readings was taken as the true peak. $PEFR_n$ was measured in an identical fashion, using the same Wright peak flow meter, but substituting an airtight face mask for the mouthpiece and instructing the subjects to keep the lips tightly closed (Fig. 1). Again, the true peak reading was taken as being the best of six. The choice of face mask is important. It must have semi-rigid edges and must not in any way obstruct nasal airflow. The nasal airways were then artificially occluded by wedging a doubled length of soft plastic catheter into one or both nostrils, the catheter being held in position by adhesive strapping. NAR and $PEFR$ through both mouth and nose ($PEFR_o$ and $PEFR_n$) were measured again. Similar maneuvers were carried out on one man suffering from coryza, before and after administration of phenylephrine nasal drops, and on two people suffering from perennial rhinitis, before and after administration of a house dust extract nasal spray.

Three experiments were carried out to investigate the stability of BI and NAR. First, 3 subjects were asked to perform maximal nasal airflow measurements repeatedly, 20 times, after which the NAR was measured again. Second, in 3 subjects both NAR and BI were

TABLE I. NAR, $PEFR_o$, $PEFR_n$, and BI measurements in different conditions of nasal obstruction

Subject	Sex	State of nose	$PEFR_o$ (L. min. ⁻¹)	$PEFR_n$ (L. min. ⁻¹)	BI	NAR (cm. H ₂ O L. ⁻¹ sec. ⁻¹)
1	M	Resting	565	400	0.292	1.19
		1 NO*	565	350	0.380	1.46
		2 NO*	565	250	0.557	1.59
2	M	Resting	590	345	0.415	1.59
		1 NO	575	190	0.669	2.01
		2 NO	580	160	0.724	2.01
3	M	Resting	660	520	0.212	1.32
		1 NO	640	460	0.281	1.32
		2 NO	650	255	0.608	3.18
4	F	Resting	400	245	0.387	1.19
		1 NO	375	165	0.560	2.15
5	M	Resting	460	445	0.032	0.92
		1 NO	465	260	0.441	2.15
6	M	Resting	510	370	0.274	1.19
		1 NO	490	345	0.296	1.59
		2 NO	480	390	0.187	1.32
7	M	Resting	510	380	0.255	1.19
		1 NO	480	300	0.375	2.15
		2 NO	480	300	0.375	3.03
8	M	Resting	535	495	0.075	0.59
		2 NO	500	445	0.110	2.73
9	F	1 NO	435	205	0.529	2.44
		Resting	440	285	0.352	1.32
10	M	Resting	535	480	0.103	0.92
		1 NO	525	405	0.228	1.05
		2 NO	535	405	0.243	1.32
11	M	Coryza	605	285	0.529	3.03
		After phenylephrine†	595	355	0.403	1.05
12	M	Resting	600	400	0.333	0.59
		5 min. after HD challenge	590	285	0.517	2.01
		10 min. after HD challenge	595	350	0.412	0.79
13	F	Resting	540	320	0.407	1.05
		5 min. after HD challenge	550	295	0.464	1.32
		10 min. after HD challenge	565	290	0.487	2.44
		5 min. after phenylephrine†	560	375	0.330	0.92

*1 NO = One nostril partially obstructed.

2 NO = Two nostrils partially obstructed.

†1% phenylephrine nasal drops.

measured at 10 minute intervals for one hour. Third, in 3 subjects the two functions were measured at 45 minute intervals for 3 hours.

RESULTS

All subjects found the peak flow device very easy to use. Insertion of the catheter into the nose caused much nasal irritation, with sneezing and discharge from nose and eyes, exactly mimicking an attack of allergic rhinitis. The NAR was found to achieve its new level after about 3 or 4 minutes and thereafter remain constant for at least 20 minutes. The action of house dust extract on the patients with allergic rhinitis was more transient, reaching a peak at about 5 minutes and disappearing within about 15 minutes. In all, 35 sets of readings were obtained (Table I). For each, the BI was calculated by the formula: $(PEFR_o - PEFR_n)/PEFR_o$. The correlation coefficient between NAR and BI is 0.52, which is significant ($p < 0.01$). The correlation coefficient between BI and

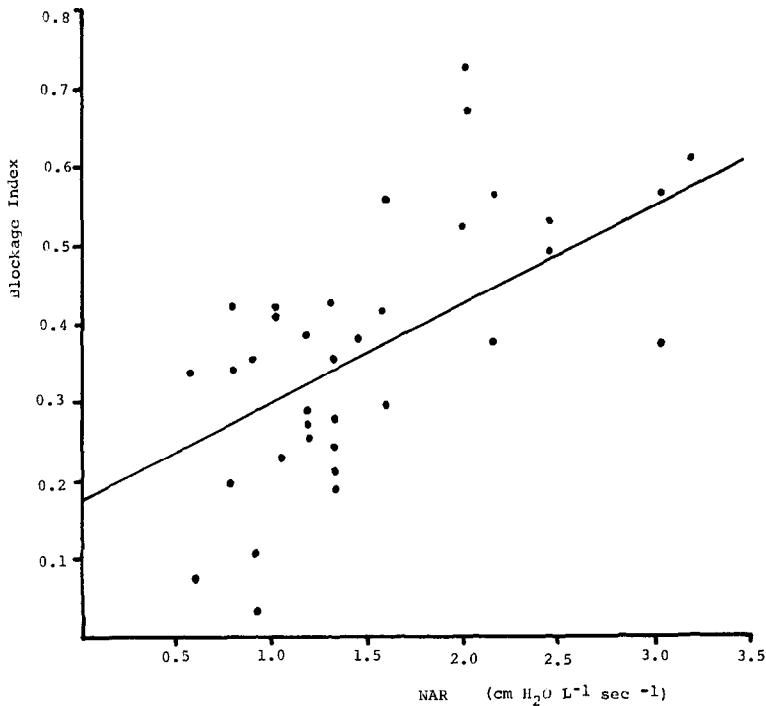


FIG. 2. Regression line showing correlation between nasal airway resistance (x - axis) and blockage index (y - axis). Correlation coefficient (r) = 0.52; $p < 0.01$. (Instructions: x - axis—NAR cm. H_2O L^{-1} sec^{-1} units from 0 to 3.5 y - axis—BI units from 0 to 0.8.)

$PEFR_0$ is 0.16; i.e., it is independent of total expiratory effort. The regression line between NAR and BI is shown in Fig. 2.

All of the data in Table I were combined to obtain these correlation coefficients; as indicated, they represent 35 measurements performed on 13 subjects. Analysis of the first, "resting" readings for the 10 *normal* subjects, gives a correlation coefficient of 0.86; analysis of all the "normal resting" figures together with the *pathological* figures (i.e., all those readings that do not rely on artificially blocking the nose with catheter) gives a correlation coefficient of 0.63. All of these coefficients are significant ($p < 0.01$).

The correlation coefficient between BI and $PEFR_n$ is -0.895 ; i.e., it is highly correlated, inversely, with nasal airflow.

The difference between oral and nasal peak flows is in itself a fairly sensitive index of NAR ($r = 0.47$; $p < 0.01$), but it also varies somewhat with total expiratory effort as measured by the $PEFR_0$ ($r = 0.435$; $p < 0.01$) and is therefore of limited value.

Inspection of the magnitudes of the changes in NAR and BI shows no consistent pattern; i.e., neither is more sensitive than the other. Analysis of their correlation yields a coefficient of 0.41, which does not quite achieve significance ($0.1 > p > 0.05$).

NAR measurements have to be made after the patient has been instructed to

clear his nose, as a mobile bolus of mucus in the nose has a profound effect. Clearly, this does not apply to BI measurements.

Experiments in which 20 maximal nasal expiratory efforts were made over a period of 10 minutes show no consistent deviation in either BI or NAR. It would appear, therefore, that the performance of the measurement does not affect the parameter measured.

Both NAR and BI were found to fluctuate slightly in 3 healthy individuals. The coefficients of variation of the 6 sets of readings show that in each case the resting NAR fluctuates more than the resting BI, the average coefficient of variation of NAR being 0.32 and that for BI being 0.18.

DISCUSSION

Two indices of nasal patency are generally accepted: the NAR, which is measured directly by machines similar to that devised by Solomon and associates,¹ and the "effective cross-sectional nasal airway," following that of Connell.⁶ Of the two parameters, the second has the theoretical advantage of being largely independent of nasal airflow. However, the apparatus for its determination is difficult to transport. The most portable apparatus for measurement of NAR is that described by Ingelstedt, Jonson, and Rundcrantz,² which dispenses with electronic devices; even so, it is more cumbersome than a Wright peak flow meter, which is an everyday piece of clinical equipment and demands the barest minimum of patient instruction.

Although there is a good quantitative correlation between NAR and BI, the correlation between changes in these parameters is not as good. This would suggest that when following changes in nasal patency under experimental conditions, serial measurements of BI give a slightly less accurate picture than serial measurements of NAR. However, BI appears to be less subject to random fluctuations, while its sensitivity is about the same as NAR measurements.

Three practical points emerged from this study concerning the use of Wright peak flow meters for measuring nasal airflow: (1) Making twelve maximal expirations is exhausting, even for healthy young adults—subjects must be instructed to rest for at least 30 seconds between each effort. (2) Where very high degrees of nasal obstruction are involved (i.e., $\text{NAR} > 5 \text{ cm. H}_2\text{O L}^{-1} \text{ sec}^{-1}$, a level at which comfortable nasal breathing is impossible), subjects tend to deliver a submaximal nasal expiratory effort due to a conscious or unconscious fear of damaging the middle ear. This usually has the effect of producing a PEFR_n so low as to be unrecordable on the flow meter used, so that at these high blockages BI cannot be calculated. (3) If there is a lot of mucous secretion from the nose, it is inevitable that some will be blown into the apparatus. Subjects should clear the nasal airways between efforts, though in any case it was observed that most of the mucus was deposited inside the mask and did not reach the instrument itself. The distributors of the instrument (Airmed Ltd., Harlow, Essex, England) claim that moisture inside will not interfere with accuracy, but that instruments should be recalibrated about once a year.

We conclude that estimation of BI by the peak-flow method is a valuable

guide to the NAR and can be performed easily, cheaply, and quickly in hospital and general practice.

REFERENCES

- 1 Solomon, W. R., McLean, J. A., Cookingham, C., Ahronheim, G., and DeMuth, G. R.: Measurement of nasal airway resistance, *J. ALLERGY* **36**: 63, 1965.
- 2 Ingelstedt, S., Jonson, B., and Runderantz, H.: A clinical method for determination of the nasal airway resistance, *Acta Otolaryngol.* **68**: 189, 1969.
- 3 Proetz, A. W.: Air currents in the upper respiratory tract and their clinical importance, *Ann. Otol. Rhinol. Laryngol.* **60**: 439, 1951.
- 4 Taylor, G., and Shivalkar, P. R.: Changes in nasal airway resistance on antigen challenge in allergic rhinitis, *Clin. Allergy* **1**: 63, 1971.
- 5 Solomon, W. R., and Stohrer, A. W.: Considerations in the measurement of nasal patency, *Ann. Otol. Rhinol. Laryngol.* **74**: 978, 1965.
- 6 Connell, J. T.: An instrument for measuring the effective cross-sectional nasal airway, *J. ALLERGY* **37**: 127, 1966.