

## NASAL SPIROMETERY

M. GOYAL<sup>1</sup>, N. S. VERMA<sup>2</sup>, A. GOEL<sup>3</sup>,  
P. KUMAR<sup>2</sup> AND S. TIWARI<sup>2</sup>

<sup>1</sup>*Department of Physiology,  
All India Institute of Medical Sciences,  
New Delhi – 110 029,*

<sup>2</sup>*Department of Physiology,  
Chhatrapati Shahuji Maharaj Medical University,  
Lucknow – 226 003 and*

<sup>3</sup>*Department of Physiology,  
Ganesh Shankar Vidyarthi Memorial Medical College,  
Kanpur – 208 002*

( Received on June 9, 2009 )

**Abstract :** Nasal obstruction is a common symptom which is difficult to quantify clinically. Rhinomanometry, Acoustic Rhinometry and Forced Oscillation methods are available for estimating nasal resistance but, these require sophisticated machines. Because of limited availability of these techniques, this potential physiological measure has not been tapped fully for research and clinical purposes. Here, we describe the use of pulmonary spirometer with little modification for quantification of nasal flow. Nasal inspiratory and expiratory flow rates along with oral inspiratory and expiratory flow rates are used to derive different nasal resistance indices. This way of reporting nasal resistance is not new but, the data for these variables is currently not available in published literature. The reproducibility of nasal flow rates were tested as variation after one day and the interclass coefficient for inspiratory and expiratory nasal flow rates were found to be within acceptable limits. Thus, nasal spirometry is able to describe the nasal resistance in a reliable manner and may be used to quantify nasal obstruction in pathological condition and also to study the physiological phenomenon like nasal cycle.

**Key words :** nasal flow rate      nasal obstruction      nasal patency  
nasal spirometry      rhinomanometry

### INTRODUCTION

Nasal obstruction is a common clinical sign/symptom which Otto-rhino-laryngologists

encounter in cases of deviated nasal septum, polyps, turbinate hypertrophy, allergic rhinitis, vasomotor rhinitis, carcinoma etc. (1, 2). Assessment of nasal obstruction is

---

\*Corresponding Author : Prof. N. S. Verma, Department of Physiology, Chhatrapati Shahuji Maharaj Medical University, Lucknow – 226 003; Phone: 0522-2257542; E-mail: narsingverma@gmail.com

subjective and with clinical examination it is difficult to quantify the obstruction. The surgical treatment often does not lead to complete patient satisfaction because of the lack of objective measurement of nasal patency. Presently, rhinomanometry, acoustic rhinometry and forced oscillation methods are available, which can measure nasal flow rates and resistance (3–5). But these require sophisticated machines and software along with trained manpower, involving higher cost and quite often not available in most of the institutions.

Here we describe the use of digital spirometer, which is primarily used for pulmonary function tests, for measuring the patency of nasal airway through flow rates and calculating resistance indices. Further, the reproducibility of the technique has been evaluated.

MATERIALS AND METHODS

The study was conducted among 15 healthy subjects who were between the age group of 18–24 years from a university. Nature of the study was explained and informed consent was obtained from each of the subjects prior to participation in the study. The protocol of the study was approved by the institutional ethical committee. A thorough history was collected and clinical examination was performed to rule out any acute or chronic nasal airways diseases for all the subjects before intervention.

Devices

The Spirobank G (MIR; Rome, Italy) device is a turbine with an infrared interruption spirometer. The Spirobank G device records spirometry parameters

including FVC, FEV1, PEF, PIF etc. Its has a flow range of  $\pm 16$  L/s and a maximal volume of 10 L, a flow accuracy of 5% or 200 mL/s, and a volume accuracy of 3% or 50 mL, whichever is greater. Spirobank G device has been tested, and found to met or exceeded the latest American Thoracic Society (ATS) accuracy standards.

Modification

Nasal piece attachment as shown in Fig. 1 was designed in institutional dental workshop with acrylic material. It is a conical structure of 7 cm length, with larger base having diameter of 3 cm corresponding to the inner diameter of mouth piece of spirometer. This end was so fashioned so that it fits in to the mouth piece of spirometer. Upper smaller end is cylindrical with 1 cm diameter. This terminal can be fitted with disposable nosepiece, which in

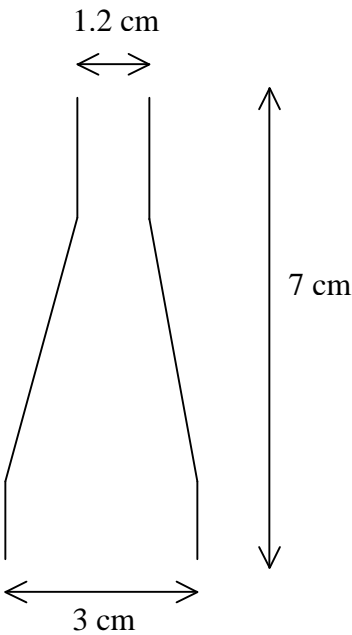


Fig. 1 : Nasal piece attachment (Upper end diameter 1.2 cm, Lower end diameter 3 cm, length 7 cm).

turn is made by cutting 2.5 cm pieces of soft PVC tube of 1.2 cm of outer diameter with the wall thickness of 2 mm.

Nasal spirometry was performed with Spirobank G using the above described nasal piece attachment fitted with nose piece. Topical decongestant was instilled. After half to one hour the subjects were asked to keep the nose piece in anterior nare on right side while closing the left nare with thumb. Subjects were instructed to inhale through nose slowly and completely, then to exhale forcefully and completely and thereafter to inhale fast and completely. Similarly, procedure is repeated for left nare. In both procedures, highest of the two sets of reading of RPNEF (Right peak nasal expiratory flow), LPNEF (Left peak nasal expiratory flow), RPNIF (Right peak nasal inspiratory flow), LPNIF (Left peak nasal inspiratory flow) were recorded.

Spirometry was performed for each subjects with Spirobank G as per the latest ATS guidelines. The test curve with the highest sum of the FVC and FEV1 was considered the best curve, and the largest FVC and FEV1 measurements were taken for analysis. The test was performed in standing position and a nose clip was used. All the readings of inspiratory and expiratory flow were recorded for all the maneuvers.

#### Statistical analysis

To evaluate the reproducibility of measurements, the intraclass correlation coefficient was calculated for PEF, PIF, RPNEF, LPNEF, RPNIF and LPNIF for both days measurement, using two-way random effect absolute agreement model. The

intraclass correlation coefficient represents the proportion of between-subject variability among the total variability. The total variability of measurements consists of the portion resulting from within-subject variability among repeated measurements as well as the portion resulting from between subject differences. An intraclass coefficient of 0 indicates that the measurement is random and completely nonreproducible, and a coefficient of 1 means that the measurement is the same for any time for a certain subject, representing perfect reproducibility.

#### RESULTS

Data collected from all fifteen subjects was analyzed. In the baseline questionnaire, none of the participants had a history of atopy, allergic rhinitis, or any seasonal or chronic respiratory illness. None of the subjects had current exposure to occupational chemicals, or environmental tobacco smoke at home or school, or used medication. All the subjects performed the test approximately at the same time on both days. None of the subjects complained of discomfort with the technique and none of them developed any complications with the test.

The baseline parameters like distributions of age, height, Weight, PEF, PIF, RPNEF, LPNEF, RPNIF and LPNIF are shown in Table I. Since each of the subjects had two measurements of peak flow over two days, the average of the two measurements were taken, and the mean value is presented in Table I. Paired t tests for each measure showed no significant difference (Table II) on day 1 and day 2.

Intraclass correlation coefficients for PEF, PIF, RPNEF, LPNEF, RPNIF and LPNIF are shown in Table III. Also, 95% CI of intraclass coefficients of all measures have been shown.

Since coefficients for Nasal Peak Flow Rates are similar to those of Oral Peak Flow Rates, the reproducibility of Nasal Peak Flow Rate is nearly as good as that of Oral Peak Flow Rates, suggesting that the nasal airway segment does not lead to significant reduction in reproducibility.

TABLE I: Distribution of age, height, weight, PEF, PIF, RPNEF, LPNEF, RPNIF and LPNIF measurements.

	<i>Mean (SD)</i>	<i>Range</i>
Age	22.0(2.33)	18–24
Height	168.9(2.71)	164–173
Weight	65.8(4.31)	57–72
PEF	7.7(1.46)	4.69–10.55
PIF	5.3(1.13)	3.71–7.96
RPNEF	1.7(1.00)	0.33–4.64
LPNEF	1.8(0.98)	0.59–4.15
RPNIF	1.5(0.71)	0.55–3.51
LPNIF	1.3(0.60)	0.34–2.93

TABLE II: Paired t test for two days measurements of PEF, PIF, RPNEF, LPNEF, RPNIF and LPNIF.

	<i>Data are Mean±SD</i>		<i>P value</i>
	<i>Day 1</i>	<i>Day 2</i>	
PEF	7.6±1.5	7.9±1.4	>0.3
PIF	5.2±1.0	5.3±1.2	>0.3
RPNEF	1.7±1.0	1.76±1.0	>0.8
LPNEF	1.8±1.0	1.8±1.0	>0.8
RPNIF	1.5±0.7	1.5±0.7	>0.8
LPNIF	1.4±0.6	1.3±0.6	>0.8

TABLE III: Intra-class correlation coefficient (R) and Two-Sided 95% CI for PEF, PIF, RPNEF, LPNEF, RPNIF and LPNIF.

	<i>PEF</i>	<i>PIF</i>	<i>RPNEF</i>	<i>LPNEF</i>	<i>RPNIF</i>	<i>LPNIF</i>
R	0.79	0.76	0.74	0.78	0.69	0.71
95% CI	0.49-0.67	0.44-0.91	0.38-0.91	0.46-0.92	0.28-0.88	0.33-0.89

DISCUSSION

Functional nasal airway measurement is important in the understanding of nasal physiology, and is a useful diagnostic tool in patients with nasal disorders. The sensation of nasal obstruction, nasal resistance, are closely related parameters of nasal patency (6) that can very well be described with nasal flow rates which represents the functional and quantitative study of the nasal airway.

The relevance of objective assessment of nasal resistance and patency has been documented in many rhinological situations and nasal spirometry can also be used as a feasible alternate for following purposes.

1. To differentiate structural or mucosal nature of the nasal obstruction by conducting the test before and after topical decongestant.
2. To assess the benefit of surgical correction (septoplasty and turbinoplasty) in alleviating nasal obstruction.
3. To provide quantitative measure of nasal mucosa response to intranasal challenges with different physical and chemical stimuli.
4. Nasal physiological studies including nasal cycle and circadian rhythm in nasal patency in health and diseases, can have research potential
5. Quantitative data of the nasal airway patency may also be used for medico-legal documentation.

The reproducibility of a test can be evaluated by repetition of the test in the

same subject. This repetition may be conducted over minutes, over days, or over even longer intervals. Since the main utility of nasal flow rates would be to measure the changes in nasal patency that may occur over days therefore, the reproducibility over one day is a logical dimension to assess the test performance. This measure of reproducibility reflects the combination of measurement error and biological variability over the relevant period. Our study shows that nasal flow rate measurements on healthy subjects possess good reproducibility with an intraclass correlation coefficient varying from 0.69–0.79. The reason for the lower intraclass coefficient in inspiratory rates may be due to chance, although we cannot exclude the possibility of maneuver-induced nasal airways collapse or congestion as a result of the forceful inhalation.

Our data reveal that nasal peak flow measurements using spirometer have comparable reproducibility to the measurements made with rhinomanometry. Intraclass correlation coefficients for nasal flow rates are comparable to that of oral flow rates in our study. It is also comparable to the results from the study by Eigen et al. (2001) in which reproducibility of bronchial peak expiratory flow was examined and intraclass correlation coefficient was 0.89 (7).

The model proposed in this study is able to describe the inspiratory/expiratory flow in the nasal cavity. The nasal flow rates and oral flow rates can further be used to derive several indices which can better represent the resistance and flow limitation phenomenon. Following parameters related to nasal inspiratory and expiratory flow can be calculated :

1.
2.  $ENPR = \frac{RPNEF}{LPNEF}$
3.  $RINRI = \frac{PIF - RPNIIF}{PIF}$
4.  $RENRI = \frac{PEF - RPNEF}{PEF}$
5.  $LINRI = \frac{PIF - LPNIIF}{PIF}$
6.  $LENRI = \frac{PEF - LPNEF}{PEF}$

*Abbreviations:* INPR (Inspiratory nasal partition ratio), ENPR (Expiratory nasal partition ratio), RINRI (Right inspiratory nasal resistance index), RENRI (Right expiratory nasal resistance index), LINRI (Left inspiratory nasal resistance index), LENRI (Left expiratory nasal resistance index)

This way of reporting nasal resistance, in terms of inspiratory and expiratory ratios/indices, is not new but the data for these variables are currently not available in published literature. The blockage index and other similar indices reported in literature are based on total nasal flow rates rather than individual nares. This may be because of the fact that the importance of right and left nasal patency has not been realized in the past. Also, the data with the available techniques and measures of nasal patency are scarce. Therefore, the potential of such independent ratios and indices needs to be assessed in clinical settings and need to be compared with available measures of nasal patency.

The results of this study reveals that inspiratory flow rates are in general lower than the expiratory flow rate. This difference probably is in part because of the collapse of nasal airways during inspiration which develops negative suction pressure. The extent of collapse of airway varies from individual to individual and depends on the supporting tissue underlying mucosa. Therefore the difference between the two rates or the ratio of the two may represent the collapsibility of nasal airways.

Although the model proposed in this study is clearly an oversimplification of complex nasal anatomic reality but, this model allows an accurate description of the flow related indices for nasal resistance in a simplest manner with simple machine and accessories. The proposed model may also represent as a useful tool for the clinician to reach a more accurate diagnosis and to predict more accurately the functional effects of the treatment. This could be especially

useful in settings where the clinicians encounter patients with vasomotor rhinitis, deviated nasal septum and similar diseases. But due to the lack of objective measures for quantitative data, unable to prove and often patient satisfaction levels are found to be low. The application of this valuable tool is not restricted to only pathological conditions but also it can be used to study the physiological phenomenon like nasal cycle, circadian changes in nasal cavity etc.

In summary, this study shows the good reproducibility of nasal flow rate measurements and serves as a pilot study for a larger epidemiologic application. Moreover, the technique described here is feasible as spirometers are usually available in most of the institutes. A study can be conducted with larger samples among normal subjects to form reference values of the flow rates and resistance indices which need to be compared with absolute measures of nasal resistance with rhinomanometry.

## REFERENCES

1. Kimmelman CP. The problem of nasal obstruction. *Otolaryngol Clin North Am* 1989; 22: 253–264.
2. Lucente FE. Rhinitis and nasal obstruction. *Otolaryngol Clin North Am* 1989; 22: 307–318.
3. Cole P, Roithmann R, Roth Y, Chapnik JS. Measurement of airway patency. *Ann Oto Rhino Laryngol* 1997; 106: 1–22.
4. Clement PAR. Committee report on standardization of rhinomanometry. *Rhinology* 1983; 22: 151–155.
5. Hilberg O, Jackson AC, Swift DL, Pederson OF. Acoustic rhinometry: evaluation of nasal cavity geometry by acoustic reflection. *J Appl Physiol* 1989; 66: 295–303.
6. Clement PAR. Functional tests. The Nose. In: P Van Cauwenberge, Wang D, Ingels and Bachert C (eds). The Nose. Kugler Publications, Amsterdam. 1998.
7. Eigen H, Bieler H, Grant D, et al. Spirometric pulmonary function in healthy preschool children. *Am J Respir Crit Care Med* 2001; 163: 619–623.