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Assessing the reproducibility of nasal spirometry parameters in the measurement of nasal patency*

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SUMMARY

The reproducibility of nasal spirometry was assessed in ten subjects at two visits. Topical nasal decongestion was applied to minimise mucosal variation. Eleven parameters of flow volume were measured. Data analysis using Spearman's rank correlation coefficients revealed peak inspiratory flow rate (PIFR) followed by forced expiratory volume in first one second (FEV1) to be the most reproducible measures, yielding significance values of <0.05. For all other spirometric parameters significance was not reached. Analysis revealed that using a naso-pulmonary index (a ratio of nasal to pulmonary flow) was detrimental to reproducibility. We conclude that future nasal spirometric studies should use PIFR and FEV1 as their derived variables of flow-volume loops in the assessment of nasal patency, and the naso-pulmonary index is of no value.

Key words: peak nasal flow, spirometry, reproducibility

INTRODUCTION

It is disappointing that the use of objective rhinologic measures have not come into routine practice, with many rhinologists using no more than a cold mirror to observe the area of misting produced by water condensation, as described by Zwaardemaker over a century ago (Jones et al., 1991). It is arguable that nasal spirometry is as fundamental to rhinology as is spirometry to respiratory medicine. Lack of enthusiasm may relate to conflicting studies relating symptomatology to airflow measurements. Gleeson et al. (1986), Enberg and Ownby (1991), and Morrissey et al. (1990) found peak flow a poor indicator of nasal patency. In addition Clarke and Jones (1994) found peak flow to be relatively insensitive to changes in nasal resistance when compared with rhinomanometry. In contrast others have reported good correlation between subjective patency and peak flow rates (Larsen et al., 1990; Jones et al., 1991; Farley et al., 1993). Also in contrast to the work of Clarke and Jones, Holmstrom et al. (1990) found good inverse correlation between peak flow and anterior rhinomanometry.

The aim of this study was to determine the reproducibility of nasal spirometry and assess which of the many parameters of nasal airflow were the most repeatable. We have also examined the effect of taking into account an individual's pulmonary function upon reproducibility. Cho et al. using a portable microspirometer (Microplus; London, UK) were able to show excellent repeatability for nasal peak inspiratory flow (PIFR) over 5 consecutive days, with an intraclass correlation of 0.89 and a coefficient of variation of 12.1% (Cho et al., 1997). Most authors have used peak inspiratory flow as their measure, presumably because this is the most clinically relevant, technically hygienic and easy to obtain, but if another index was more repeatable, then the use of PIFR would be questionable. Since Davies' original work proofing the feasibility of using a vitalograph to assess nasal patency (Davies, 1978), interest in flow measurements has been generated, but most publications since have simply used a Wrights or Youltens flow meter, or an electronic modification of these to assess peak flow.

MATERIALS AND METHODS

Ten healthy volunteers, with no nasal symptoms and signs, and no previous nasal surgery were recruited. On each visit the nose was decongested with five drops of 0.1% w/v xylometazoline hydrochloride to each side. Fifteen minutes later peak nasal airflow was measured using a King Systems face mask, with a compressible rim attached to a Transfer Test Autolink spirometer (P. K. Morgan Ltd). The best of six attempts was taken. By convention the best recording is the one used. Six attempts were allowed because of the difficulty of the test, which requires some practice before consistent results are produced. Lung function tests were then done, with the best of three reading taken. The subjects were re-tested on a different day, in an identical manner. All measurements were undertaken by the first author.

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RESULTS

Data for all ten subjects and their eleven parameters was assessed using Spearman's rank correlation method to assess the strength of association between variables on different days. Reproducibility for each individual subject was also assessed by the inter-visit coefficient of variation, defined as the absolute value of the difference between visits expressed as a percentage of the mean of the two measures. Data was analysed using the statistical package SPSS for Windows.

The spirometer produces flow-volume loops and calculates the following eleven parameters of airflow:

FEF 25	maximum forced expiratory flow in the first quarter of vital capacity (VC)
FEF 50	maximum forced expiratory flow in the first half of VC
FEF 75	maximum forced expiratory flow in the first three quarters of VC
FEF 25-75	maximum forced expiratory flow between the first and third quarters of VC
FET	forced expiratory time
FEV 0.5	forced expiratory volume in half a second
FEV 1	forced expiratory volume in one second
FEV 1/ FVC	ratio of FEV 1 to forced vital capacity
PEFR	peak expiratory flow rate
PIFR	peak inspiratoy flow rate
FIF 50	forced inspiratory flow in the first half of time

Spearman's correlation coefficients

Using Spearman's correlation coefficients the reproducibility of each of the above parameters was assessed (Table 1).

PIFR was the most reproducible (r=0.7455; p=0.013) measure, closely followed by FEV 1 (r=0.7091; p=0.022). Of all the further measures only FIF 50 came anywhere near reaching significant correlation (r=0.6242 p=0.054). Using a naso-pulmonary index (ratio of nasal to pulmonary flow) the reproducibility of both PIFR and FEV1 was decreased dramatically and on the whole most other indices were less reproducible, other than FET (Table 2). For pulmonary function, as expected FEV 1 was the most reproducible (r = 0.9762; $p<0.0001$) and PEFR was also quite good (r=0.6727; p=0.033) but both FIF 50 and PIFR were not significantly correlated.

Inter-visit coefficients of variation

Data for individual subject reproducibility is presented in Table 3. Here FEV1 and FEV1/FVC are the best parameters, closely followed by PIFR. Variation in reproducibility amongst subjects was high for both PIFR (range 2.11% to 49.46%) and FEV1 (2.07% to 24.46%).

DISCUSSION

Nasal spirometry requires attention to detail during data acquisition, with errors resulting in under-estimation. Therefore, by convention and logic the highest value is taken. It is important to calibrate the spirometer prior to use. All equipment joints and interfaces should be air-tight to prevent air leakage. The interface of face mask and patient may also be an area of technical failure. The operator must ensure the face mask is firmly applied. It is important to observe the subject during forced maximal breathing because some may unknowingly breath through their mouth rather than their nose. Since the technique is difficult, the first one or two attempts tend to be under-estimations. However, with multiple recordings the subjects tend to fatigue, and the last may not be the best. With maximal respiratory effort alar collapse occurs and therefore occasionally

Table 1. The day to day reproducibility of various nasal airflow parameters as assessed by using a Spearman correlation coefficient.

FEF25	0.2364	FEV0.5	-0.1707
FEF50	-0.365	FEV1	0.709*
FEF75	0.297	FIF50	0.6242
FEF25-75	0.5952	PEFR	0.4316
FET	0.3939	PIFR	0.7455*
FEV1/FVC	0.4321		

** $p<0.05$*

Table 2. Day to day reproducibility using a naso-pulmonary index, as assessed by the Spearman correlation coefficient.

FEF25	34.90	FEV0.5	-0.0909
FEF50	0.3091	FEV1	0.1667
FEF75	0.5394	FIF50	0.5394
FEF25-75	0.4524	PEFR	0.297
FET	0.6121	PIFR	0.3697
FEV1/FVC	0.4762		

** $p<0.05$ for all parameters*

Table 3. The day to day reproducibility of the various nasal airflow parameters as assessed by the mean of the inter-visit coefficients of variation (%).

FEF25	34.90	FEV0.5	23.83
FEF50	28.75	FEV1	8.64
FEF75	18.61	FIF50	21.02
FEF25-75	16.92	PEFR	44.5
FET	29.73	PIFR	15.05
FEV1/FVC	8.627		

Table 4. Raw Data for each patient between visits, including the coefficients of variation.

Patient	Pifr 1st visit (1/sec)	Pifr 2nd visit	Coeff Of var. %	Pev1 1st visit (1/sec)	Pev2 2nd visit	Coeff Of var. %
A	2.33	3.11	28.68	3.22	3.03	6.08
B	3.76	3.96	5.18	3.42	3.35	2.07
C	2.7	2.4	11.76	2.44	3.12	24.46
D	2.53	3.38	28.76	3.37	3.79	11.73
E	4.04	4.3	6.24	3	3.57	17.35
F	4.61	5	8.12	2.45	2.4	2.06
G	2.42	4.01	49.46	3.07	2.94	4.33
H	5.42	5.1	6.08	2.85	2.73	4.3
I	3.2	3.07	4.15	3.82	3.71	2.92
J	5.15	5.26	2.11	3.57	3.99	11.11

as the patient fatigues, airflow rate may actually increase, despite the decrease in pressure differences, because with less effort there is less alar collapse.

The reproducibility of a test is defined by its measurement error and biological variability. Nasal decongestion minimises the normal biological variability, and therefore our study truly identifies the variability of the test day to day. The nasal cycle is known to vary the resistance of each nasal fossa ten fold, with the total nasal resistance being relatively constant (Jones et al., 1991) Nevertheless, total nasal resistance may vary twofold over time and decongestion minimises this. Therefore studies not eliminating this biological variability introduce much uncertainty, and in the absence of control groups should be treated with caution. This caveat is also applicable to those studies comparing rhinomanometry to peak flow but which fail to decongest the nasal mucosa.

PIFR and FEV1 are the best rhinologic measures and therefore the use of simple peak flow devices to assess nasal function is justified in this aspect. Other investigators have used various electronic (Youlten flow meter, microspirometer, micromed spirometer) and mechanical devices (Wright and mini-Wright Flow meter) and these have the advantage of being portable and quick to use. However, this makes it difficult to compare studies using different techniques. The spirometer used in this study is a sophisticated piece of equipment which is calibrated each day prior to use. It is readily available in all respiratory laboratories and as such is a well established and validated tool of respiratory medicine, with internationally agreed protocols and standards of data acquisition. It is clearly the gold-standard measure of peak flow and we would commend this tool in future studies. Other flow meter devices which can be calibrated may serve as reasonable substitutes, and in this context it is reassuring that both Holmstrom et al. (1990) and Jones et al. (1991) demonstrated very good correlation between peak flow measures and active anterior rhinomanometry. However, these simpler devices may miss more subtle changes and such studies may therefore be prone to type II errors. Their convenience makes them an attractive clinical tool, but as a research tool, logically they are likely to be inferior to a formal spirometer. This may explain why Clark and Jones found the Youlten meter to be an insensitive instrument when compared to rhinomanometry, where as Davies in his study using a vitalograph was able to clearly demonstrate changes in nasal flow on intranasal histamine challenge over time (Clarke and Jones, 1994; Davies, 1978).

The chest is the driving force for nasal airflow, and the consideration of individual lung function should logically improve upon the repeatablity. Oluwole et al. (1997) found improvement on the reproducibility of peak inspiratory flow using a naso-oral index, but we were only able to demonstrate a gain in repeatability for FET, and for the other three most significant measures the use of a naso-pulmonary index was deterimental. Frolund and colleagues (1987) were unable to demonstate any correlation between posterior rhinometry and the naso-oral (Naso-pulmonary) index. Davies (1978) found his nasal patency index (the ratio of FIV 0.5 through the nose and mouth) to be reproducible, but this was over a one hour period only and he did not show this derived variable to be more useful than a simple pure measure. We conclude that the use of a naso-pulmonary index is not recommended in healthy patients, although it may be more useful in those patients who have lower airways disease, where the peak flow is limited.

It is surprising that PIFR is more reproducible than PEFR (and FEV 1- using Spearman's correlation coefficient) since nasal valvular collapse results from the Bernoulli effect on the nasal vestibule during forced inspiration. This may be overcome by conscious flaring of the nares, which was observed in a few of our subjects. The use of alar splints may improve upon repeatability. In addition, expiratory parameters were better than inspiratory ones for lung function, and one would expect nasal spirometry to mirror pulmonary spirometry. FEV 1 is therefore probably the best reproducible overall spirometric parameter, although we have not conclusively shown this, with an inter-visit coefficient of variation of 8.64%. This is comparable to the studies of Cho and co-workers (1997) who found a portable microspirometer to have a coefficient of variation of 12.1% for PIFR readings. Likewise, Shelton and colleagues (1985) reported a coefficient of variation of 9.8% for PIFR, but found anterior rhinomanometry to be the most sensitive measure, with a coefficient of variation of 6%. It is recommended that future studies should use a formal spirometer with nasal FEV 1 and PIFR as their nasal patency measures.

REFERENCES

1 Cho S-I, Hauser R, Christiani, DC (1997) Reproducibility of nasal peak inspiratory flow among healthy adults. Chest 112:1547-53.

2 Clarke RW, Jones AS (1994) The limitations of peak nasal flow measurements. Clin Otolaryngol 19: 502-504.

3 Davies, H J (1978) Measurement of nasal patency using a vitalograph. Clinical Allergy 8: 517-523.

4 Enberg RN, Ownby DR (1991) Peak nasal inspiratory flow and Wright peak flow: a comparison of their reproducibility. Annals of Allergy 67:371-374.

5 Fairley JW, Durham LH, Ell SR (1993) Correlation of subjective sensation of nasal patency with nasal inspiratory peak flow rate. Clin Otolaryngol 18: 19-22.

6 Gleeson M J, Youlten L J, Shelton, D M, Siodlak MZ, Eiser NM, Wengraf CL (1986) Assessment of nasal airway patency: a comparison of four methods. Clin Otolaryngol 11: 99-107.

7 Holmstrom M, Scadding GK, Lund VJ, Darby YC (1990) Assessment of nasal obstruction. A comparison between rhinomanometry and nasal peak inspiratory peak flow. Rhinology 28: 191-196.

8 Jones AS, Viani, L, Phillips D, Charters P (1991) The objective assessment of nasal patency. Clin Otolaryngol 16: 206-211.

9 Larsen K, Oxhoj H, Grontved A, Kristensen S (1990) Peak flow nasal patency indices in patients operated for nasal obstruction. Eur Arch Otorhinolaryngol 248:21-24.

10 Morrissey MSC, Alun-Jones T, Hill J (1990) The relationship of peak inspiratory airflow to subjective airflow in the nose. Clin Otolaryngol 15, 447-451.

11 Oluwolfe M, Gardiner Q, White P S (1997) The naso-oral index: a more valid measure than peak flow rate? Clin. Otolaryngol 22:346-349.

12 Shelton D M, Youlten LJF, Chan TB (1985) A comparison of three methods of assessing nasal airway response to topical histamine. Thorax 40:216

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ANNOUNCEMENT

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While working on the project the fellow may attend activities in the Department (Head Prof. Dr G.J.Hordijk). Optional visits to other Dutch University ENT clinics may be arranged.

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