
Summary
Peak nasal inspiratory flow rate is a simple, cost effective and reliable objective measure of airflow obstruction. This is a sensitive test and correlates closely with patients’ symptoms of blockage and other measures of nasal airway function. Peak inspiratory flow rate has been used to evaluate medical and non-medical therapies and also as an outcome measure in nasal challenge testing. Nasal / Oral flow ratios have also been developed in order to account for the influence of lower airway function on peak nasal inspiratory flow and to increase the sensitivity of the test.

Importance of Nasal Disease
Allergic rhinitis is an inflammatory condition of the upper airways, which has an increasing incidence throughout the western world\(^1,2\) and occurs in up to 20% of the population\(^3\). Although it does not have an associated mortality it causes distress and impaired quality of life in sufferers. This results in decreased productivity and potentially absenteeism from work or schooling\(^4\). Surgical causes of airflow obstruction are also areas of increasing interest due to the development of minimal access surgery.

Subjective vs Objective
The assessment of treatment response in any condition can either be through subjective or objective measures. Subjective assessment has the advantage of reporting treatment response from the patient’s point of view and therefore can be considered to be the most important endpoint, at least in the short term. However, they tend to be qualitative in nature and therefore standardised symptom scoring systems have been developed and validated\(^5\). Objective measures have the advantage of being quantitative and are devoid of emotional influence. An optimal objective measure is repeatable, simple to perform, non-invasive, inexpensive, and results influence treatment response or disease activity.

Measures of Nasal Obstruction
Nasal airflow obstruction is an important component of the allergic rhinitis syndrome\(^6\), and of structural nasal abnormalities. Nasal blockage causes distress to patients, exacerbation of lower airways disease due to mouth breathing and facial pain and headaches from sinusitis if the sinus ostia are involved.

Both acoustic rhinometry and rhinomanometry are recognised to be sensitive and reliable methods in assessment of nasal obstruction\(^7,9\). Acoustic rhinometry has been validated using high resolution computerised tomography scanning and magnetic resonance imaging\(^8,10\). However these measurements require trained personnel and technical difficulties have been acknowledged. For example, with acoustic rhinometry artefacts may arise from positioning the probe and from acoustic leaks at the nostril\(^11\). Measurements made beyond the posterior end of the nasal septum are less reliable\(^9,12\). Anterior rhinomanometry is easy to perform although involves making a seal around one nostril at a time. Posterior rhinomanometry, although having the advantage of
assessing total nasal resistance, is also technically difficult to perform and may be impossible in some patients.

Just as peak expiratory flow rate has been used as a measure of disease control in asthma\(^{(15)}\), investigators have used nasal flow to assess upper airways function. Nasal peak expiratory (nPEFR) and inspiratory flow rate (nPIFR)\(^{(14,15)}\), and nasal peak inspiratory and inspiratory volume in 1 second have been used\(^{(16)}\). nPIFR is considered to be a better measure than nPEFR as nPIFR is usually restricted by nasal flow limitation\(^{(17)}\), and avoids expelling nasal secretions, although both measures correlate closely\(^{(14)}\). In 1980, Youlten\(^{(18)}\) developed a peak nasal inspiratory flow meter, which was non-invasive and had the advantages of simplicity, portability and economy.

The repeatability of nPIFR has been shown to be sufficiently good to be used in epidemiological studies\(^{(19)}\). The coefficient of variation has been calculated at 8%, which equates to a change of 19 l/min being adequate to detect a clinically relevant alteration in response in the laboratory setting (unpublished data). However, Enberg and Ownby showed that the response to treatment was less than the variation in the test\(^{(20)}\).

Assuming adequate co-operation, nPIFR can be used in children as well as adults\(^{(21)}\), and studies with children have shown a linear increase in nPIFR with age, height and weight\(^{(22)}\).

**Relation to Rhinomanometry**

Studies have shown good correlation with nPIFR and rhinomanometry when altering nasal patency with allergen or histamine nasal challenge in the laboratory\(^{(14,23,24)}\). Jones et al\(^{(25)}\) compared anterior and posterior rhinomanometry with different indices of nasal and oral flow (including nPIFR, oral PEFR, nasal FEV\(_1\), and oral FEV\(_1\)) and showed that anterior rhinomanometry had the closest correlation with nPIFR \((r=-0.678\ \ p=0.000)\). However it is considered that changes with rhinomanometry are greater than those of nPIFR\(^{(17,26)}\).

**Relation to Symptoms**

Clinical examination and anterior rhinometry have been shown to correlate poorly with patients subjective sensation of upper airway patency\(^{(27,28)}\). Gleeson however showed that nPIFR \((r=0.54)\) had a closer correlation with the sensation of nasal blockage, after increasing and decreasing resistance with histamine and cocaine respectively, compared to anterior \((r=0.47)\) and posterior rhinomanometry \((r=0.45)\). Significant correlations were also seen in a longitudinal study in healthy volunteers\(^{(29)}\), and in terms of morning and evening results in patients with seasonal allergic rhinitis\(^{(30,31)}\). However, Panagou et al\(^{(32)}\) showed poor correlation between patient’s symptoms and nPIFR.

**Evaluation of Medical Therapy**

Several studies have assessed the efficacy of intranasal corticosteroids in patients with nasal polyposis using nPIFR\(^{(33-36)}\). Each showed a significant increase in nPIFR, which was accompanied by subjective improvement of nasal blockage, and in most cases an associated reduction of nasal polyp size. Studies in patients with seasonal and perennial allergic rhinitis have also shown significant treatment response in patients using nPIFR\(^{(21,30,37-39)}\).
The disease severity in seasonal allergic rhinitis varies over a short-term basis and therefore it has been suggested that the use of domiciliary peak inspiratory measurements may be more informative than one-off clinic measurements of rhinomanometry\(^{(38,30)}\). This can be considered similar to the use of daily peak expiratory flow rate when monitoring asthma control.

**Evaluation of Non-Medical Therapy**

Lund and Scadding\(^{(41)}\) performed a study evaluating objective measures of endoscopic sinus surgery, which showed that neither nPIFR nor rhinomanometry significantly improved following the operation, despite subjective improvements in nasal blockage. However Marias et al\(^{(42)}\) showed improvements in nPIFR after septoplasty, as did Cook et al\(^{(43)}\) after laser therapy for rhinitis. nPIFR has also been utilised to evaluate the effectiveness of nasal splints when used in the management of alar collapse, which is an important cause of airway flow limitation at high inspiratory velocities\(^{(44)}\).

**Outcome Measure in Allergen Challenge**

Terrien et al\(^{(45)}\) used nPIFR (along with acoustic rhinometry and symptoms) as an endpoint in determining the reaction threshold of nasal allergen challenge. In another study using both acoustic rhinometry and nPIFR response to allergen challenge a reaction threshold (a 26% change) was achieved by all patients with nPIFR\(^{(46)}\). With nasal allergen challenge, Scadding et al\(^{(47)}\) found a significant reduction in nPIFR, worsening of symptom scores and increase in nasal lavage histamine and prostaglandins. Hellegren et al\(^{(48)}\) found nPIFR to be more sensitive than rhinomanometry or acoustic rhinometry with histamine challenge in patients with seasonal allergic rhinitis out with the pollen season. Intranasal fluticasone propionate has been shown to exhibit a 37% and 96% reduction in nPIFR in the early and late phase response respectively in nasal allergen challenge\(^{(49)}\). nPIFR has also been used during nasal aspirin\(^{(50)}\) and hexahydrophthalic anhydride challenge\(^{(51)}\). However recent guidelines on nasal provocation challenges suggested that nPIFR was less accurate than rhinomanometry\(^{(52)}\).

**Nasal Oral Index**

Peak nasal inspiratory flow rate is determined by nasal obstruction and by the maximum negative pressure generated from the lower respiratory tract. Changes in either inspiratory effort or lower airways resistance will alter the peak nasal inspiratory flow independently of nasal obstruction. Phagoo et al\(^{(17)}\) increased intra thoracic airways resistance with histamine challenge and showed misleading results with nPIFR during nasal challenge especially if patients had high baseline nasal conductance. For this reason, methods of correcting for respiratory function have been developed. Taylor et al\(^{(15)}\) suggested a blockage index (peak oral flow minus peak nasal flow divided by peak oral flow) and showed this to compare well with rhinometry. This index has been used by other authors\(^{(19)}\). Larsen et al\(^{(53-55)}\) developed peak expiratory and inspiratory nasal patency indices (the ratio of nasal to oral flow rate) which correlated with subjective response to septoplasty. Also in surgical patients, the ratio of forced inspiratory volume in one second through the nose and mouth has been shown to correlate better to symptoms of nasal blockage than nasal forced inspiratory volume in 1 second\(^{(56)}\).

**Limitations**


There are several limitations of peak nasal inspiratory flow rate. It does not seem as sensitive as, for example, rhinomanometry (13). In a study with histamine challenge, small changes in airway resistance with low dose histamine were detected with rhinomanometry but not by nPIFR (57). At very low flow rates (<30 l/min) nPIFR may not be possible and assessment should be made with rhinomanometry. Furthermore, no information is obtained regarding the structure of the nose or the location of nasal obstruction with nPIFR, as is the case with acoustic rhinometry. nPIFR is also patient dependant, like spirometry, and requires a maximal effort by the patient. However, peak nasal inspiratory flow seems to be an inexpensive, simple and portable test, which is reproducible and sensitive, correlates well with symptoms and enables the clinician to determine changes in response to medical and surgical therapy.

Reference List


18. Youlten LJ. The peak nasal inspiratory flow meter: a new instrument for the assessment of the response to immunotherapy in seasonal allergic rhinitis. Allergol immunopathol 1980;8:344


