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Comparison of rhinometric measurements methods in intranasal pathology*

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SUMMARY

The objective of this study was to determine how well different rhinometric measurement methods identify intranasal changes during acute viral rhinitis. A total of 69 patients acutely ill with the common cold were examined. Acoustic rhinometry (AR), rhinomanometry (RMM), nasal PEF (nPEF) and Visual Analogue Scale (VAS) recordings were performed before the subjects became ill and after the onset of the infection, on days 3 and 10. In AR the minimal cross-sectional area and nasal cavity volumes decreased in a statistically significant manner during the early stage of infection (20.0% vs. 20.4% lower than baselines), and at the end of the infection the values were normalizing towards the baseline values, although still 7.2% vs. 10.4% lower than baselines ($p < 0.05$). In RMM the total resistances during expiration and inspiration strongly increased, 39.7% vs. 41.6% higher than baselines on day 3. On day 10 the resistances were normalizing slowly but remained 34.1% and 41.5% higher than baselines ($p < 0.05$). In nPEF the decrease in rates was also seen on day 3 (25.0% lower than baseline) and recovery in rates on day 10 (only 3.1% lower than baseline, $p < 0.05$). The changes in VAS were similar to those seen in objective rhinometric measurements. Statistically and clinically significant correlations were calculated within AR parameters ($r = 0.96$) and RMM parameters ($r = 0.98$), other rhinometric parameters did not correlate in a clinically significant manner ($r < 0.40$). We concluded that these 4 rhinometric methods support each other very well in pathological noses, and the methods employed identify intranasal changes very sensitively during an intranasal mucosal pathology.

Key words: acoustic rhinometry, nasal obstruction, nasal PEF, rhinomanometry, VAS

INTRODUCTION

Various rhinometric methods are widely used in clinical work. These methods are generally reliable, safe, easy to use and relatively cheap following equipment acquisition costs. Rhinometric measurements have helped to advance modern rhinology and have increased our understanding of the complexity of the nose.

Viral-induced acute rhinitis is one of the most common upper respiratory infections found in clinical practice. Rhinoviruses are responsible for a large number of illnesses and viruses such as corona virus, influenza virus, adenovirus and respiratory syncytial virus account for a minor proportion of viral common colds (Gwaltney, 1985). Acute rhinitis, nasal obstruction and general infection signs characterize this self-limited illness. The normal duration of viral common cold is 7 – 10 days, depending on the etiology of the illness. Despite clinical asymptomatology, pathological changes in the nasal mucosae caused by the infection can still be seen after 3 weeks (Rautiainen et al., 1992). Due to these pathological changes acute rhinitis patients are most suitable for comparison study of rhinometric methods. These methods give us greater understanding of symptomatology and make it possible, for example, to measure the severity of the nasal obstruction. The most commonly used objective rhinometric methods are acoustic rhinometry (AR), rhinomanometry (RMM), nasal peak expiratory flow (nPEF) and nasal peak inspiratory flow (nPIF). The Visual Analogue Scale (VAS) is also widely used as a subjective method to assess the grade of different nasal functions.

The purpose of the present study was to determine how well AR, RMM and nPEF as objective rhinometric methods, and VAS as subjective method, could identify the pathological changes observed in nasal cavity geometry and nasal function during an acute viral upper respiratory infection, which affects the nasal mucosae. Secondly, recordings of the methods were compared with each other in healthy and pathological noses.

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MATERIALS AND METHODS

AR, RMM, nPEF and VAS were performed in 69 patients (47 females and 22 males) with acute viral rhinitis. The patients were selected on a voluntary basis from a pool of 249 previously healthy subjects from The Medical School and The Nursing College of Tampere, Finland. The exclusion criteria were any allergies, sinusitis, nasal polyps, deformities of the nose or regular use of any drug. The mean ages were as follows: females 23.7 (range 19 – 40) years, and males 23.3 (range 20 – 26) years. Before the onset of an acute viral infection all subjects of the pool underwent rhinometric measurement (AR, RMM and nPEF) and these values was used as baseline values (day 0). Two to three days after onset of the viral infection the patients began the seven-day study. Rhinometric measurements including VAS were then performed on days 3 and 10 during the infection. For all methods, changes in values were followed from healthy to pathological values and back again to post infectious status. The Tampere University Hospital Research Ethics Committee approved the study protocol and all subjects gave informed written consent.

Acoustic Rhinometry

An A1/2 acoustic rhinometry (G.M. Instr., Glasgow, UK) and program version 3.02 were used for measurements. All measurements were performed with the technique described earlier (Hilberg et al., 1989; Numminen et al., 2002). The parameters we used allowed us to analyse one local minimum cross-sectional area (MCA) and the distance (ARd) to the point from the nostril. The data also produced nasal cavity volume (NCV), which was defined as volume in the nasal cavity in the region between 20-50 mm posterior from the nostril, so called turbinate area. The measurements were made according to the guidelines recommended by the Standardization Committee for Acoustic Rhinometry (Hilberg and Pedersen, 2000).

Rhinomanometry

A Rhinomanometry NR6 (G.M. Instr., Kilwinning, UK) version 1.1 was used for measurements. The equipment consisted of a compact computer unit, a facemask and connecting tubes for the recording of both pressure and flow. The anterior active method was used and both unilateral and bilateral resistances at a radius of 200 according to Broms in a polar coordinate system were analysed (Broms et al., 1982). The technical arrangements and data calculations were made according to recommendations of the International Standardization Committee for Rhinomanometry (Clement, 1984).

Table 1. Median values of different rhinometric results during a common cold. MCA (cm^2), NCV (cm^3), NAR (Pa/l/s), nPEF (l/min) and VAS (mm). * = VAS in baseline is theoretical.

n = 138 (AR) n = 69 (RMM, nPEF)	Baseline	Day 3	Day 10
MCA	0,695	0,555	0,645
NCV	3,23	2,57	2,90
NARexp.tot.	302	422	405
NARinsp.tot.	296	419	419
nPEF	320	240	310
VAS*	0	62,5	37,5

Nasal PEF

A Mini-Wright peak flow meter (Airmed, Clement Clarke International Ltd, London, UK) connected to an anaesthetic facemask (Flexomask, UK) covering the nose and mouth were used for nPEF measurements. NasalPEF measures the maximum outflow of air from nasal cavities. The best of 3 measurements of blowing through the nose with mouth closed was recorded and used for calculations (Taylor et al., 1973).

Visual Analogue Scale

Visual Analogue Scale (VAS) was used to measure the patient's subjective degree of nasal obstruction on days 3 and 10. The obstruction was self-assessed by the patient using a 100 mm visual analogue scale. The ends of the scales were marked as completely open (0 mm) and completely obstructed (100 mm). Baseline values of the rhinologically healthy subjects were assumed to be theoretically 0 mm on day 0.

Statistics

Descriptive statistics were expressed as median values with minimum and maximum values. Comparison of changes in rhinometric values between different time points was tested with Friedman's non-parametric test. The strength and direction of a linear relationship between the different rhinometric data were tested with the Pearson correlation coefficient test. Values of p less than 0.05 were considered statistically significant. Multiple line charts and scatter plots were chosen for the graphical presentation of the results. A standard PC equipped with the statistical software packages SPSS for Windows release 10.0 and Excel 2000 for Windows was used for statistical evaluation and graphical presentation of the results.

RESULTS

Statistically significant changes in intranasal dimensions and functional parameters were measured with all the rhinometric methods used in the present study ($p < 0.05$) (Table 2). Statistically significant volumetric changes was measured with AR, MCA 20.0 % and NCV 20.4 % smaller than baselines during the early stages of the infection, and the partial recovery of nasal geometry was measured at the end of the infection, showing MCA 7.2 % and NCV 10.4 % smaller than baselines on day 10 ($p < 0.05$), (Figure 1). In RMM the total resistances strongly increased during expiration and inspiration in the infection. On day 3 the values were 39.8 % vs. 41.6 % and on day 10, 34.1 % vs. 41.5 % higher than baseline recordings ($p < 0.05$), (Figure 1). The nPEF rates reacted simultaneously with 25.0 % lower rates on day 3 and only 3.1 % lower rates on day 10 of the infection compared with baseline recordings ($p <$

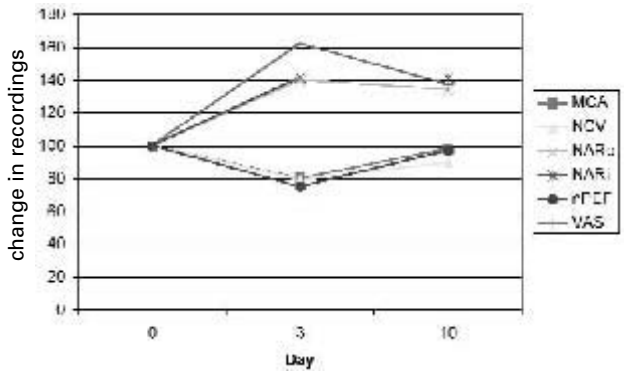

Figure 1. Changes in AR, RMM, nPEF, and VAS measurements during intranasal pathology.

Table 2. Difference between the baseline value and values on day 3 and day 10 for the all rhinometric measurements. Baseline value (Day 0) is 100 as index value. * = VAS is a theoretical change based on an assumption that VAS is 0 mm in baseline.

n = 138 (AR) n = 69 (RMM, nPEF, VAS)	Baseline	Day 3	Day 10	p-value
MCA	100	80.0	98.2	< 0.05
NCV	100	79.6	89.6	< 0.05
Rexp.tot.	100	139.7	134.1	< 0.05
Rinsp.tot.	100	141.6	141.5	< 0.05
NPEF	100	75.0	96.9	< 0.05
VAS*	100	162.5	137.5	< 0.05

0.05), (Figure 1). The VAS measurements on day 3 and day 10 also gave simultaneous results (Figure 1). The measurements obtained with AR showed statistically and clinically significant correlation between the MCA and NCV ($r = 0.96$), (Figure 2a). MCA and NCV comparison with other method's parameters such as unilateral and total nasal airway resistance (NAR), VAS, and nPEF showed statistical significance but not clinical significance, $r < 0.40$, $p < 0.05$. RMM also showed a statistically and clinically significant correlation between the expiratory and inspiratory NAR ($r = 0.98$). Total NAR values compared to VAS and nPEF also correlated in a statistically but not clinically significant manner, $r < 0.40$, $p < 0.05$, (Figure 2b).

DISCUSSION

The rhinometric measurement techniques and methodological principles are well known and are well described in earlier published material. The methods have gained increasing popularity among clinicians due to their simplicity and non-invasive nature. Despite the commonness of the methods, many questions remain. In most of the study settings the simultaneous use of several methods is a rarity. Most often only one of these methods is used in studies, e.g. in evaluation of rhinosurgery patients. Rhinometric methods describe the nasal geometry and function very easily and reliably and therefore should be used more often in clinics. In the present study we chose to simultaneously use AR, RMM, nPEF and VAS in rhinometric measurements. The nPIF is also a valuable measurement and widely used tool in rhinology, having several advantages compared with the expiratory flow rate meter especially in studies where large amounts of intranasal secretion are produced (Youlten, 1980). In the present study we were more interested in the effect of mucosal changes on rhinometric measurements, and to avoid the effect of the valvular area we chose nPEF instead of nPIF.

The patients in this study were previously healthy subjects who became ill with viral-induced acute rhinitis. Symptomatology of the common cold is very similar irrespective of viral etiology. One of the main symptoms of the common cold is nasal obstruction; in the present study the grade of obstruction was measured and described with 4 different methods through an episode of acute mucosal disease in the nasal cavities (Figure 1). When considering on the nature of an upper respiratory infection and the damage observed in the nasal mucosae, it is assumed that the intranasal geometry and function should be changed in the following way: the NCV and MCA should be smaller, the resistance during expiration and inspiration should be higher and expiratory flow rate

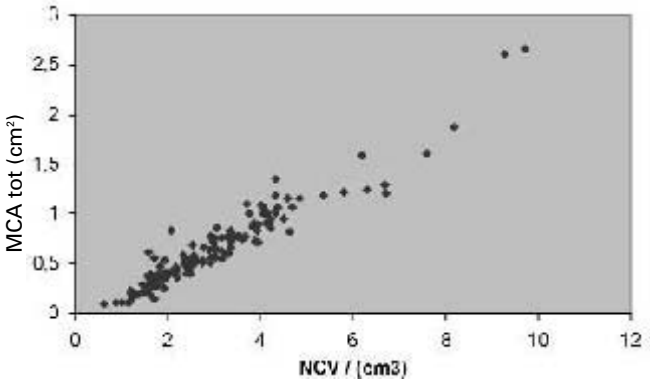

Figure 2a. Correlation between MCA and NCV on day 3.

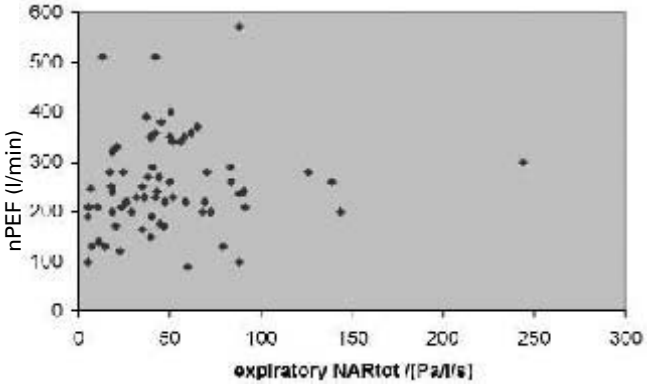

Figure 2b. Correlation between nPEF and expiratory total NAR on day 3.

should be lower during an acute infection. These changes are based mainly on the swelling of the nasal mucosae and increased quantity of nasal secretion that occurs during an upper respiratory infection. All changes should also normalize during the healing process and eventually achieve original values. In the present study these intranasal changes are, for the first time in the literature, reported simultaneously with 4 different methods. Despite patient recovery from viral respiratory infection the changes in nasal mucosae are still found as documented in an earlier study using electron microscopy (Rautiainen et al., 1992). An interesting detail is that 10 days after the onset of viral infection the rhinometric methods can also reveal that the nasal mucosae are not completely healed. All methods showed abnormal values on day 10 when the clinical signs had subsided, a finding observed in all patients.

The agreement between these rhinometric methods was also tested in healthy and pathological nasal cavities. In our earlier study the different rhinometric methods appeared to show a quite weak correlation with each other in healthy subjects (Numminen et al., 2002). The 4 methods measured independent parameters in healthy noses, which described intranasal geometry and nasal function. The separate parameters did not describe the healthy nose very precisely due to extensive individual variations. In the present study, however, these methods identified the changes in mucosal pathology extremely well. Differences between the methods were seen and 2 observations were made: the recovery of the values appeared to be slower in RMM than in AR between days 3 and 10 and, it appeared that the subjective sensation of nasal blockage measured with VAS decreased faster than the recovery of nasal stuffiness measured with objective rhinometric methods (RMM and nPEF). The changes measured with these methods correlated and supported each other better than in healthy subjects (Table 2). Therefore, in rhinological disorders it is crucial to measure the rhinometric values at different time periods, so that the progress of intranasal pathology can be followed with a reliable degree of accuracy. The accuracy of measurements increases when more than one rhinometric measurement method is used simultaneously in clinics.

The sources of errors in the results in this study may be caused by a "nasal cycle" and unilateral obstruction of the nasal cavity during an upper respiratory infection. Understanding of the "nasal cycle" is still very confusing and there is a very little evidence for any true periodicity (Flanagan and Eccles, 1997). The alternating "nasal cycle" happens only in 13 % of individuals reported by Gilbert and Rosenwasser by their most stringent criteria. Furthermore, the periodicity of this cycle is seen to vary between the individuals and between tests in the same individuals (Gilbert and Rosenwasser, 1987). During the rhinometric measurements the "nasal cycle" may vary, but with the possible incidence being about 13 %, the error introduced in the measurements is very little. The unilateral obstruction of the nose may also be found in patients with common cold and when rhinometric methods are compared it may affect the results, and should be taken account in further studies.

We concluded that the rhinometric methods should be used simultaneously in clinical practice in patients with intranasal mucosal pathology. Occasional measurement with the methods does not give enough information and therefore it is also recommended that 2 or more measurements in the same patient be made at different times. The methods are sensitive enough to recognize the intranasal mucosal changes, and measurements support each other better in pathological noses than in healthy subjects.

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