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Prediction of nasal obstruction based on clinical examination and acoustic rhinometry*

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SUMMARY

The aim of this study was to find variables which characterize nasal obstruction. Scores from the clinical history, anterior rhinoscopy and objective values from acoustic rhinometry were found of importance. In a randomly-selected adult population of 230 individuals, 14% had the subjective feeling of nasal obstruction. The variables of significant value to predict nasal obstruction were: (1) symptoms of hypersensitivity/allergy and infection; (2) anterior septal deviations; and (3) small anterior dimensions of the nasal cavity. A minimum cross-sectional area (MCA) equal to 0.50 cm^2, a cross-sectional area at the piriform aperture of 0.70 cm^2 and a large effect of decongestion at MCA were found to be the best variables to separate obstructed from normal noses. Also, differences between each side of the nose were found of predictive value. In conclusion, a nose at risk for nasal obstruction is one with symptoms of allergy, frequent infections, small dimensions anteriorly, large difference between both sides, and a large degree of swelling of the mucosa.

Keywords: nasal obstruction, acoustic rhinometry.

INTRODUCTION

The feeling of nasal patency is known to be influenced by the nerve supply in the vestibulum and the nasal cavity (Eccles, 1983; Jones et al., 1987; Clarke and Jones, 1992), by the dimensions of the anterior nasal segment, the *ostium internum* and the piriform aperture (Haight et al., 1983; Naito et al., 1988; Grymer et al., 1989), and by changes in the rhythm of the nasal cycle (Hasegawa et al., 1979).

Nasal obstruction, defined as the feeling of impaired nasal patency, is a subjective parameter. The aetiology of the obstruction and the treatment strategy are mainly based on clinical history and rhinoscopy and, if available, on objective methods. Lund (1991) has stressed the importance of a battery of objective methods as a basis for evaluation of the results of a given treatment.

Acoustic rhinometry was introduced (Hilberg et al., 1989) as a new objective method that, based on sound reflection, gives information about the dimensions of the nasal cavity. It has been proved useful to show the changes induced by surgery (Grymer et al., 1989, 1993, 1995, 1996; Hilberg et al., 1990) and to follow the effect of nasal provocation and allergy treatment (Hilberg et al., 1995). Normal values in Caucasians (Grymer et al., 1991) have been published.

The purpose of this study has been to describe factors of predictive importance in the evaluation of nasal obstruction in a randomly-selected adult population sample. The study was based on information from a rhinologic questionnaire, rhinoscopy, and acoustic rhinometry.

MATERIAL AND METHODS

Individuals studied

A random population of 230 individuals entered the study. They were randomly drawn from the municipal register. They were chosen from a group participating in a nose-irrelevant study and therefore were unbiased concerning nasal complaints. The mean age was 35 years (range: 18-73 years). There were 118 males (mean height: 179 cm [range: 150-204 cm]; mean weight: 80 kg [range: 50-123 kg]) and 112 females (mean height: 167 cm [range: 150-192 cm]; mean weight: 60 kg [range: 36-102 kg]).

Methods

A questionnaire (Table 1) was designed with questions concerning: (1) the environment at home and at work; and (2) nasal mucosa complaints related to allergy/hypersensitivity and infections. A score was calculated for the environment (at home: “homescore”; at work: “workscore”) and also a score for abnor-

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Table 1. Questionnaire and score calculation.

questions	scores
home: carpets? pets? high humidity? high temperature?	*home score:* 1 point is given for a positive answer of each question: carpets, pets, high humidity, high temperature
work: dust? smoke? high humidity? high temperature? Nose and work connected complaints?	*work score:* 1 point is given for a positive answer of each question
hypersensitivity/allergy, mucosa factor: abundant clear secretion? daily sneezing? itching? eye-symptoms?	*allergy score:* 1 point is given for a positive answer of each question
infections (chronic rhinitis/sinusitis): more than 3 colds per year? duration longer than 2 weeks? purulent secretion present?	*cold score:* 1 point for a positive answer to each question
feeling of nasal obstruction?	yes/no answer (1 point for yes, otherwise 0)
diminished sens of smell?	yes/no answer
headache?	yes/no answer
mouth-breathing	yes/no answer
snoring	yes/no answer
mouth dryness in the morning	yes/no answer
smoking	yes/no answer

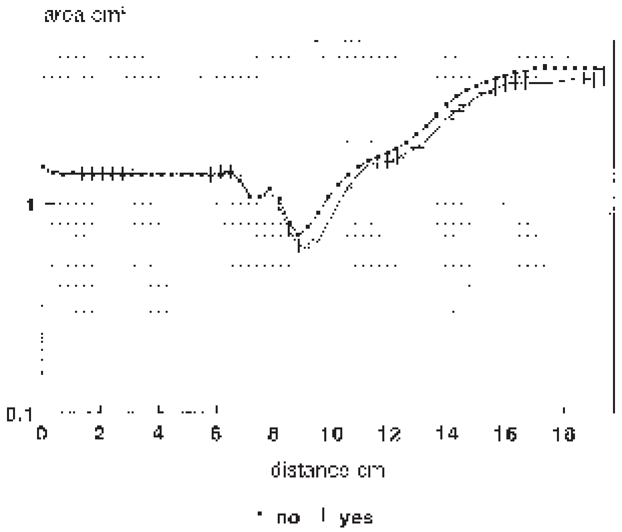

Figure 1. Mean acoustic rhinometry curve in individuals with feeling of nasal obstruction and in individuals with subjective normal feeling of nasal patency.

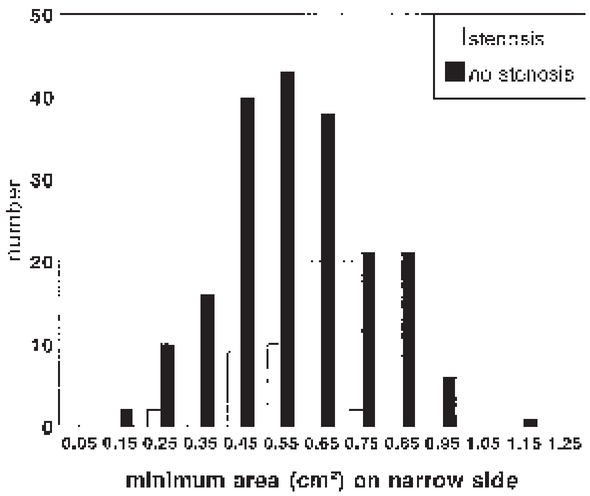

Figure 2. Distribution of values of the minimum cross-sectional area of the narrow side of the nose in individuals with (no stenosis) and without (stenosis) subjective normal nasal patency.

malities of the nasal mucosa ("allergy score" plus "infectious score" equals "cold score"). Adverse influence was expected with high score values. Single questions (with "yes" or "no" answers) about subjective feeling of nasal obstruction, mouth-breathing, snoring and mouth dryness in the mornings.

Anterior rhinoscopy determined if there were septal deviations and in that case their location. Anterior deformities were located at (or anterior to) the anterior edge of the inferior turbinate. Posterior deformities were those located posteriorly to that region (Grymer et al., 1989).

Acoustic rhinometry (GJ Electronics, Skandenborg, Denmark) was done before and 15 min after decongestion. Maximal decongestion was obtained by flushing the nasal cavity with 0.12% ephedrine, followed by two sprays of xylometazoline hydrochloride (0.5%) at the top and bottom of each nasal cavity. Each measurement was repeated 3 times, alternating from side to side. A nosepiece of the conical type, with either a 10- or 12-mm internal diameter, was used. Each side of the nose was studied separately and the sides were analyzed not as right and left but as the smallest and the widest side, and we analyzed the minimum cross-sectional area (MCA), and cross-sectional areas at 3.3 cm (CA-3.3) and at 4.0 cm (CA-4.0) from the end of the nosepiece. The degree of swelling of mucosa at these areas was calculated as the difference between values for decongested and non-decongested states.

The volume of the nose was obtained by integration of the area-distance curve between the end of the nosepiece and 7.2 cm posteriorly. Total values were obtained as the sum of both sides of the nose.

Statistics

Using stepwise logistic regression analysis a model describing nasal obstruction with subjective nasal obstruction as the dependent variable was created. Different models were examined and a specific model was chosen, based on an optimum of predictability of the model and a reasonable (limited) number of variables. The variables included were mouth-breathing, mouth dryness in the morning, anterior septal deviation, allergic symptoms (allergy score), infection symptoms (cold score), non-decongested MCA, effect of decongestion at MCA in the smallest side, and difference of non-decongested CA-4.0 between sides. Secondly, the relation between the single variables in the model and the feeling of nasal obstruction was examined. The single-variables' predictive values were determined. The predictive variable was described by its sensitivity (tp/[tp+fn]) and specificity (tn/[fp+tn]) where *tp* is truely positive, *fp* is false positive, *tn* is truely negative, and *fn* is false negative. The relative risk (RR) for each variable was calculated as: RR=(tp/[tp+fn])/(fp/[fp+tn]). Based on the predictive variable from the regression analysis a critical value (the value that separates the obstructed from the normal noses with the highest degree of significance) was found for each relevant variable.

RESULTS

Thirty-two subjects had subjective feeling of nasal obstruction (Table 2), bilateral and shifting obstruction in 27 subjects, and unilateral in 5 subjects. From the questionnaire (Table 3) the symptoms of mouth-breathing, mouth dryness in the morning, allergy/hypersensitivity and frequent nasal infections were highly predictive of nasal obstruction. Diminished sense of smell and bad home-environment were significant. Anterior septal deviation was predictive of nasal obstruction, while posterior deviations, i.e. crests and spurs, were independent of anterior deviations and not related to nasal obstruction. The relative risk for nasal obstruction was 12.5 times higher in cases with symptoms of allergy/hypersensitivity. In cases with symptoms of infection RR was 4.2 times higher, and if an anterior septum deviation was present RR was 3.1 times higher. The significantly predictive variables were all variables related to dimensions of the anterior part of the nose.

In the narrow side of the nose (Table 4) the minimum cross-sectional area (MCA) before decongestion, large effect of decongestion at MCA and small CA-3.3 before and after decongestion were predictive of nasal obstruction. A large difference of the MCA, CA-3.3, CA-4.0 and volume before decongestion, between the widest and narrowest side of the nose was also of predictive value (Tables 5 and 6). A small total CA-3.3 decon-

Table 2. Frequency of nasal obstruction, rhinoscopic findings, respiratory habits and snoring in 230 adults.

complaint	No.	%
nasal obstruction	32	14
anterior septal deviation	41	18
posterior septal deviation	123	54
nose breathing	161	70
mouth-breathing	28	12
breathing mode unknown	41	18
snoring	55	24
mouth dryness in the morning	34	15

Table 3. Nasal obstruction and predictive variables from questionnaire and rhinoscopy. Calculated are the relative risk (RR) and the interval of confidence (IC) of each variable.

predictive variable	RR	IC
bad home environment (high home score)	2.5	1.1-5.5 (p=0.01)
hypercensitivity/allergy (high allergy score)	12.5	5.1-31 (p=0.000)
frequent and long-lasting colds (high cold score)	4.2	1.8-10 (p=0.000)
habitual mouth-breathing	4.5	1.9-11 (p=0.000)
mouth dryness in the morning	11.9	4.1-35 (p=0.000)
diminished sense of smell	2.8	1.2-6.4 (p=0.01)
anterior septal deviation	3.1	1.2-8.6 (p=0.01)

Table 4. Acoustic rhinometry variables of predictive value in relation to nasal obstruction. Narrow side of the nose. CV, critical value. RR, relative risk of obstruction if value below CV. IC, intervals of confidence, SENS, sensitivity and SPEC, specificity.

variable critical value (CV)	RR	IC	SENS	SPEC
CA-3.3 non-decongested CV=0.70 cm^2	3.6	1.7-7.8	0.50	0.78
CA-3.3 decongested CV=1.40 cm^2	3.1	1.4-6.7	0.56	0.70
MCA non-decongested CV=0.50 cm^2	2.1	1.0-4.5	0.56	0.62
MCA decongested CV=0.27 cm^2	2.2	1.0-4.8	0.59	0.60

MCA = minimum cross-sectional area; CA-3.3 = cross-sectional area at 3.3 cm from nostrils.

Table 5. Acoustic rhinometry variables of predictive value in relation to nasal obstruction. Differences between wide and narrow side of the nose. CV, critical value, RR relative risk of obstruction if value below CV. IC, intervals of confidence. SENS, sensitivity and SPEC, specificity. Model, values from the multivariate approach.

variable critical value (CV)	RR	IC	SENS	SPEC
CA-3.3 non-decongested CV=0.50 cm^2	2.4	1.1-5.0	0.53	0.67
CA-4.0 non-decongested CV=0.60 cm^2	3.3	1.5-7.1	0.56	0.72
MCA non-decongested CV=0.20 cm^2	3.3	1.5-7.2	0.59	0.70
Volume CV=3.00 cm^3	2.8	1.3-6.1	0.46	0.76
Model	6.3	4.3-9.2	0.87	0.86

Table 6. Dimensions of the nasal cavity of 198 individuals with subjective normal feeling of nasal patency. Values of narrow and wide side of the nose and total values (sum of narrow and wide side) in men and women versus MCA (minimum cross-sectional area), CA-3.3, and CA-4.0 (areas 3.3 and 4.0 cm from nostril) before and after decongestion.

	total value		wide side		narrow side	
	men mean (SEM)	women mean (SEM)	men mean (SEM)	women mean (SEM)	men mean (SEM)	women mean (SEM)
MCA non-decongested	1.37 (0.03)	1.28 (0.03)	0.78 (0.01)	0.71 (0.01)	0.58 (0.01)	0.56 (0.01)
MCA decongested	1.78 (0.04)	1.64 (0.04)	0.93 (0.02)	0.85 (0.01)	0.85 (0.02)	0.79 (0.02)
CA-3.3 non-decongested	2.34 (0.08)	2.38 (0.08)	1.40 (0.05)	1.33 (0.05)	0.94 (0.03)	0.99 (0.03)
CA-3.3 decongested	3.88 (0.11)	3.99 (0.12)	2.14 (0.06)	2.11 (0.08)	1.74 (0.06)	1.87 (0.06)
CA-4.0 non-decongested	2.96 (0.09)	2.98 (0.08)	1.75 (0.06)	1.71 (0.05)	1.21 (0.04)	1.27 (0.03)
CA-4.0 decongested	5.22 (0.11)	5.04 (0.13)	2.81 (0.07)	2.69 (0.08)	2.41 (0.06)	2.34 (0.07)

SEM: standard error of the mean

gested and the effect of decongestion on the total MCA were of predictive value.

Concerning the dimensions of the nose, the relative risk for the sensation of nasal obstruction was 2-4 times for dimensions under the critical value. The sensitivity of each single acoustic rhinometry variable as evaluated by univariate analysis was about 0.50 and the specificity was 0.60-0.79 (Tables 4-5). A multivariate approach was established (Table 5) including the variables: mouth-breathing, mouth dryness in the morning, nasal allergy and infection symptoms, anterior septum deviation, MCA non-decongested, effect of decongestion at MCA in the smallest side and difference of CA-4.0 between widest and narrowest side; evaluated by multivariate analysis the sensitivity became 87.3 and the specificity 85.6. The relative risk for sensation of nasal obstruction increased to 6.25 (IC=4.25-9.18).

DISCUSSION

The subjective feeling of nasal obstruction is a main diagnostic problem for the rhinologist because of its frequency (80% of the rhinologic patients) and variety of aetiologies.

Questionnaires may be extensive and time consuming but they are necessary as a guideline to decide which other examinations should be done before the right treatment is chosen. Four questions in the questionnaire (Table 1) were of significant importance. Mouth dryness in the morning and habitual mouth-breathing as well as symptoms of allergy and/or nasal infections increased significantly the relative risk of nasal obstruction.

Rhinoscopy is important to evaluate gross deformities of the septum and the presence of tumours, but – although absolutely necessary – is a subjective evaluation especially of the mucosal lining.

Rhinomanometry has been used so far as the main objective method to quantitate nasal obstruction. It is a dynamic method that cannot distinguish between abnormal nasal resistance due to either skeletal or mucosal components (McCaffrey and Kern, 1979) and it gives information only about the most narrow part of the nose.

Acoustic rhinometry is a static method that provides information about the dimensions of the nasal cavity and the amount of decongestable mucosa present at different distances into the nasal cavity. Only some of the obtained values seem to be of importance in relation to nasal obstruction. Although it is known (Haight and Cole, 1983) that the main part of resistance to airflow is found at the nasal valve, it is interesting to notice that the sensation of nasal obstruction is related not only to the dimensions of the smallest side of the nose but also to differences between dimensions of both sides of the nose, to the total dimension of the area at the piriform aperture (CA-3.3), and to the effect of decongestion. All these variables are related to the nasal valve and, as we have pointed out previously (Grymer et al., 1991), we may define the nasal valve not as a point but as a region extending from the *apertura pyriformis* and anterior edge of the inferior turbinate to the *ostium internum* anteriorly. In some individuals the non-decongested MCA may represent the *isthmus nasi* and the *ostium internum* may be the decongested MCA. Genetic differences, small septal deviations or the nasal cycle may explain our findings. Nevertheless, the sensitivity and specificity are low (Tables 4-5) for each acoustic rhinometry variable when considered isolated. There is a wide range of normal values and a large overlapping between normal and obstructed noses (Figures 1-2). This is likely to be due to the fact that we have studied values from a randomly-selected population sample without severe nasal problems that may have caused consultation with a rhinologist. However, the feeling of nasal obstruction may have different aetiology and to describe nasal obstruction by a single variable does not seem justified. In the multivariate approach we include clinical symptoms, rhinoscopy findings and dimensions of the nasal cavity. Then the diagnostic accuracy increased to an acceptable sensitivity and specificity. The next step forward will be the analysis of large number of rhinologic patients.

In conclusion, we may define the nose at risk for sensation of obstruction as one with small dimensions anteriorly, large differences between both sides, large effect of decongestion, and symptoms of allergy and nasal infections.

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ANNOUNCEMENT

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