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A study to assess the usefulness of a portable spirometer to quantify the severity of nasal septal deviation*

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SUMMARY

***Introduction**: An objective measure of the severity of septal deviation would help the surgeon to select patients, and could also be used to assess the effectiveness of surgery. The aim of this study was to determine the usefulness of a portable spirometer to assess the severity of septal deviation.*

***Methods**: Six healthy subjects and 26 patients awaiting nasal septal surgery for the treatment of chronic complaint of nasal obstruction were recruited. The severity of septal deviation was calculated as a nasal partitioning ratio (NPR) determined by rhinomanometry (NPRcon) and spirometry (NPRvol). NPR is expressed as a ratio scale, where –1 equals complete left side obstruction, zero equates to equal airfow on each side of the nose, and 1 equals complete right side obstruction.*

***Results**: The spirometer proved to be useful in measuring the degree of septal deviation in terms of NPRvol (range from –0.21 to 0.20 in healthy subjects, and –0.66 to 1.0 in patients awaiting surgery). The correlation between NPRvol and NPRcon was good ($r = 0.77$, $p = 0.01$). In 20 out of 26 patients there was agreement on the side of septal deviation as determined by patient's subjective assessment and the objective assesment with spirometry.*

***Discussion**: The results demonstrate that the severity of septal deviation may be quantified in terms of a nasal partitioning ratio determined by use of a portable spirometer (NPRvol). This new measure of septal deviation may prove to be useful to the surgeon in selecting patients for septal surgery and in measuring the success of septal surgery.*

Key words: nasal septum, rhinomanometry, spirometry, septal surgery

INTRODUCTION

Subjective nasal obstruction to airflow associated with a septal deviation is a common symptom, and patients are often referred to the otolaryngologist for its correction. In a large study from Korea, where the diagnosis of nasal septal deviation was made on simple anterior rhinoscopy, the prevalence of nasal septal deformity was found to be 22.38% (Min et al., 1995). Of these patients with nasal septal deviations only 2.8% complained of subjective nasal obstruction. This suggests that most people with a nasal septal deformity on simple clinical examination do not complain of nasal obstruction. The reason for this is the importance of the anatomical location of the deviated septum. Small deviations of the septum placed anteriorly in the nasal "valve" area cause a significant increase in resistance to nasal airflow, whereas large deviations of the septum placed further posteriorly may be asymptomatic (Cole, 2000).

Another explanation for the discrepancy between clinical findings and complaints of nasal obstruction, is the poor correlation between subjective sensation of nasal obstruction and objective measurements of nasal airflow (Eccles, 1998).

The symptoms of nasal obstruction may be unilateral, bilateral, intermittent, of variable duration, or a combination of these, at different times. The cause of nasal obstruction may be a structural abnormality, mucosal disease or a combination of the two, which results in increased resistance to nasal airflow. A study based on a questionnaire found that 2-3% of a randomly selected Swedish population had nasal obstruction attributable to nasal septal deviation (Jessen et al., 1989). Simple prevalence figures are perhaps not very useful unless other factors such as inflammation of the nasal mucosa or the spontaneous changes that occur in the nasal mucosa are taken into account. It is useful for the surgeon to be able to decide the extent to which the nasal obstruction is caused by structur-

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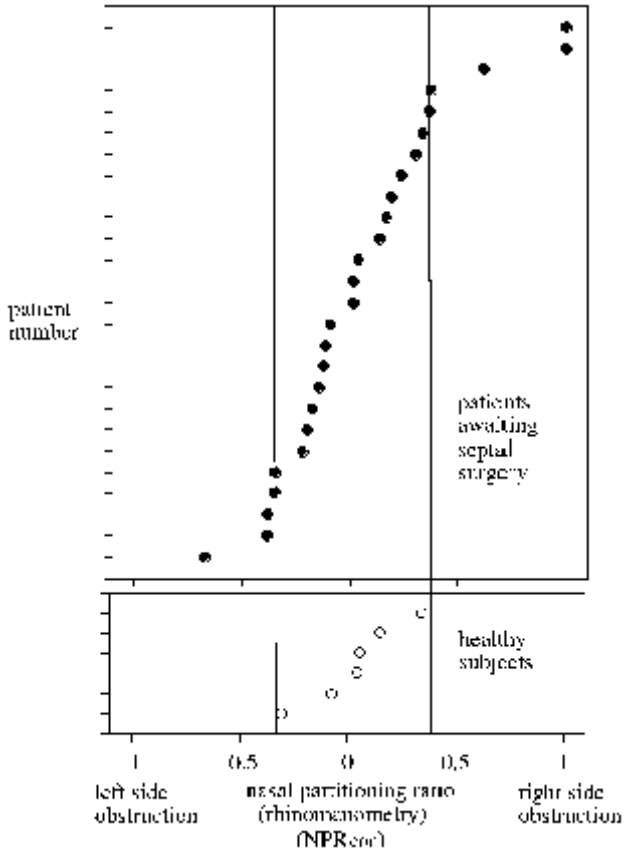

Figure 1. Nasal partitioning ratio of airflow as determined by measurement of nasal conductance with rhinomanometry (NPRcon) in six healthy subjects (open symbols) and 26 patients awaiting nasal septal surgery (filled symbols). The NPRcon ranges from −1 with complete left nasal passage obstruction, to +1 with complete right nasal passage obstruction. Measurements are plotted in ascending order. The vertical lines mark the range of NPRcon in the healthy population.

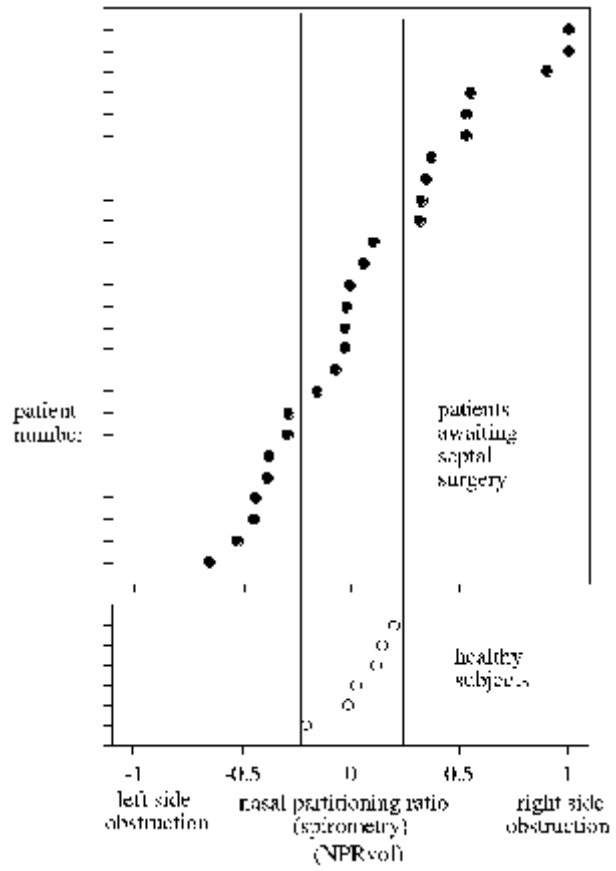

Figure 2. Nasal partitioning ratio of expired volumes of air as determined with spirometry (NPRvol) in six healthy subjects (open symbols) and 26 patients awaiting nasal septal surgery (filled symbols). The NPRvol ranges from −1 with complete left nasal passage obstruction, to +1 with complete right nasal passage obstruction. Measurements are plotted in ascending order. The vertical lines mark the range of NPRvol in the healthy population.

al factors and the extent of mucosal factors causing the symptoms. It is also important to be able to distinguish between mucosal and structural factors causing the nasal obstruction when conducting studies on nasal airflow. There is considerable variation in unilateral nasal airway resistance in healthy individuals with anatomically normal noses, caused by spontaneous changes in mucosal congestion, commonly known as the "nasal cycle" (Eccles, 2000). A simple and easy method of eliminating mucosal congestion caused by the spontaneous changes attributed to the nasal cycle or congestion caused by inflammation is by the administration of a topical nasal decongestant. A topical nasal decongestant is commonly used to eliminate any mucosal congestion when studies are performed evaluating nasal obstruction to airflow caused by fixed structural abnormalities such as a deviated nasal septum (Cole, 1997; Szucs et al., 1998). The contribution of mucosal congestion to nasal airway resistance can be assessed by measuring nasal resistance before and after the administration of a topical nasal decongestant.

A deviated nasal septum is easily corrected by surgery, and septoplasty is one of the common operations that an otolaryngologist performs. The decision to place a patient on the waiting list to correct a deviated septum by a septoplasty, is almost always based solely on the clinical history and the clinical examination. A topical nasal decongestant is not usually administered prior to making the clinical examination of the nose, and an objective measurement of resistance to nasal airflow is rarely used preoperatively, because of the limited availability of suitable equipment, and the time and expertise required to make rhinomanometric measurements. Thus there will be occasions where the major component of a patient's complaint of nasal obstruction may be mucosal factors such as rhinitis, and in such cases the treatment of the rhinitis will prove more useful than surgery. In a large prospective study from Finland, Sipila & Suonpää performed preoperative rhinomanometry on a large number of patients from their waiting list and selected only those patients with a high nasal airflow resistance and treated the remainder for rhinitis (Sipila et al.,

1997). It was found that in 25% of the patients the symptoms were secondary to rhinitis and this group was successfully treated medically, thus avoiding surgery.

Total nasal airway resistance is not a very useful criteria to use for selecting patients for septoplasty, as it is likely than many patients with a deviated nasal septum have unilateral nasal obstruction but have a total nasal airway resistance that falls within the normal range. If the purpose of septoplasty is to correct a septal deviation then the surgeon needs an objective measure of the preoperative severity of septal deviation. Such an objective measure of septal deviation would be useful in selecting patients for surgery, and would also allow the surgeon to assess the degree of success of septoplasty postoperatively.

Recent studies in this centre have demonstrated that it is possible to quantify the partitioning of nasal airflow associated with the nasal cycle by measuring the nasal partitioning ratio with a portable spirometer (Hanif et al., 2001). The aim of the present study was to investigate the use of a portable spirometer in measuring the severity of septal deviation. The measures of septal deviation obtained with the spirometer was compared with a measure of septal deviation obtained with rhinomanometry, and with the patient's subjective assessment of septal deviation.

MATERIALS AND METHODS

Patients

Twenty-six patients that were on the waiting list at local hospitals for a septoplasty or a submucosal resection of the septum, and 6 healthy subjects without any nasal symptoms were recruited for this study. The 6 six healthy subjects were examined by anterior rhinoscopy to ensure the nasal septum was in the midline. In total, therefore, 32 subjects were included in the study (28 males and 4 females; aged 18-65).

Rhinomanometry

All 32 subjects underwent measurements of unilateral nasal airway resistance by posterior rhinomanometry. Unilateral nasal airflow was measured using posterior rhinomanometry (GM Instruments NR6-2 rhinomanometer, Ayrshire, Scotland, UK) at the inspiratory reference pressure of 75Pa. Posterior nasal pressure was measured with an oral cannula. Prior to each measurement the patient was asked to gently blow their nose to clear any excess secretions. Each nasal airway was then measured whilst the opposite nostril was occluded with surgical tape. The results are expressed as unilateral and total nasal airflow at a fixed sample pressure of 75Pa, which are measures of unilateral and total nasal conductance. A mean nasal airflow for each nasal passage was calculated over 4 consecutive breaths. Patients were asked to breathe at a normal rate and depth throughout the measurement. After recording the mean of the first four breaths, the procedure was repeated and a mean recorded for the next four breaths. The measurement of unilateral nasal airflow was only accepted if the coefficient of variation between the two mean readings was less than 15%. If the coefficient of variation was greater than 15% then the procedure was repeated until a coefficient of variation of 15%, or less was achieved. If the coefficient of variation remained above 15% after 30 minutes of rhinomanometry measurements, then the patient was excluded from the study.

If it was not possible to measure unilateral nasal conductance due to complete or almost complete obstruction of the nasal airway, then the airway was deemed to have a conductance value of zero airflow. Zero conductance measurements were only accepted when the following criteria were met, (a) a severely deviated septum with no airway was seen on anterior rhinoscopy, and (b) the patient had great difficulty breathing through this nasal passage during the procedure of rhinomanometry, when the contralateral nasal passage was taped over.

The rhinomanometer was calibrated daily. Pressure measurements were calibrated using a sloping, paraffin filled, manometer and flow was calibrated using a rotameter.

Spirometry

The MIR Spirobank portable spirometer (Medical International Research, Rome, Italy) is a small hand-held device that is programmed to measure lung function parameters. For the purposes of this study, the volume of air expired through each nasal passage was recorded as follows:

Instead of the mouthpiece a plastic nasal adaptor was connected to the spirometer. This adaptor is similar to that used for studies using acoustic rhinometry.

The spirometer was programmed to record vital capacity (VC). The nasal adaptor was then placed on the nasal passage under test, covering the nostril completely with an airtight seal, so

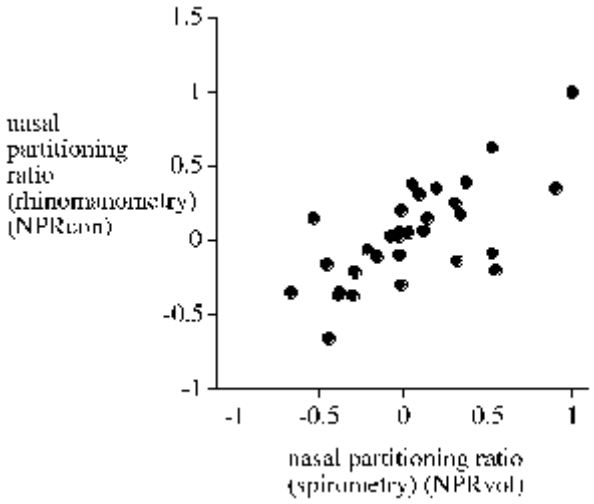

Figure 3. Correlation between nasal partitionong ratios as obtained by rhinomanometry (NPRcon) and spirometry (NPRvol). The results for 6 healthy subjecs and 26 patients awaiting nasal septal surgery are plotted ($r = 0.77$. $p = 0.01$).

that all the expired air through this nasal passage was measured by the spirometer. It is important to note that the contralateral nasal passage was not occluded. Some of the air was expired through the test nasal passage and the remainder through the other nasal passage. In other words, the subject exhaled his/her slow expired vital capacity, which was partitioned into left and right sides by the nasal septum. The expired volume through one nasal passage was measured with the portable spirometer. This procedure was repeated for the same nasal passage and the mean of the two recordings was calculated and used for the statistical analysis. The mean expired volume measurement for the contralateral nasal passage was then recorded in the same way. The expired volume measurement for the left nasal passage was always recorded before the right side. The spirometer was calibrated daily with a 1 litre precision syringe.

Nasal decongestion

Otrivine Nasal Spray (Xylometazoline Hydrochloride 0.1% w/v, Zyma Healthcare) was used as a standard nasal decongestant. This was administered to the volunteer at a dose of 2 sprays (0.3 mls) to each nostril. A period of twenty minutes was then allowed for nasal decongestion to occur before further measurements were made on the decongested nose.

Subjective assessment of septal deviation

After decongesting the nose, all participants were asked to indicate if one nasal passage was subjectively more blocked than the other by placing a tick in the appropriate left or right box on a questionnaire.

Calculation of nasal partitioning ratio (NPR)

The partitioning of airflow between the two nasal passages is expressed as a nasal partitioning ratio (NPR). The NPR can be calculated from the unilateral nasal conductance values obtained by rhinomanometry (NPRcon) and from the expired volumes obtained by spirometry (NPRvol). The NPR ranges from –1 to +1, with a value of –1 indicating complete obstruction of the left nasal passage, and a value of +1 indicating complete obstruction of the right nasal passage. When NPR equals zero there is complete symmetry of nasal airflow.

The nasal partitioning ratio NPR = L – R / R + L, where L and R relate to left and right nasal conductance measured by rhinomanometry or left and right expired volumes measured by spirometry.

RESULTS

Nasal partitionong ratio for conductance in healthy subjects and patients

The NPRcon for all healthy subjects and all patients is plotted in Figure 1. The figure illustrates that the NPRcon in healthy subjects ranged from –0.31 to 0.34, whereas in patients the range was from –0.67 to 1.0. The figure illustrates how there is overlap in the range of NPRcon in healthy subjects and patients, with 16 of the patients having an NPRcon in the same range as the healthy group.

Nasal partitionong ratio for spirometry in healthy subjects and patients

The NPRvol for all healthy subjects and all patients is plotted in Figure 2. The figure illustrates that the NPRvol in healthy subjects ranged from –0.21 to 0.20, whereas in patients the range was from –0.66 to 1.0. The figure illustrates how there is less overlap between healthy subjects and patients in the range of NPRvol obtained with spirometry, compared to NPRcon obtained with rhinomanometry. Only 8 of the patients have an NPRvol in the same range as the healthy group.

Correlation between nasal partitioning ratios as measured by rhinomanometry and spirometry

The correlation between NPR measured by rhinomanometry and spirometry is illustrated in a scatter graph in Figure 3. The correlation coefficent (r) is 0.77 (p =0.01) indicating a good agreement between the two measures of NPR.

Subjective versus objective measures of nasal partitioning of airflow

The patient was asked to indicate if one side of the nose was more blocked than the other after decongestion. The threshold used to categorise the NPRvol as left or right obstruction was –0.25 to 0.25, and therefore any values greater than 0.25 were considered as a right-sided obstruction, and values less than –0.25 as left sided obstruction. –0.25 to 0.25 was chosen as a suitable range since the range of NPRvol in the six healthy subjects was –0.21 to 0.20.

Agreement between the subjective assessments of the side of obstruction and the side of obstruction as determined by spirometry was found in all of the healthy subjects and in 20 of the 26 patients.

DISCUSSION

The results of this study demonstrate that it is possible to quantify the partitioning of nasal airflow in terms of nasal conductance measured by rhinomanometry and in terms of expired air volume measured by spirometry. Previous studies using acoustic rhinometryand rhinomanometrhave used measures of unilateral obstruction on the side of the septal deviation to quantify the severity of septal deviation and have not attempted to quantify the severity of septal deviation in terms of asymmetry of nasal airflow (Szucs et al., 1998; Pirila et al., 2001). Cases of left or right-sided nasal obstruction can be quantified in severity on a scale of 1 to –1. An interesting finding is that many of patients awaiting septal surgery have an NPR value within the same range as that of the small group of healthy subjects recruited for the study. This is the first study to attempt to quantify the degree of septal deviation so some caution is necessary in interpreting the findings, but they do

indicate that in many of the patients selected for septal surgery, the small degree of septal deviation may not be the cause of their symptoms of nasal obstruction.

The side of nasal obstruction as judged by the patient agreed with the NPRvol in 20 of the 26 patients. The lack of agreement in 6 patients may be explained by the relatively mild degree of septal deviation, making it difficult for the patient to determine the most obstructed side.

At present there is no objective measure that can be used to assess the severity of nasal septal deviation. This paper puts forward the measurement of NPRvol by means of a portable spirometer as a new measure of nasal septal deviation that may prove to be useful to the surgeon. If progress is to be made in the assessment and treatment of nasal disorders, unilateral measures of nasal function are essential (Carney et al., 2000). In a study involving unilateral measures of nasal function with rhinomanometry and acoustic rhinometry it was shown that correction of a septal deviation often caused an increased obstruction of the nasal passage contralateral to the deviation and that correction of a septal deviation could induce harmful effects (Pirila et al., 2001).

In the present study, the portable spirometer was found to be easier to use than the rhinomanometer, especially when measuring NPR in patients with septal deviation. In the patients awaiting septal surgery, one side of the nose was often found to be obstructed or completely blocked. It is not possible to measure unilateral nasal conductance by means of anterior rhinomanometry when one side of the nose is completely obstructed, and that is why anterior rhinomanometry was not used in the present study. Posterior rhinomanometry was used in the present study to measure unilateral conductance and measurements were found to be difficult when dealing with cases of low conductance or complete obstruction. This is because one side of the nose must be taped off in order to make unilateral measurements with posterior rhinomanometry. When measuring the conductance of the obstructed side of the nose, the patient must breathe through only the obstructed side, and this inevitably causes high nasal pressures that sometimes disturb the seal on the taped side of the nose.This is not the case with spirometery, as the subject breathes through both sides of the nose during measurements of NPRvol. For this reason, it is likely that the NPRvol measurements are more reliable than the NPRcon measurements of septal deviation. A perfect correlation between NPRvol and NPRcon would not be likely, because of problems with rhinomanometry when making unilateral measurements of obstructed nasal passages.

As with the interpretation of any clinical laboratory data, care is required when interpreting the relevance of NPRvol measurements. NPRvol is a measure of nasal partitioning of expired volume and this parameter does not provide any information about nasal resistance to airflow. NPRvol will be influenced by any anatomical problem that disturbs the partitioning of airflow through the nasal passages, such as the presence of a nasal polyp or nasal tumour. However, the measurement of NPRvol in patients that have been selected for septal surgery on the basis of clinical history and clinical examination, will provide an objective measure of the severity of septal deviation. Care will be needed in the case of 'S' shaped deviations as NPRvol may not be outside a normal range, but in the majority of patients selected for septal surgery, the measurement of NPRvol may provide useful objective data to the surgeon. Further studies are needed to determine the normal range of NPRvol in a population of healthy subjects without any complaint of nasal obstruction. This normal range of NPRvol could provide a useful guide to the surgeon when considering septal surgery.

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