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POSTERIOR RHINOMANOMETRIC EVALUATION OF SURGICAL TREATMENT FOR NASAL AIRWAY INTERFERENCE

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Surgical correction of nasal airway interference is a frequent subject of discussion in the surgical literature. However, it is only recently that surgeons have been challenged to use objective measures of nasal patency prior to and following surgery. The objective assessment of nasal airway patency is typically achieved by simultaneous measurement of nasal air pressure and nasal air flow. This method is called rhinomanometry and was first employed by Zwardenaker in 1889.

Rhinomanometric research has enhanced our understanding of nasal respiratory physiology. For example, the existence of the nasal breathing cycle and the nasal valves have been substantiated with rhinomanometry. More importantly, rhinomanometry has important applications for the study of normal and pathological nasal function.

Rhinomanometry techniques and the advantages and disadvantages of each have been discussed in this journal in the past (Riski, 1983, 1988). Techniques include anterior or posterior testing, active or passive testing or uninasal or binasal testing. Active, anterior testing is preferred by many clinicians because it is less complicated and most patients are easy to test. This technique allows only unilateral measures and distorts the anterior nares. Active, posterior testing is preferred by many researchers because bilateral or unilateral measures are possible. Further, there is little distortion of the anterior nares with this technique. However, Kern (1973) reported that 25% of patients could not be tested in this manner. He cited difficulty relaxing the posterior tongue. The tongue occluded the airway and prevented the necessary oral pressure measures.

Surgeons have been challenged to use rhinomanometry to justify surgery. Mygind (1980) offered the observation that just as the otologist needs audiometry pre- and post-operatively, so does the rhinologist need rhinomanometry. He further observes that rhinomanometry is used almost exclusively by writers of articles dealing with rhinomanometry. However, the surgeon who is concerned about appropriate patient selection and the functional results of surgery should use rhinomanometry as a simple matter of quality control. Warren (1984) strongly states that the risks of surgery require that the selection of such treatment should be based on tangible and measurable criteria. The assessment of structures and their function should be performed in a quantitative manner requiring reproducible data. Warren uses posterior rhinomanometry.

Responses to these challenges are now found in the surgical literature. Some studies were of the effects of single surgical procedures such as septoplasty (Broms, Jonson and Malm, 1982; Nicklasson and Lunden, 1982; Mertz, McCaffrey and Kern, 1984), while others evaluated the outcomes of multiple procedures (Courtiss and Goldwyn, 1983; Jalowayski, Yuh, Kozial and Davidson, 1983). Anterior rhinomanometry was used in each of these studies.

Purpose

The purpose of this study was to evaluate our use of active posterior rhinomanometry for the evaluation of nasal airway patency pre- and post-operatively. While it is difficult to avoid discussion of surgical technique, an evaluation of the various surgical procedures was not the primary focus of this investigation.

METHODS

Rhinomanometry

The posterior test procedure was used since it avoids distortion of the anterior nasal airway. Instrumentation for the rhinomanometric assessment included the PERCI-II (Palatal Efficiency Rating Computed Instantaneously) and its associated transducers. At the time these data were collected, the pressure and the flow signals were recorded on a General Scanning strip chart recorder. The system has now been upgraded to the Perci-PC (MicroTronics Corp., Box 399, Carrboro, NC 27510) which digitizes the analog signal for manipulation, analysis and storage on an IBM (or compatable) personal computer.

The instrumentation has been described previously (Riski, 1983), but will be detailed here for completeness. Transnasal pressure is measured via two catheters each with 1.5mm internal diameter. One catheter is placed as far posteriorly in the oral cavity as can be tolerated, and connected to the high side of an appropriate differential pressure transducer (Statham PM 5 ETC). The second catheter is placed through the wall of an anesthesia mask and the other end connected to the low side of the same transducer. After experimenting with several masks, we have found that the Vital Signs Incorporated mask, with an inflatable, low pressure cushion, provides an excellent seal on a great variety of face sizes and contours. In addition, this seal is achieved with minimal pressure. Therefore, there is little risk of distorting the anterior nasal valve.

Transnasal air flow is collected in the mask and directed through a heated pneumotachometer (Beckman #872423

Type I). The process of heating prevents condensation from developing in the wire mesh and altering the resistance. The pneumotachometer is in turn connected with appropriate tubing to an appropriate differential pressure transducer (Statham PM 15 ETC). The pressure and flow transducers are connected to the appropriate channels of the PERCI-II and then to separate channels of the strip chart recorder.

Prior to testing, the pressure channel of PERCI-II and the strip chart recorder were calibrated at 2cm H20 using a U-tube manometer. The flow channels of the respective instruments were calibrated at .500 LPS using a rotameter (Fisher-Porter, full scale = 500 ml/sec.)

Nasal Patency Measures

Rhinomanometry results are often expressed in terms of nasal airway resistance. Resistance is the relationship of flow to the driving force required to produce that flow. Whereas both the flow rate and the driving force are measurable, resistance is a calculated quantity and cannot be measured directly. Resistance is calculated by dividing the differential pressure (driving force, measured in centimeters of water pressure: cm H20) by the flow, measured in liters per second (LPS).

The inverse of resistance is conductance and is calculated by dividing the flow by the differential pressure. It can also be computed by dividing one by the resistance. There are some advantages to using conductance rather than resistance; the most obvious being that in total nasal obstruction resistance is infinity, since zero divided into any number is infinity. In this same example, however, conductance is zero, since zero divided by any number is zero.

Subjects

Twenty-two consecutive patients from the division of otolaryngology were tested pre- and post-operatively. The pre-operative assessment was used to quantify the patients' complaints of reduced nasal airway patency. Each patient was then tested one to four months post-operatively (mean time post-operatively was 2.4 months) to assess the results of the surgery. The cost of follow-up including transportation and other costs to the patients precluded multiple or long-term follow-up. This follow-up period is consistent with other similar studies.

One patient had a repaired unilateral cleft of the lip and palate and one had a diagnosis of Treacher-Collins syndrome. The remaining patients were free of craniofacial anomalies.

The patients' average age was 26.8 years and ranged from 7.3 years to 50.2 years. Fifteen of the patients were female and seven were male.

Surgical Procedures

The surgical procedure performed in each case was the decision of the surgeon. This decision was made from the outcome of the physical examination of the airway. In each case either a septoplasty, turbinectomy or both was done.

Procedure

Each patient was tested in a seated, upright position. Prior to testing, the nose was cleared of excess nasal debris. Each patient was instructed to inhale through the mouth and then to exhale through the nose with the lips closed. Lip closure could be observed through the clear anesthesia mask. Normal exhalatory effort was observed prior to testing and every attempt was made to duplicate this effort during the test. Pressure and flow valves were measured at peak air flow points for at least five exhalation cycles. It was not possible to measure pressure at a standard flow rate because of the wide discrepency of flow values. A patient was asked to protrude the tongue any time it was thought to occlude the nasopharynx.

Results

The pre- and post-operative conductance measures for each of the 22 patients are found in Figure 1. Of the 22 patients, 20 (91%) demonstrated some improvement in nasal patency post-operatively. The improvement ranged from .02 to .84 LPS/cmH20. One patient was slightly worse post-operatively (.36 LPS/cmH20 pre-operatively and .34 LPS/cm H20 post-operatively). One patient demonstrated no change when retested three months post-operatively. Pre-operatively, conductance averaged .19 LPS/cm H20 (s.d. = .11). While post-operative conductance measures averaged .40 LPS/cm H20 (s.d. = .21).

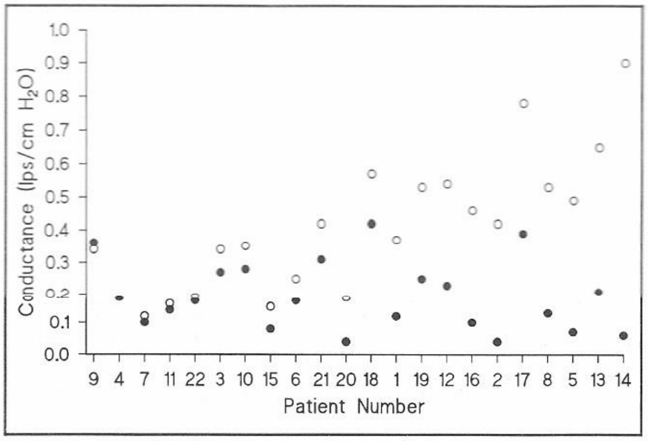

Figure 1

The figure displays the conductance values for each of the 22 patients. The closed circles indicate the pre-operative measures and the open circles indicate the post-operative measures. The patients are listed from left to right in order of increasing improvement.

All patients were testable using posterior rhinomanometry. Admittedly, some patients required more time to test than did others.

Discussion

Our ability to test all patients using posterior rhinomanometry was one of our early concerns because of Kern's (1973) report of only a 75% success rate using this technique. Kern attributed failure to the patient's inability to relax the posterior oropharynx sufficiently to measure oropharyngeal pressure. All patients in this series were tested without difficulty. The problem of the tongue occluding the posterior oral pharynx is easily overcome by testing the patient with the tongue protruded. The lips then seal around the oral catheter and tongue. This is an important modification that allows the posterior technique to be used with almost all patients. Thus, anterior airway problems such as liminal valve narrowing or the alar collapse seen in the cleft lip/palate population can be evaluated.

It is useful to analyze these data in light of recent information about "normal" nasal patency. Warren (1984) has advocated the use of the hydrokinetic equation which estimates a minimal cross-sectional area of the nasal passages from pressure and flow measures. The advantage of this calculation is that the hydrokinetic equation controls for the turbulence of air flow. We now use this technique rather than conductance or resistence, as it provides a more accurate evaluation of nasal patency.

The hydrokinetic equation calculates the minimal cross-sectional area of the nasal passages in centimeters squared (CM^2). This happens to be very close to the numerical values obtained in the calculation of conductance since flow is in the numerator and pressure is in the denominator of each formula. For example, at a differential pressure of 1.0 cm H20 and a transnasal flow of .202 LPS conductance is .20 LPS/cmH20 and cross-sectional area is .22 cm^2. The calculated resistence for these same values is 5.0 cmH20/LPS. However, at higher, more turbulent flow rates the difference becomes greater. At a pressure of 1.0 cmH20 and a flow of .556 LPS conductance is .543 LPS/cmH20, cross-sectional area is .60 cm^2, and resistence is 1.82 cmH20/LPS.

Recent investigations by Warren and his colleagues (1987 and 1988) have redefined the requisite for intermittent mouth breathing. For some time it has been generally accepted that a nasal resistance of 4 to 5cm H20/LPS (or higher) will necessitate mouth breathing. This is equivalent to a conductance of .20 to .25 LPS/cm H20 and a cross-sectional area of approximately .20 cm^2. Warren and his colleagues have suggested that intermittent mouth breathing may be required at a cross-sectional area of .40 cm^2. This is equivalent to a conductance of .361 LPS/cmH20 and a resistance of 2.77 cmH20/LPS. Thus, it is now presumed that only one-half as much nasal resistance is needed to require some degree of mouth breathing.

It has been enlightening to interpret our results with regard to this new information. Considering a conductance of .361 LPS/cmH20 as a cut-off separating normal from impaired nasal airways, pre-operative measures indicated that 20 of our patients (91%) fell below that level and demonstrated impaired airways. Thus, we were successful in identifying individuals with impaired airways.

However, post-operative measures revealed that only 12 patients (54%) demonstrated conductance values above that level. These results indicate that surgery was unsuccessful in correcting nasal airway interference in a large number of patients. Further, we might conclude that the underlying cause of the nasal airway interference may have been something other than enlarged turbinates or a deviated septum. This study indicates the need for team evaluation of airway complaints with a careful, complete evaluation of the nasal airway and identification of the exact nature of the interference.

Summary

Posterior, active rhinomanometry is an effective tool for measuring nasal patency and identifying nasal airway interference. The test procedure may require more care in testing than does the anterior technique but all patients could be tested with our modification. Surgical outcome can be judged by comparison of pre- and post-operative results.

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