Airway Interference: Objective Measurement and Accountability

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Rhinomanometry is the measurement of the patency of the nasal airway. Rhinometric measures provide for the objective assessment of the airway and the ability to account for the need and the effectiveness of management procedures. Rhinomanometry is of interest to the myofunctional clinician because the obtained measures assist the clinician in treatment planning.

Purpose

It is the purpose of the article to review briefly the mechanics of rhinometric assessment, the instrumentation and test procedures employed in our clinical setting and the need for objective data in a controversial area.

Background

Rhinometric research has enhanced our understanding of nasal respiratory physiology. For example the existence of the nasal breathing cycle[1,2] and the nasal valves[3] have been substantiated with rhinomometry. More importantly rhinomanometry has important applications for the study of normal and pathological nasal function.[4] It is generally accepted that a nasal resistance of 4 to 5cmH_2O/LPS (or higher) will necessitate mouth breathing. However, it has been argued recently that this value may be too low.[5]

Rhinometric 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 using the formula

$$R = \frac{\Delta P}{\dot{V}}$$

where

R = resistance

ΔP = Difference in pressure from one point to another, differential pressure (or driving force) measured in centimeters of water pressure (cmH_2O)

$\dot{V}$ = flow, measured in liters per second (LPS).

Conductance is the inverse of resistance and is calculated using the formula

$$C = \frac{\dot{V}}{\Delta P}$$

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.

Rhinometric techniques include anterior or posterior testing, active or passive testing or uninasal or binasal testing.

Anterior rhinomanometry involves placement of the measurement devices in the anterior nasal vestibule. Results obtained from this technique may be invalid since the nasal vestibule may be physically distorted and the liminal valve may be inactivated. This is unfortunate since minimal anatomic abnormality of these areas may result in significant airway obstruction[1,6]. Also this is a frequent obstruction site in the cleft lip/palate child due to the deformity and collapse of the alar wing. Thus, rhinometric assessment is most valid if these areas are not distorted during testing.

Posterior rhinomanometry relies on the use of a mask to collect transnasal air flow which is then directed to a pneumotachometer. A pneumotachometer is a wire mesh device of a known resistence. The wire mesh should be heated to prevent any condensation which might alter the resistence. The drop in pressure, as the air passes through the mesh, is detected by a differential pressure transducer. This drop in pressure, or pressure differential, is directly related to the rate of air flow through the pneumotachometer.

Transnasal pressure is recorded by a catheter inserted into the mask. This catheter is connected to the low side of a second differential pressure transducer. Oral pressure is measured by a catheter inserted directly into the oral cavity and connected to the high side of the second differential pressure transducer.

Kern[4] cites only a 25% success rate in testing patients with posterior rhinomanometry because of difficulty in relaxing the oropharyngeal muscles enough to permit adequate recording of oral pressure. On the contrary, we have experienced a 100% success rate in testing patients with posterior rhinomanometry. Although Kern reports a poor success rate he still acknowledges posterior rhinomometry as the method of choice for research

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investigation because this technique does not interfere with the anterior nasal valves and thus testing is completed during an undisturbed physiologic state.

Active rhinometry depends on the patient's own respiratory effort while passive rhinometry uses a stable air flow rate forced through the patient's nasal airway from an external source. Uninasal testing indicates that only one nasal cavity is being tested. The nontest side is blocked with gauze. Binasal indicates that both nasal passages are tested simultaneously.

Rhinometric Instrumentation

Our test procedure employs the posterior test procedure since it generally yields more valid data. Our instrumentation for rhinometric assessment includes the PERCI-II (Palatal Efficiency Rating Computed Instantaneously)* and its associated transducers (Figure 1). The pressure and the flow signals are recorded on a General Scanning strip chart recorder.**

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.

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** General Scanning Inc., 500 Arsenal St., Watertown, MA 02172

*** Vital Signs Inc., 1 Madison St., East Rutherford, NJ 07073

Transnasal air flow is collected in the mask and directed through a heated pneumotachometer (Beckman #872423 Type 1). The process of heating prevents condensation from building on the wire mask 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. PERCI-II displays the calculated nasal airway conductance in digital form on its front panel when the conductance mode is selected. PERCI-II calculates conductance rather than resistance because of the reasons listed previously. In addition, conductance can be calculated at .250LPS or .500LPS by selecting the desired flow rate allowing for repeated testing and identical flow rates.

We have found that a strip chart printout of the transnasal pressure and transnasal flow values is an extremely useful addition. This is especially true when a patient with a severe nasal airway obstruction cannot drive .250LPS of air through the nose and the PERCI-II cannot calculate conductance. In such cases nasal airway conductance can be calculated from the recorded peak pressure and peak flow values.

Prior to testing, the pressure channel of PERCI-II and the strip chart recorder are calibrated at 2cm H_2O using a U-tube manometer. The flow channels of the respective instruments are calibrated at .500LPS using a rotameter.

Our standard testing procedure includes measuring transnasal air flow and pressure differential for inhalation and exhalation. Pilot study has suggested that the calculated conductance is nearly identical for inhalation and exhalation and quiet breathing levels since the liminal valve is not activated by low air flow rates. However, inhalatory conductance is considerably less than exhalatory conductance for high flow rates (such as during a quick sniff) when the liminal valve is activated.

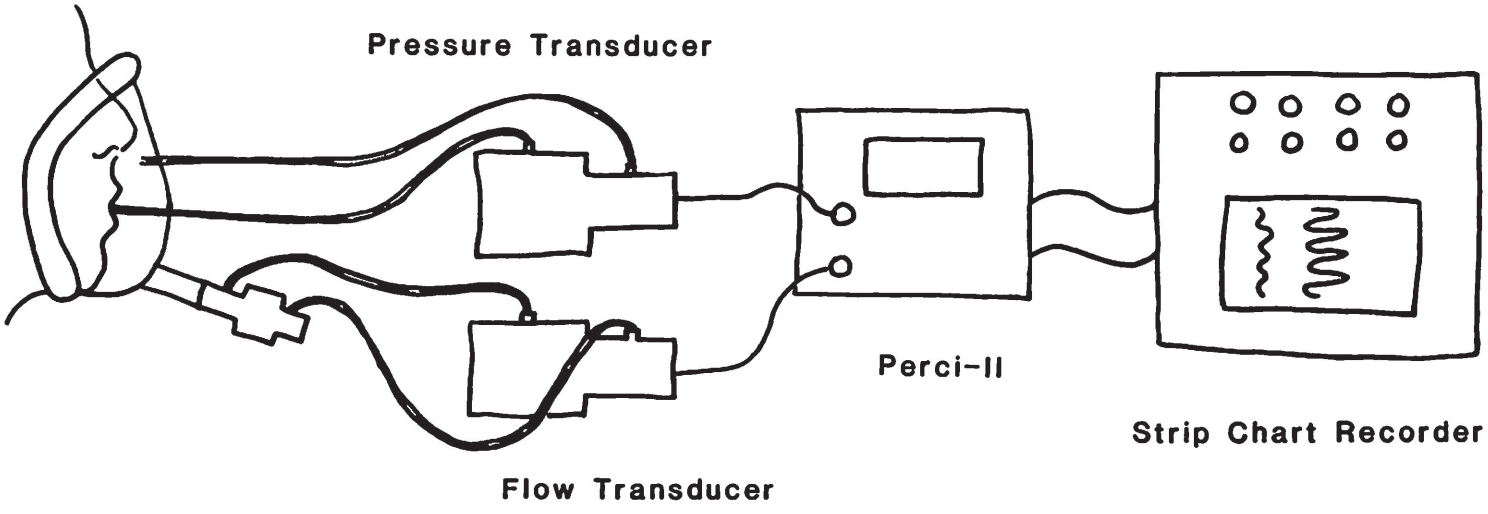


FIGURE 1. The PERCI-II, its associated pressure flow transducers and the strip chart recorder. The catheters and tubing enter the mask and are arranged to measure transnasal pressure differential and transnasal air flow.

Our testing procedure also includes testing binasal, right uninasal, and left uninasal conductance. In addition, considerable insights into breathing and nasal anatomy can be obtained by measuring conductance prior to and following clearing the nose of nasal secretions or use of an antihistamine spray. Also cleft palate patients with alar collapse are tested once using a mask and again with tubing inserted intranasally to elevate the collapsed alar wing. Comparison of the two calculated values provides important information on the role of the alar collapse in nasal obstruction.

Since the nasal mucosa is undergoing continuous change due to the nasal cycle and in response to allergies, repeated longitudinal testing is almost essential to provide an accurate picture of nasal conductance.

An example of conductance measures taken before and after the use of an antihistamine spray is show in Figure 2. Prior to spraying, peak transsnasal air flows averaged .417LPS and peak transnasal pressures averaged 1.43cm H_2O. The calculated pre-spray conductance was .29LPS/cm H_2O. Fifteen minutes after spraying, peak transnasal air flows averaged .440LPS and peak transnasal pressures averaged 0.5cm H_2O. The calculated conductance improved nearly three-fold to .85LPS/cm H_2O.

Rhinomanometry in perspective

It appears at this time that no single measure provides all the necessary information to adequately evaluate nasal airway patency. Rhinomanometry should be an essential aspect of a test protocol since it provides quantification, and in today's world quantification is a necessity. With the quantification of nasal airway patency in any one patient, the values may be compared first to established standards. That is, does this patient have a patent airway or an obstruction? It is generally accepted that nasal airway patency exists when conductance exceeds .25LPS/cm H_2O (or when resistance is less than 4 to 5cm H_2O/LPS). As a cautionary remark it should be remembered that these are not absolute values. The second important use of quantifiable values is to compare a patient's measures pre and post intervention. This answers the question "did the intervention plan succeed?"

Also quantification is valuable since individuals appear to have poor insight into their own airway patency. As an example of this, let us relate briefly the history of two patients. The first, an adult female, appeared at our clinic, referred from a plastic surgeon. She complained of difficulty with nasal breathing for the past several months. yet conductance testing yielded conductance values exceeding 1.2LPS/cm H_2O. She appeared to be

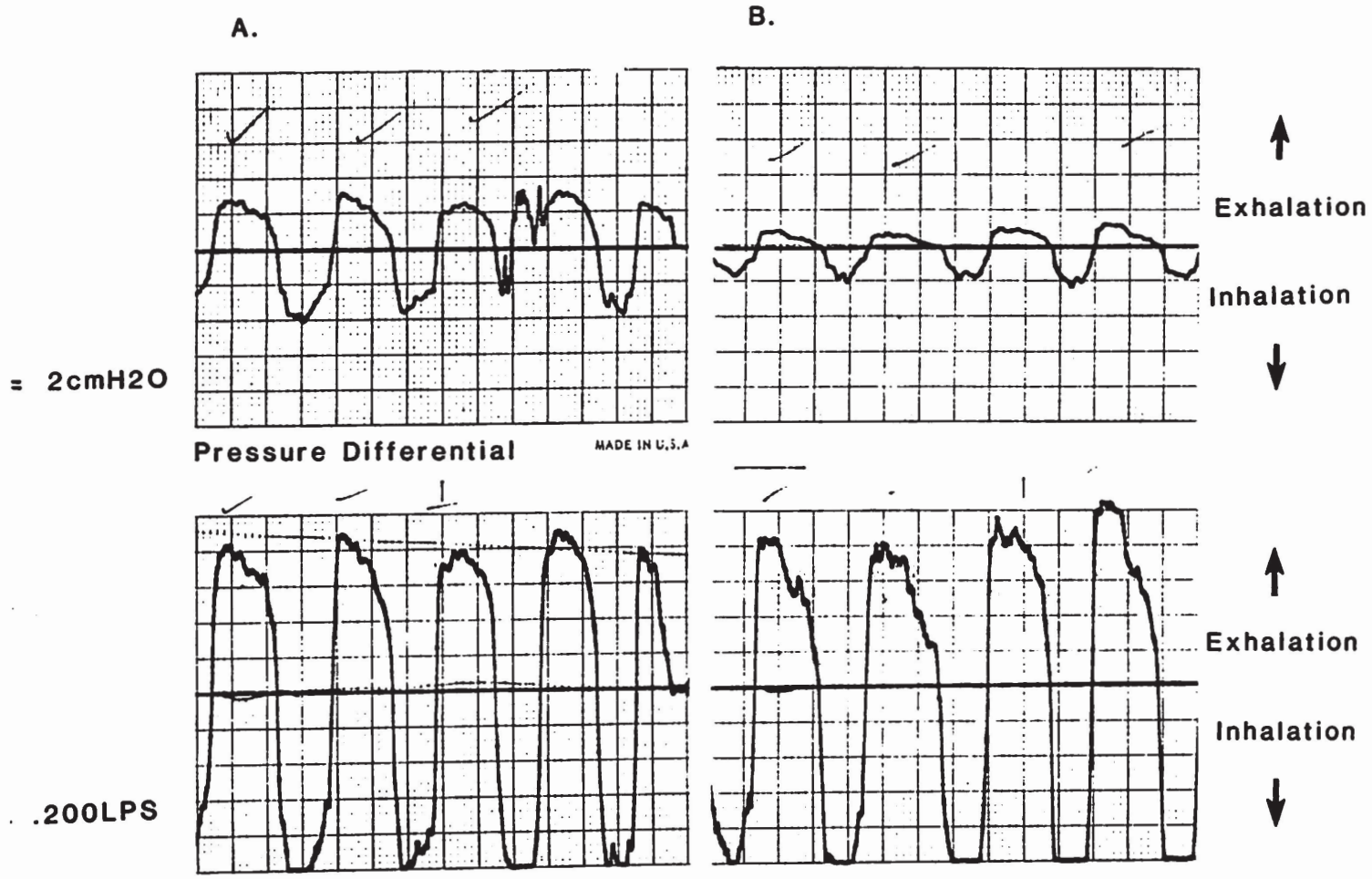


FIGURE 2. A. Transnasal pressure and air flow prior to use of antihistamine: pressure differential averages 1.43cm H_2O, flow averaged .417LPS and calculated conductance was .29LPS/cm H_2O.
B. Transnasal pressure and air flow after use of antihistamine: pressure differential averaged 0.5cm H_2O, flow averaged .440LPS and calculated conductance was .85LPS/cm H_2O.

responding to changes in the patency of individual nasal passages due to the nasal cycle. That same afternoon an adult male presented for evaluation unrelated to breathing. He presented with a moderate - severe hyponasality (usually an indication of nasal obstruction), chronic open mouth breathing posture and chapped lips. When asked, he denied any difficulty with nasal breathing. However, conductance testing indicated conductance values below .10LPS/cm H_2O.

Finally the individual with suspected or documented nasal airway interference is best evaluated and managed by an interdisciplinary team which may include an otorhinolaryngologist, allergist, myofunctional therapist, and dental specialist. Assessment tools, including pressure flow instrumentation, radiography, endoscopy and physical examination are necessary to determine adequately the extent and the nature of nasal obstruction. The myofunctional therapist is frequently in an excellent position to identify patients who will benefit from interdisciplinary evaluation and management and the use of objective data. The ability to use objective data is an important step to ensure accurate diagnosis and effective management.

References

1. Principato, J.J.. and Ozenberger, J.M.: Cyclical changes in nasal resistance. *Arch. Otolaryngol.*, 91:71-77, 1970.
2. Stoksted, P.: Rhinometric measurements for determining the nasal cycle. *Acto Otolaryngol.*, (Suppl), 109:159-175, 1953.
3. Bridger, G.P.: Physiology of the nasal valve. *Arch. Otolaryngol.* 92:543-553, 1970.
4. Kern, E.B.: Rhinomanometry. *Otolaryngol. Clinics North Amer.* 6:863-874, 1973.
5. Vig, P.S.; Sarver, D.M.; Hall, D.J. and Warren, D.N.: Quantitative evaluation of nasal air flow in relation to facial morphology. *Am. J. Orthod.*, 79:263-272, 1981.
6. Bridger, G.P. and Proctor, D.F.: Maximum nasal inspiratory flow and nasal resistance. *Ann. Otol.*, 79:481-489, 1970.