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Standardization of rhinomanometry

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SUMMARY

Current methods of rhinomanometry used by various workers from around the world were investigated. The data for this communication were based on the studies of 11 scientists who have an accumulation of approximately 81 years of experience with more than 20,000 rhinometric examinations. The results of this survey provide a consensus of methods, procedures, data collection, and presentation which should be considered so that rhinomanometric uniformity may be achieved. It is fully recognized that standardization of rhinomanometry requires further inquiry and evaluation and that this is not the final communication on the subject but merely a current consensus from a limited few working in the field.

THIS communication is an analysis of current methods of rhinomanometry used by different workers from around the world. The purpose is to summarize some of the contemporary concepts and methods of rhinomanometry used internationally so that progress and development in the field of nasal physiology through rhinomanometry can continue in a conjoined fashion.

METHODS AND MATERIALS

A questionnaire was sent to 18 investigators who have worked in the field of rhinomanometry, most of whom have written extensively. The data for this communication were based on the work of Cottle (1968) plus the responses to the questionnaire received from the following investigators, listed in alphabetic order: Drs. Pierre Arbour, Börje Drettner, Kenneth Hinderer, Eugene B. Kern, A. E. Kortekangas, Hellmuth Masing, Donald Proctor, Kiyoshi Togawa, J. M. Montserrat-Viladiu, and E. A. van Dishoeck. These 11 workers represent approximately 81 years of experience, and more than 20.000 rhinomanometric examinations have been performed under the guidance of these investigators. The persons administering these tests were either physicians or laboratory workers familiar with the equipment and procedures. In most instances these tests were performed while the subject was sitting (occasionally reclining in positions of sleep).

FINDINGS AND CONSENSUS

Most did not consider specific techniques to remove CO_2 or water vapor, although or anterior rhinomanometry with a mask superior to anterior rhinomanometry with

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nozzles, because the use of a mask avoids disturbing the vestibule or valve when both pressure and flow are measured simultaneously.

Most did not consider specific techniques to remove Co_2 or water vapor, although a few did warm the pneumotachometer and one did have a vacuum in the mask for removal of CO_2 and water vapor. These considerations perhaps deserve further inquiry. Most held the mask firmly to the face with a band or strap.

There was no uniformity in transducers used, as expected, because good pressure and flow transducers were easily available in each country represented. Most observed the transnasal pressure and nasal air flow relationship simultaneously on paper as a direct write-out tracing, and some (4 of 11) used the oscilloscope loops to evaluate the pressure-flow changes. Most workers (10 of 11) had at least two-channel recorders, and just fewer than half (5 of 11) used three or more channels to record their data.

Almost all (9 of 11) investigators calculated nasal resistance or conductance; however, the actual formulas varied, probably because of the problem of air-flow turbulence. Four calculated nasal resistance (Rn) by dividing the pressure value (P) by the flow value ($\dot{V}$) ($Rn = P/\dot{V}$), whereas one divided pressure by flow to the power 1.75 ($Rn = P/\dot{V}^{1.75}$) and another divided pressure by flow squared ($Rn = P/\dot{V}^2$). One worker looked at the pressure (studying only normal subjects) at the fixed flow rate of 0.5 liter/sec, whereas another expressed "nasal patency" as flow at a fixed pressure of 10 mm H_2O. One investigator looked at resistance as a coefficient of resistance, $W = \frac{P}{\dot{V}^2} \times 10^3$. Most did not calculate the work of breathing. Half evaluated the patency of the maxillary ostium with their equipment when this determination was appropriate.

Concerning recording conventions, inspiration was a downward deflection for all those (10 of 11) who used recording equipment. When an oscilloscope was used, nasal air flows were on the ordinate and the transnasal pressure changes were on the abscissa. There were some variations in direction and these can easily be standardized by changing recording leads. Subject or patient data always included age and sex, and often a history and physical examination were carried out. One worker even included an estimation of the pulmonary status in each subject.

Nine of the 11 used topical vasoconstrictive medication to eliminate the congestion of the nasal cycle. Almost all waited approximately 10 minutes before retesting the nose in the decongested state. Xylometazoline HCl 0.1% and 0.5%, ephedrine 1%, neosynephrine 1%, oxymetazoline chloride 0.25%, and epinephrine 1 : 100,000 were each mentioned.

The symbol "P" for transnasal pressure change (units either cm H_2O or mm H_2O) was used most often, and the symbol "$\dot{V}$" for nasal air flow (units either liters per second or liters per minute) appeared most often. Nasal resistance was calculated most often in cm H_2O per liter per second (cm H_2O/L per sec).

Results of the survey provide a consensus that allows the following "standards" to be considered so that uniformity in methods, procedures, data collection, and presentation can be achieved:

1. Mask rhinomanometry (anterior or posterior mask techniques), which avoids the difficulties of anterior nozzle rhinomanometry, is preferred. The disadvantages of the anterior nozzle technique are possible distortion of nasal valve and difficulty in obtaining an airtight seal when a caudal-end septal deformity exists.

2. Any readily available, high-quality gas or pressure transducer that can be adapted to a mask is acceptable.

3. Further work is necessary to clarify whether CO_2 and water vapor may affect the accurary of prolonged mask studies.

4. An amplifier and strip chart (minimum two-channel) recorder are mandatory so that at least transnasal pressure and nasal air flow changes may be studied simultaneously.

5. An oscilloscope is advantageous, especially for posterior rhinomanometry, not only to study the flow pressure loop but also to ensure the occurrence of quiet, unobstructed (by tongue) respiration.

6. Further discussion is needed to clarify the use of formulas and the most advantageous point during the respiratory cycle (possible peak of inspiration during quiet breathing) at which to calculate nasal resistance. The problems with using either a fixed flow or a fixed pressure point are that patients (disturbed nasal physiology) may not be able to reach these fixed points.
At present, until further inquiry and discussion, it is best to continue data collection by the use of the current choice of formulas:

$$Rn = P/\dot{V} \text{ (laminar air flow)}$$
$$Rn = P/\dot{V}^{1.75} \text{ (partly turbulent air flow)}$$
$$Rn = P/\dot{V}^{2} \text{ (turbulent air flow)}$$
$$W = \frac{P}{\dot{V}^2} \times 10^3$$

and so on.

7. Quiet respiration in a sitting position was most frequent and seems most appropriate at present. Stress (exercise) tests and sleep positions are still investigative. Some consideration should be given to specific instructions before the patient is tested, such as avoidance of nasal sprays, oral decongestants, and increased activity. It is preferable to have the test administered by the physician or a laboratory person who is familiar with the procedures.

8. Considerations of age, sex, history, and physical examination should be part of each study. Total nasal resistance (both sides) can be calculated directly from the binasal pressure and flow data (posterior mask technique). Total nasal resistance can be calculated from the uninasal pressure and flow data from the right and

left sides. Then the binasal or total nasal resistance can be calculated according to the formula:

$$\text{Total nasal resistance (T Rn)} = \frac{1}{\frac{1}{Rn_{rt}} + \frac{1}{Rn_{lt}}} \text{ or}$$

$$\text{T Rn} = \frac{\text{Product}}{\text{Sum}} = \frac{(Rn_{rt} \cdot Rn_{lt})}{Rn_{rt} + Rn_{lt}} \text{ in cm } H_2O/L \text{ per sec.}$$

These calculations can then be repeated after decongestion. Each uninasal resistance value should probably be based on the mean of four consecutive breaths taken at the peak of quiet inspiration. The type of decongestant is probably not as important as use of the same type and amount each time.

9. Because nasal resistance (uninasal right or left and binasal or total) changes from moment to moment, there are probably no absolute values, and the role of rhinomanometry should be that of a tool for continued investigation into normal and abnormal nasal respiration.

10. Standardization of rhinomanometry probably requires further inquiry and reevaluation.

This is certainly not the final communication on this subject, merely a current consensus from a limited few working in the field. I apologize to those serious workers and students whom I may have omitted from this inquiry; however, upon request I will send a questionnaire to any concerned scientist. Perhaps at the next World Congress a broader group will be represented and progress in rhinomanometry can lumber forward.

REFERENCE

1. Cottle, M. H., 1968: Rhino-sphygmo-manometry: an aid in physical diagnosis. Int. Rhinol. 6, 7-26.

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Standarisation de rhinomanometrie

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En s'appuyant sur le travail de Cottle (1968) et les réponses de 11 auteurs à un questionnaire, E. B. Kern analyse et compare les techniques actuelles de rhinomanométrie.

En rhinomanométrie antérieure et postérieure, il existe un certain consensus pour l'utilisation du masque car il évite les déformations du lobule et de la valve, surtout si le débit et la pression sont enregistrés simultanément. Dans tous les pays, il existe maintenant de bons capteurs de pression et de débit. Les types utilisés sont donc variés. L'oscilloscope est avantageux, mais l'enregistrement graphique à 2 canaux simultanés est nécessaire (pression et débit). L'examen se fait surtout en position assise. La vasoconstriction est très généralement utilisé au cours des tests. L'histoire clinique est notée soigneusement et, pour certains, le dossier doit comporter une appréciation de l'état fonctionnel pulmonaire.

Les divergences apparaissent surtout pour les calculs de la résistance nasale avec les symbolisations suivantes: Rn pour la résistance, P pour le gradiant de pression transnasale, $\dot{V}$ pour le débit. Différentes formules sont exposées en respiration libre, à débit ou à pression constants.

L'inspiration est enregistrée comme déflection négative de la courbe par presque tous les auteurs (10 sur 11), tandis que les enregistrements à débit ou à pression constants sont liés aux difficultés éprouvées par les patients pour atteindre ces valeurs constantes.

La résistance nasale change d'un instant à l'autre: elle n'a donc pas une valeur absolue et son rôle doit être celui d'un instrument pour le développement de l'exploration de la respiration nasale normale et pathologique. La standardisation nécessitera d'autres enquêtes et estimations.

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