RHINO-SPHYGMO-MANOMETRY AND RHINO-REVMA-SPHYGMO-MANOMETRY

Maurice H. Cottle, M.D.
Roland M. Loring, M.D.
Irwin E. Gaynon, M.D.

What is usually referred to as rhinomanometry is actually rhino-sphygmo-manometry. Rhino-sphygmo-manometry is a method of measuring intranasal pressures as air flows in and out of the nose. Pressures are usually measured with a manometer via a nozzle placed in one nostril. Pressure may also be measured via a tube in the closed mouth, but our discussion will be limited to nasal aperture pressures.

History: Goodale in 1896 and Mink in 1903 used (liquid) manometry in measurement of nasal pressures and they in turn reported similar experiments by many of their predecessors, notably Kaiser, Aschenbrondt and Mac Donald. Much work was done in France from 1900 to 1920. Simple "U" tube water manometers, some with trapping mechanisms, and spring type (Escat) manometers were employed. In 1927 van Dishoeck used inclined manometers in the measurement of nasal resistances in his studies of the inflow method of measuring nasal resistance. Cottle introduced the use of a single oil manometer for both upright and inclined manometry. In the upright position maximum or "snorting" pressures up to 300 millimetres of water can be determined. The inclined position of the manometer registers the smaller positive and negative pressures which occur during normal and abnormal breathing cycles. These figures are observed directly and if recorded a graphic chart can be made of the extent of breathing pressures.

Electronic Recorder: When a transducer and an electronically controlled recorder are attached to the manometer, more realistic graphs can be had. The rate of breathing, amplitudes, and normal and abnormal phases of a single breath are among the many interesting products of these examinations.

For clinical purposes, a single channel recorder is satisfactory. As one becomes proficient in its use and more familiar with recordings one becomes more and more dependent upon this objective test of one of the nasal functions, especially for preoperative evaluations of nasal patencies.

In doing the test the nozzle of the manometer is moistened and placed into one nostril. It must fit well, not impinge on the septum or cause deformity of the opposite nostril. The nostril containing the nozzle is now part of a closed system in which only the other nostril permits passage of air. The pressure within the respiratory tract at any given moment is uniform throughout. Hence, information regarding an open nostril pressure obtained at the other nostril is reliable. In this way we obtain what we call "pressure curves" of the breathing cycles.

The inspiratory pressure is usually 6 to 15 millimetres of water. The expiratory pressure is 2 to 4 millimetres less. The pressure during a test may remain constant for 5 to 6 breaths or may become less with each breath, until the patient is unable to continue. The pressure may increase markedly in 2 to 4 breaths making further testing impossible. Many other variations occur of which we shall show some typical examples, but it can be noted at once that insufficiency of the nasal valve, atrophy or flattening of the nose result in decreased pressures, and that pressures are increased in stenosis and obstructions in the vestibules and valve areas.

A Breath: The recorded curve of a single breath may be divided into five parts: 1. The inspiratory phase to the height of negative pressure. 2. A pause at the height of inspiration. 3. Expiratory phase during which the maximum positive pressure is reached. 4. The pause at the height of the expiratory phase. 5. A period of resolution as the positive pressure gradually returns to the basic zero level.

In our graphs, the large squares from left to right represent seconds. Each of the small squares up and down represents the pressure of 2 millimetres of water.

Inspiration is quick and reaches its maximum in less than ½ a second, usually. The inspiration pause lasts about 1 second. Expiration (parts 3, 4, and 5) is normally prolonged. A sixth phase is occasionally seen in pressure curves in which there is a pause of one second or more at the base line where there is no positive or negative pressure, and this pause we call the "mid-cycle rest". Its exact significance is not completely understood, but we believe it to indicate some profound constitutional disease or disturbance frequently of the cardio-vascular system which in a direct or remote way is associated with depletion of tissue oxygen.

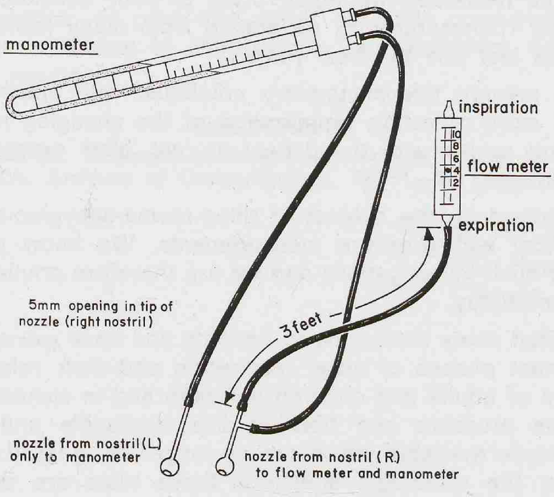
Work Coefficient: The work of breathing through the nose can be ascertained according to the formula W/M = P x V x R, in which W/M is work per minute, P is pressure in millimetres of water at the height of inspiration, R is the rate of breathing per minute, and V is the tidal volume. The determination of the volume is not easy to do as a routine examination procedure and for our immediate purpose can be set aside. In actual practice we have found that the inspiration pressure, P, and the rate, R, of breathing are both easily obtained. Their product constitutes a work coefficient according to the formula W/M is proportional to P x R where W/M, or work per minute, is proportional to the pressure multiplied by the rate per minute. This has proved in thousands of observations to be of inestimable value.

Sleep: The following paragraphs concerning "Nasal Valve Movements (Especially Related to Sleep and Fatigue)" from Cottle's article (1) are well worth repeating: "Nostril pressures with the head in different positions are readily determined. They demonstrate the effects of the movement of the distal portion of the lateral wall of the cartilage vault towards and away from the septum (valve). Such movements occur when a person shifts his head about as in sleep. Coordinated with these movements is the changing size of the turbinates, especially the inferiors. With the head on one side the turbinates of the top side normally constrict, allowing free breathing, while those of the low side become engorged and impede or inhibit the passage of air through this nasal chamber. Turning the head brings the lower turbinates to the top position and vice versa. The size of the turbinates changes promptly, and the subject immediately starts breathing through the (other) side of the nose which now is on top.

"The influence of the turbinates on the nasal pressures can be practically eliminated by shrinking them with astringents or decongesting anesthetic agents, making the pressure effects of the valve movements, brought about by gravity, available for objective studies. Usually in a normal nose (after shrinking the turbinates) with the head on one side, the nasal pressure is higher on the top side and lower on the under side than when the head is upright. This is because the terminal portion of the upper lateral cartilage falls toward the septum — on the top side — making the valve aperture smaller, while just the opposite occurs on the lower side. If a valve area is stiff or absent, as may occur after surgery or severe trauma, no appreciable change in pressures is brought about by a change of position.

"Nasal valve changes and turbinate excursions probably are important factors in initiating head and body movements in sleep, all of which together are greatly responsible for the "rest" the whole body can obtain during the sleep period."

Revma-sphygmo-manometry: This subject was first introduced by Doctor Cottle in 1958 at the Fourth Annual Meeting of the American Rhinologic Society. The pressure necessary to overcome the nasal resistance to air flowing through it at different rates of speed can be determined for both inspiration and expiration. A flow meter in contact with one nostril and a



Inclined manometer and flow meter connected for making flow-pressure determinations.
Manomètre incliné et flux-mètre connectés pour la mesure de la pression du flux.

manometer with the other provide a relatively uncomplicated apparatus ample for this purpose. The readings can be diagrammatically recorded on a chart. Synchronized graphs can be made on a two-channel electronically controlled recorder and provide additional informative data. As the rate of flow of air changes, so does the resistance and the changes can be visualized in the pressure graphs. Thus a single channel recorder for the pressures alone suffices for this test. The "testee" can control his exhalation and inhalation and permit the passage of air at given rates of flow. We use 2, 4, 6, and 8 litres of air per minute. The patient can be tested with no medication in the nose, after shrinkage with vasoconstrictors, following local anesthesia, and after exercise. A common finding in nasal obstruction is that on the normal side air flowing at 8 litres per minute creates a pressure of less than 100 millimetres of water while on the side of obstruction a flow of only 2 or 4 litres per minute will also create a pressure of 100 millimetres of water. Upright and positional rhinometry is diagnostically revealing in 84 percent of those patients who show pressure changes. The flow pressure curve findings will disclose the other 16 percent besides contributing valuable data in many of the others.

COMMENT Zarnicko long ago insisted that a simple rapid test for nasal patency was urgently needed in rhinology and thought that Bruning's method of timing maximal inspiration through each nostril separately was such an ideal test. Time has proved that this was not so.

Before him Zwaardemaker had profoundly and prophetically declared that a test for a nasal breathing capacity should be with a simple apparatus and in the hands of all those who practice any branch of medicine.

So with some hesitation we again bring to your consideration a simple methodology for rhinomanometry developed from many forms of apparatus used during the last one hundred years.

Second, we present this manometry combined with electronic recorders for easier and more revealing visualization of the changing nasal pressures during breathing cycles with the patient at rest, after exercise, and in the sleeping positions.

Thirdly, we introduce the subject of rhino-revma-sphygmo-manometry, the synchronous flow and pressure measurements. We know of no previous presentation of such investigations and we are therefore privileged to present this report to you today.

We have tested many thousands of patients and have gained much insight into the important phases of nasal respiration and their relationship to the general welfare of adults and children in health and in sickness. We believe that with these pressure and flow studies invaluable and indispensable knowledge is made available which can no longer be ignored by the medical profession. For the rhinologic specialist these tests are dependable and objective, they are most important diagnostic aids, and they serve as a guide for evaluating medical and surgical treatment especially from the viewpoint of nasal function.

RHINO-SPHYGMO-MANOMÉTRIE ET RHINO-REPMA-SPHYGMOMÉTRIE

Il y plusieures années que Z. insista d'une part sur le fait qu'un test rapide pour la perméabilité nasale était absolument nécessaire en rhinologie et d'autre part que la méthode de B., mesurant l'inspiration maximale par chaque narine séparément, représentait une épreuve idéale. Notre époque a démontré son erreur. Précédemment Z. a déclaré d'une façon prophétique qu'un test mesurant la capacité de la respiration nasale devrait pouvoir être réalisé par un appareillage simple, que tous les médecins, appartenant à n'importe quelle spécialité, devraient savoir employer.

Après une certaine hésitation, nous voulons pourtant vous présenter une technique simple de rhinométrologie; celle-ci a été réalisée en partant de différents appareils, ayant servi durant le siècle précédent.

Ensuite nous vous présentons cette manométrie combinée à un enrégistreur électrique, afin de démontrer plus facilement les changements de pression durant la respiration. Le malade se repose en respirant et même après un certain entrainement il peut le faire durant le sommeil.

Nous introduisons également les notions de R., du flux synchronisé et de la mesure de la pression. Nous ne connaissons pas de recherches antérieures à celle-ci et nous sommes très heureux de vous présenter cette découverte aujourd'hui. Nous avons examiné des milliers de malades et nous avons obtenu des connaissances approfondies des différentes phases de la respiration nasale et de leurs relations avec l'état général des adultes et des enfants, malades ou en bonne santé. Nous croyons qu'avec ces recherches de pression et de flux, des données importantes peuvent être obtenues, que la profession médicale ne peut plus ignorer.

Pour le spécialiste rhinologue ces tests représentent des épreuves sur lesquelles il peut compter d'une façon objective. Ces tests sont très importants pour les diagnostics; on peut s'en servir de guide pour évaluer le résultat des traitements médicaux et chirurgicaux, principalement du point de vue de la fonction nasale.

BIBLIOGRAPHY

1. **Cottle, Maurice H.:** Concepts of Nasal Physiology as Related to Corrective Nasal Surgery, A.M.A. Archives of Otolaryngology, 72 : 11—20 (July) 1960.

M. H. Cottle, M.D.
530, Hawthorne Place,
Chicago 13; Ill. U.S.A.