THE PART OF THE VALVE AND THE TURBINATES IN TOTAL NASAL RESISTANCE

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The conductivity of the Nose is the sum of the conductivity of both nasal passages, this value being inversily proportional to the resistance of each side. This resistance results from several factors of which the flow resistance through the narrow Valva area of the vestibule and the resistance caused by the turbinates are by far the most important. Whereas the valve resistance is more or less fixed, the resistance in the nasal chamber is an ever changing value.

From the observation and measurements of **Heetderks, Stockstedt, Drettner, Keuning, a.o.,** we are acquainted with the alternating nasal cycle. During this cycle of 2—6 hours, one nasal passage closes, whereas the other side opens — the total conductivity of the nose remaining remarkably unaltered. This perfectly normal cyclic congestion and decongestion of the turbinates is somehow ruled by the autonomic nervous system.

During decongestion or in pathological wide noses the turbinal resistance will be at its lowest and the Valve-resistance will be uppermost. During congestion the reverse will happen. In pathological conditions such as septum deviation, cristae and spinae the resistance in one or both nasal chambers may increase considerably. In pathological conditions of the upper and lower laterals and the caudal end of the septum the valve resistance will be altered.

Nasal resistance can be measured in the naso-pharynx. The resistance while breathing through the right side can be measured by connecting the left nostril to a manometer. In doing this the left nasal chamber becomes simply a lengthening of the manometer tube up to the naso-pharynx, recording the pressure at that place without any flow of air through this side. The total resistance of the nose can be measured with a straight manometer tube through the closed lips at the level of the relaxed soft palate.

Several kinds of manometers are in use. They allow direct readings of pressure, but not of flow. As the pressure depends on the flow, the comparability of the readings is based on the righteous assumption that the ventilation of patients in rest is a fairly constant value. The Revma-rheo-manometry introduced by Cottle *) and the technic of Drettner enables us to measure pressure and flow with one apparatus.

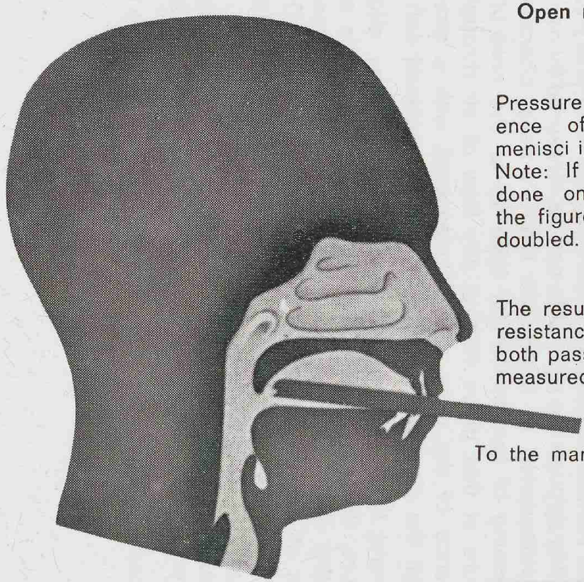
It must be reminded that the cross sections of the Valve and nasal chamber are very irregular surfaces. However they can be converted into circular surfaces with the same hydraulic properties according to the formula: $Rh = \frac{2\,O}{F}$

NASAL PRESSURES

measuring & recording

Manometry-readings are simple and quickly done. The resistance of a system (the nose) to a certain flow is equal to the difference at the entrance and the exit. The pressure at the nostril being ± atmospheric, it is enough to measure the **pressure in the nasopharynx.**

In measuring both nasal passage the mouth is used.



The resulting resistance of both passages is measured.

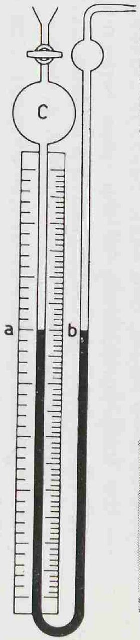
To the manometer.

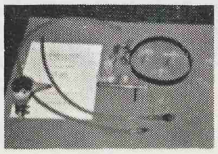
Open manometer.

Pressure is difference of the **two** menisci in cm water. Note: If reading is done on one side the figures must be doubled.

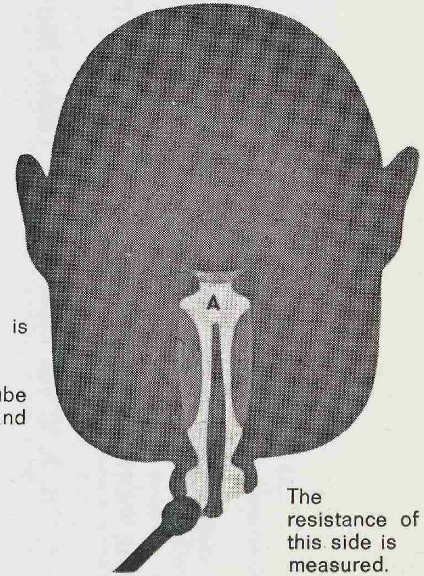
Closed manometer.

Pressure is the compression of the air in C. Readings must be calibrated with a open manometer.





Measuring one nasal passage.



Nasopharyngeal Pressure at A is recorded. The passage is degraded to a tube between nose and pharynx.

The resistance of this side is measured.

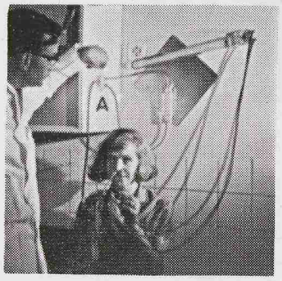
To the manometer.

Pneumophone as nasal manometer.

The pneumophone measures the middle ear pressure. By closing the tube leading to the ear (x) the manometer is ready for use.

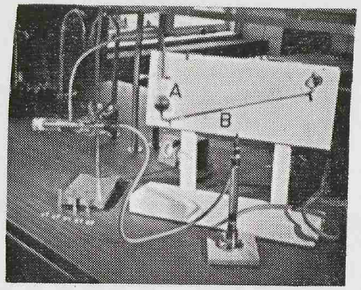
Rhino - rheo - manometer.

This method measures the pressure-drop along one nasal cavity at a known flow.

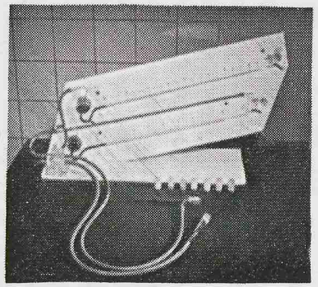


Cottle's method. The flow through the flowmeter can be reversed at A, so both in- and expiratory pressures can be read.
A nostril-nozzle is used, so the pressure drop from naso-pharynx up to the naris is measured. The manometer has two scales, one for the most sensitive readings (the slanting position) and the other for less sensitive readings (upright position).

Oblique manometer with balloon.



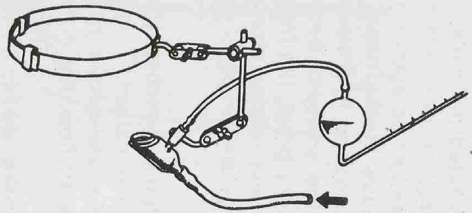
The sensitivity is considerable increased by the slanting position. As on small pressures the meniscus in the balloon A changes little, the pressure difference can be read directly at B.

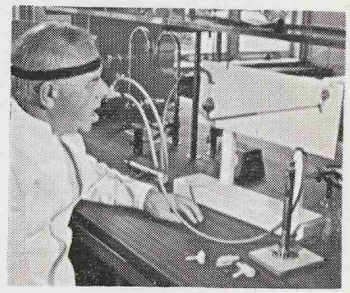


Keunings method. A pressure-tube is used as a flowmeter having a low internal resistance. The nozzle used is inserted up to the os internum so only the expiratory pressure-drop along the nasal cavity proper is measured. A two-way switch can shut the whole system, so the pressure-drop can be read at leisure when a certain flow has been reached.

Electronic recording with pressure transducer.

Inflow-method for determining nasal resistance.





in which Rh is the "hydraulic radius" of the calculated round cross-section, O the irregular cross-section and F the circumference of this cross-section.

The cross-section and circumpherence of the Valve can be measured by trimming a piece of calibrated millimeter paper to a mold which fits into this area. By counting the square millimeters and measuring the circumference with a thread these values can be approximated. The cross-section and circumference of the air-passage in the nasal chamber can be approximated by röntgen tomography. According to Poiseulle's law the resistance in this part will be determined by the smallest hydraulic cross-section. As the circumference in this area is very great, the hydraulic radius will be relatively small.

In model-experiments and related observation in patients we could demonstrate and study these relationships of the valve and turbinal resistances.

Valve Resistance

In a nose-model without conchae the measurable resistance is caused exclusively by the internal ostium. This could be proved by narrowing and widening this slit. If the model-ostium is equal in shape to the normal human ostium with comparable air-flow, the normal nasopharyngeal pressures could be imitated.

In patients we can make similar observations. In the atrophic nose or in the one-sided very wide nose, provided the vestibulum is normal, a normal pharyngeal pressure is measured. On inspiration this negative pressure is slightly higher because of the slight sucking in of the nose wing, whereas on expiration the positive pressure is slightly lower because of the pushing out. A slight pressure on the nose wing or a loading with some grams is enough to raise the resistance and to illicit active inspiratory contractions of the dilatator naris which can be recorded easily.

Widening of the vestibule and internal ostium by means of a speculum result in a lowering of the pharyngeal pressure, provided that the turbinal resistance does not take over, which in normal noses often happens.

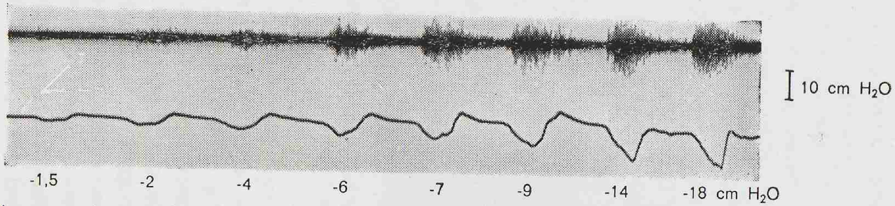
Turbinal resistance

The part of the turbinates in nasal resistance is more difficult to study and also, because of their ever changing volume, more difficult to describe. In the above mentioned cast of a human nose without turbinates the total resistance is ruled by the narrow isthmus comparable to the tap in a gas service-pipe. By mounting in the cast a small inflatable rubber balloon-imitating the turbinates - this nasal chamber can be narrowed and widened according to want.

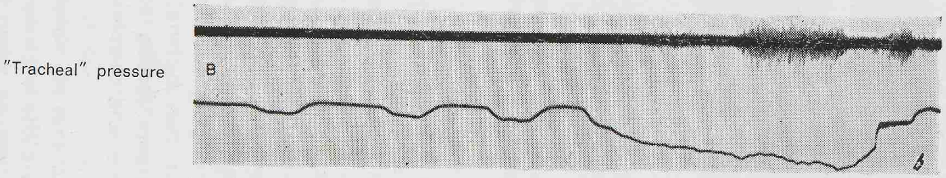
It appeared that in the beginning of the process of slow inflation of the balloon, no increase of resistance could be measured. However as soon as on one single point the remaining cross-section of the nasal chamber became less than the cross-section of the isthmus, a sharp rise in resistance occurred. This is demonstrated even more impressively by the lack of increase of resistance when a tube of the cross-section of the valve is placed on the bottom and the balloon is inflated at maximum.

In normal test persons we can demonstrate the changing role of both resistances during the nasal cycle. When one side is maximally decongested, pharyngeal pressure is caused by the internal ostium. This can be proved by means of the above mentioned **dilitation test** viz. from the lowering of the

Electromyography of the nose wings

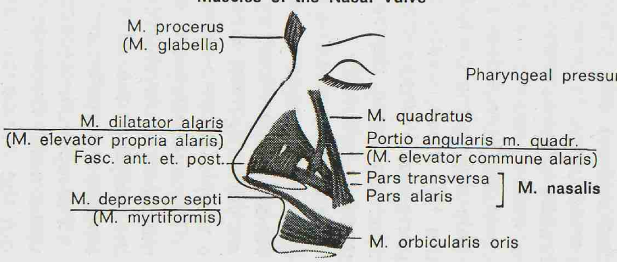


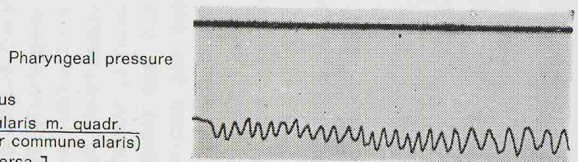
In a normal testee during increasing ventilation; the action potentials are present beginning with pharyngal pressure of about 2 cm of water



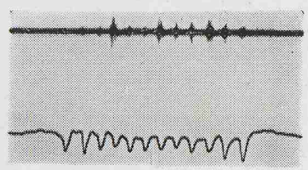
In a laryngectomized patient; in normal respiration action potentials are absent' only during stenosis they appear.

Muscles of the Nasal Valve





In a normal testee during passive movements of the wings obtained by closing the nostrils; no action potentials are present.



In a normal testee during sniffing movements; in some testees the action potentials are absent, in others they are small.

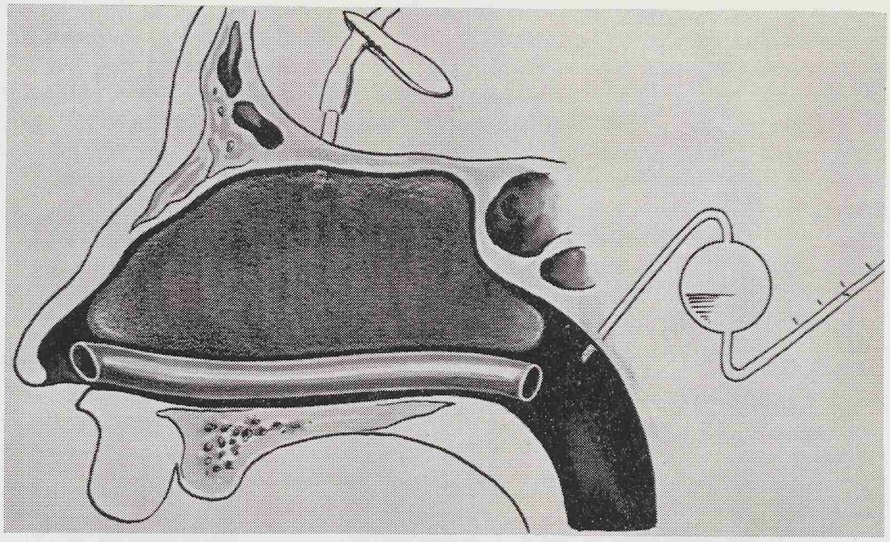


Fig. 3. Cast of the human nose with a small inflatable balloon in order to study the influence of nasal congestion on the resistance.

pressure and consequently the absence of an important resistance in the nasal chamber. Moreover a moderate congestion of the turbinates can be induced by compression of the jugular veins in the neck. If during this **compression test** the pharyngeal pressure does not increase, we may conclude that without this procedure the turbinates are to much shrunken to be of consequence. Consequently during the greatest part of the nasal cycle, breathing takes place mainly through the decongested side and the resistance is mainly caused by the isthmus. This conception explains the remarkably constant both-sided pharyngeal pressure as measured through the mouth. Only during the period of changing over, breathing will be devided between the two nasal passages and then turbinal friction-resistance will be of importance. Perhaps the airstream forces some blood out of the turbinates, thus regulating the resistance and maintaining the total resistance approximately unaltered.

These observations suggest that the nasal cycle is to some extent regulated by the pharyngeal pressure viz. the force needed for inspiration and expiration. Whereas the nasal cycle continues when the nostrils are closed with tape, we certainly must look for a more complicated neural regulation and disregard a simple proprio-receptive mechanism.

The consequences of these considerations, observations and model-experiments of the evaluation of the breathing curves of our patients are important. In the presence of an abnormal resistance we have to decide whether the trouble is located in the valve or in the nasal chamber.

The speculum (dilatation) test will rule out any abnormal resistance in the valve area. Decongestion of the turbinates by means of adrenaline will rule out the accidental congested phase of the nasal cycle.

However if after decongestion the pressure is normalised it must not be forgotten that such a patient may suffer severely from nasal obstruction when his only good-side is in the congested phase.

As one third of our life is spent in bed lying on one side and changing over repeatedly, we must consider the influence of gravity (Cottle) and one-sided compression of the jugular vein during sleep too.

A program of breathing-tests should include

a. before shrinkage breathing through each side (nozzle in other side)
breathing through both sides (tube in mouth)
breathing in sleeping position (nozzle in upside nostril, tube in mouth)

b. after shrinkage breathing through each side.
Dilatation test.
Compression test.

c. Flow tests.

For a scientifically-minded rhinologist the time needed for such a test is well spent. Especially the evaluation of the function before and after operation distinguishes him from the plastic surgeon who is up to now mainly concerned about the appearence of his patient. Moreover these measurements will learn us more on the mechanism (reflexes, allergies, deviations) causing nasal symptomatology.

RÉSUMÉ

La conductivité du nez est la somme des conductivités des deux fosses nasales et ces dernières conductivités sont en raison inverse des résistances respectives. Parceque le cycle nasal produit une congestion et une decongestion alternative des cornets, cette résistance sera déterminée pour la phase de congestion par les cornets (résistance interne) mais pour la phase de décongestion elle le sera par le diamètre de l'ostium interne du vestibule (résistance de l'isthme). Cette thèse fut prouvée par nos expériences sur des modèles et chez nos malades.

Au moyen d'une moulage du nez il fut constaté que sans cornets la résistance était déterminée par l'orifice interne — un minime changement de diamètre ayant déjà un effet considerable, comparable à l'effet d'un robinet d'eau. Durant le gorflement d'un ballon dans la chambre nasale, comparable à la congestion des cornets, il n'y avait d'abord pas de changement dans la pression au niveau du pharynx (résistance), mais au moment même que la lumière restante dépasse celle de l'isthmus la résistance s'accroit considérablement.

Chez les malades ayant une chambre nasale bouchée il est apparu que la dilatation de l'isthme ne diminue pas la pression pharyngienne, tandis que chez les malades ayant une chambre nasale large, cette épreuve de dilatation diminue la résistance. Inversement, en causant une congestion passagère des cornets par pression légère sur les veines jugulaires, la résistance augmente si les cornets sont en jeu, mais pas si la résistance anormale est determinée par l'isthme.

Ainsi «l'épreuve de dilatation» exclura toute anormalité dans la région du vestibule et de la valve (section pathologique), la décongestion par l'adrénaline exclura une congestion accidentelle due au cycle nasal et le test de compression indiquera si la chambre nasale n'est pas trop large.

Il est souligné que si chez un malade, avec adrénaline, la pression est normalisée cela ne vent pas dire qu'il ne souffira pas d'obstruction nasale sévère quand le seul coté bon qu'il possède se congestionne à cause du cycle nasal.

Il est hautement désirable que l'appareillage et le programme des épreuves nasales, soient étudiés et normalisées afin qu'ils puissent être introduits dans toute traitement et chirurgie nasale.

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