# POSITIVE PRESSURE PASSIVE RHINOMANOMETRY
# THE INFLUENCE OF POSITION ON NASAL AIRWAY CONDUCTIVITY

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The increased interest in the measurement of nasal airway resistance has recently begun to produce much needed, new information in the field of rhinologic physiology. Methods of accomplishing this have been varied. Most of these, however, have demanded the active participation of the patient being tested. Occasionally, problems have arisen from both the subjective variables involved in a test patient trying to breathe "normally", as well as the often cumbersome and awkward face masks and instruments employed in testing. Systematic rhinomanometric studies on the influence of position on nasal airway conductivity are scarce. This appears to be due partly to the fact that

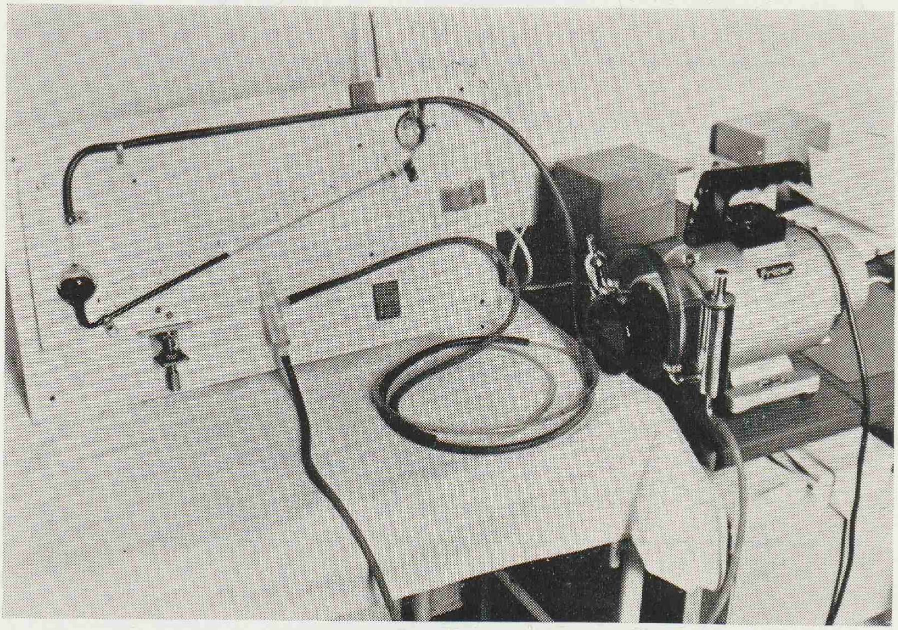

Figure A: Equipment for positive pressure passive rhinomanometry including a compressor--aspirator pump, a sensitive water manometer scaled in millimeter units on a 17 degree angle extrapolated from the vertical fluid column, and the special nozzle

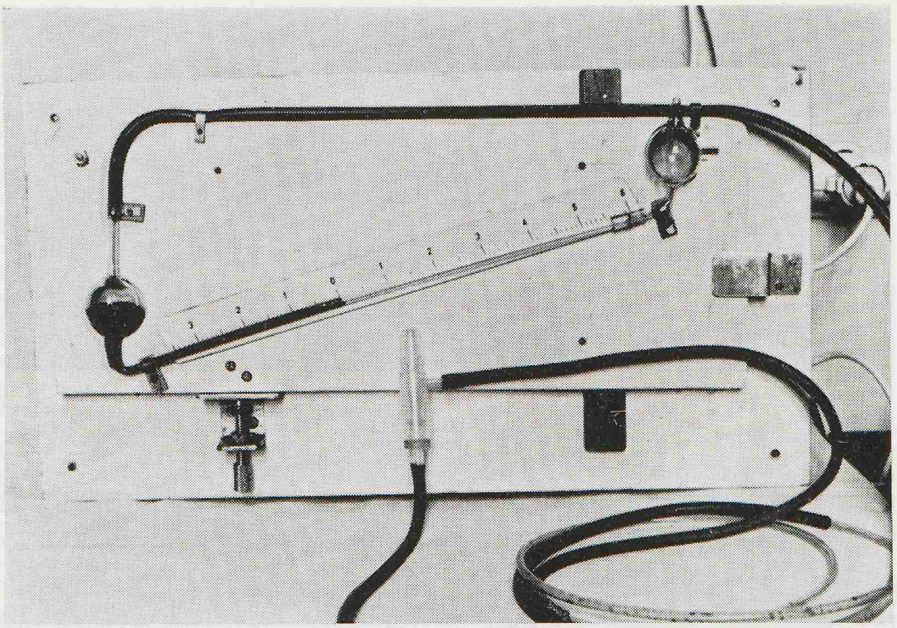

Figure B: Detail of "sensitized water manometer". The millimeter scale is spread out by being on a 17 degree angle instead of being vertical.

rhinomanometric instrumentation presently is highly individual, with no method, so far, gaining wide acceptance. Perhaps this is due to the sophistication and expense of many of these instruments. Positive pressure passive rhinomanometry offers a simple method to obtain in a short test, information needed to study the effects of body position on nasal airway resistance, as well as routine upright testing.

A method of testing nasal airway resistance by blowing an air current into the nose and measuring its resistance to passage was introduced by Professor H. A. E. van Dishoeck in his early studies of infrared radiation, and by van Dishoeck and van Dishoeck in their later studies (van Dishoeck, 1935, Dishoeck, H. A. E. van, and Dishoeck, E. A. van, 1970). This method has been adapted to investigate both anatomic and physiologic factors involved in position testing of nasal airway resistance.

**Instrumentation**

A sensitive water manometer with an angle from the horizontal of 17 degrees was used. This angle allowed greater accuracy in determining small occilations of the fluid column. A compressor-aspirator pump (Fricar LK 49) supplied the air flow for testing at a positive or negative pressure of twenty liters per minute. A special nozzle was designed to decrease the turbulence of the positive pressure air stream, making it a more laminar column of air. The limits of testing with this manometer were 60 mm of water resistance. (Figures A, B, and C.)

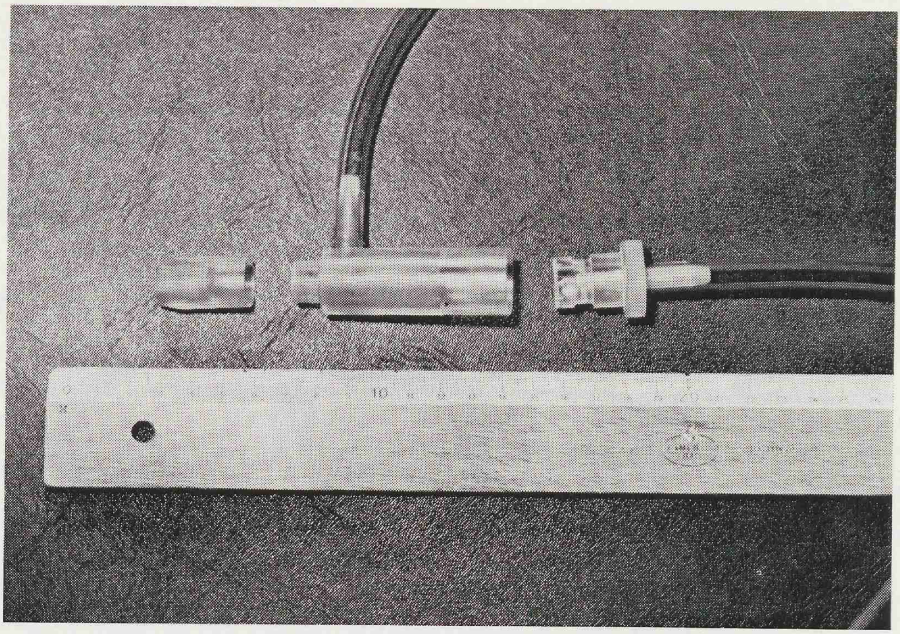

Figure C: The nozzle detail. Designed to decrease turbulence and create a more laminar flow of air.

## Method

The method used consists of blowing an airstream into either the right or left nostril, or the mouth, and measuring the resistance to its passage while the patient is temporarily not breathing. Nasal airway resistance is measured as that pressure of air which, in not passing through the nasal airway, backs up into the manometer raising the water column in millimeter units. Nasal airway resistance, therefore, is inversely related to the volume of nasal air flow. The main advantage is that nasal airway resistance is measured independently of pulmonary ventilation; for an artificial air pump supplies a constant airstream, and not the ever-changing rate of air flow via the lung pump.

A specific protocol for testing was designed to study the patient (Figure D), not only in the usual sitting position, but also in the left and right recumbent positions as well as the Trendelenburg position (Figures E, F, G, H, I and J) The use of jugular compression in the sitting position was also employed to study the effects of increased venous pressure on nasal airway resistance. It was found that jugular compression for at least 30 seconds without compromise of carotid arterial flow, caused maximal increase of intra-nasal resistance to be attained.

A randomly sampled clinic population was studied in an attempt to correlate rhinomanometric findings with specific clinical diagnoses.

## Results and discussion

More than one-half of the life span is spent in the recumbent position. It is common knowledge that nocturnal nasal stuffiness and/or total blockage of

Laboratory:

| I. Flow Rate: | Sitting Position | | Recumbent L | R | Supine | Trendellenburg |
|---|---|---|---|---|---|---|
| In Mouth ---------------------------- Out Both Nostrils | | | | | | |
| In Mouth -- Out Both Nostrils -- Jugulars Compressed | | | | | | |
| In Mouth -- Out Right Nostril -- Left Nostril Occluded | | | | | | |
| In Mouth -- Out Left Nostril -- Right Nostril Occluded | | | | | | |
| | + | — | | | | |
| In Mouth -- Out R. -- L. Occluded -- Jugulars Compressed | | | | | | |
| In Mouth -- Out L. -- R. Occluded -- Jugulars Compressed | | | | | | |
| In Right Nostril -- Out Left Nostril -- Mouth Closed | | | | | | |
| In Left Nostril -- Out Right Nostril -- Mouth Closed | | | | | | |
| In Right Nostril -- Out Mouth -- Left Nostril Occluded | | | | | | |
| In Left Nostril -- Out Mouth -- Right Nostril Occluded | | | | | | |

Figure D.

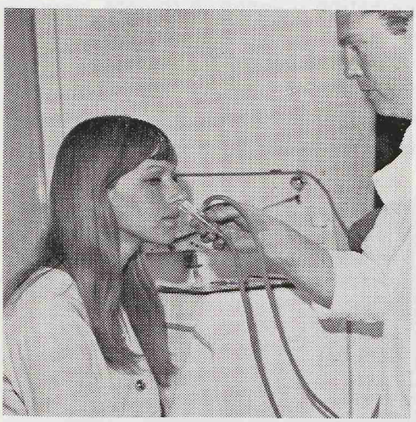

Figure E: Air stream entering mouth and exiting via both nares. The procedure best tolerated initially by test-patient. Note: Nozzle must be aimed directly toward mesopharynx to obtain lowest most accurate) resistance.

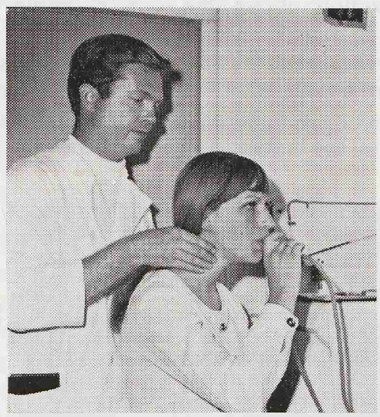

Figure F: Jugular compression. Gentle, firm pressure on both jugular veins for a minimum of 30 seconds before testing. Increased airway resistance approximates resistances in recumbent positions.

the nasal airways frequently accompanies certain pathologic states. Often it is hard for the clinician to appreciate these bona fide complaints while examining the patient, for nearly always the patient is in the sitting position. Venous pressure in the turbinate erectile tissue in this position is normally less by a substantial degree than in the supine, prone, right or left recumbent positions. In the data presented in table A, one can readily appreciate the obvious increase in the nasal airway resistance in the recumbent positions. Test results were similar when testing of both nasal airways was performed with added

jugular compression. It was observed in most patients that a point of critical congestion occurred between the erect sitting position and the recumbent positions. Occasionally, patients who had adequate airways for normal nasal respiration in the sitting position, became blocked in the recumbent positions. Nasal respiration, essentially, was impossible for these patients while they were sleeping. Other patients with good nasal airways in the erect position, showed borderline nasal airways with high resistances when recumbent. This group complained of intermittent nocturnal nasal blocking and total nasal blocking during allergic rhinitis episodes or upper respiratory infections.
It was noted that if the patient slowly assumed the supine position from the erect sitting position by graded changes, no increase in nasal airway resistance would occur until the patient's head and back were below an angle of 25 degrees made with the horizontal. This critical angel of congestion is clinically significant for patients with allergic rhinitis, upper respiratory tract infections, static (partial anatomic) nasal airway blockages, or dynamic (intermittent) nasal airway blockages. The physiological recuperative state of rest or sleep in the recumbent position is basic to both mental and physical health. Nasal airway blockages, whether relative or absolute, preclude optimal recuperative benefit from repose in this position. Many patients, however, with mild relative blocking in the recumbent position may have an open nasal airway state if the head is elevated 25 degrees or more while sleeping. This elevation above the critical angle of congestion causes turbinate venous congestion to be dissipated.
Jugular compression, administered unilaterally or bilaterally, by finger pressure, elastic band compression, severe turning of the head, or with controlled pressure measured with a water manometer, has given valuable information as to the specific reactivity of the intra-nasal soft tissue structures. Jugular

Figure G: Nasal airways tested in series. Air stream enters left nares and exits via right nares. Mouth remains closed. Nozzel tip in all testing just touches the nostril circumference creating an airtight seal. At no time does nozzel tip enter into vestibule. This prevents distortion of alae and nasal valve.

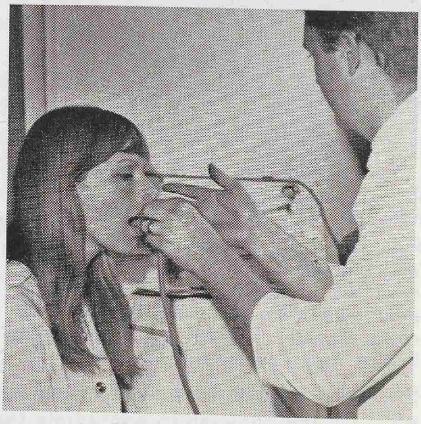

Figure H: In right nostril and out mouth, with left nostril gently occluded by examiner's finger. This simulates inspiration passively through right nasal airway.

| Testing<br>Air Flow Rate<br>20 Liters/min. | Patient 1 51M<br>No Rhinologic Complaints<br>Normal Rhinologic Examination<br>No Allergic Diathesis | | | Patient 2 23 F<br>No Rhinologic Complaints<br>Normal Rhinologic Examination<br>No Allergic Diathesis | | | Patient 3 32 M<br>Mild Nocturnal Blocking Left Nasal Airway<br>Exam: Septum Deviated to Left & impacted into turbinate | | | Patient 4 45 F<br>Crusting in Nasal Vault<br>Foul Odor<br>Klebsiella ozena<br>Corynebacterium belfonti | | | Patient 5 20 M<br>Allergic Rhinopathia<br>Skin Tests:<br>House Dust 4+<br>H. influenza 4+<br>Pneumococcus 4+<br>Staphylococcus 5+<br>Exam: Congested Turbinates | | | Patient 6 29 M<br>Atopic Rhinitis<br>Exam: Concomitant Septal Deviation to Left Side Posteriorly | | | Patient 7 18 F<br>Sleeps better on Right Side<br>Exam: Deviation and spurring of Septum to Right<br>Narrow tall Leptorrhine Nose | | | Patient 8 35 M<br>Intermittent Dryness & Crusting of Mucous Membrane<br>Allergic to peanuts<br>Exam: Tall thin nose - Narrow airways | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. | Sit. | L. Rec. | R. Rec. |
| IM - OBN | 8 | 14 | 12 | 15 | 25 | 22 | 17 | 22 | 16 | 3 | 8 | 8 | 27 | 32 | 48 | 22 | 48 | >60 | 14 | 19 | 14 | 4 | 16 | 14 |
| IM - OBN - JC | 15 | - | - | 23 | - | - | 17 | - | - | 7 | - | - | 38 | - | - | >60 | - | - | 23 | - | - | 16 | - | - |
| IM - OR - L. Occ. | 17 | 23 | 17 | 28 | 60 | 50 | 20 | 30 | 32 | 9 | 11 | 11 | >60 | >60 | >60 | 45 | >60 | >60 | 38 | 42 | >60 | 10 | 22 | 40 |
| IM - OL - R. Occ. | 13 | 17 | 28 | 33 | 42 | 44 | 32 | >60 | 43 | 10 | 11 | 11 | 48 | >60 | 52 | 42 | 60 | >60 | 29 | 17 | 29 | 12 | 44 | 25 |
| IM - OR - L. Occ. JC | 19 | - | - | 50 | - | - | 34 | - | - | 11 | - | - | >60 | - | - | >60 | - | - | 58 | - | - | 12 | - | - |
| IM - OL - R. Occ. JC | 20 | - | - | 43 | - | - | 44 | - | - | 11 | - | - | >60 | - | - | >60 | - | - | 32 | - | - | 20 | - | - |
| IR - OL - MC | 14 | 24 | 24 | 29 | 55 | 60 | 38 | 48 | 43 | 11 | 16 | 16 | 54 | >60 | 34 | 55 | >60 | >60 | 33 | 45 | 42 | 17 | 52 | 42 |
| IL - OR - MC | 15 | 22 | 23 | 30 | 60 | 60 | 33 | >60 | 43 | 11 | 17 | 17 | 55 | >60 | >60 | 60 | >60 | >60 | 35 | >60 | 60 | 17 | 50 | 43 |
| IR - OM - L. Occ. | 6 | 9 | 9 | 15 | 33 | 26 | 8 | 17 | 16 | 5 | 8 | 8 | 16 | 29 | 46 | 17 | 40 | >60 | 25 | 35 | 33 | 9 | 12 | 24 |
| IL - OM - R. Occ. | 9 | 14 | 17 | 15 | 20 | 33 | 32 | 42 | 42 | 5 | 8 | 8 | 26 | 41 | 15 | 30 | >60 | 32 | 20 | 13 | 42 | 12 | 47 | 21 |
| Comment | Normal Adult Male | | | Normal Adult Female | | | Borderline Blocking of Left Nasal Airway in Recumbent Position | | | Ozena Diminished Turbinate Congestibility | | | Hyper-reactive Turbinates in Dependent Recumbent Position | | | Hyper-reactive Turbinates Dependent Predominance of Resistance | | | Collapsing Upper lateral Cartilages | | | Dependent Predominance of Resistance; Turbinate on Dependent side swells greatest | | |

Table A.

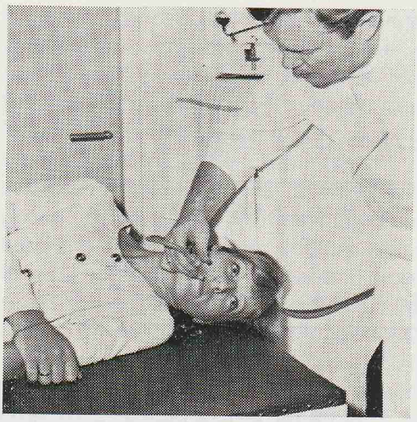

Figure I: Series testing of nasal airways in the left lateral recumbent position. This position must be maintained for 60 seconds to attain maximal airway resistance prior to testing.

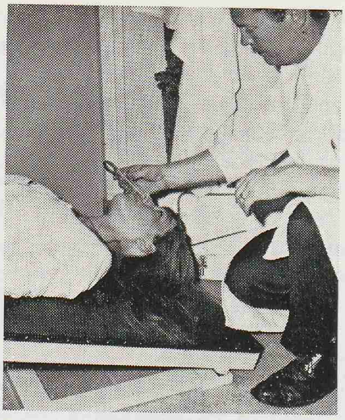

Figure J: Series testing of nasal airways in the Trendelenburg position.

compression performed for 30 seconds prior to testing nasal airway resistances, artifically approximates the decreased nasal air flow state (increased nasal airway resistance) found in the prone, supine, right or left recumbent positions.

Position testing with positive pressure passive rhinomanometry explored the hyper-reactive, hyper-congestable state of the turbinate erectile tissue in atopic and non-atopic nasal allergy states. Cases # 5 and 6 in table A show increased nasal airway resistance due to the hyper-congestability of the turbinate tissue in the recumbent positions as well as in the erect positions with jugular compression. Although these cases are included only as examples of the hyper-reactive state, many other cases demonstrated similar findings. The effect of the nasal valve (internal ostium) and the nasal alae were also studied with positive pressure passive rhinomanometry. In nasal pyramids where these structures are flaccid and easily movable, they constitute a very real cause of increased nasal airway resistance. This phenomenon, however, can only be appreciated when testing is performed in several different positions. Cases 7 and 8 in table A demonstrated this phenomenon. When patients with flaccid upper lateral cartilages were tested with the same test procedure in first the right recumbent, and then the left recumbent positions, often there were significant discrepancies in the data obtained. This is understandable when one can actually visualize the falling away from the midline of the alar rim and the upper lateral cartilages on the dependent side in one recumbent position, and then the collapsing in toward the septum of these structures in the opposite recumbent position with a concommitant increase in nasal airway resistance.

## SUMMARY

A new method of testing nasal airway resistance is presented. The simplicity and accuracy of this method of testing makes it valuable to both the clinician

and laboratory investigator. The importance of testing in various body positions is discussed and amplified by data obtained from test patients. The similar results of testing with jugular compression and testing in recumbent positions is discussed. The point between the erect and recumbent positions below which turbinate congestion cccurs, and above which turbinate congestion disappears, has been called the critical angle of congestion. A complete protocol for testing is presented in such a way that test patients will adapt best to the test conditions and thereby give accurate data.

## REFERENCES


1. Dishoeck, H. A. E. van, 1935: Infra-red radiation and nasal obstruction. J. Hygiene, Vol. XXXV, nr. 2.
2. Dishoeck, H. A. E. van, and Dishoeck, E. A. van, 1970: Nasal resistance measuring without breathing. Rhinology, Vol. VIII, nr. 1.



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