RHINOMANOMETRIC STUDIES COMPARED TO BODY-PLETHYSMOGRAPHIC MEASUREMENTS

Werner Ey, Heidelberg, West-Germany

I know — and I am sure, most of you, too know — the excellent studies of Ogura, Unno and Nelson (1968) about plethysmographical measurements of airway resistance and pulmonary compliance during nasal breathing as well as mouth breathing. He observed — you remember — a decreased compliance and an increase in pulmonary resistance during mouth breathing in the presence of nasal obstruction.

We, ourselves, were more interested in comparing the results of rhinomanometric measurements with those obtained by body-plethysmographic procedures; for we wanted to learn how to evaluate both these methods, especially with regard to the nasal function.

Following the work of Courtade (1903), continued and mostly developed by Cottle (1963), Stoksted and Nielsen (1957), van Dishoeck (1965), Spoor (1965) and Masing (1966) and other excellent investigators, we have made rhinomanometric measurements in numerous normal persons and in more than 250 cases with different nasal obstruction (Ey, 1968).

We were using electromanometers and a Fleisch-Pneumotachograph in a Siemens-Elema Unit — specified by Masing (1966) — for measuring the trans-nasal pressure difference $\triangle$ p in mm H_2O and the flowrate of nasal airstream Q (or $\overset{\circ}{V}$) in L/sec. and the respiratory volume per minute. We were able to have a bilateral nasal, so called posterior rhinomanometric measurement, using an airthight facemask, and also unilateral anterior procedures of the right and the left nasal cavity.

The coefficient of nasal resistance, i.e. the nasal P — Q — relationship, we call it λ,

$$(\lambda = \frac{P}{Q^2} \cdot 100)$$

is — in our view — a very excellent indicator for changing in nasal respiratory function.

In body-plethysmographic measurements (Du Bois, et al, 1956) the most important factor for our comparing studies is the airway — resistance, defined as the quotient of alveolar pressure-change ($\triangle$Palv) to the rate of airflow ($\overset{\circ}{V}$)

$$R = \frac{\triangle \text{ Palv}}{V} \qquad \frac{\text{cm } H_2O}{\text{L/sec}}$$

This definition we may find again in our rhinomanometric P-Q-relationship

$$\lambda = \frac{\Delta P}{Q} \cdot \left(\frac{1}{Q} \cdot 100\right); \quad \frac{\Delta P}{Q} \triangleq \frac{\Delta Palv}{\mathring{V}} = R$$

MOUTH

13.2.69. E.H. m. 27 Y.

$\alpha_2 = 49,50$

$\beta_2 = 76,50$

$R_2 = 2,45$

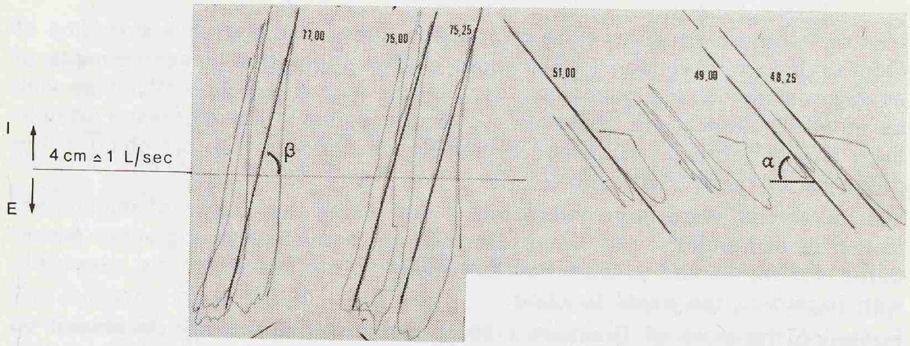

Figure 1. Body-plethysmographic curves of mouth breathing. Left: airway resistance curves with the angel β of the box pressure flowrate-diagram.
R = 2,45
Right: curves with angel α as relationship between changes of box pressure and alveolar pressure for determining the functional residual capacity, FRC.
FRC mouth = 2,73.

NASAL, both sides open

13.2.69. E.H. m. 27 Y.

$\alpha_1 = 47,75$

$\beta_1 = 67,25$

$$R = \frac{\tan \alpha_1}{\tan \beta_1} \cdot K$$

$R_1 = 4,36$

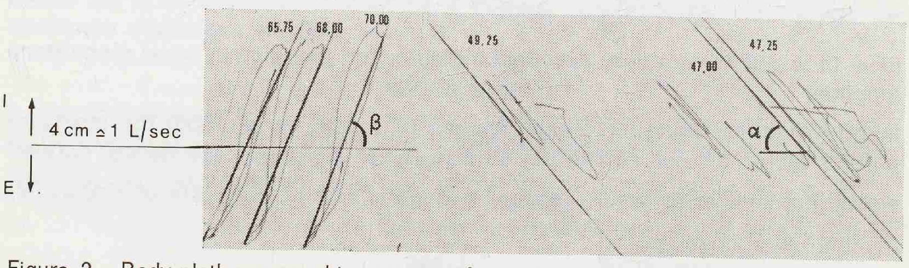

Figure 2. Body-plethysmographic curves of nasal breathing, both sides open.
R = 4,36 FRC = 2,92

NASAL, right side open

13. 2. 69. E.H. m. 27 Y.

$\alpha_3 = 44{,}25$

$\beta_3 = 32{,}50$

$R_3 = 14{,}94$

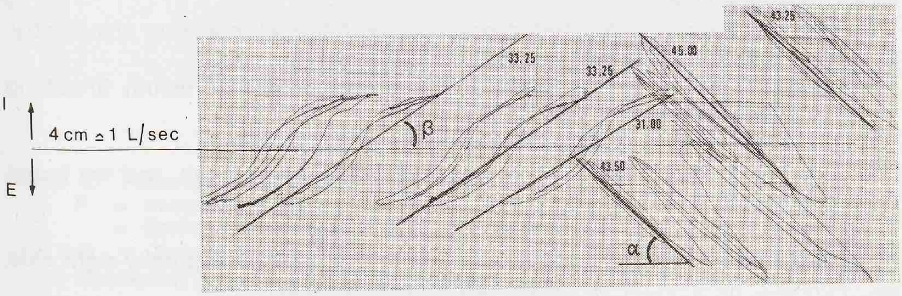

Figure 3. Body-plethysmographic curves of nasal breathing, right side open
R = 14,94 FRC = 3,32

NASAL, left side open

13. 2. 69. E.H. m. 27 Y.

$\alpha_4 = 47{,}25$

$\beta_4 = 58{,}00$

$R_4 = 6{,}52$

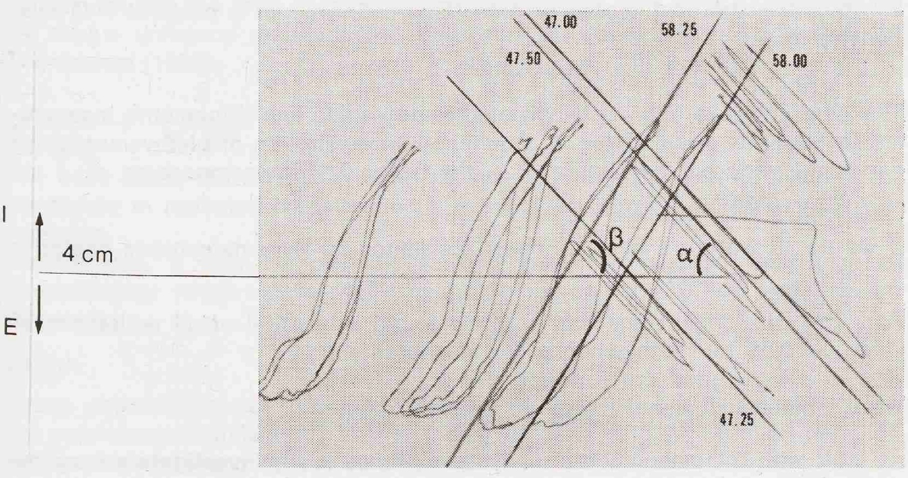

Figure 4. Body-plethysmographic curves of nasal breathing, left side open
R = 6,52 FRC = 2,93

So we have the possibility of calculation λ by plethysmographically measuring of alveolar pressure and rate of airflow. Now, I may be allowed to give you one example of our series of 58 rhinomanometric-plethysmographical investigations.

We measured — in a young man — the airway resistance R, Volume $\mathring{V}$ and functional residual capacity FRC by body-plethysmography for mouth breathing, nasal breathing, both sides open, also only right nasal cavity open and vice versa only left side open.
Then, we did the rhinomanometric procedures; bilateral, posterior rhinometry, unilateral anterior rhinometry, left and right side.
The Figure 1 shows us the plethysmographical curves of mouth breathing with an airway resistance of

R = 2,45 and a flowrate of 1,25 L/sec.

The Figure 2 gives a picture of nasal curves, both sides open, and we found a resistance of

R = 4,36 with 0,87 L/sec

and furthermore (Figures 3 and 4) unilateral nasal plethysmography right side R = 14,94, left side R = 6,52.
Now, we calculate, as nasal resistance, the difference between nose and mouth breathing
(getting a nasal pressure difference
of $\triangle$ P 1,91 cm H_2O/L/sec or 0,318 mm H_2O/L/min.
and a nasal flow rate
of $\mathring{V}$ = 0,8 L/sec or Q = 48,0 L/min.)
and may calculate the coefficient

$$\text{as } \lambda = \frac{\triangle P}{Q^2} \cdot 100$$

and find the plethysmographical measured nasal P-Q-relationship of

λ_{Ple} = 0,65 mm $H_2O/L^2/min^2$

By rhinomanometrical measurements (Figure 5) we got a bilateral P-Q-relationship of

λ_{Rh} = 1,14 mm $H_2O/L^2/min^2$

The different calibration between plethysmographic and rhinometric measurements requires — as to see in simultaneous registration of plethysmographic and rhinometric curves (Figure 6) — the factor 0,63 for comparision of

λ_{Ple} and γ_{Rh}

If we do so we get a bilateral nasal resistance by rhinomanometria posterior of λ_{RH} = 0,71

And you will kindly remember that we found a bilateral nasal resistance of γ Ple = 0,65 by plethysmographic measurements.
This is a very good correspondence.
Now, what conclusions are to be drawn?

At first: with rhinomanometric measurements we really investigate a very important part of airway function and in regarding the pulmonary airway resistance we must always know the nasal resistance.

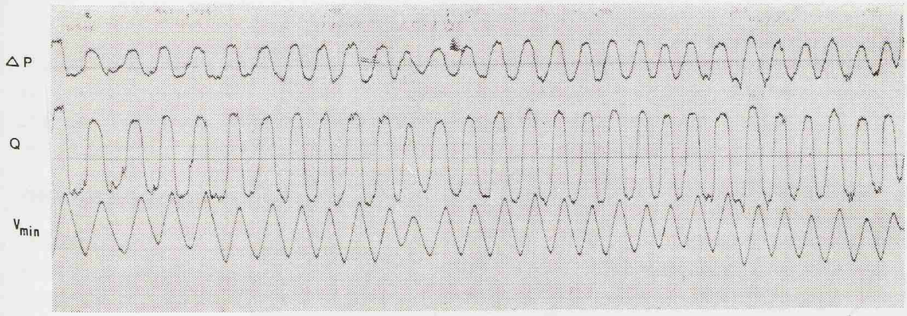

Figure 5. Posterior rhinomanometric curves.
Δ P = transnasal pressure changes
Q = flowrate of nasal airstream
V min = Volume per minute
λ = Coefficient of nasal resistance (average)

Second:

Provided we consider the P-Q-relationship λ as a practicable indicator for nasal respiratory we have no need of body-plethysmography; on the contrary in rhinomanometric procedures we are directly measuring the nasal resistance coefficient and have not to calculate the difference between nose — and mouth breathing, what appears — as Ogura, Unno and Nelson (1968) supposes — not quite correct.

Third:

In rhinomanometric investigation we are allowed — as proved by experiences — to calculate the total nasal resistance coefficient with quite correct results by simple unilateral measuring of right and left nose, using this formula of Arentschild (1966).

$$\frac{1}{V\lambda \text{ right}} + \frac{1}{V\lambda \text{ left}} = \frac{1}{V\lambda \text{ total}}$$

We have seen, that the total nasal resistance coefficient shows a sufficient constancy in repeated measurements, even in unilateral rhinomanometric differences.

Furthermore, it may be possible to determine the isolated resistance of nasopharynx, which occasionally might be increased, e.g. by hypertrophic adenoids.

Fourth:

Some observations let us suppose that it will be possible to calculate even the pulmonary compliance by rhinomanometric measuring of λ, which depends on the flow rate and on the volume.

Therefore, I think, we should have more effort in observation of characteristical aberrations in rhinomanometric curves, like a mid-cycle rest of which Cottle

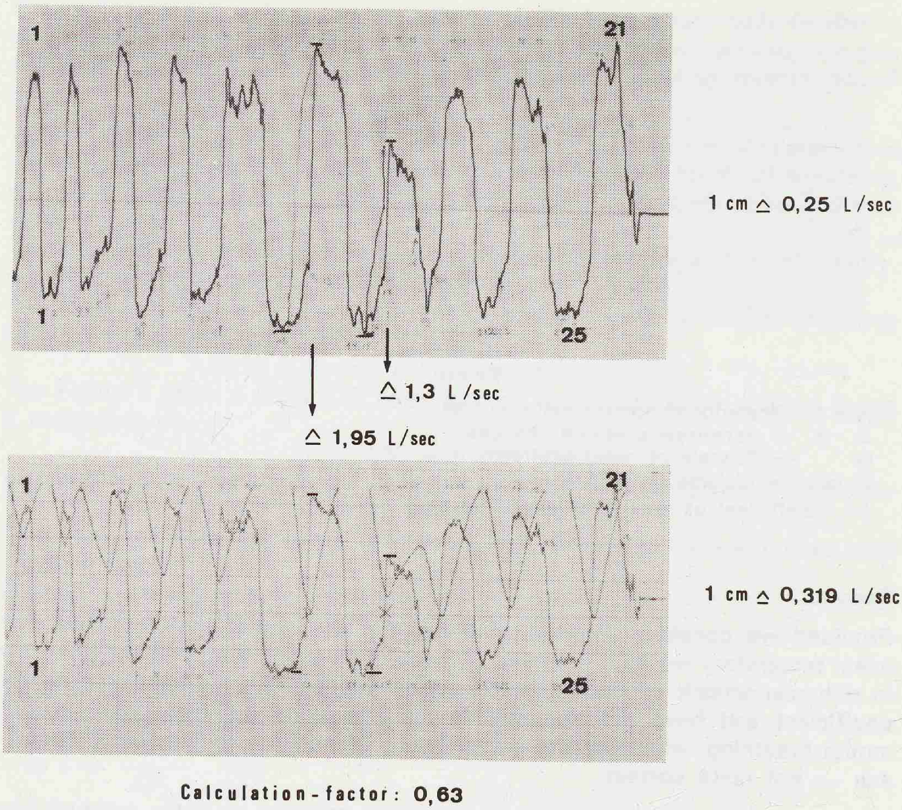

Figure 6. Simultaneous registration of flowrate by body-plethysmograph and rhinomanometrical. Calculation factor for comparision of both values = 0,63.

(1963) reffered, and which may be the expression of derailements of the total respiratory function; then, in addition, in such cases, body-plethysmography, supplied by other practicable methods of lung function examination will support our efforts in exploring the naso-pulmonary interdependence, in which we all are very interested.

SUMMARY

Measuring of airway resistance in mouth and nasal breathing by body-plethysmography followed by rhinomanometric measurements in the same normal persons allow us to evaluate both methods especially in regard to nasal function. Therefore it is necessary to determine the coefficient of nasal resistance — so called P-Q-relationship λ — by rhinomanometric procedures and to calculate this coefficient by the results of body-plethysmography. Comparing this gives a very good correspondence in both methods. Regarding to nasal function and to the naso-pulmonary interdependence the valuation of rhinomanometric and additional lung function examinations are discussed.

RÉSUMÉ

Ayant mésuré la résistance aérienne de la respiration buccale et nasale par la pléthysmographie du corps et les mensurations rhinomanométriques de la même personne permêt juger de deux méthodes surtout en considération de la fonction nasale. Pour cela il faut déterminer le coefficient de la résistance nasale — qu'on appelle P-Q-rélation λ ($\lambda = \frac{\triangle p}{Q^2} . 100$; $\triangle p$ = difference de pression, Q = vélocité du courant d'air nasal) — par des mensurations rhinomanométriques et calculer ce coefficient par les résultats de pléthysmographie du corps. Si l'on établit un parallèle on trouvera une correspondence très bonne entre le deux méthodes. La valeur de la fonction rhinomanométrique et de l'adjonction de l'examen fonctionnel du poumon est discuté en regard de la fonction nasale et de l'interdépendence naso-pulmonaire.

REFERENCES

1. Arentschild, O., v., 1966: Der Nasenwiderstand bei Eigen- und Fremdstrommessung. Arch. Ohr.-Nas.-KehlkHeilk., 187, 664.
2. Cottle, M. H., 1963: Rhino-sphygmo-manometry and rhino-rheo-sphygmo-manometry. Int. Rhinol., 1, 23.
3. Cottle, M. H., 1968: Rhino-sphygmo-manometry an aid in physical diagnosis. Int. Rhinol., 6, 7.
4. Courtarde, A., 1903: Obstruction nasale. Étude clinique et physiologique. Arch. int. Laryng., 320, 884.
5. Dishoeck, H. A. E. van, 1965: The part of the valve and the turbinates in total nasal resistance. Int. Rhinol., 3, 19.
6. Du Bois, A. B., et al., 1956: New method for measuring airway resistance in man using a body plethysmograph. J. clin. Invest., 35, 327.
7. Ey, W., 1968: Rhinomanometrische Untersuchungen bei funktionsplastischer Chirurgie der Nase. Arch. Ohr.-Nas.-KehlkHeilk., 191, 689.
8. Masing, H., 1966: Die klinische Bedeutung der Nasenwiderstandsmessung. Arch. Ohr.-Nas.-KehlkHeilk., 187, 664.
9. Masing, H., 1967: Die Rhinomanometrie. Electromedica, 2, 6.
10. Ogura, I. H., Unno, T. and Nelson, I. R., 1968: The effect of nasal obstruction on pulmonary, airway and tissue resistance. The Laryngoscope, 88, 1119. (Here to find further bibliography of Ogura and co-workers).
11. Spoor, A., 1965: A new method for measuring nasal conductivity. Int. Rhinol. 3, 27.
12. Stoksted, P. and Nielsen, I. Z., 1957: Rhinomanometric measurements of the nasal passage. Ann. Otol. Rhinol. Laryng., St. Louis, 66, 187.

The University ENT-Clinic of Heidelberg and from the Medical Department - Ludolf-Krehl-Klinik - of University of Heidelberg.

This work had been performed with the assistance of H. Enzmann and Dr. G. Utz.