The indirect measurement of nasal airway resistance

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SUMMARY

This is a comparative study of two indirect methods for measuring nasal airway resistance.
1. In 499 patients, nasal airway resistance was studied with the alternating pressure principle. Using mathematical and computer analysis, nasal resistance averaged 18,7 and 15,4 mm $H_2O/1/sec.$, respectively. This correlates well with literature data of nasal resistance, as defined by different methods.
2. In 760 patients nasal airway resistance was studied with the body plethysmograph. The mean value was 11,5 mm $H_2O/1/sec.$ We believe, that there is a methodical failure due to leakage of the mask during exspiration against a mechanical closing mechanism of the body plethysmograph.

THE description of the principle of body plethysmography by DuBois in 1956, led to the first indirect measurement of nasal airway resistance by Butler in 1960 using this method.
After defining the tracheobronchial resistance in mouth-breathing and subsequently the total airway resistance while nose-breathing, the difference of the two resulted in the definition of the nasal airway resistance. For defining indirect nasal resistance, Dirnagl (1953) described an alternating pressure recording as a further method.

METHODS

a) *The body plethysmograph*
With patients in the body plethysmograph (fig. 1), breathing excursions of the thorax result in a fluctuation of the cabin pressure. First, the pressure changes in the cabin are registered during a respiratory airflow of 1 l/sec. Subsequently, the corresponding alveolar pressure is recorded interrupting the airflow mechanically. In addition, this gives us the intrathoracic gas volume of patients knowing their weight (intrathoracic gas volume = functional residual capacity) (DuBois, 1956). Like Butler (1960), Guillerm (1961 and 1967) and Cohen (1969 and 1970), we evaluate our curves at a point corresponding to an airflow 0,5 l/sec., obtaining a laminar airflow and a linear relation of pressure and flow volume.

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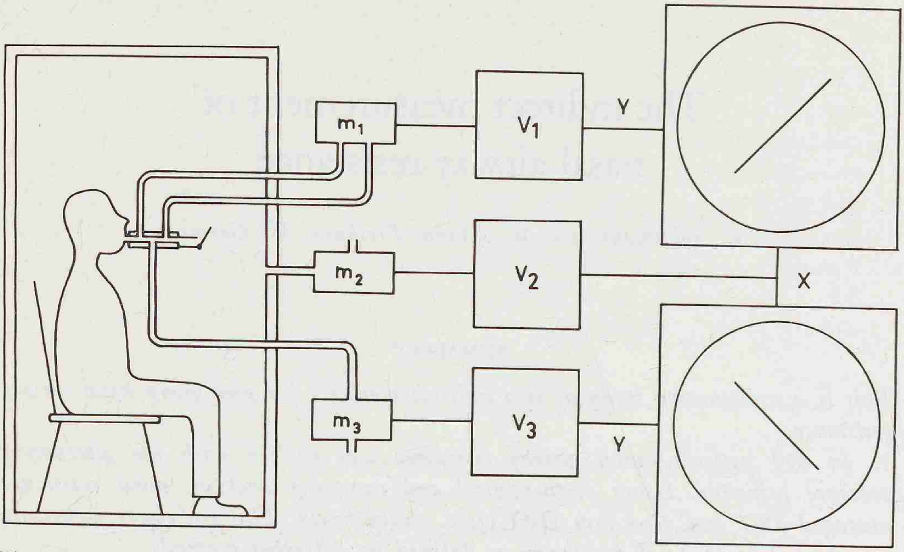


Fig. 1: The body plethysmograph; m_1, m_2, m_3: manometers; V_1, V_2, V_3: amplifier; x-y: registration.

b) *The alternating pressure recording*

This method is as accurate as the body plethysmography and has first been reported by Dirnagl (1953), registering the airway resistance during respiration. After

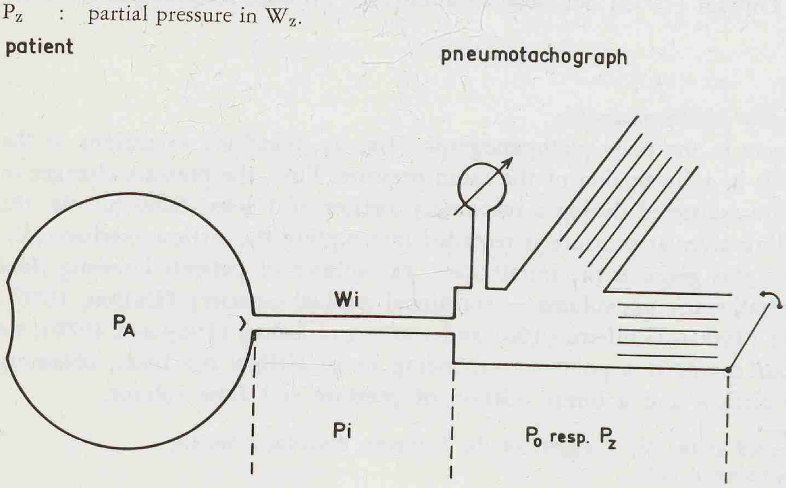
Fig. 2: Measurement of the airway resistance with alternating pneumotachographic resistance.

P_A : alveolar pressure; W_i: airway resistance;

P_i : partial pressure in W_i; W_o: mechanical resistance with an open system (3,6 mm H_2O/1 a. sec);

P_o : partial pressure in W_o; W_z: mechanical resistance with a closed system (11,9 mm H_2O/1 a. sec);

P_z : partial pressure in W_z.



passing through the airway (fig. 2), the airflow is conducted through a pneumotachograph having a deliberately changeable resistance with different partial pressures proportionally to the airway resistance.
In order to obtain a continous dynamic measurement of human airway resistance, we alternate the mechanical resistance of the pneumotachograph in a controlled manner. The subsequent change of airflow indicates the airway resistance (Dirnagl, 1953). With monograms and computerized analysis this method is even more facilitated.

RESULTS

I *Boby plethysmograph*

a) The indirect nasal resistance in 606 adults using the body plethysmograph averaged 11,9 mm H_2O/l a. sec. The data of our population were:

mean age: 24,75 ± 8,20 years
height : 175,88 ± 6,87 cm
weight : 73,89 ± 10,56 kg

The mean tracheobronchial airway resistance was 14,9 mm H_2/1 a. sec. as defined by an average pneumotachogram-cabin-pressure angle of 79,61 ± 3,77 degr. and an alveolar-cabin pressure angle of 45,25 ± 5,76 degr. Using a breathing mask, the equivalents were 69,85 ± 7,99 degr. and 39,63 ± 6,21, respectively. The total resistance while breathing through the nose was 26,8 mm H_2O/1 a. sec. The average functional residual capacity was 3180,0 ml.

b) The nasal resistance in 154 children aged 5 to 16 years was 11,0 mm H_2O/1 a. sec. The data of this population were:

mean age: 9,89 ± 2,31 years
height : 142,34 ± 21.56 cm
weight : 35,62 ± 10,86 kg

The tracheobronchial resistance was 34,1 mm H_2O/1 a. sec. with a pneumotachogram-cabin pressure angle of 80,13 ± 3,21 degr. and an alveolar-cabin pressure angle of 64,91 ± 6,77 degr.
Using the mask, the total airway resistance was 45,1 mm H_2O/1 a. sec., with angles of 73,15 ± 5,30 degr. and 57,93 ± 6,87 degr., respectively. The mean functional residual capacity was 1470 ml.

II *Alternating pressure method*

Using an alternating pressure method, we registered the indirect nasal airway resistance in 39 patients. Oud population had following data:

mean age: 22,6 years
height : 179,3 cm
weight : 73,0 kg

5680 hand analysed registrations averaged a nasal resistance of 18,7 mm H_2O/1 a. sec. This correlates well to the literature. In further tests we used a computer for direct analysis and printing of the results in 460 patients. The data of this group were:

mean age: 23,02 years
height : 176,81 cm
weight : 74,08 kg

The computerized mean thracheobronchial resistance was 17,5 mm H_2O/1 a. sec., the average total resistance 32,1 mm H_2O/1 a. sec., resulting in a nasal resistance of 15,4 mm H_2O/1 a. sec., respectively.

DISCUSSION

Evaluating our data for nasal airway resistance as calculated mathematically or by a computer, 18,7 mm H_2O/1 a. sec. and 15,4 mm H_2O/1 a. sec. correlated well with data reported in the literature.

While using the body plethysmograph, nasal resistance in children averaged 11,0 mm H_2O/1 a. sec. and 11,9 mm H_2O/1 a. sec. in adults respectively. These results contrast to the nasal resistance as defined by the alternating pressure method.

We believe that the discrepancy between the two mehods is methodically and caused by the elasticity of the mask with possible minimal air leakage, when patients are breathing against the mechanically interrupted airflow.

Additional hazards may be caused by changes of tracheobronchial resistance while switching from mouth to nose breathing. For measuring the nasal airway resistance, we now use exclusively the synchronous method with simultaneous x-y registration at an airflow of 0,5 l/min.

The body plethysmograph and the alternating pressure recording is reserved for measurements of laryngeal and tracheal airway resistance.

RÉSUMÉ

Il s'agit de l'étude comparative de deux méthodes indirectes de mesure de la résistance nasale.

1o Ches 499 patients, la résistance est mesurée sur le principe de la pression alternante. La résistance nasale moyenne est de 18,7 mm H_2O/1/sec. pour le calcul manuel et de 15.4 H_2O/1/sec. pour l'ordinateur.

2o Chez 760 patients, la résistance est étudiée à l'aide d'un pléthysmographe corporel. La valeur moyenne est 11,5 mm H_2O/1/sec.

Les auteurs pensent que cette différence de valeur est un défaut de la première méthode par fuite au niveau du masque pendant l'expiration, contrastant avec la fermeture mécanique du pléthysmographe.

ZUSAMMENFASSUNG

Bei 760 Versuchspersonen bestimmten wir mit einem Körperplethysmographen indirekt den Nasenwiderstand, in dem wir zunächst den tracheobronchialen Widerstand bei Mundatmung und anschliessend den Gesamtewiderstand bei Nasenatmung registrierten. Wir fanden hierbei als Differenz einen mittleren Nasenwiderstand von 11,5 mm H_2O/1 u.sec. Gegenüber den bislang gefundenen Werten ist unser Ergebnis auffallend gering. Wir vermuten einen methodischen Fehler in der Abdichtung der Maske, wenn die Versuchsperson mit ihr gegen Verschluss atmet.

Mit der Wechseldruckmethoden fanden wir bei 499 Versuchspersonen einen

mittleren Nasenwiderstand von 18,7 (Handauswertung) mm H_2O/1 u.sec. und 15,4 (Computerauswertung) mm H_2O/1 u.sec. Beide Werte stimmen gut mit den Werten überein, die man mit anderen Methoden gefunden hat.

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