

From the Department of Microbiology and Public Health, The Chicago Medical School, Chicago, Illinois, U.S.A.

A SIMPLE METHOD FOR MEASURING NASAL RESISTANCE

By

W. KOCH & DEBORAH KAPLAN

Various methods are known for measuring the degree of nasal obstruction. These methods were reviewed by *Blanchard et al.* (1) and *Solomon et al.* (6).

The methods may be divided into the following groups: First, a method in which condensation of moisture serves as index to the flow (2). In this method the patient breathes against a mirror held horizontally under the nose against the upper lip. Second, each nostril is alternatively closed, as the patient breathes forcibly (2). The pitch of the tone given off by the column of air will be the same, if both sides are freely open. If one side is partially constricted, the pitch will be higher on that side. Both methods compare the nostrils with each other, and do not take into account the case in which both sides are equally constricted.

Third, measuring air flow by means of a gas flow meter (8). Air flowing through the nose is expressed as a percentage of that flowing through the mouth. Fourth, measuring air flow by establishing pressure differences between the nasopharyngeal cavity and the free, outside air (4). In this method a pair of tubes is led through the mouth into the pharynx; mouth and glottis are tightly shut. Through one tube a small amount of air is released, while the other tube is connected to a pressure registering device.

The fifth method is that described by *Semerak* (5); he lets his patients breathe regularly. One nostril is connected to

a pneumotachograph, which measures flow rate; the other nostril is connected to a monometer, which measures the pressure in the naso-pharynx. Both, flow rate and pressure, are registered continually by a photokymograph. Smerak's method was criticized because it inserts a connector into the nostril, which might alter the direction of the air stream. Nevertheless, *Tonndorf* (7) felt that the insertion of a connector is not so objectionable as it was assumed.

Sixth, the Butler-Ivy technique, a modification of which has been recently used by *Blanchard et al.* (1). In this procedure the pressure is measured by an inclined manometer, filled with a colored ether solution, whose readings, in arbitrary units, indicate air flow through the nose; the higher the numerical reading, the less air is entering the nasal passages due to congestion. Also here an olive is inserted into one nostril, with sufficient pressure, so that no air escapes around the side of the olive, as the air stream is directed into the atrium. The authors claim that the method has an advantage over many others described by being free from complex and expensive electrical devices. Because of its simplicity, it does not produce apprehension in patients, making it possible to test a large number many times. Seventh, *Connell* (3) described an instrument for measuring the smallest cross-sectional area of the nasal airway. The patient breathes through a mask, which has two openings, the nose and an orifice to the atmosphere. The area of this latter opening can be varied. Pressures in the mask and pharyngeal pressure are recorded. A formula is given in which the connection between nasal airway, pharyngeal pressure and opening to the atmosphere is shown.

METHOD

Flow rates through the nose not only depend on the degree of constriction but also on air pressure, and consequently vary with different breathing rates. Therefore, in the method to be described, the subjects do not breathe during the test; this test usually takes only a few seconds.

Flowing air is provided by a bellows type spirometer. As the test persons do not breathe into the apparatus, the spirometer has to be kept at an angle

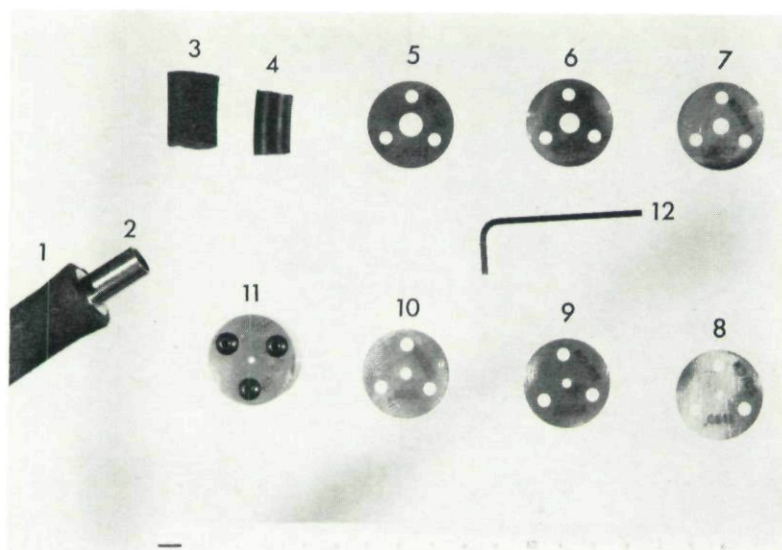


Fig. 1.

Fig. 1 shows the rubber tube (1), to which the nostril tip (2) is attached; two differently sized, hollow rubber pieces (3 and 4) to be slipped over the tip (2); discs with different central orifices, and three holes for the holding screws (5 to 10); a disc screwed to the block beneath (11); screw driver (12).

normal to its usual upright position, so that the bellows contract under their own weight. The rubber tube terminates in a cylindrical metal tip, whose inner diameter is about 0.8 cm. The outer surface of the metal tip can be covered with one of two differently sized rubber sleeves, as to fit different nostrils (Fig. 1, Nos. 1, 2, 3, and 4). The bellows contract under their own weight not completely, but from 6,000 ml to only 1,350 ml, where pressure becomes zero. Static pressures were measured by connecting the spirometer tube (Fig. 1, No. 1) to a U-shaped water manometer. Volumes and their corresponding static pressures are shown in Table 1.

TABLE 1
Static Pressures (cm Water) at Different Bellows Position.

Bellows Position	Pressure (cm water)
5,000 ml	1.45
4,000 ml	1.20
3,000 ml	0.85
2,000 ml	0.50
1,350 ml	0

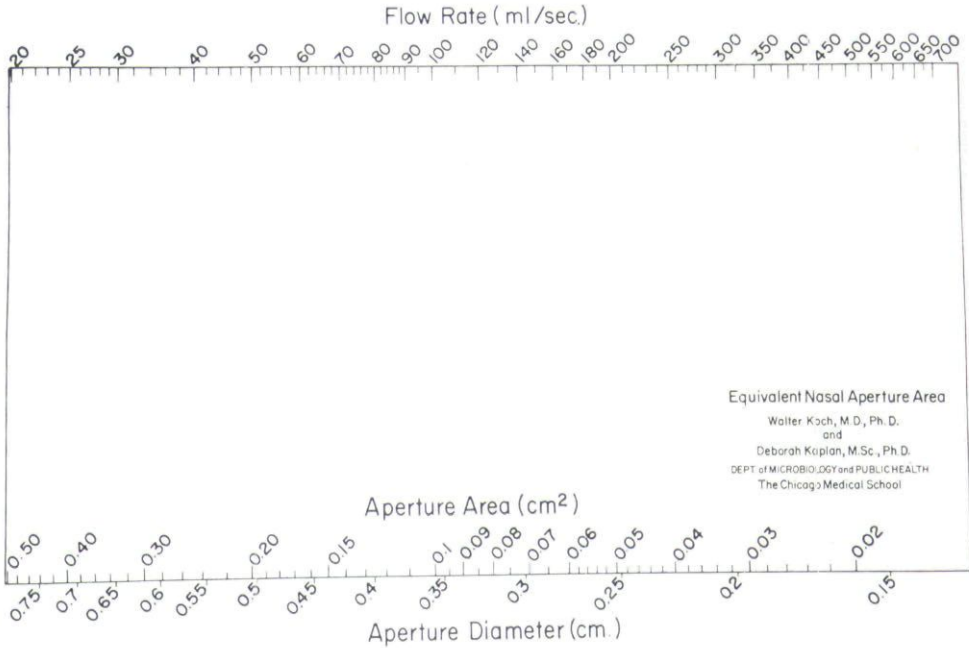


Fig. 2.

Nomogram for converting flow rates (ml/sec) to equivalent aperture areas (cm²). The lower scale is a double scale, showing aperture areas as well as their diameters (cm).

From Table 1 it can be seen, that a static pressure of about 1 cm water is attained at a bellows position between 4,000 and 3,000 ml. Flow rates obtained with bellows contracting from 5,000 to 4,000 ml are higher than flow rates obtained between 4,000 and 3,000 ml, where pressure is lower. Consequently, flow rates are measured with bellows contracting from 4,000 to 3,000 ml, where pressure is approximately unity.

Having selected a static pressure of approximately 1 cm water, flow rates through circular orifices of precisely known size, were determined. Over the tip (Fig. 1, No. 2) fits a metal tube, the bore of which is the same as the outer diameter of the tip. To this tube the discs with the different orifices can be attached by means of three screws (Fig. 1, No. 11). Discs with different orifice sizes are shown in Fig. 1, Nos. 5-10. A screw driver, Fig. 1, No. 12, and a trace of vacuum grease, help to make a gas tight connection.

Flow rates through different orifices simulate different degrees of nasal constriction.

Results are expressed at the area (cm²) of a circular orifice, which has the

same resistance to air flow as one half of the nose. This area is the Equivalent Aperture Area.

Plotting logarithms of orifice areas ($\log \text{ cm}^2$) versus logarithms of their flow rates ($\log \text{ ml/sec}$) a straight line results. The coefficient of correlation is almost one ($r = 0.99923$). From the data a regression line was calculated:

$$\log \text{ Aperture Area } (\text{cm}^2) = 0.99962 \times \log \text{ Flow Rate } (\text{ml/sec}) - 3.117622$$

In order to eliminate calculation, and to obtain directly equivalent aperture areas from flow rates, a nomogram, based on this regression line, has been constructed, and is shown as Fig. 2.

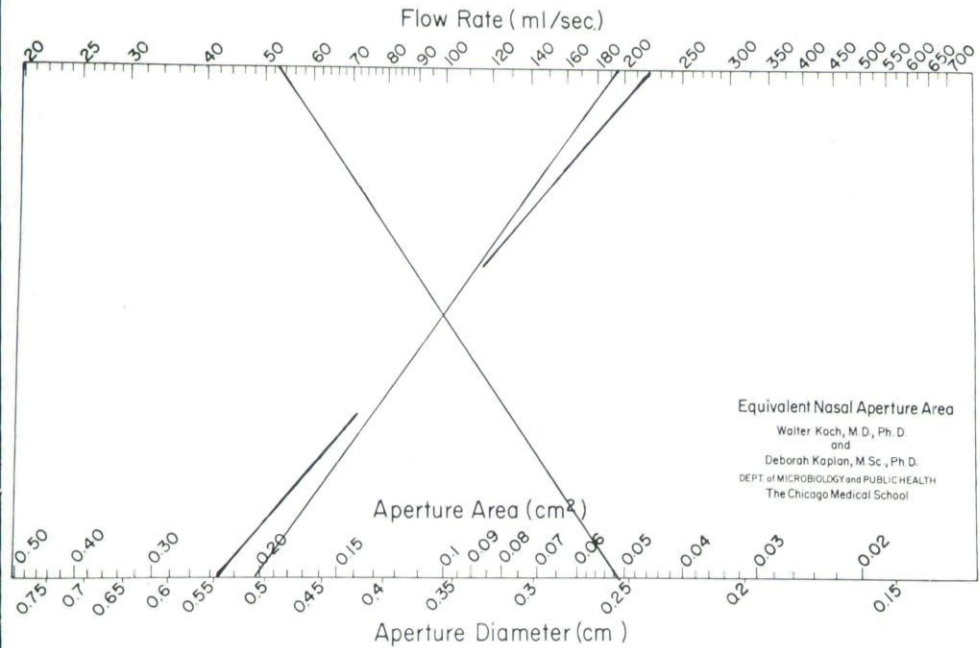


Fig. 3.

Fig. 3 shows how to standardize the spirometer by means of two orifices of known size. Each aperture area is connected with its corresponding flow rate. The two resulting lines intersect. Any flow rate obtained from a patient is connected with this intersection point, and the line extended until it cuts the lower scale, where the aperture area is read. In the present example (interrupted line) a flow rate of 222.2 ml/sec corresponds to an aperture area of 0.235 cm^2 .

The nomogram consists of two parallel lines. On the upper line flow rates are marked. The lower line has a double scale, equivalent aperture areas and the diameters of these areas. Upper and lower scales run in opposite directions.

In order to calibrate the spirometer for measuring equivalent nasal aperture areas, it suffices to obtain flow rates through only two orifices. For instance, a disc with an aperture area of 0.051 cm^2 yields a flow rate of 52.7 ml/sec ; a disc with an aperture area of 0.201 cm^2 yields a flow rate of 195.4 ml/sec . We now connect by a straight line 52.7 ml/sec on the upper scale with 0.051 cm^2 on the lower scale, and 195.4 ml/sec with 0.201 cm^2 . The resulting two lines intersect, as shown in Fig. 3. The intersection point is marked on the nomogram. This point is the common reference point, through which all lines, connecting flow rates and their respective aperture areas, pass.

How to perform the test:

- a) A bellows type spirometer is set up in a lying position.
- b) A chart is inserted.
- c) A rubber sleeve is drawn over the metal tip.
- d) The operator expands the bellows to their maximum volume, and keeps the bellows expanded for a few seconds, until they are completely filled with air.
- e) The tip with the rubber sleeve is inserted into the nostril, and the person instructed to open his mouth and not to breathe, as soon as the operator says: "Now".
- f) The operator lets the bellows collapse until the stylus reaches about 4,200 ml, then switches on the moving mechanism of the chart, and says: "Now".
- g) The operator stops the moving mechanism of the chart at a stylus position of about 2,800 ml.
- h) The chart is removed, and the number of seconds, and fractions thereof, which took the stylus to travel from 4,000 to 3,000 ml, is noted. In Fig. 4, for instance, the average travel time is 4.5 seconds.
- i) 1,000 ml air, at a pressure of about 1 cm water, pass through one half on the nose in 4.5 seconds, hence $1,000/4.5 = 222.2 \text{ ml}$ is the flow rate per second.
- j) This flow rate, 222.2 ml/sec is entered on the upper scale of the nomogram (Fig. 3), and a straight line is drawn through the intersection point, and extended to the lower scale, where the reading is made (0.235 cm^2); This line is shown as an interrupted line in Fig. 3.

Figure 4 shows a test, performed four times in the same nostril of the same person in the same session. Stylus travel time between 4,000 and 3,000 ml was nearly the same in all four tests, indicating good reproducibility.

Illustrative examples are shown in Table 2.

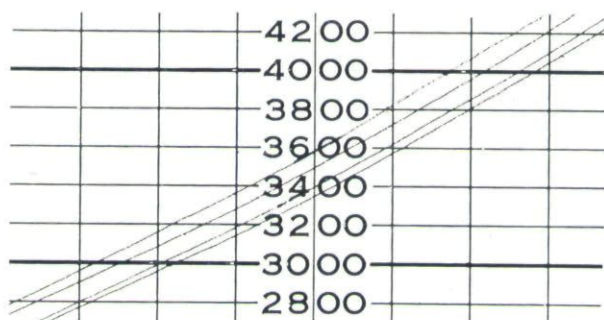


Fig. 4.

The reproducibility of the method is shown: Repeated tests in the same nostril of the same person in the same session.

TABLE 2
Equivalent Aperture Areas (cm²)

Diagnosis	Equivalent Aperture Area (cm ²)	
	Right Nostril	Left Nostril
1. Apparently normal	0.246	0.251
2. Allergic rhinitis	0.058	0.068
3. Polyp. swelling, left	0.200	0.058
4. Polyp. swelling, left	0.250	0.074
5. Allergic rhinitis, septum deviation		
Before treatment	0.034	0.041
After shrinkage	0.225	0.165
6. Allergic rhinitis, septum deviation		
Before treatment	0.123	0.090
After shrinkage	0.222	0.260

DISCUSSION

From the literature it can be seen that complex equipment and procedures had to be used for estimating nasal resistance.

In the method described a standard spirometer is used. Only a few inexpensive pieces have to be added in order to convert the spirometer into an instrument capable of measuring nasal resistance. As air flows from the spirometer into the nostril,

the danger of contaminating the apparatus is minimized. The method is simple, reproducible, and the test itself takes only a few seconds.

It was also tried to let air enter through the mouth, and to let it escape through one nostril; for this, a rubber mouth piece, as used in basal metabolism tests, was connected to the rubber tubing. This arrangement we tested on ourselves, with results comparable to those described; the maximum difference was 16 per cent. However, when applying the mouth method to patients, difficulties were encountered; not everybody was able to keep the pathway open. No objections were raised by patients to the direct nostril method, which always worked.

The method described enables the physician to quantitatively appraise nasal obstruction, and to quickly estimate the effectiveness of treatment. One half of the nose, with its complex structure, is reduced to a circular orifice. Different orifice sizes represent different nasal constrictions. Transformation of air flow rates through one half of the nose to equivalent aperture areas is easily done with the help of the nomogram.

SUMMARY

Air flow through the nose is measured with a spirometer. Air is blown into one nostril, and the mouth is kept open. Flow rates are measured at a static pressure of approximately one centimeter water. The resistance to air flow in one half of the nose is expressed as the resistance of a single, round orifice. The area of an opening, which has the same resistance as one half of the nose, is the equivalent aperture area. Logarithms of flow rates and logarithms of aperture areas show a linear relationship. A nomogram is presented, based on this relationship. With this nomogram flow rates are converted, without calculations, into aperture areas. The method was tested on patients before and after treatment. Several examples are shown.

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