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Respiratory rhinometry, a review of recent trends

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SUMMARY

Rhinometry of respiratory airflow is discussed and disadvantages of invasive methods are emphasized. The stability of the series of pressure-flow relationships of respiratory air which is repeated through consecutive nasal breaths may be exploited to provide an index of nasal obstruction – different techniques and their limitations are outlined.

The use of an inexpensive microprocessor interfaced with standard respiratory laboratory pressure and flow measuring apparatus is described and advocated for assessment of resistance to respiratory airflow in the nasal cavities and other flow resistant segments of the airways.

INTRODUCTION

It requires no more than a brief survey of the literature to discover that there are many different methods for assessment of nasal obstruction to airflow in terms of resistance (R_N); at least 20 are in current use. The present paper is concerned with measurements of nasal obstruction to respiratory airflow by techniques which require little interference with normal function.

Physiological Considerations

Nasal mucosa is very reactive, its vascular and secretory responses each contribute to airflow obstruction. These mucosal changes may be brought about by remote, general and local, thermal (Drettner, 1963) or tactile (McLean et al., 1976) stimuli, by medication (Jackson, 1970), posture (Rundcrantz, 1969), exercise (Dallimore & Eccles, 1977), Allergens (Mygind, 1978), irritants (Frank, 1970) and even emotion (Holmes et al., 1950). It is important that for reliable assessment of nasal obstruction disturbing stimuli be minimised or controlled and this places limitations on the use of invasive instrumentation of the nasal cavities. In addition to induced mucosal changes the nasal valve must also be considered in assessment of nasal airway resistance, since it is an important and dynamic resistor, (Van Dishoeck, 1965; Mann et al., 1977) and distortion by invasive instrumentation creates a marked departure from normal function. Furthermore, in measurement of separate nasal cavities the consequences of the spontaneous resistive nasal cycle must be recognized (Stoksted, 1953).

These observations indicate how anterior rhinometry may entail substantial limitations and although these are acceptable in some instances, our main interest in this paper concerns the less invasive posterior rhinometric technique with measurement of transnasal pressure and respiratory airflow in subjects in a comfortable and stable or controlled environment in a state of rest or controlled exercise.

METHODS

Transnasal pressure – is measured by means of a sensitive differential transducer, one port of which is connected by a peroral tube to the pharynx and the other to the proximity of the anterior nares. We have found Validyne MP45-3 and Statham PM5 transducers to be entirely satisfactory.

Respiratory airflow – is measured by a pneumotachometer. In our experience Fleish instruments have adequate linear response when inserted in the face-piece of a mask.

Masking – There are several methods of masking:

a. A scuba type mask which has a small physiological dead-space and excludes the mouth.
b. An anaesthetic type mask which includes the mouth.
c. A split or divided mask may be used for simultaneous measurements in the separate nasal cavities (Konno, 1969; Cole et al., 1979a).
d. A large face mask with a seal around the periphery of the face and a bias airflow to reduce the physiological dead space (Kern and Hasegawa, 1978).
e. A head-out body plethysmograph (Bouhuys et al., 1966; Niinimaa et al., 1979) which measures airflow from changes in thoracic volume.
f. An inflated jacket is used for infants, pressure changes in this jacket indicate respiratory airflow.

In our laboratory, methods (a), (b), (c) and (e) are in current use.

RESULTS

Display and Recording

Transducer signals representing pressure and flow are employed to produce an oscilloscope display and photographic or pen recording. An Electronics for Medicine DR8 Recorder with SGM carrier amplifiers has been used for most of our work.

Data Handling

In addition to display and recording our data are processed by an Imsai 8080A or A Rockwell AIM # 65 microprocessor with an analog-to-digital converter, interfaced with the recorder to express relationships between pressure and flow, e.g. $P/\dot{V}$ = resistance or $P \times \dot{V}$ = power, $P \times V$ = work. An on-line read-out and/or print-out is produced.

DISCUSSION

Some observers (Cottle, 1968) make their assessments by inspection of the pressure and flow tracings. The shape of the nasal pressure and/or flow curve of respiratory air has complex determinants (Proctor and Hardy, 1949) in addition to the nasal cavities; subtle changes in shape may represent local or remote pathology and may be recognizable only by visual inspection (Cottle, 1972; Heinberg and Kern, 1974; Montserrat-Viladiu, 1977). However, the trend today and our present interest is to obtain a factor from the pressure and flow measurements which will indicate the extent of nasal obstruction to respiratory airflow.

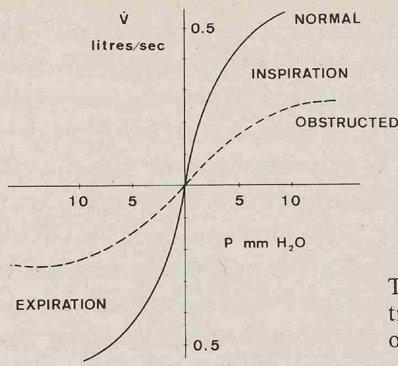
When an instantaneous plot of transnasal pressure against respiratory nasal airflow is made with an *x–y* recorder, the tracing shows a curvilinear relationship which indicates that resistance ($P/\dot{V}$) is different at every instant of a respiratory cycle. Observation of this tracing in an individual subject shows a remarkable consistency, the moving spot may travel over a greater or lesser portion of the tracing, depending on the breathing pattern, but its course line remains constant from breath to breath.

Many different methods are employed to represent each consistent sigmoid curve by a simple expression for resistance. Common methods either measure $P/\dot{V}$ at a point on the curve (Solomon and Stohrer, 1965) or approximate the general slope of a portion or all the curve graphically or mathematically (Cole et al., 1979b; Kern, 1977; Masing and Frimberger, 1974). Methods such as these are accepted in pulmonary airflow resistance measurement where the largely laminar flow pattern produces a fairly linear $P–\dot{V}$ curve, but the greater the departure from linearity as with the turbulent, eddiform and orifice flow of the nose and larynx the less representative these expressions become.

Evaluation of this sigmoid tracing must include consideration of the time course; recordings show that during much of the respiratory cycle pressure and flow values are near the extremities of the pressure flow curve where it is least linear, and little time is spent in its more linear portion. In other words, higher resistances are maintained for much of the cycle and lower resistances are of briefer duration.

The pressure flow curve represents a stable series of pressure-flow relationships which is repeated throughout a lengthy succession of breaths, and the configuration of the curve changes only if impedence to airflow is altered. Jonson (1978) obtained nasal $P–\dot{V}$ curves from a larger number of recruits to the Swedish armed forces and found that curves from individual subjects could be arranged in radial order, each representing a different degree of nasal obstruction and each curve rarely crossed another.

Jonson's results suggest that a point representing any single nasal pressure-flow relationship can lie only on one curve. Thus from a single measurement of pressure and flow a characteristic curve can be constructed which will predict all pos-



Typical respiratory pressure-flow tracings of a normal and an obstructed nose.

sible pressure flow relationships for an individual subject at the time of measurement. Polar co-ordinates may be conveniently employed and by means of a programmed calculator nasal resistances which these different curves represent may be compared.

The P-$\dot{V}$ curves Jonson describes were obtained by anterior rhinometry and probably one could also obtain a similar series of pressure-flow curves at each flow resistive segment of the airways – i.e. both nasal cavities combined, the larynx, mouth and pulmonary airways but it is unlikely that the characteristics of the curves obtained from different flow resistive segments would be identical and therefore comparison between segments might not be simple.

An alternative approach which offers advantages in comparing different segments is by rapid sampling of pressure and flow values from which work, power, mean pressure, mean flow and mean resistance may be derived. Mean nasal resistance has been shown to change very little with alterations in breathing pattern and ventilation (Cole et al., 1979c).

Employment of an interface, an analog-to-digital converter and a microprocessor enables pressure and flow signals from standard equipment to be sampled at frequent intervals, the values may be stored and mathematically processed for on-line digital display and print-out of the results from any chosen number of breaths. [Sampling every 20 milliseconds produces about 200 observations per breath from which an accurate analog could be reconstructed]. Different flow resistive segments may thus be compared in the same terms namely: mean pressure, mean flow, mean resistance, power or work. This technique, which employs standard respiratory laboratory pressure and flow equipment, requires the addition of a microprocessor which at the time of writing costs less than \$ 500.* The present writer has found the technique sensitive, simple and convenient for the assessment of airway obstruction in separate or combined nasal cavities (Cole et al., 1979a and 1979c), the mouth, larynx and pulmonary aiways.

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* Rockwell International Microelectronic Devices, Anaheim, California, U.S.A.

ZUSAMMENFASSUNG

Die Messung des Atem Luftstroms in der Nase ist diskutiert worden und die Nachteile der Eingriffs Methoden werden betont. Die Stabilität der Aufeinanderfolgen von Druck-Strom Verhältnissen der Atemluft, die sich durch fortlaufende Atemholungen durch die Nase wiederholt, kann verwertet werden, um einen Index für Obstruktion in der Nase anzugeben; verschiedene Techniken und deren Begrenzungen sind umrissen worden.

Der Gebrauch eines Kosten geringen Mikroprozessors zusammen – mit Standard Labor Druck und Strom Messgerät – ist beschrieben worden und wird empfohlen zur Berechnung des Widerstands gegen den Atmungsluftstrom in den Nasenhöhlen und anderen Stromwiderstehenden Segmenten der Luftwege.

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