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THE CENTRAL RHYTHM OF THE NASAL CYCLE

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Abstract. The resistance to air flow of each nasal passage was recorded in 2 subjects over a period of 7 days. The cyclical changes in nasal resistance observed were very regular, with a consistent pattern apparent over the period of study. The regular changes in nasal resistance recorded under laboratory conditions may be directly related to changes in activity of an autonomic centre in the brain.

The spontaneous changes in the resistance to air flow of each nasal passage associated with the nasal cycle are believed to be regulated from a nasal centre in the hypothalamus or medulla. A hypothalamic centre regulating the nasal cycle was first proposed by Stoksted in 1953 and in 1959 Malcomson demonstrated that electrical stimulation of the cat hypothalamus caused a nasal vasoconstriction. A nasal centre associated with the respiratory centre in the medulla has also been suggested as changes in nasal resistance are often associated with changes in respiration (Dallimore & Eccles, 1977). The nasal resistance is influenced by many factors in the environment but under controlled laboratory conditions one might expect the changes in nasal resistance to be directly related to an endogenous rhythm in the nasal centre. The present study is concerned with demonstrating the marked regularity of the nasal cycle under laboratory conditions and provides further evidence for a nasal centre as the regulator of the spontaneous changes in nasal resistance.

METHODS

Experiments were performed on 2 male subjects: R. E. (the author, age 28) was of British origin and had been exposed to the Indian climate in Delhi for 2 weeks prior to the experiments, and A. K. (age 25) was an Indian resident of Delhi. Both subjects were healthy and were not prone to any allergic disorders, or chronic nasal or sinus infections. There were no external signs of a deviated nasal septum and no previous history of trauma to the nose or paranasal sinuses in either subject.

The resistance to air flow of each nasal passage was determined by measuring the pressure and flow characteristics associated with normal breathing and plotting the pressure against flow by display on a storage oscilloscope. The slope of the plot on the oscilloscope screen between flows of ± 10 l/min was determined by fitting a straight line to the graph and the nasal resistance was expressed in units of cm H_2O/l/sec (R). Only the flow rates between ± 10 l/min were used for the calculations as at higher flow rates the air flow in the nasal passages is not laminar and the resistance is not a direct linear function of pressure and flow. In the present experiment the formula $R = \Delta P/V$ described the relationship between pressure, flow and resistance.

To measure pressure and flow a soft plastic cannula was inserted approximately 0.5 cm into each nostril. The cannulae were 22 cm in length with an internal diameter of 0.9 cm and a wall thickness of 2.5 mm.

A cannula from one nostril was connected to a pneumotachograph cone to measure air flow (V), with a differential pressure transducer (Hewlett Packard model 270) to determine the pressure change across the cone. The signal from the transducer was fed into an amplifier (Hewlett Packard 88058) and then displayed on the horizontal axis of a storage oscilloscope (Tektronix type 5103N).

The cannula from the other nostril was connected to one arm of a differential pressure transducer (Statham PM 283 TC) and this measured the nostril pressure which under the conditions of the experiment was equal to the posterior nares pressure as no air flow occurred in this cannula. The other arm of the transducer was connected to a large-bore syringe needle inserted into the other cannula used to record air flow, and the pressure was measured close to the nostril. With this arrangement the pressure change from the posterior nares to the nostril could be measured (ΔP). The signal from the transducer was fed into an amplifier (Statham bridge amplifier mod SC 100) and then to the vertical axis of the storage oscilloscope.

With the cannulae inserted into the nostrils the pressure and flow relationships of one nasal passage during normal respiration were plotted on the oscilloscope, and then the cannulae swopped around and the other nasal passage monitored.

The resistance of both nasal passages in each subject was determined at approximately 30 min intervals throughout the day (09.00–19.00). The subjects remained in the laboratory for the duration of the experiment each day, and avoided any exertion. The temperature range for the duration of the study was between 25–33°C and the relative humidity between 64–98% saturated.

RESULTS

The changes in nasal resistance of the subjects for 3 consecutive days of recording are shown in Figs. 1 and 2. Both subjects had regular cyclic changes in nasal resistance with a definite reciprocal relationship between the resistance of left and right nostrils.

The cyclic changes in nasal resistance for subject R. E. shown in Fig. 1 are remarkably similar for the 3 days illustrated. At the start of recording in the morning the left nasal passage has a high resistance and the right nasal passage a low resistance with most of the air flow occurring through the right nostril. The changeover from right to left nostril dominance of air flow occurs at about 11.30 hr with further crossover points at 14.00 and 16.00 hr. The crossover points for 3 days of recording are joined with a straight line through the graphs to demonstrate the regularity of the cycle.

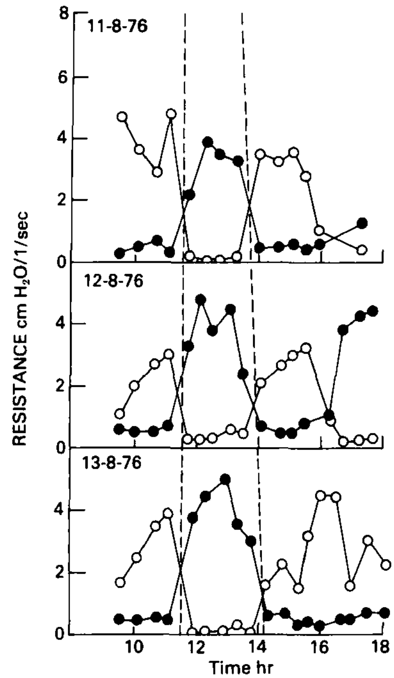

Fig. 1. Changes in nasal resistance in subject R. E. for 3 consecutive days. ○, Left nasal passage; ●, right nasal passage.

The Indian subject A. K. showed similar regular changes in nasal resistance yet the crossover points between left and right dominance showed some phase shift each day as demonstrated by the straight lines drawn through the crossover points on the three consecutive graphs (Fig. 2). In both subjects the crossover points could not be correlated with the taking of food or drink or any change in the laboratory environment.

The changes in reistance were similar for both subjects with the maximum resistance for a nasal passage varying between 4–6 cm H_2O/l/sec and the minimum resistance between

0.02–1.0 cm H_2O/l/sec, depending on the phase of the cycle.

The period of the cyclic changes in resistance in the two subjects varied between 1–2½ hr between crossover points depending on which nostril was dominant. Subject R. E. had a very regular cycle with the time periods of left or right dominance of approximately equal duration giving a crossover approximately every 2 hr.

The times of the crossover points of the graphs of the nasal cycle are tabulated in Fig. 3 for the seven days of recording. Subject R. E. has a very regular pattern of crossover points with changes in resistance at 11.00 and 14.00 hr which are consistent for the 7 days of recording and unaffected by the weekend break on the 14th and 15th of the month. The changes in resistance which occur after 14.00 hr do not have the same regular pattern.

The crossover times for subject A. K. as shown in Fig. 3 appear to have a random distribution on first inspection yet a regular phase shift in the period of the cycle is apparent on closer examination, similar to that observed in Fig. 2.

The total nasal resistance calculated for both nasal passages in parallel varied according to the phase of the cyclic changes in resistance. The changes in total nasal resistance for subject R. E. are shown in Fig. 4, where it is apparent that there is some regularity in the changes in resistance from day to day, with a range in nasal resistance from 0.06–0.64 cm H_2O/l/sec. Subject A. K. showed similar changes in total nasal resistance with a range from 0.21–1.14 cm H_2O/l/sec during the three days of recording.

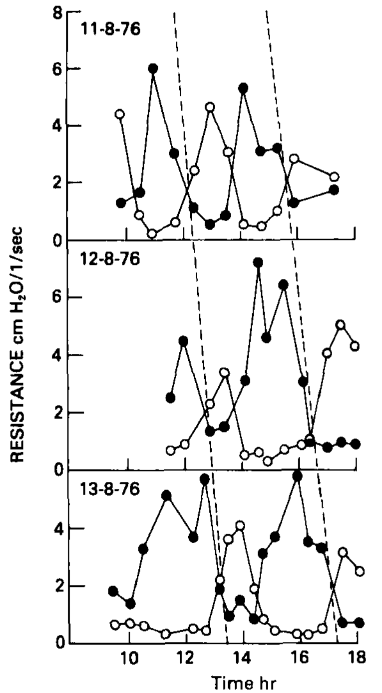

Fig. 2. Changes in nasal resistance in subject A. K. for 3 consecutive days. ○, Left nasal passage; ●, right nasal passage.

DISCUSSION

The results demonstrate that there are regular reciprocal changes in nasal resistance in both the subjects studied. Similar results have been previously reported, but other workers have not recorded the changes in nasal resistance in the same subjects on consecutive days.

In subject R. E. the changes in resistance of each nasal passage occur at approximately the same time each day (11.00 and 14.00 hr) with no apparent phase shift. The changes in nasal resistance which occur after 14.00 hr are not as consistent from day to day as the crossover times observed at around 11.00 and 14.00 hr. If the nasal cycle was in some way connected with the time of rising from sleep and this time was consistent each day then it is possible that the cycle could be set by this time and gradually drift from the set point towards evening. The daily changes in nasal resistance which occurred at around 11.00 and 14.00 hr were not related to any intake of food or drink, as meal and snack times were alternated in both subjects.

The nasal cycle of subject A. K. shows a significant change in the time of crossover each day yet this is probably a regular phase shift, although it would be necessary to record over a longer period to confirm this result.

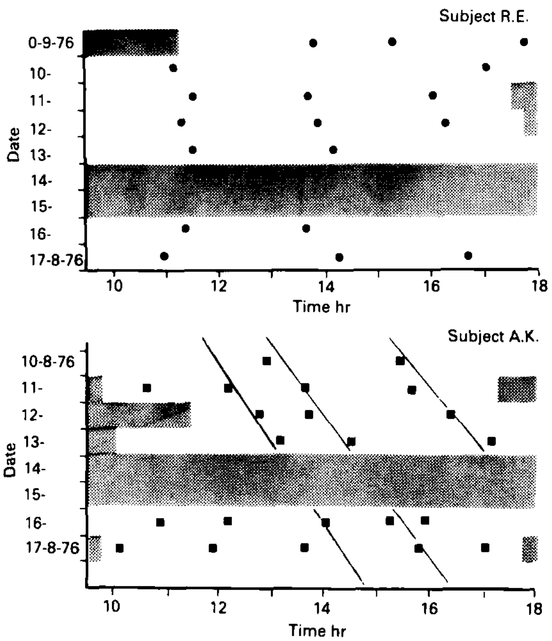

Fig. 3. A plot of the crossover times of changes in nasal resistance. The shaded areas represent the periods during which recordings of nasal resistance were not made.

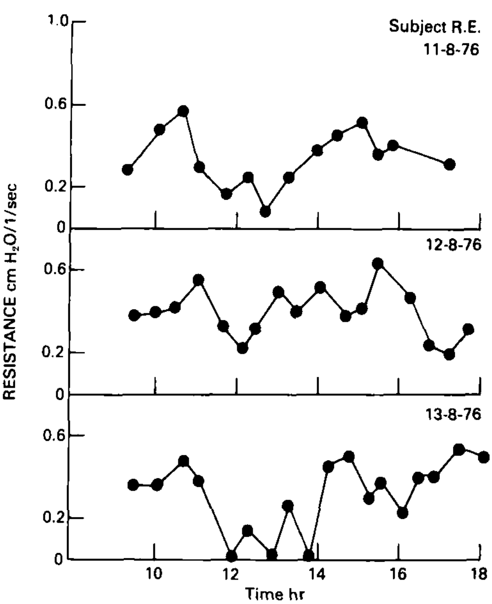

Fig. 4. Changes in total nasal resistance in subject R. E. for 3 consecutive days.

The phase shift each day may be explained by the relationship between the time period of the cycle and whether or not it is divisible into a 24-hr period. If the period of the cycle is exactly divisible into 24 hr then the crossover times will occur at exactly the same time each day, and if the period is not divisible into 24 hr then there will be some phase shift each day. The regularity of the nasal cycle from day to day indicates that the cyclic changes in nasal resistance occur throughout the 24-hr period and that changes in nasal resistance may continue during sleep.

The total resistance of the nasal passages to air flow has been previously stated to remain relatively constant during the reciprocal changes in the resistance of each nasal passage (Stoksted, 1953). The results of the present study show that the total nasal resistance may vary according to the phase of the cycle. In subject R. E. the total nasal resistance ranged from 0.06–0.64 cm H_2O/l/sec and in subject A. K. from 0.21–1.14 cm H_2O/l/sec. The variation in total nasal resistance is probably associated with an undetected asymmetry of the nasal passages.

The functional significance of the cyclic changes in resistance is obscure; the changes in the state of the erectile tissue have been noted to coincide with changes in the secretory activity of the nasal mucosa (Lillie, 1923), and it is possible that there is periodic activity of the nasal mucosa in conditioning the inspired air, with one nasal passage undergoing a rest period whilst the air flow is directed through the other passage.

The vasomotor and secretory activity of the nasal mucosa is regulated by the autonomic nervous system (Änggård & Edwall, 1974; Eccles & Wilson, 1974; Malm, 1973), and the changes in activity of autonomic outflow which occur during the nasal cycle must be regulated centrally. The hypothalamus has been proposed as an area of the brain most likely to be involved in regulation of the nasal cycle (Stoksted, 1953) and experiments on the cat have demonstrated that electrical stimulation of the hypothalamus causes a decrease in nasal resistance (Malcomson, 1959).

The results of the present study indicate that the cyclic changes in nasal resistance are very regular when recorded under laboratory conditions, probably because the control of nasal resistance is then dominated by the endogenous nasal centre. Normally the activity of the nasal centre might be expected to be influenced by many factors such as, exercise and arterial pCO_2 (Dallimore & Eccles, 1977), emotion (Wolf, 1954) and skin temperature changes (Drettner, 1961). When changes in these factors are limited then the central rhythm of the nasal cycle is apparent and this is very regular from day to day.

Persons trained in *pranayama* (breathing exercises in Yoga) are able to alter their nasal air flow at will from one nasal passage to the other and presumably they have developed conscious control of the autonomic nasal centre. Ancient documents relating to the practice of Yoga describe changes in nasal air flow as related to changes in the state of meditation and mood (Sing & Chhina, 1974) and if the nasal centre is indeed located in the hypothalamus as proposed by Stoksted then there may be a physiological basis to these ancient beliefs, with changes in mood affecting the activity of a hypothalamic nasal centre.

SUMMARY

1. Cyclic changes in nasal resistance have been observed in 2 subjects over a period of 7 days.
2. The period of the nasal cycle was regular, with a consistent pattern apparent for the changes in resistance throughout the 7-day study.
3. The total nasal resistance of each subject varied according to the phase of the nasal cycle.
4. The regular changes in nasal resistance recorded under laboratory conditions may be directly related to changes in activity of an autonomic nasal centre in the brain.

ZUSAMMENFASSUNG

Bei zwei Versuchspersonen wurde während einer Zeit von sieben Tagen der Luftstromwiderstand in den beiden Nasengängen registriert. Die beobachteten zyklischen Veränderungen des Nasenwiderstandes wiesen ein sehr regelmäßiges und während der Beobachtungszeit gleichbleibendes Muster auf. Die unter Laborbedingungen registrierten regelmäßigen Veränderungen des Nasenwiderstandes könnten in direkter Verbindung mit Veränderungen der Aktivität eines autonomen Zentrums im Gehirn stehen.

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REFERENCES

Änggård, A. & Edwall, L. 1974. The effects of sympathetic nerve stimulation on the tracer disappearance rate and local blood content in the nasal mucosa of the cat. *Acta Otolaryngol 77*, 131–139.

Dallimore, N. S. & Eccles, R. 1977. Changes in human nasal resistance associated with exercise, hyperventilation and rebreathing. *Acta Otolaryngol 84*, 416–421.

Drettner, B. 1961. Vascular reactions of the human nasal mucosa on exposure to cold. *Acta Otolaryngol*, Suppl. *166*.

Eccles, R. & Wilson, H. 1974. The autonomic innervation of the nasal blood vessels of the cat. *J Physiol 238*, 549–560.

Lillie, H. I. 1923. Some practical considerations of the physiology of the upper respiratory tract. *J Iowa Med Soc 13*, 403–408.

Malcomson, K. G. 1959. The vasomotor activities of the nasal mucous membrane. *J Laryngol Otol 73*, 73–98.

Malm, L. 1973. Stimulation of sympathetic nerve fibres to the nose in cats. *Acta Otolaryngol 75*, 519–526.

Singh, B. & Chhina, G. S. 1974. Some reflections on ancient Indian physiology. In *The Science of Medicine and Physiological Concepts in Ancient and Mediaeval India* (ed. N. H. Keswani & S. K. Manchanda). 26th International Congress of Physiological Sciences, New Delhi.

Stoksted, P. 1953. Rhinometric measurements for determination of the nasal cycle. *Acta Otolaryngol*, Suppl. *109*, 159–175.

Wolf, S. 1954. Reactions in the nasal mucosae. *Arch Otolaryngol 59*, 461–475.

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