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Further studies on nasal sensation of airflow

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SUMMARY

The effect of applying a eutectic mixture of local anaesthetics cream (EMLA) to the nasal vestibule, upon both nasal sensation of airflow and action of menthol was studied in 25 normal subjects. Anaesthesia of the vestibule was shown to decrease nasal sensation of airflow, $p < 0.001$. *The action of menthol in enhancing the sensation of nasal airflow was unchanged,* $p > 0.05$. *This shows that sensory nerve endings located within the nasal vestibule and mucosa, are likely to be important in conveying nasal sensation. This study expands basic scientific knowledge in this important clinical area. The site and nature of sensory nerve endings responsible and possible neurophysiological mechanisms involved are discussed.*

Nasal obstruction is the commonest presenting symptom in rhinological practice. Despite this, relatively little basic knowledge exists as to the mechanisms responsible for conveying the subjective sensation of nasal airflow. Only relatively recently has there been active research in this extremely important clinical area.

Studies have revealed the presence of sensory nerve endings within the nasal vestibule of the cat, which are sensitive to changes in nasal pressure and airflow (Davies and Eccles, 1985). Such stimuli can influence the activity of muscles surrounding the cat nostril leading to dilatation of the nostril. In man, similar muscles insert into the alar wing of the nose and are particularly important since they stabilize the nasal valve region during inspiration. They thereby, help contribute to the regulation and control of nasal airflow. Studies in humans have shown that a passive nasal airflow stimulus may also influence the activity of these muscles (Tolley and Eccles, 1987). The site and nature of sensory nerve endings responsible for such an effect whether primarily vestibular, mucosal, or a combination of the two, requires further study.

There is experimental evidence in humans, that the nasal vestibule contains sensory nerve endings responsible for conveying sensation of nasal airflow

(Jones et al., 1989). However, it is controversial whether sensory nerve endings present within the nasal mucosa have an additional contribution to make.
Eccles and colleagues (1988), have shown that the application of topical lignocaine onto the nasal mucosa results in a decreased sensation of airflow, subjects reported feeling more blocked. In addition, the action of menthol in enhancing the sensation of airflow was also decreased. This study showed, that at least in part, the subjective sensation of nasal airflow and action of menthol, resulted from an interaction at the mucosa. The following study is an extension of this work, the aim being to investigate what contribution sensory nerve endings within the nasal vestibule make to the subjective appreciation of nasal airflow and action of menthol.

METHODS

A blind randomised study was performed in a total of 34 normal subjects recruited from the hospital staff population. All subjects gave no history of nasal disease or surgery which may have influenced the study, and all had been free of coryzal illness for three weeks prior to the study. None of the subjects had knowledge of the aims and objectives of the study.
Two randomised groups were selected. One group contained 25 subjects, seven males, 18 females, mean age 27.8, range 17–45 years. A second control group contained nine subjects, nine females, mean age 35.2, age range 23–50 years. The female bias in the second group reflects the preponderance of females in the hospital population and was not a result of preselection. Ethical approval for the study was obtained from the Hospital Ethics Committee. Informed consent was also obtained from each subject taking part in the study.
After completion of a health questionnaire and rhinological examination, each subject was given an explanation of the experimental procedure. Each also read instructions on how to operate a visual analogue scale, which would be used to record subjective change in nasal sensation of airflow. The scale was a 100 mm line labelled at the ends as either "Maximum or Minimum feeling of air passing through your nose". The centre of the scale (50 mm) was defined as the starting point of the experiment, subjects were thus able to convey change in sensation by placing a mark to a range of 50 mm on either side of the centre point of the scale.
Nasal resistance was measured by active anterior rhinomanometry using a sample point of 150 Pa (Mercury Electronics, Glasgow, U.K.). The protocol was as follows.
Subjects were instructed to breathe freely and told that their sensation of nasal airflow at the start of the experiment would be represented at the centre point of the visual analogue scale (50 mm). Nasal airflow resistance was then measured. Subjects were then instructed to inhale for five seconds from a wick inhaler containing menthol at a concentration of 125 mg/ml. Change in nasal sensation

was then recorded on the visual analogue scale, and nasal airflow resistance again measured. In the group of 25 subjects a eutectic mixture of local anaesthetics cream (EMLA, Astra) was then applied to the skin lined nasal vestibule by a cotton wool applicator under direct vision. A period of one hour was allowed for the cream to take effect. The degree of anaesthesia was assessed by means of a hypodermic needle. After one hour each subject was instructed to breathe freely and change in nasal sensation was recorded followed by measurement of resistance. Subjects then inhaled from a wick inhaler containing menthol, and this was followed by recording of nasal sensation and measurement of nasal airflow resistance.

To serve as a control, an identical protocol was followed in the group of nine subjects. However, an emulsifying cream E45 (Crookes) was applied to the nasal vestibule instead of EMLA cream.

RESULTS

Figure 1 shows the mean visual analogue scores in mm before and after applying EMLA cream to the nasal vestibule. Results were analysed by two-way analysis of variance.

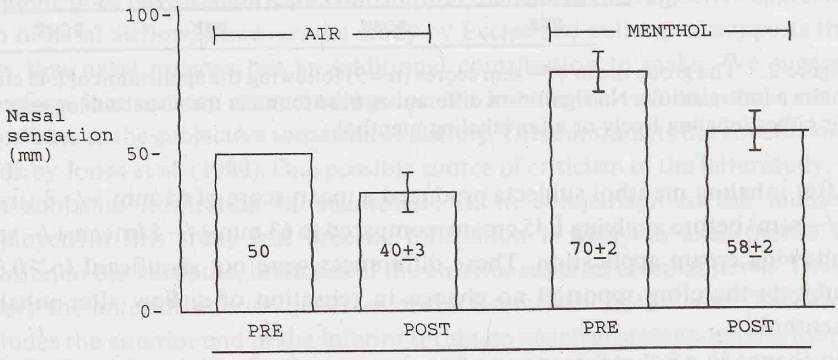

Figure 1. The group mean +/− sem scores (n=25) following the application of EMLA cream to the nasal vestibule. Anaesthesia of the vestibule significantly decreased the visual analogue score. Subjects reported feeling more blocked as a result of anaesthetising the nasal vestibule. The action of menthol, however, remained unchanged.

After inhaling freely, subjects produced a mean score of 40 mm +/−3 (mean +/− sem) after applying EMLA cream, compared to an initial score of 50 mm before applying cream. This change was highly significant $p<0.006$, $n=25$. Subjects therefore reported feeling more blocked.

After inhaling menthol, subjects produced a mean score of 70 mm +/−2 (mean +/− sem) before applying EMLA cream, compared to 58 mm +/−2 (mean +/− sem) following cream application. Inhaling menthol, therefore, increased the

visual analogue scores by 20 mm +/−2 (mean +/− sem) before applying EMLA cream, compared to 18 mm +/− 2 (mean +/− sem) after applying the cream, $p > 0.05$. The action of menthol in enhancing the sensation of nasal airflow was therefore unchanged as a result of applying EMLA cream to the nasal vestibule. Figure 2 shows the mean visual analogue scores in mm before and after applying E45 cream to the nasal vestibule. After inhaling freely, subjects produced a mean score of 49 mm +/−2 (mean +/− sem) after applying E45 cream, compared to an initial score of 50 mm before applying cream. This change was insignificant $p > 0.05$. Subjects therefore reported no change in sensation of nasal airflow.

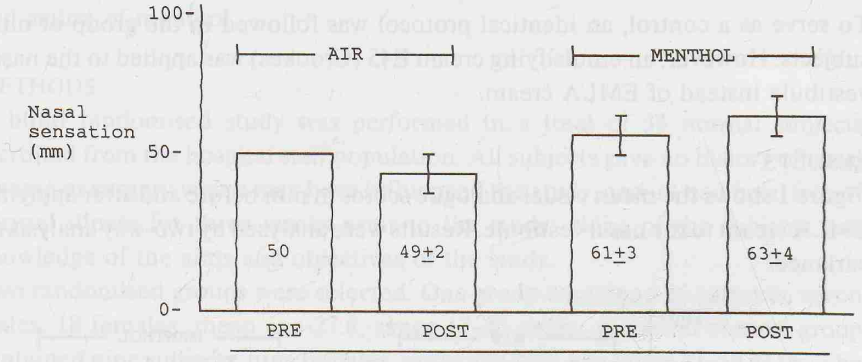

Figure 2. The group mean +/− sem scores (n = 9) following the application of E45 cream to the nasal vestibule. No significant differences were found in the visual analogue scores for either inhaling freely or after inhaling menthol.

After inhaling menthol subjects produced a mean score of 61 mm +/−3 (mean +/− sem) before applying E45 cream, compared to 63 mm +/−4 (mean +/− sem) following cream application. These differences were not significant ($p > 0.05$). Subjects therefore reported no change in sensation of airflow after inhaling menthol.

No change in nasal resistance was found as a result of applying either EMLA or E45 creams at any stage of the study.

DISCUSSION

This study shows that anaesthesia of the skin lined nasal vestibule results in a decreased sensation of nasal airflow. Each subject feeling more blocked as a result of anaesthetising the vestibule. It further reveals that sensory nerve endings responsible for conveying sensation, are likely to be present within both the nasal mucosa and vestibule, as the action of menthol was unchanged as a result of anaesthetising the vestibule. Further experimentation will be required to elucidate the precise location of sensory nerves responsible for conveying the subjective sensation of nasal airflow. This work adds significantly to our

knowledge of the location of nerve endings responsible for conveying nasal sensation, as it implies that the skin lined vestibule and nasal mucosa contribute to sensation.

The study by Eccles et al. (1988), showed that the application of topical lignocaine would not be expected to anaesthetise the skin lined nasal vestibule, despite this, subjects still reported a significantly decreased sensation of airflow and action of menthol after spraying the nasal cavities with lignocaine. The present study expands these findings by showing that sensory nerve endings contained within the nasal vestibule, also conveys information relating to the subjective appreciation of nasal airflow. Jones and colleagues (1989), have shown that sublabial infiltration of the nasal vestibule with lignocaine leads to a sensation of nasal blockage. In addition, Jones, Wight and Durham (1989), have identified the presence of warm and cold receptive fields within the vestibule, which have a significantly different density compared to adjacent malar skin. Similar cold and warm receptors could not be identified upon the nasal mucosa. From their studies, they conclude that the nasal vestibule is the dominant area for conveying sensation of airflow, the nasal cavum lined by mucosa making little contribution. The present study supports the findings of Jones and colleagues in that the nasal vestibule does have a significant contribution to make to the subjective appreciation of nasal airflow, however, the study by Eccles and colleagues supports the view that nasal mucosa has an additional contribution to make. We suggest therefore, that sensory nerve endings located in both the vestibule and cavum contribute to the subjective sensation of airflow. This contradicts the conclusions made by Jones et al. (1989). One possible source of criticism of the latter study, is that sublabial infiltration of anaesthetic is, in comparison to the method employed in this study less precise. Infiltration is likely to anaesthetise in addition to the vestibule, branches of the anterior superior alveolar nerve. These supply the anterior inferior quadrant of the lateral wall of the nose. This area includes the anterior end of the inferior turbinate which possesses erectile tissue under the influence of central sympathetic tone. In the congested state it can protrude into the valve region and thereby alter nasal resistance (Haight and Cole, 1983). The area of the nose innervated by the anterior inferior alveolar nerve also includes the middle meatus, which is the site of main inspiratory airflow (Swift and Proctor, 1977). In addition, as far as we are aware, patients who have undergone neurosurgical section of the maxillary division of the trigeminal nerve for neuralgia, do not complain of nasal obstruction. This might be expected if the vestibule was the only site responsible for conveying nasal sensation, since this is innervated by the maxillary division of the trigeminal nerve. We feel that the method employed in this study is more precise, but is however, not totally beyond criticism in this respect.

Whether the site of sensory nerve endings responsible for conveying nasal

sensation be primarily located in mucosa, vestibule or both, it is highly probable that anteriorly located sensory nerve endings have a greater contribution to make to the appreciation of nasal airflow. The neurophysiological mechanisms responsible for transduction of an airflow stimulus into sensation still remain unknown and speculative. However, the cool sensation produced by inhaling menthol and the effect of cold air might suggest mediation via a nasal thermoreceptor. The findings by Jones and colleagues is particularly interesting in this respect. The nose warms and humidifies inspired air which will naturally lead to mucosal cooling by an effect produced by loss of latent heat of water evaporation. The nasal vestibule being skin lined does not contribute to the conditioning of inspired air and would not, therefore, be expected to be subject to such surface cooling effects. The anterior mucosal surfaces will, in addition, have higher demands placed upon them since air reaching the more posterior locations, will have already been warmed and humidified. The greater the inspiratory airflow the greater the demands placed upon the conditioning mechanisms, and therefore, the greater the mucosal surface cooling. If surface mucosal cooling is a mechanism responsible for triggering some physiological thermoreceptor, mucosal cooling from the foregoing explanation might be expected to be greater in the more anterior regions of the nose. Sensory nerve endings within this location might, therefore, have greater importance in conveying subjective sensation.

Cauna et al. (1969), stated that the nasal mucosa has a limited capacity for localization of stimuli and discrimination of sensory modalities. In histological studies, they found that the nasal mucosa possesses only one type of receptor organ, a terminal arborization of non-myelinated cholinergic nerve fibers. This suggests that within the bony cavum, sensation of airflow and action of menthol arise by an interaction upon only one morphological type of nerve ending. Whether an airflow stimulus exerts an interaction upon similar morphological endings located within the nasal vestibule, remains unknown. It is also possible that airflow being a non-specific stimulus, might influence a variety of different morphological receptors within the nasal vestibule e.g. tactile, pressure and thermoreceptors. We can still only speculate what underlying neurophysiological mechanisms are responsible for conveying nasal sensation to airflow. However, it is likely from the results of this and other studies, that sensory nerve endings located within the nasal vestibule and cavum have a combined contribution to make. Clearly we are only "scratching the surface" in this intriguing area. Much more research will be required before the full mechanisms and nature of sensory nerve endings responsible for conveying the subjective sensation of nasal airflow are fully elucidated.

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