Influence of Nasal Obstruction on Smell Function

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Severe bilateral airway obstruction, such as that associated with some types of nasal or sinus disease, can alter the ability to smell by restricting airflow to the olfactory epithelium. Such obstruction can also decrease the major component of food flavor, which depends upon the active dispersion of molecules from the oropharynx to the olfactory receptors via the retronasal route. The degree to which milder degrees of obstruction alter olfactory function or the perceived flavor of foods is not well established, despite the use of improved smell as justification for a number of intranasal operative procedures, including nasal septoplasty.

This article reviews the limited clinical and experimental data available on the relationship between nasal airway obstruction and the ability to smell. The reader is referred elsewhere for comprehensive treatises on rhinomanometry (the article "Objective Assessment of Nasal Obstruction"), the physics of nasal airflow (the article "The Biophysics of Nasal Airflow"), and chemosensory psychophysical measurement.

DESCRIPTION OF AIRFLOW WITHIN THE NASAL CHAMBERS

In a comprehensive review, Swift and Proctor summarized the basics of nasal airflow determined from in vivo and water-flow mod-

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that the volume of the nasal mucosa decreases slightly upon inspiration, an effect that is not mechanical in origin but is mediated via the cervical sympathetic nerves (Eccles, Malm, Wang, and Widdicombe, unpublished, cited in Cole6).

RELATIONSHIP BETWEEN NASAL AIRFLOW RESISTANCE AND OLFACTOR Y FUNCTION IN NORMAL SUBJECTS

Whether and to what degree normal fluctuations in nasal resistance influence olfactory sensitivity in healthy individuals has received little attention. It is well documented that the airflow resistance of a given nasal chamber changes periodically in most persons across time, reflecting the side-to-side alterations in engorgement of the nasal turbinates (the so-called nasal cycle). Total resistance across the two sides of the nose, however, remains relatively constant.

We recently addressed the question of whether unilateral olfactory threshold sensitivity is altered, in a straightforward manner, by the aforementioned cyclic changes in nasal engorgement. Threshold and suprathreshold (that is magnitude estimation) measures of 2-butanone odor perception were determined in 42 right-handed and 38 left-handed subjects for each side of the nose during two test sessions separated from one another by a 1.5-hr interval. The stimuli were generated using an air-dilution olfactometer and presented to each naris individually via sampling ports on a rotating table (Fig. 2). Nasal resistance of each nasal chamber was determined before and after each olfactory threshold or suprathreshold measurement using anterior rhinomanometry. No significant main effects of subject gender or handedness were found for either the threshold or suprathreshold measure; however, a significant handedness by nostril interaction was present (P < 0.05), suggesting asymmetries in sensitivity related to handedness. Furthermore, a small but statistically significant correlation was found between nasal resistance and threshold sensitivity for the right nostril in the second test session (r = 0.224, P < 0.05), but not in the first test session (r = 0.133, P = 0.26). Correlations among the same variables for the left nostril were not significant. Most importantly, average threshold values did not differ significantly between the extremes of the engorgement cycle for either side of the nose (P > 0.50). No significant analogous relationships were observed for the suprathreshold measure (that is the power-function exponent relating stimulus intensity to perceived intensity).

Overall, these data lend little support to the hypothesis that unilateral olfactory sensitivity varies as a function of normal fluctuations in nasal engorgement. Complex relations were found between bilateral olfactory sensitivity and phases of the nasal cycle, however, likely reflecting the cycle’s association with ultradian autonomic nervous system alterations.

Although the aforementioned study suggests that a direct association between unilateral nasal engorgement and olfactory sensitivity
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Figure 3. Apparatus used to present odorants and induce various degrees of airflow resistance via a mesh monofilament screen. (From Younentaub SL, Stern NM, Mozell MM, et al: Effect of airway resistance on perceived odor intensity. Am J Otolaryngol 7:187, 1986; with permission.)

nomenon would appear to have significance only in cases in which considerable nasal obstruction is present.

Influence of Medical or Surgical Interventions Designed to Improve Airway Patency on Olfactory Function

Adenoidectomy

The presence of adenoid tissue can, in extreme instances, completely block the nasal airflow of children. Furthermore, hypertrophic adenoids significantly influence nasal airflow in children with patent nasal airways. Crysdale, Cole, and Emery,7 for example, noted a 43 per cent reduction in nasal resistance following adenoidectomy in a group of 67 children ranging in age from 4 to 17 years prior to surgery, and Fielder22 reported a 19 per cent postoperative reduction in such resistance in a group of 19 children admitted for adenoidectomy and myringotomies (with or without tonsillectomy) who had at least 1 g of adenoid tissue removed. A small, but statistically significant, correlation between the weight of the adenoid tissue removed opera-
Surgical Intervention and Corticosteroid Treatment in Nasal Sinus Disease

Surprisingly few studies have appeared that have empirically documented alterations in the ability to smell as a function of nasal sinus disease, even though associations between smell loss and such problems as allergic rhinitis, polypsis, and sinusitis have long been reported. Furthermore, although claims of recovery of smell function in persons with nasal sinus disease following intranasal surgical intervention, allergic desensitization, or corticosteroid treatment abound, objective demonstrations of such phenomena have only recently appeared.

In an early but largely descriptive study, Hotchkiss examined a group of 30 patients with nasal obstruction secondary to polypsis. All of these individuals were treated with prednisone and were reexamined on the seventh day of treatment. Although no attempt was made to assess olfactory function quantitatively, restoration of smell function was reported to have occurred following this period, with the magnitude of the restoration being proportional to the amount of shrinkage of the polyps. This restoration was claimed not to be related to the duration of the loss of smell function. Less shrinkage was noted for patients with the fibrous type of polypsis than in those with mucous polypsis, and the change in smell function was reportedly not as pronounced.

Ten years later, Fein, Kamin, and Fein selected 18 patients who reported loss of smell associated with allergic rhinitis. Of these 18 patients, 14 had other pathologies, including polypsis, sinusitis, and bronchial asthma. Severity of the smell loss was classified as mild, moderate, or severe, apparently upon the basis of self-report. Of the four patients who had only allergic rhinitis, two reportedly had a mild loss of smell and two a moderate loss. Of the 14 patients who had other pathologies, 2 apparently had mild loss, 6 moderate loss, and 6 severe loss of smell function. In this latter group, severe loss seemed to be associated with the presence of both polypsis and sinusitis. Although these authors report some improvement in some of the subjects from hyposensitization, antibiotics, polypectomy, or various combinations of these treatments, lack of a well-defined experimental protocol, failure to measure olfactory function quantitatively, and the introduction of the treatments in various combinations without any control for their order or time greatly limits the value of this work.

Recently, Jafek and colleagues described two cases of “steroid-dependent anosmia,” defined as “an olfactory disorder that, although long recognized, has only recently been characterized. It is a syndrome consisting of inhalant allergy, nasal polyps, and anosmia. The anosmia is temporarily reversible by high doses of corticosteroids.” In Case 1, a dramatic improvement in scores on the University of Pennsylvania Smell Identification Test (UPSIT) and on a butanol threshold test was observed 4 months following an intranasal sphenoidectomy (and intranasal antrostomies) and a daily regimen of
prednisone. There was no significant association with a previous history of nasal polyps. None of the patients had nasal polyps at the time of the trial." The time course of the positive effect was quite variable, ranging from a few hours to 7 days. Loss of smell function after the end of the prednisone treatment was also reported to be variable, with some losing smell function within 1 day, some within a week or 2, and one only after about 5 months. Unfortunately, it appears that smell function was not quantitatively tested after the discontinuance of the prednisone treatment and that the latter conclusions are based solely upon patient reports.

More recently, and with a sensitivity to the potential problems of prolonged systemic corticosteroid use, Scott and Cain sought to determine the efficacy of flunisolide nasal spray in restoring olfactory function in a selected set of patients with perennial rhinitis and nasal polyposis. In this report, seven patients were evaluated. These individuals were initially placed on a 2-week course of antibiotics. Flunisolide and nasal decongestant sprays were then introduced on day 15, with the decongestant being discontinued a week later. The olfactory testing was performed at home, and the self-administration of the nasal sprays was done in the Moffat's position to enhance delivery of the sprays. Daily subjective ratings and a self-administered smell test revealed a return of smell function to the midhyposmic range was noted in five of the seven patients after approximately 2 weeks of the flunisolide treatment.

In summary, it appears that allergic rhinitis, polyposis, and sinusitis are clearly associated with anosmia and hyposmia. Furthermore, recent studies suggest that some improvement can be noted in the smell function of a number of these patients following surgical or medical intervention. Although corticosteroid therapy, particularly that given systemically, dramatically alters the olfactory function of many of these patients, additional research is needed to ascertain whether a safe regimen of topical corticosteroid therapy can be devised that will effectively manage these problems over a long period of time.

Septoplasty and Rhinoplasty

Although the few available studies suggest that septoplasty and rhinoplasty have little or no negative influence on the ability to smell and, in some cases, may improve smell function, methodologic limitations limit the degree to which confidence can be placed in their conclusions, as indicated in the following section.

Champion questioned 200 patients regarding their ability to smell following rhinoplasty. Ten percent reported temporary anosmia lasting from 6 to 18 months after the operation and all apparently reported regaining normal smell function. Because no empirical olfactory testing was performed, it is impossible to verify whether any postoperative olfactory deficits were present. This is not a moot point, because many persons with smell dysfunction are unaware of their deficit.
additional group of 16 patients was tested 2.5 years or longer after the operation. Of the initial 24 subjects, 22 evidenced a decrease in olfactory thresholds postoperatively, which, on the average, was about two orders of magnitude lower than the preoperative values. None of the other 16 patients evidenced abnormal smell ability, suggesting that this operation is not accompanied by long-term decrements in smell function.

An important observation of the aforementioned study was that only 51 per cent of the patients questioned preoperatively were aware of an olfactory disability, even though objective evaluation revealed that all were severely impaired. This observation supports the point made earlier in this review that patients are often unaware of the status of their ability to smell and emphasizes the need to use objective measures to assess the influences of operative procedures on smell function. Such a disparity also occurs, under some circumstances, in the ability of subjects to assess their airway patency. Thus, inhalation of a number of odorants (for example vanilla, camphor, eucalyptus, and menthol) leads to reports of increased nasal patency, even though objective measures of airflow resistance are unchanged. It is of interest that most of these stimuli produce cool intranasal sensations.

INFLUENCE OF LARYNGECTOMY ON OlfACTORY FUNCTION

Laryngectomy clearly results in loss of smell function. DeBeule and Damste, for example, noted that 95 per cent of their patients reported noticeable loss of olfaction following laryngectomy; however, half indicated that their smell returned to at least some degree within a year of the surgery.

In a relatively early study, Ritter hypothesized that the laryngectomy-related loss of smell function was due to the inability of the patients to force odorized air through the nose. To examine this question, Ritter used a 50-cc syringe to inject vapors of oil of peppermint, lemon extract, oil of clove, vanilla extract, oil of wintergreen, tincture of iodine, and turpentine toward the olfactory cleft of 18 laryngectomized patients (all of whom were aware of a postoperative smell loss). The least amount of volume needed for identification of the odorant was recorded. Control subjects were instructed to inhale and hold a maximal inspiration before the odors were similarly injected into the nose. Percentages of odors correctly identified by laryngectomized and control patients following such presentations were very similar (70 per cent vs 74 per cent), as were the volumes required for identification (31.0 ml vs 34.6 ml). These findings led Ritter to conclude that laryngectomy patients have an intact sense of smell and that olfaction does not change with disuse.

In contrast to Ritter's view that lack of airflow to the receptors is the basis for impaired smell function in laryngectomized patients, Henkin and associates have argued that the loss of smell function
sniffing behavior or to changes in the functioning of the olfactory system per se is not known.

Overall, the aforementioned studies suggest that the major reason for altered smell function of laryngectomized patients is decreased airflow to the olfactory epithelium; however, factors other than decreased airflow may contribute, to at least some degree, to their olfactory deficit.

SUMMARY

This article has reviewed studies that document a relationship between loss of smell function and disturbances in nasal airflow function. In some cases (for example, hypertrophied adenoids and nasal sinus disease), medical or surgical intervention appears to be useful in restoring some, if not all, of the smell loss associated with the disorder. In other cases (for example, septoplasty), empirical evidence of such efficacy is wanting. Given the current research interest on these topics, however, a clear understanding of both the positive and negative influences of surgical and medical interventions in most cases of obstructive nasal disease or malformities will be forthcoming.

REFERENCES

13. Doty RL, Gregor T, Settle RG: Influences of intertrial interval and sniff bottle
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