EFFECT OF THE DISTRIBUTARY OF NASAL MEATUSES ON OLFACTION *

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Abstract: Considering the effect of distributary of the interior meatus and middle meatus on olfaction, an unsteady two-dimensional model of olfaction has been developed with describing the mean cross-sectional velocity of odorant flow in the common meatus as a function of axis coordinate. The analytical solution is obtained, and it reveals the relation among the physiological parameters of the model. The obtained results are in agreement with those of experiments. This investigation is valuable for a research for the mechanism of olfaction.

Key words: nasal cavity; olfaction; mathematical model; analytical solution

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Introduction

In the realm of chemoreception, the sense of smell remains one of the most obscure provinces. More recently, the artificial electric nose lies good prospect for variable aspects such as public security, national defence and forbidden narcotics with the development of tissue engineering and biomechanics. So the research for mechanism of olfaction is attracting people’s attention[1].

Olfactory perception is achieved when chemical odorant molecules in air are drawn along the nasal flow path through the olfactory region and gain access to the olfactory receptor cells located in the olfactory mucus layer in the upper posterior portion of the nasal cavity (Fig. 1, Fig. 2 and Fig. 3)[2]. In the human nose, odorant molecules don’t have immediate access to olfactory receptors, and have to pass through four inter related events, they are: (i) convective-diffusion transport of odorants from ambient air to the surface of olfactory region by inhaled air; (ii) sorption of odorant molecules into the mucus at the mucus interface; (iii) diffusion of odorant molecules through the mucus layer; and (iv) interaction of odorant molecules with the olfactory receptor cells stimulates olfactory cells discharge then comes into being olfaction. An appropriate theoretical model should include analysis of all of the above mechanisms. But most of the previous theoretical models have focused on one of the related events. A mathematical theory of

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olfaction with emphasis on the odorant transport in the air phase was constructed firstly by Stuiver\textsuperscript{[3]}. Although this model was somewhat successful in explaining some overall psychophysical data, it was lacking in detail and cannot be used to explain local phenomena at various points on the olfactory mucus. Mozell et al developed a chromatographic model to explain the spatial distribution property of inhaled odorant molecules across the olfactory mucus\textsuperscript{[4]}. The importance of the molecular diffusion of odorant molecules from the surface of the olfactory mucus to the receptor site had been discussed in detail by Getchell\textsuperscript{[5]}. These models had a common disadvantage that they have focused on only one of the related events. Recently, Xu Mingyu et al have developed an unsteady one-dimensional model of olfaction with considering the above four related events\textsuperscript{[6]}. They assumed mean local longitudinal velocity of the odorant carrier gas to be constant without considering the effect of distributary of nasal meatus. Hahn et al constructed an anatomically correct and enlarged scale model of the right nasal cavity from coronal CAT scan image. The velocities were measured for inspiratory flow using a hot-film anemometer\textsuperscript{[7]}. Different steady air flow rates through one side of the real nose were studied. The distribution of flow was that about 30% passed through the inferior meatus, 40% passed through the middle meatus, and 30% through the olfactory region for the velocity at the anterior tip of the nose equivalent to 15.4 m/s. It showed that the mean cross-sectional velocities in the common meatus were not constant. In this study, considering the distributary of the inferior meatus and middle meatus, the mean cross-sectional velocity is described as a function of axis coordinate. Then we have developed an unsteady two-dimensional model of olfaction with describing the common meatus as an open circular tube. The analytical solution of this model is obtained. The results calculated by use of the formulary of this work are in good agreement with those of experiments\textsuperscript{[8,9]}. The analytical solution reveals the relation among the physiological parameters of the model. This investigation is valuable for research for the mechanism of olfaction.

1 Model of Olfaction

Nasal cavity is a complex long lacuna. It begins at the anterior nares, and leads to the