REVIEW

Mechanoreceptors in the nose

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Abstract  Nasal obstruction is a common symptom. Usually it is due to the presence of enlarged inferior turbinates, adenoid hypertrophy or pathological nasal mass. The most commonly encountered is nasal polyp. The presence of a physically obstructing mass causing the symptom can be easily explained. However, there are some patients with nasal polyp who do not have the feeling of congestion or nasal obstruction. There might be due to the mechanoreceptor that is free from stimulation despite the presence of the polyp. This review was made in the process of understanding the presence and type of mechanoreceptors in animal as well human nose.

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Contents

1. Introduction ................................................................. 9
2. The mechanoreceptors .................................................. 10
3. Mechanoreceptors in animal nose ................................... 10
4. Mechanoreceptor in human nose .................................... 11
5. The role of thermoreceptors .......................................... 11
6. Conclusion .................................................................... 11
   Conflict of interest ....................................................... 11
   References .................................................................. 11

1. Introduction

The nasal cavity mucosa receives sensory nerve supply from the maxillary division of the trigeminal nerve.1 It plays an important role in the protective function of the nose by provoking defensive reflexes in response to foreign body and mechanical stimulation ranging from sneezing, bronchospasm to cardiorespiratory arrest.7

Besides, whenever triggered by allergy or infection, there will be a release of inflammatory mediators like histamine and interleukins. These will lead to dilatation of the venous sinusoids in the submucosa with increased secretion and subsequent mucosal edema leading to nasal congestion. Those
inflammatory mediators also can cause modulation in the sensory afferent of the nasal mucosa with subsequent feeling of nasal obstruction.³

Nasal polyp patients commonly present with nasal obstruction. It seems that the polyp exerts pressure on the nasal mucosa causing mechanical stimulation to the sensory afferents with subsequent feeling of nasal obstruction. Such sensory functions of the nasal mucosa have been thought to be mediated by nasal trigeminal afferents and several types of mechanoreceptors such as pressure, drive and touch.⁴ However, there are some patients with nasal polypl who do not have the feeling of congestion or nasal obstruction.

2. The mechanoreceptors

Mechanoreceptors are a group of receptors that are stimulated by a variety of external stimuli like touch, change in pressure and vibration. In addition, it is believed that they play a major role in the development of different body tissues such as bones, skeletal system, blood vessels and cartilage. They also play an important role in maintaining the intracellular hemostasis.⁵

Mechanoreceptors are present in the skin and in other part of the body such as joint and mucosal surface.⁶ They are formed by the terminal ending of the sensory nerve fibers that innervate the skin and other part of the body.⁷ Some of the sensory nerve fibers in the skin and mucosal surface ended with expanded terminals called the corpuscles which have a capsule and contain mitochondria and vesicles.⁸ These corpuscular nerve terminals act as mechanoreceptors stimulated by mechanical force applied to the skin and mucosal surface.

Mechanoreceptors are classified into five types based on their morphology: Merkel, Ruffini, Meissner, Pacinian corpuscles and free nerve ending.⁹ The four first corpuscles are encapsulated and the myelinated sensory nerve fibers that supply the skin or the mucosa lose their myelin sheath upon entering the capsule. The fifth type is non-encapsulated and they are considered simple non-expanded free nerve terminals of the sensory nerve fibers.¹⁰

The mechanoreceptors also can be classified into five types depending on their physiological properties in response to mechanical stimulation.¹¹ They are slowly-adapting type I receptor, slowly-adapting type II receptor, rapidly-adapting type I receptor, rapidly adapting type II receptors and the C-mechanoreceptor.

3. Mechanoreceptors in animal nose

Most information about the distribution of these mechanoreceptors in the nasal cavity is obtained from animal study. Very little is known about human nasal mucosal mechanoreceptors. In rats, pressure-responsive receptors had been identified in the nasal mucosa and they were distributed at the ethmoidal nerve area. However the majority of these receptors were stimulated by maintained positive pressure and they are inactive in maintained positive pressure. The exact mechanism by which these mechanoreceptors are stimulated is unknown. However one explanation is that the distortion of the mucosa during negative pressure application leads to stretching and stimulation of these endings.¹¹

While in cats, the mechanoreceptors stimulated by drive and/or pressure were found mostly in the posterior nasal and infraorbital nerve area. Only one receptor was found in the ethmoidal nerve area.¹²

In guinea pigs, 22 mechanoreceptors were identified by mechanical probing to the vestibule and the alae nasi. They were consisting of touch-responsive receptors and probably a smaller number of pressure and drive-responsive receptors. The touch-responsive receptors were silent until stimulated by probing and they are rapidly adapting receptors. None of these mechanoreceptors were stimulated by ammonia inhalation.¹³

In avian, 75 mechanoreceptors were identified and they were distributed throughout the nasal mucosa. Part of those receptors was slowly adapting receptors and others were rapidly adapting receptors. When the receptors were exposed to ammonia, 24 receptors showed response to chemical stimulation. These receptors are thought to be polymodal receptors which respond to mechanical and chemical stimuli with different thresholds.¹⁴

All the above mentioned studies shared the same principles of identifying the numbers, distribution and the physiological properties of the mechanoreceptors in the animal nasal mucosa. The animal was anesthetized and tracheotomized. The infraorbital nerve, ethmoidal nerve and posterior nasal nerve were dissected, exposed and connected to electrodes. The nasal mucosa was then stimulated by different type of stimuli (probing, negative and positive pressure, air jet stimulation and ammonia). The response to each stimulus was recorded from each nerve namely the latency, duration and frequency of discharge through the nerves.

However there are other animal studies which describe the morphological and histological properties of the mechanoreceptors in the nasal mucosa.

In rat, the Ruffini corpuscle (slowly adapting mechanoreceptors type II) was identified as expanded axon terminals in the periodontal ligament by using the immunohistochemical staining.¹⁵ Polyclonal anti-calretinin anti serum was used to identify those Ruffini corpuscle.

Calretinin is one of the intracellular calcium-binding proteins. There are two groups of calcium-binding proteins inside the cell, the first group is the “trigger” group such as calmodulin which change their shape upon binding to calcium. The second group is the “buffering” group which simply binds to calcium without changing their shape. Calretinin and calbindin D-28K are considered from the last group.¹⁶

The role of these calcium-binding proteins is to regulate the intracellular calcium concentration which plays a very important role in the transduction of the mechanical stimuli to an electrical signal.¹⁷

When the cell is targeted by neurotransmitters, an intracellular second messenger like cAMP and intracellular calcium are activated. These messengers then target another intracellular proteins such as protein kinase, G-protein and calcium-binding proteins like calretinin.¹⁸

In mechanoreceptors, the mechanical stimuli result in deformation of the axon terminals of the receptors which leads to rapid influx of calcium into the terminals. One of the roles of calcium-binding proteins is to buffer the increase in the intracellular calcium concentration.¹⁹

Recently, the use of these calcium-binding proteins as neuronal markers by using antibodies against them is increasing. This allows study of the anatomical and morphological properties of different cells of the nervous system. They can
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There is a need of morphological study of mechanoreceptors in human nose. The information about the distribution, concentration as well as the morphology of the mechanoreceptors in the nasal mucosa seems to be very important in the understanding of many symptoms and signs of patient with different nasal pathology such as the nasal polyp. It seems to be that these mechanoreceptors in the nasal mucosa play an important role in the feeling of nasal obstruction.

6. Conclusion

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Conflict of interest

None declared.

References


4. Mechanoreceptor in human nose

So far there is significant lack in the histological information of the mechanoreceptors in the human nasal mucosa. There is only one study done to explain the morphology of the sensory nerve fibers in the nasal mucosa in general. The study shows that the nasal respiratory epithelium is supplied by non-myleinated nerve axons devoid of nerve sheath. These nerve fibers enter the mucosa in fascicles containing 200 axons and ending in the lamina propria. These fibers contain mitochondria and granules and fine vesicles. Studies had shown the presence of these mechanoreceptors in other part of the body. Meissner corpuscles and free nerve ending had been demonstrated in the oral cavity. By using the electron microscope, the Meissner corpuscle was located in the mucosa of soft palate, hard palate, gingiva and cheeks while the free nerve ending was seen in the submucosa and extends into lamina propria just beneath the epithelium.

Using the immunohistochemistry technique, the Merkel corpuscle was identified in the mucosa of the gingiva, palate and buccal mucosa together with free nerve ending which was located in the submucosa and some of them extend between the epithelial cells.

However the Ruffini corpuscles were identified as expanded nerve terminals in the anterior cruciate ligament of the human knee. Using immunohistochemistry with neurofilament antibody, it was able to identify eight Ruffini corpuscles in normal ligament and six corpuscles in ruptured ligament. Neurofilaments are one type of proteins that form the neural axon filaments. They are present almost exclusively in neural axons and consider as intermediate filament between the other filaments of the nerve axons namely the actin and microtubules filaments. They form a major component of the cytoskeleton support for the axonal cytoplasm.

Labeled antibody against this neuronal protein is used for the identification of nerve cells and axons in the central and peripheral nervous system using the immunohistochemistry technique.

5. The role of thermoreceptors

Under certain conditions, the sensation of nasal patency or nasal airflow can be entirely independent of any objectively measurable change in nasal resistance. There is a great debate about the role of thermoreceptors and chemoreceptors in sensing airflow in comparison to the role of mechanoreceptors alone in the nose. One can feel the stuffiness even without any change in the nasal structural architecture. Application or inhalation of menthol, camphor and other trigeminal irritants can make the patient sense the reduced nasal stuffiness, or interpreted as increase in the sensation of nasal patency.

On the contrary, being in the real cold place or subjects who underwent nasal provocation with cold-dry air will induce nasal symptoms including congestion. Exposure to known allergens as well will lead to turbinate hypertrophy which can be objectively seen and measured, as in the clinical presentation of allergic rhinitis patients. This is suggestive that the sensation of fullness is also contributed by some mechanical factors. Thus the role mechanoreceptors especially in human nose is still an area to be deliberated.

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