AFFERENT FIBERS FROM THE UPPER RESPIRATORY TRACT IN BRANCHES OF THE TRIGEMINAL NERVE

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The distribution of afferent fibers from the lower respiratory tract has been studied reasonably fully [12, 15, 17, etc.]. However, because of difficulty of access to branches of the trigeminal nerve innervating the upper respiratory tract, afferent fibers in these branches have not been described, although the participation of the nasal cavity in regulation of the act of respiration has been demonstrated conclusively [2, 3, 6, 7]. Afferent impulses from the upper respiratory tract participate in the formation of tonic activity of fibers innervating the smooth muscle of the bronchial tree, the heart, the blood vessels, gastro-intestinal tract, liver, and other organs [2, 4, 10, 11].

The authors studied the distribution of afferent fibers from the upper respiratory tract in branches of the trigeminal nerve.

EXPERIMENTAL METHOD

Silver electrodes were used to record impulses from the peripheral segment of the nerve. Recordings were made on an instrument made at the workshops of the Institute of Experimental Medicine, Academy of Medical Sciences of the USSR. The amplifier circuit was modified so that the noise line was restricted, so that in necessary cases the amplitude of the recorded impulses could be increased to a maximum.

EXPERIMENTAL RESULTS AND DISCUSSION

Attempts to approach the nasal branches of the trigeminal nerve from the temporal fossa by resecting the zygomatic bone [9] were unsuccessful because of the considerable bleeding from the tissues and the narrow operation field. A transorbital approach with enucleation of the eye proved successful. After careful removal of the eye and the connective tissue lining the orbit, two nerves supplying the nasal cavity were identified in the cat's orbit.

The anterior ethmoidal nerve (a branch of the ophthalmic nerve) penetrates through the foramen of the same name and, to judge from these dissections, it supplies the upper parts of the nasal cavity in cats. The posterior nasal nerve (a branch of the maxillary nerve) penetrates into the nasal cavity through the pterygopalatine foramen and supplies the lower parts of the nasal cavity.

Afferent impulse activity, correlated with the respiratory rhythm in the frequency of its impulses (Fig. 1a), was recorded in both the anterior ethmoidal and the posterior nasal nerves. During forced breathing through the investigated half of the nasal cavity by stopping the access of air through the second nostril, this impulse activity was intensified. If the circulation of air through half the nasal cavity was artificially stopped, impulses in the nerves from the corresponding side became infrequent and their frequency did not correlate with respiration. During quiet breathing, the frequency of the impulses reached a maximum during inspiration and at the beginning of expiration (Fig. 1a), i.e., at the time of greatest fall of pressure in the nasal cavity. In one experiment during forced expiration, the frequency of impulses reached a maximum at the beginning of expiration (Fig. 1b).

The results of these experiments are in agreement with data published by V. A. Bukov [2] who concluded from indirect experiments that the most powerful stimulus for the upper respiratory tract during quiet breathing is a fall in the air pressure on the surface of the mucous membrane. Carbon dioxide, humidity, and a low temperature within the limits of very slight variation are weak stimuli for the mucous membrane of the nasal cavity. The mechanoreceptors of the mucous membrane of the upper respiratory

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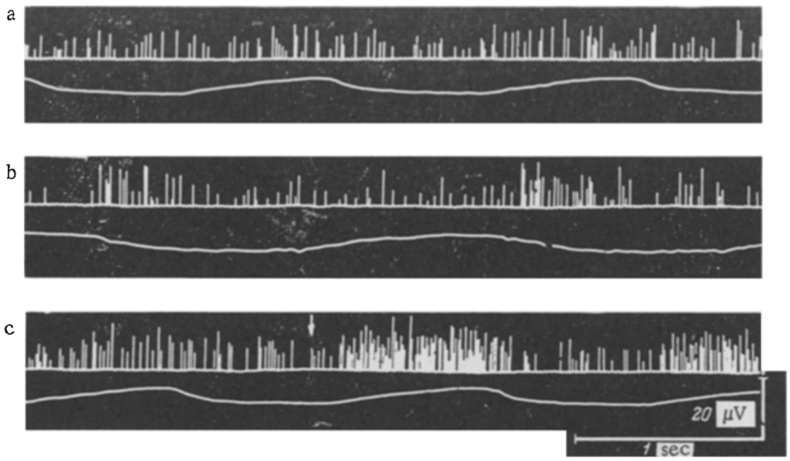

Fig. 1. Impulse activity in afferent fibers of the nasal branches of the trigeminal nerve during quiet breathing (a), breathing with forced expiration (b), and during application of cotton wool with ether (arrow) to the nasal orifices (c). From top to bottom: neurogram, pneumogram (upward deviation represents inspiration).

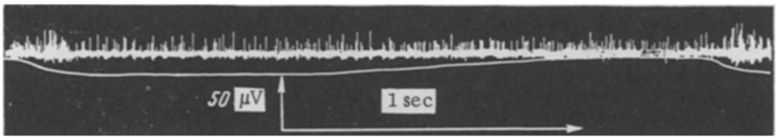

Fig. 2. Impulse activity in afferent fibers of the superior laryngeal nerve. Legend as in Fig. 1.

tract, reacting to air movement, have the character of diffuse arborizations of sensory nerve fibers [5]. These receptors take part in the sneezing reflex.

Touching the mucous membrane, or bringing cotton wool soaked in ammonia or ether to the nasal orifices (Fig. 1c) produced an increase in impulse activity. The receptors of the vestibule of the nose became adapted to touch within a few seconds.

Changes in afferent impulse activity under the influence of inhalation of ether were observed only in the anterior ethmoidal nerve. This may be related to differences in the structure of the mucous membrane in the regions supplied by the anterior ethmoidal and posterior nasal nerves.

Evidence has now been obtained to suggest that the pathways of cortical activation by excitation of receptors in the nasal cavity travel in the reticular formation of the brain stem [14, 16].

It is interesting to note that the "respiratory" afferent impulse activity from the upper respiratory tract (nasal branches of the trigeminal nerve) are analogous in character to afferent impulses from the middle respiratory tract (superior laryngeal nerve, Fig. 2): the same increase in frequency depending on the rate of air movement, and the same "burst" of impulses during forced expiration are present. In the latter case the "burst" is also attributable to the fact that during forced expiration the rima glottidis constricts, thus further increasing the velocity of air movement. This "burst" was not caused by contraction of the cricothyroid muscle on the same side, for the muscular branch of the superior laryngeal nerve was divided and took no part in the experiment. It is more difficult to explain the origin of the high-amplitude impulses which appeared regularly during the respiratory pause (Fig. 2). The fibers probably carry discharges from chemoreceptors reacting to CO_2.

In these experiments attempts were made to record afferent impulses correlating in frequency with the act of respiration, and also afferent impulses in the afferent fibers running from the pterygopalatine ganglion. Sometimes afferent activity of constant frequency was observed in these branches. No "respiratory" impulse activity could be observed.

It may thus be postulated on the basis of morphological [5] and electrophysiological data that the branch of the trigeminal nerve innervating the upper parts of the nasal cavity is a mixed nerve and contains fibers from individual olfactory cells.

The nasal branches of the trigeminal nerve are characterized by "spontaneous" activity [5], i.e., activity in the absence of stimulation by the passage of air. This afferent activity, unrelated to respiration, can be recorded if the access of air to the investigated half of the nasal cavity is stopped.

During the act of respiration, an impulse activity associated with the passage of air, dependent on the velocity of air movement, and having maximal frequency during inspiration and at the beginning of expiration (when the velocity of air movement is greatest) appears in the branches of the trigeminal nerve supplying the upper respiratory tract. This distinguishes the afferent impulses from the upper respiratory tract from those from the lower respiratory tract, which reach their maximum at the height of inspiration. This latter property is explained by the existence in the lungs of special stretch receptors, responsible for the Hering-Breuer reflex. Afferent impulses from the upper respiratory tract not only take part in the formation of the tonic activity of the respiratory center [6], but also influence the "tone" of the cerebral cortex [2, 8], and participate in the formation of tonic activity in various fibers of the autonomic nervous system [2, 4, 10, 11].

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