THE PART PLAYED BY THE MUCOUS MEMBRANE OF THE ACCESSORY NASAL SINUSES IN REGULATING BREATHING

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Respiration rate is to some extent controlled by reflexes originating from the mucous membrane of the upper part of the respiratory tract [2, 3, 4, 7, 8, 15 and others]. It may be taken as established that stimulation of the trachea, larynx, and nose by various stimuli including a stream of air is a factor which has an important effect on respiratory movements. In the works of the Pathophysiological Laboratory of the Scientific Research Institute of the Ear, Nose, and Throat, it has been shown that reflex influences from the upper respiratory tract are of particular importance, especially in pathological conditions, in regulating the activity of various organs and systems, in particular the heart, stomach, kidneys, etc. [5, 6, 9, 11].

Less attention has been paid to the part played by the mucous membrane of the accessory nasal sinuses in regulating respiration.

Some workers [1, 10, 12] have indicated the possibility of reflex control of the respiration from the mucous membrane of the accessory nasal sinuses. Others deny this [13 and others]. It may be that these differences have developed through work having been done on animals in acute experiments using different kinds of anesthetics and different depths of anesthesia.

Our present task is to determine the extent to which the mucous membrane of the frontal sinus takes part in reflex regulation of the respiration.

METHOD

Chronic experiments were carried out on dogs, no anesthetic was used, and there was no painful stimulation. The frontal bone was trepined over the frontal sinus, on the left and right sides, under ether anesthesia. A fistula was established by introducing a duralumin tube and sealing it hermetically into the opening in the bone. The tube was fixed into the bone by means of threaded sleeve over which the skin was sewn. After 6-7 days from the time of the operation, when all inflammatory changes had subsided, the animal was ready for the experiment. A current of air, and mechanical, chemical and thermal stimuli were applied to the mucous membrane.

The animal was placed on a stand having a special adaptation for holding the trunk and head still. A pneumograph was used to record the respiration on a kymograph. The cover was then unscrewed from the fistula, and the mucous membrane of the frontal sinus stimulated. Altogether 220 experiments on 7 dogs were carried out.

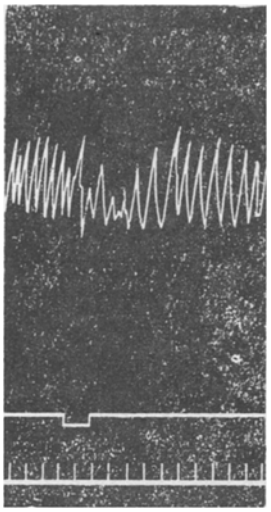

Fig. 1. Changes in the respiration in the dog Soroka in response to mechanical stimulation of the mucous membrane of the frontal sinus. Curves, from above downwards: respiration; stimulus marker; time marker (1 second).

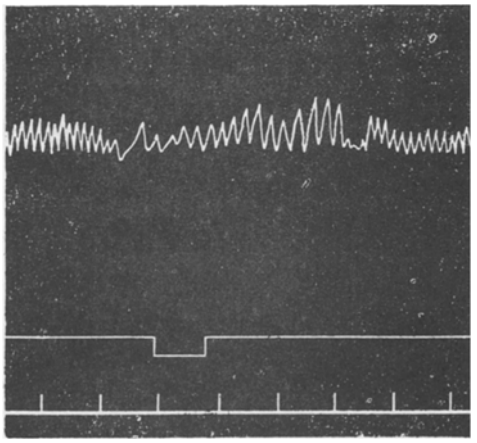

Fig. 2. Changes in respiration in the dog Sharik in response to cold stimulation of the mucous membrane of the frontal sinus. Curves as in Fig. 1.

RESULTS

In 29 experiments the effect of mechanical stimulation of the mucous membrane of the frontal sinus on the respiration was determined. Various parts of the mucous membrane of the sinus were touched by introducing a fine metal wire through the fistula. In order not to cause damage to the membrane, the end of the wire was covered with a fine layer of cottonwool.

In 19 experiments, mechanical stimulation of the mucous membrane of the frontal sinuses caused a slowing of the respiration rate and an increase in the amplitude of the respiratory movements, while in 5 experiments there was no reaction, and in 5 others the respiration rate was raised and the amplitude reduced. It must be noted that stimuli which were above the level of the tactile sensibility, caused a motor response to the pain caused, and this led to errors in recording respiratory movements. This probably accounts for failure to obtain results in many experiments. Thus, it must be supposed that, as a rule, mechanical stimulation causes a change in the rate and amplitude of respiratory movements (Fig. 1).

To study the action of thermal stimuli on the frontal sinus, we introduced 0.2-1 ml of water at temperatures from 5 to 50°. From the results of 48 experiments, it was found that the effect of both cold and hot water was the same as that of mechanical stimulation (Fig. 2).

As chemical stimuli, in 28 experiments we used a solution of penicillin (150,000 units per ml), and in eighteen, a 0.1 N solution of hydrochloric acid, and in a further eighteen, a 0.1 N solution of caustic soda. In each case, 0.2-1 ml of the substance was introduced into the sinus. The temperature of the solutions was between 16 and 18°. In all the experiments, there was an increase in the amplitude and a decrease in the rate of respiration (Fig. 3, a).

The most revealing experiments were those in which the mucous membrane of the frontal sinus was stimulated by air, i.e., by the stimulus which is effective under normal conditions. The air was introduced into the sinus through the fistula tube, under control of a manometer. The pressure varied from 20 to 140 mm of mercury. In spite of the different stimulus strengths, in 38 out of the 54 experiments there was an increase in amplitude and decrease in rate of respiration. Only in 9 experiments did the reverse change occur, while in 7 there was no reaction.

When using oxygen as a stimulus, controlled by the manometer, in 16 out of the 25 experiments there was some change in the amplitude of respiration (either an increase or a decrease, while in 2 experiments there was no change; reduction in the respiration rate was found only in 10 experiments, there being no change in the remaining 15. Changes in the amplitude were less marked than in the case of the other stimuli.

Thus oxygen is a considerably less potent stimulus for the receptors of the mucous membrane of the frontal sinus than is air, and the effect is chiefly on the amplitude rather than on the rate of respiration (Fig. 3, b).

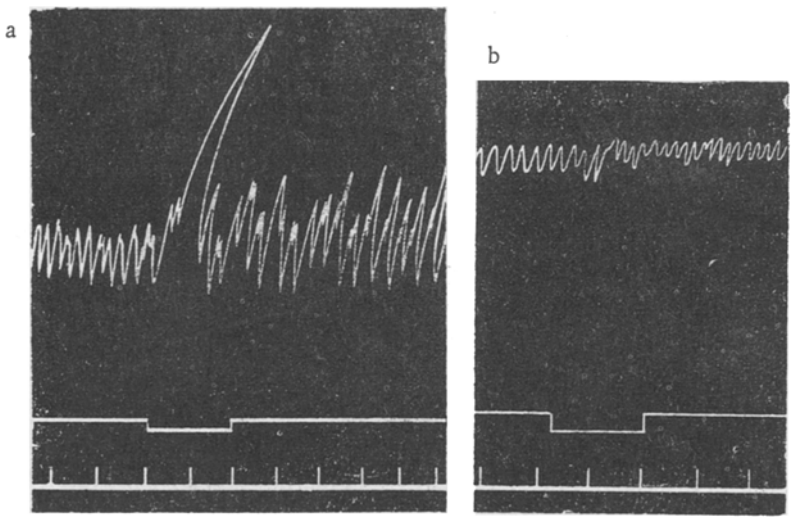

Fig. 3. Changes in respiration (a) in the dog Umka, on introducing penicillin solution into the frontal sinus, (b) in the dog Soroka in response to oxygen on the same mucous membrane. Traces as in Fig. 1.

From these results it may be concluded that in the mucous membrane studied there are chemo-, baro- and thermoreceptors. All the types of sitimuli applied to the mucous membrane of the accessory sinuses have some effect on the respiration.

The results we have obtained do not agree entirely with other published accounts [1, 4]. Thus, A. A. Atkarskaya [1] reports that with mechanical stimulation of the mucous membrane of the frontal sinus, the respiration rate is raised, and stimulation with water at a temperature of 3 or 4° has no effect. Chemical stimuli such as ether and ammonia solution have no appreciable effect on respiration, and cause only a reaction of the animal in response to the pain induced.

As far as stimulation of the mucous membrane of the sinuses with air is concerned, our results agree with those of A. A. Atkarskaya with respect to the slowing of respiration rate, but do not agree with her findings on the amplitude of the respiratory movements. She reports a reduction, whereas, in most cases, we observed an increase in amplitude. Reduction in the amplitude and rate of respiration in response to an air stimulus should, according to A. A. Atkarskaya, be interpreted as the result of an inhibition, which is usually a characteristic of the trigeminal nerve.

However, E. N. Pavlovskii and Shpiss have shown that stimulation of the trige minal nerve causes an increase in the depth of respiration, a result which agrees with our findings. Kerekes [12] has found that weak stimuli cause an increased and strong stimuli a decreased ventilation; the effect depends upon the strength of the stimulus.

It is not easy to compare our results with the others reported above, because the experiments were carried out by different methods.

From the results obtained we may conclude that the accessory nasal sinuses take part in the regulation of respiration.

SUMMARY

Chronic experiments were performed on dogs with a fistula established in the frontal sinus. The effects on respiration of mechanical, chemical, and thermal stimuli, as well as of air and oxygen currents were investigated.

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