THE ROLE OF BARORECEPTOR SYSTEMS OF THE NASAL CAVITY IN REGULATION OF RESPIRATION IN MAMMALS

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Our previous communications [2, 3] described the baroreceptor olfactory-respiratory system in amphibia (frogs) and birds (pigeons). It was shown that this system formed a component part of the single baroreceptor system of the upper, middle and lower respiratory passages which was the afferent system for the respiratory center and maintained its tonus at a definite level. This system was named the baroreceptor respiratory system. Its role in the regulation of the respiratory center activity at the different stages of phylogenesis depends on the species and conditions of existence of the animal.

Investigation of the role of the baroreceptor respiratory system (baroreceptors of the olfactory apparatus in particular) in the regulation of respiration in mammals (rabbits, dogs) is the subject of the present communication.

EXPERIMENTAL METHOD

A total of 89 experiments on 22 rabbits and 11 dogs was carried out. The rabbits weighed 1-2 kg, the dogs 4.3-15 kg. The respiratory movements were recorded from the thorax and abdomen of the animals by means of two rubber cuffs connected by a T-piece with a Marey's tambour. The intranasal baroreceptors were stimulated by rhythmic forcing of a stream of room-temperature air into a mask covering the animal's nostrils. The pressure of the air stream was measured by a water manometer. Application of the air stream was recorded on a kymograph.

Part of the experiments were performed on a long-term basis on tracheotomized animals. At tracheotomy the upper portion of the trachea was carefully closed either by ligation (rabbits) or by a skin-muscle flap (dogs) and a tracheal cannula was inserted into the lower portion of the trachea.

Olfactory afferentation was abolished by removal of the olfactory bulbs or by transection of the olfactory nerves by a somewhat modified technique of B.N. Klosovskii and E.N. Kosmarskaia [4]. Trigeminal afferentation was interrupted by extirpation of the Gasserian ganglia. The influence of the cerebral hemispheres was studied by mechanical stimulation (trauma, excision of meninges) and by decerebration of the animals.

EXPERIMENTAL RESULTS

The initial respiratory rhythm in rabbits was 42-55 respiratory movements per minute, the amplitude being 3-10 mm; in dogs the rate was 18-24 per minute and amplitude 5-20 mm. When even weak stimuli (1-2 mm Hg) were applied to nontracheotomized animals, stimulation of the intranasal baroreceptors was associated with complete adoption of the stimulus rhythm and a sharp decline in the amplitude of respiratory movements. Such a type of reaction can be explained by artificial mechanical inflation of the lungs.

Tracheotomy led to slowing of the rate of respiratory movements, with no appreciable effect on their amplitude, in both groups of animals. The general background of the respiratory trace became more even with no change in the form of movement. The respiratory rate varied in rabbits from 30-50 and in dogs from 12-18 respiratory movements per minute. Rhythmic forcing of an air stream into the nasal passages of tracheotomized animals led to some diminution of amplitude and reduction of the rate of respiratory movements. It is interesting that in a considerable number of experiments the animals' respiratory rate approached the rate at which air was being blown in (i.e., phenomenon of "rhythm adoption"), and the lowering of amplitude was so marked that by the end of stimulation apnea set in. These experiments show once again the role of reflex mechanisms in the origin of apnea.

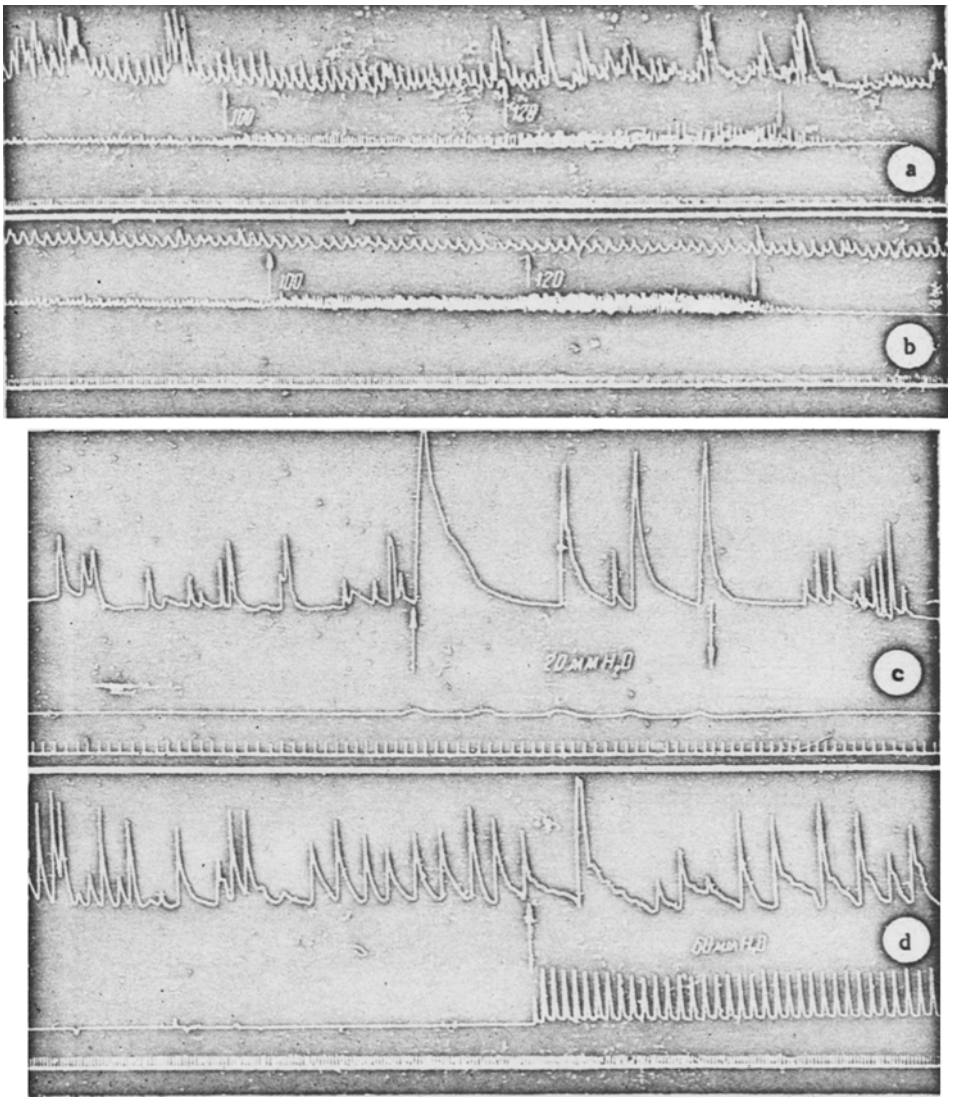

Fig. 1. Respiratory reactions in tracheotomized dogs in response to baroreceptor stimulation of nasal mucosa. A) Experiment 10/8/1956. "Rhythm adoption" phenomenon and reflex apnea in tracheotomized dog; B) absence of respiratory reactions in the same dog after cocainization of nasal mucosa; C) experiment 5/29/1956. Respiratory reaction and respiration of tracheotomized dog on forcing air into the nose; D) absence of respiratory reaction in the same dog 11 days after bilateral bulbectomy (6/9/1956). Records from above down: pneumogram, stimulus marker between ↑ and ↓ (forcing of air into nose under pressure), time marker (1 second).

Tracheotomized rabbits showed less marked respiratory reactions than tracheotomized dogs. However, rabbits also showed the phenomenon of "rhythm adoption" and onset of reflex apnea.

The "rhythm adoption" phenomenon associated with stimulation of the intranasal baroreceptors in tracheotomized animals indicates the important role played by the afferent system under consideration in the activity of the respiratory center. The significance of reflex factors is clearly demonstrated in experiments with anesthesia of the intranasal mucosa achieved by 2% cocaine solution in which the "rhythm adoption" phenomenon disappeared completely (Figure 1).

On abolition of olfactory afferentation (bulbectomy) the animals (6 rabbits and 4 dogs) showed slowing of the rate and diminution of the amplitude of respiratory movements similar to those following tracheotomy. The general background respiration tracing becomes even more even than after tracheotomy alone. No perceptible change in the form of respiratory movements could be observed. Rhythmic forcing of air into the nasal cavity of tracheotomized and bulbectomized animals did not, as a rule, elicit any definite respiratory reactions. The "rhythm adoption" phenomenon was never observed in these experiments.

The excitability of the nasal mucosa to baroreceptor stimulation was even more sharply reduced when trigeminal afferentation was interrupted. Rhythmic forcing of an air stream into the animal's nasal cavity in these experiments caused only the appearance of an undulating background respiratory tracing without changes in the rate or amplitude of respiration; at small pressures of up to 100 mm water there was no change in respiration whatsoever.

Complete deafferentation of the intranasal mucosa (interruption of the olfactory and the trigeminal elements) abolished completely the effect of even strong baroreceptor stimuli (pressure above 120 mm water) on respiratory movements (Figure 2).

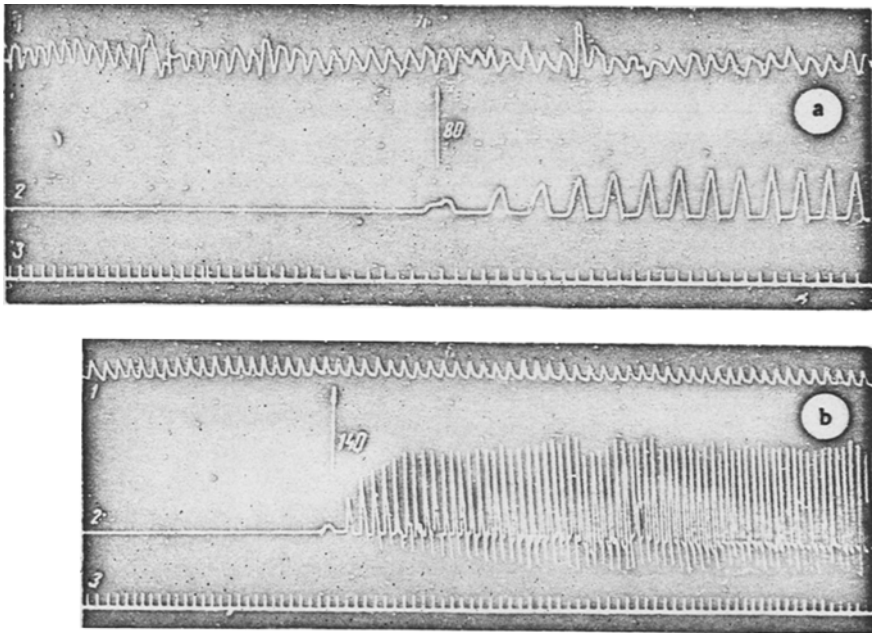

Fig. 2. Respiratory reaction in tracheotomized rabbit to rhythmic forcing of air into the nasal passages. A) Experiment 10/11/1955. Attenuation of respiratory reaction to forcing of air into the nose after bilateral bulbectomy; B) total absence of respiratory reaction in the same rabbit 3 days (experiment 10/14/1955) after deafferentation of the nasal mucosa. Records from above down: the same as in Figure 1.

The role played by the cerebral hemispheres was studied in experiments on decerebrate animals and in experiments with mechanical stimulation of the hemispheres.

Removal of the cerebral hemispheres carried out in five experiments invariably led to considerable acceleration of the rate and enhancement of the amplitude of respiratory movements. Thus, for example, in the case of rabbits the rate increased up to 55-78 per minute and the amplitude up to 8-14 mm. The respiratory reaction to stimulation of the nasal mucosa baroreceptors was expressed in a sharp decrease of amplitude without change of rate of respiration. The reaction occurred after a longer latent period than prior to decerebration, and return of respiration to normal was also considerably delayed.

Mechanical stimulation of the cerebral hemispheres (trauma, excision of meninges) caused marked reduction of the rate and amplitude of respiratory movements as well as of the reactivity of the intranasal mucosa baroreceptors: even strong baroreceptor stimuli (above 100 mm water) failed to elicit perceptible changes in respiratory movements.

It follows from the material presented that the intranasal mucosa carries receptors of two afferent systems of the respiratory center – the olfactory nerve system and the trigeminal nerve system. The latter ensures the more important and at the same time the more crude adaptation reactions of the respiratory center to changes in environmental conditions. Olfactory afferentation, developed later than the trigeminal in the process of phylogenesis, regulates the activity of the respiratory center by means of finer reflex influences. Both these systems are more reactive in the mammals than the corresponding ones in the amphibia and birds. The cerebral cortex exerts an inhibitory, "correcting" influence on the activity of both systems.

SUMMARY

It was established that there are two baroreceptive afferent systems of the upper respiratory tract in mammals (rabbits and dogs) – trigeminal and olfactory. These systems are more reactive to variations of pressure in the nasal cavity than those in amphibia and birds. The significance of these systems in regulation of respiration is demonstrated by their adaptive effect on the activity of the respiratory center; it is directly dependent on the conditions of the animal habitat.

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*Original Russian pagination. See C.B. translation.

**In Russian.