REFLEX STIMULATION AND DEPRESSION OF RESPIRATION IN CATS

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There are two hypotheses concerning the explanation of the variety of reflex changes in respiration. Some investigators explain it by the existence of definite afferent nerve fibers which either increase or depress respiration [1, 6, 9, 10]. Others explain all the various reflex changes in respiration by the excitation of different numbers of afferent fibers all of the same type, i. e., by differences in the number of impulses reaching the respiratory center [2, 3, 5, 8, 11]. The problem is not clear and requires further study.

A. I. Smirnov has demonstrated [6] that stimuli of equal strength applied to different fibers isolated from the vagus in dog could produce, at unchanged blood pressure level, either only acceleration or enhancement of respiration, or only its depression. A. I. Smirnov concluded that in the vagosympathetic trunk in dog there are different varieties of afferent fibers; those that accelerate and enhance respiration and those that depress it.

The present work is concerned with further studies of the specificity of reflex stimulation and depression of respiration.

EXPERIMENTAL

Experiments were performed on 30 cats under urethane anesthesia (1 g per 1 kg body weight intraperitoneally). The vagus and sympathetic nerves were exposed in the neck, and cut, usually on the left side only but sometimes bilaterally. Their central ends were dissected down, under a binocular magnifying glass, to separate nerve bundles, which were stimulated with induction currents of different strengths. Arterial pressure was recorded by means of a Ludwig mercury manometer connected to the right carotid artery. Respiration was recorded by means of a hollow needle inserted into the trachea and connected with a Marey tambour.

It was sometimes possible to find a special nerve twig in the vagus or sympathetic nerve, whose adherence to one or the other nerve showed considerable variation. When this twig was stimulated, immediately after preparation or after 1-2 hours, well-marked reaction of respiratory stimulation was observed. Having once appeared, this reaction could be repeated during several hours (until the end of the experiment), despite the use of quite strong stimuli (inter-coil distance up to 7 cm, voltage 4-5 v). In many cases no change in blood pressure occurred during changes in respiration (Fig. 1).

These experiments showed that the reaction of respiratory stimulation is not determined by changes in blood pressure; the direction of such reactions need not depend on changes in the number of impulses travelling to the respiratory center on stimulation of the nerve twig being investigated; and, finally, reactions of respiratory stimulation reveal great stability on repetition over several hours. In the same experiments, stimulation of the

remaining parts of the vagus or the sympathetic nerve caused depression of respiration (vagus) or exerted no appreciable effect (sympathetic nerve). Therefore, the reactions of respiratory stimulation mentioned cannot be explained only by a certain functional tendency established in the organism, since afferent discharges from other conductors stimulated with a variety of stimulus strengths produced the opposite reflex change in respiration (inhibition instead of stimulation).

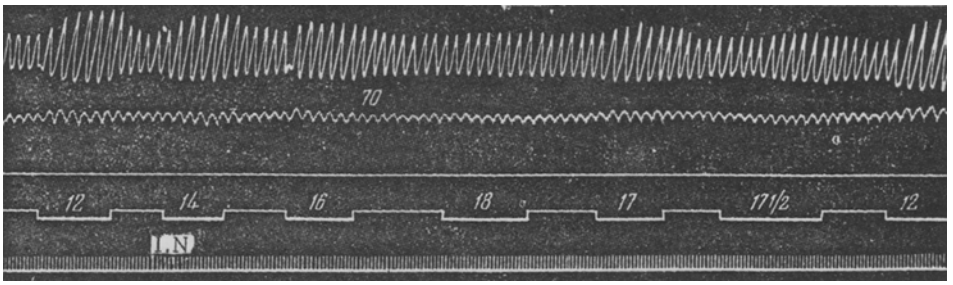

Fig. 1. Dependence of the degree of respiratory enhancement on the strength of stimulation applied to the nerve twig under investigation (I. N.) which formed part of the left vagus.
Records from top to bottom: respiration; blood pressure in mm of mercury; stimulation of nerves being investigated; time marker (1 sec). Strength of stimulus (distance between coils) in cm.

However, the reactions of respiratory stimulation on stimulating the nerve twig mentioned can be also explained from the point of view of those workers who associate the variety of reflex changes in respiration with excitation of different numbers of afferent fibers of the same type, i.e., it can be taken that during the stimulation of the fine nerve twig only a small number of fibres was always excited. The small number of effective fibers could limit the character of the reflex respiratory reaction.

Further studies, therefore, had to include the elucidation of the role of quantitative factors in the formation of respiratory stimulation reactions observed during stimulation of the nerve twig in question, as well as investigation of the effect of changed states of the respiratory and vasomotor centers on these reactions.

In these experiments the stimulating action of the nerve twig on respiration was analysed against the background of vagal stimulation (induction current).

Stimulation of the central end of the vagus modified the state of the respiratory and vasomotor centers, producing depression of respiration and lowering of blood pressure. Under these conditions, stimulation of the nerve twig continued to evoke enhanced respiration. The degree of respiratory stimulation was at every moment in direct ratio to the strength of stimulus applied to the nerve twig and in inverse ratio to the degree of respiratory inhibition associated with vagal stimulation (Fig. 2).

Investigations showed that the stimulating effect exerted by the twig on respiration was not determined by the presence in it of only a small number of effective fibers. When the twig fibers were added to fibers of the vagus which had previously evoked depression of respiration, respiratory stimulation and not increased inhibition was observed; in other words, the respiratory stimulation reaction continued in spite of increased numbers of effective afferent fibers. Inhibition of respiration was increased in those cases where the number of effective afferent fibers was increased either by stronger stimulation of one vagus or by stimulation of one vagus against the background of stimulation of the other. In the latter case the degree of further respiratory inhibition on additional stimulation of the vagus was at every moment in direct ratio to the strength of vagal stimulation and to the degree of respiratory inhibition caused by the background stimulation of the other vagus (Fig. 3).

On the other hand, simultaneous stimulations of "stimulating" nerve twigs isolated in the neck from the left and right neurovascular bundles caused further marked increase in respiration.

Under the same experimental conditions, stimulation of the sympathetic nerve against the background of vegal stimulation did not alter the character of respiratory inhibition caused by the latter.

The experiments carried out demonstrated that the specificity of respiratory stimulation reactions caused by excitation of the nerve twig in question was preserved during altered states of the respiratory and vasomotor centers and could not be explained merely by the limited number of afferent impulses reaching the respiratory center. The different reflex changes of respiration (stimulation or depression) are associated with the stimulation of different afferent pathways and cannot be determined only by the number of afferent impulses reaching the respiratory center.

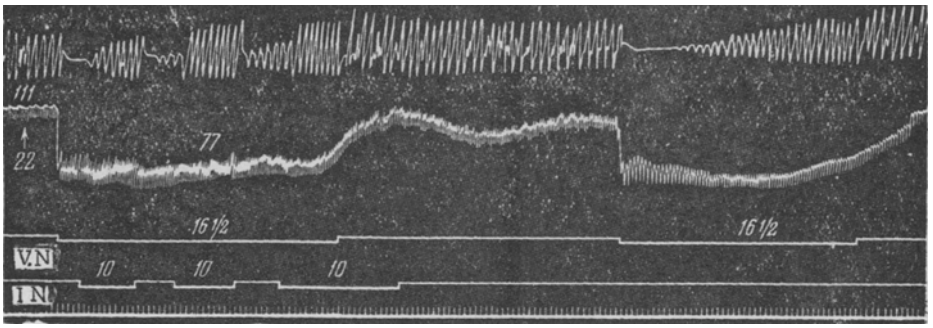

Fig. 2. Stimulation of respiration by excitation of a nerve twig (I.N.) extraneous to the vagus and sympathetic nerves against background of vagal stimulation (V. N.). Records as in Fig. 1.

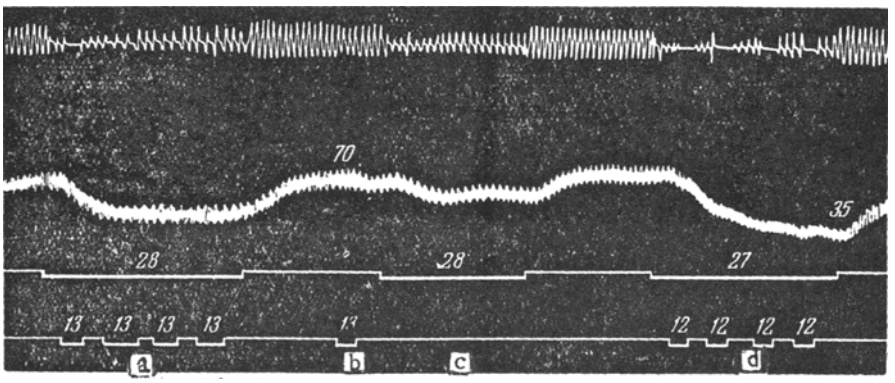

Fig. 3. Further depression of respiration on stimulation of the right vagus against background stimulation of the left vagus.
a, d) Stimulation of right vagus against background stimulation of left vagus;
b) Stimulation of right vagus only;
c) Stimulation of left vagus only.
Records from above downwards: respiration; blood pressure (in mm of mercury); marker for stimulation of left vagus; marker for stimulation of right vagus. Stimulus strength (inter-coil distance) in cm.

Morphological examination performed at the end of the experiments showed that the nerve twig under investigation, whether it was associated with the vagus or the sympathetic nerve, became a separate nerve in the vicinity of g. nodosum. This nerve partially entered the superior laryngeal nerve. Such an anatomical picture is characteristic for the aortic nerve [7]. Often the twig was separate from the vagus and the sympathetic nerves, which is characteristic of the aortic nerve in rabbits. In 5 out of 30 cats the spontaneous discharge from the twig was recorded oscillographically; the record showed the picture typical of the aortic nerve.

Thus the nerve twig which can be referred to as the aortic nerve, contains fibers associated with respiratory stimulation in addition to definite (depressor) vasomotor fibers.

This throws doubt on A. N. Krestovnikov's findings [4] on the stimulating action of the cervical sympathetic nerve on respiration. The author stimulated the left sympathetic trunk in cat, not taking into account the fact that the aortic nerve often lies within this trunk in cat [7], and apparently erroneously ascribed the respiratory stimulation observed in his experiments solely to sympathetic influences. The respiratory stimulation in Krestovnikov's experiments was most probably associated mainly with simultaneous excitation of the aortic nerve.

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