IMPORTANCE OF THE MECHANOCEPTORS AND CHEMOCEPTORS OF THE CAROTID SINUS IN THE REGULATION OF RESPIRATION AND THE CIRCULATION

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The interconnection between the respiratory and circulatory systems, in consequence of whose harmonious activity the oxygen supply to the tissues is maintained, is usually emphasized in the literature. It is considered, in particular, that stimulation of the chemoceptors of the arterial system—in the carotid-sinus and cardio-aortic zones—by a lowered partial pressure of oxygen causes a combined increase in the level of excitation of the respiratory and vasomotor centers, while stimulation of the mechanoceptors of this system by changes of pressure in the carotid sinus leads not only to reflex changes in the arterial pressure (AP), but also to changes in respiration (Moissejeff's reflex) [8].

The author has suggested that the importance of the chemoceptors and mechanoceptors in the regulation of respiration and of the arterial pressure, as one of the parameters of the circulation, is unequal, and that one type of receptor may play a more important role in the regulation of one of these closely related yet separate systems, while the other type of receptor is more concerned with the function of the second system.

A lowered oxygen tension stimulates respiration purely by stimulating the chemoceptors situated in dogs in the carotid sinus and aortic zones, and in rabbits, according to the author's previous findings [1], in the carotid body only. In special experiments carried out in V. N. Chernigovskii's laboratory, the author also showed that hypoxia is not a stimulus acting on the tissue receptors of the intestine and kidney, for which qualitatively different stimuli [2] are adequate.

EXPERIMENTAL METHOD

To determine the importance of the various receptors in the regulation of respiration and the arterial pressure, adequate stimuli were used: for the chemoceptors of the carotid body—a lowered oxygen tension, and for the mechanoceptors of the carotid sinus—a change in the blood pressure in the carotid sinus.

Experiments were carried out on the same animals, which inhaled a gas mixture consisting of 7% oxygen and 93% nitrogen for 3 min, and in which the blood pressure in the carotid sinus also was lowered for 3 min. The AP and pneumogram were recorded; in addition, by means of gas meters the magnitude of the pulmonary ventilation was measured each minute—the minute volume of respiration (MVR). This is an index of decisive importance, for it is the only one to reflect the changes in respiration quantitatively. The experiments were carried out on rabbits and cats; in the latter, the two depressor nerves were first divided so that the chemoceptors of the carotid sinus zones could be stimulated in isolation.

In all the experiments intravenous urethane anesthesia was used (1.0-1.2 g/kg for the cats and 1.2-1.5 g/kg for the rabbits).

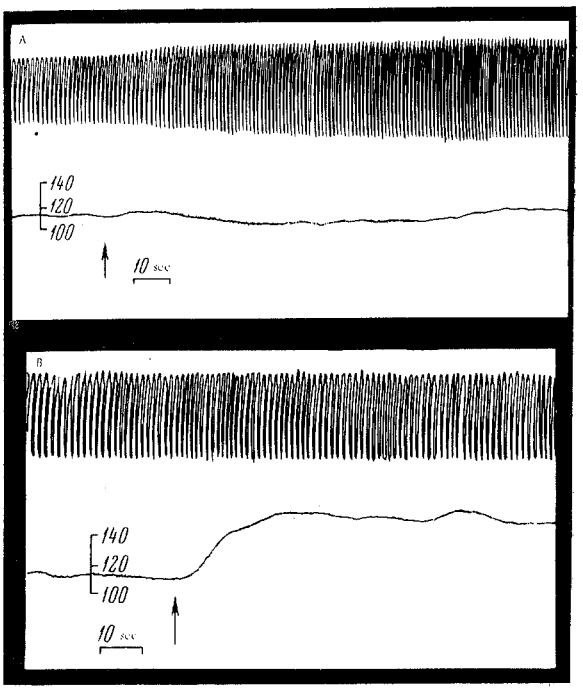

Fig. 1. Changes in respiration and arterial pressure in rabbits. A) During inhalation of a gas mixture with 7% oxygen; B) with a fall in pressure in the carotid sinuses. From top to bottom: pneumograms; arterial pressure; the arrow denotes the beginning of action of the factor concerned.

EXPERIMENTAL RESULTS

In the experiments on rabbits inhalation of a gas mixture containing 7-8% oxygen, as might be expected, caused a marked increase in the MVR, but the changes in AP were only slight. In the same animals a considerable rise of AP took place in response to a fall in pressure in the carotid sinus, but no changes or only very slight changes were observed in respiration in these circumstances (Fig. 1).

In the experiments on cats, the results were similar but not identical. Inhalation of a gas mixture with 7% oxygen —stimulation of the chemoceptors—caused a marked increase in respiration and slight but divergent changes in the AP. As a rule, a fall in the pressure in the carotid sinus was accompanied by a sharp increase in the AP, while in many experiments the MVR was unchanged and in some cats it increased by up to 30% of its initial value.

The results of each experiment on the rabbits are given in Fig. 2A, from which it is clear that stimulation of the chemoceptors always caused an increase in the MVR but hardly changed the AP, which usually varied only within the limits of ± 10%. When action was directed toward the mechanoceptors, the considerable increase in AP was not accompanied by any change in MVR.

The results of the experiments on the cats are given in Fig. 2B. They differ in that in some experiments, when the pressure in the carotid sinus fell, the MVR increased, although the increase amounted to 30% only in individual experiments.

The mean values of the MVR and the AP are given in the table.

It is clear from the table that a considerable increase in the MVR was found only in response to stimulation of the chemoceptors, and the AP changed only in response to stimulation of the mechanoceptors. The results of a statistical analysis of the material showed that these changes were significant. The increase in the MVR in response to stimulation of the mechanoceptors in the cats was also statistically significant, but it was very small (mean value 8%), and none was present in the rabbits.

In these experiments either no change took place in the MVR or, in a few cases, the changes were very slight (Fig. 3).

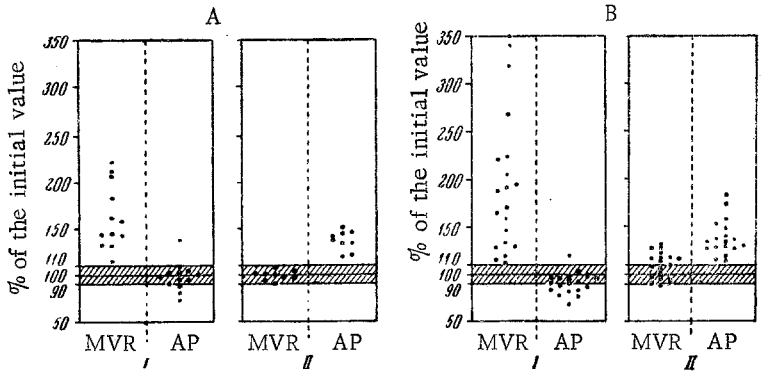

Fig. 2. Changes in the minute volume of respiration and the arterial pressure during inhalation of a mixture with 7% oxygen (I) and a fall of pressure in the carotid sinuses (II) in rabbits (A) and cats (B).

Minute Volume of Respiration and Arterial Pressure (in % of initial value)

Conditions	MVR		AP	
	rabbits	cats	rabbits	cats
Inhalation of gas mixtures with 7% oxygen	163	195	98	90
Fall in pressure in carotid sinuses	98	108	137	140

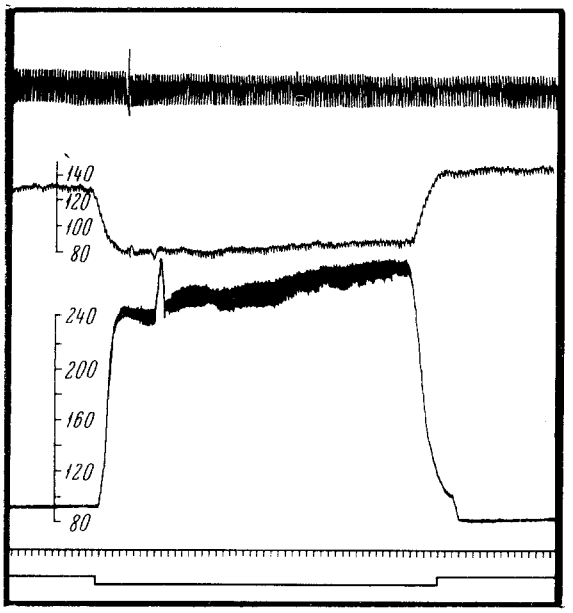

Fig. 3. Changes in respiration in response to an increase in pressure in the carotid sinuses of a cat. From top to bottom: pneumogram; arterial pressure in femoral artery; pressure in carotid sinus; time marker; marker of stimulation.

The results of these experiments showed that stimuli adequate for a particular type of receptor give rise to their main reflex reaction almost exclusively in one particular system: in response to stimulation of the carotid chemoceptors the reaction was mainly in the form of a change in the MVR, while in response to stimulation of the carotid mechanoceptors it was mainly a change in AP.

The chemoceptors of the carotid body may therefore be regarded as the principal receptor apparatus of the respiratory center and the mechanoceptors of the carotid sinus as the receptor apparatus of the vasomotor center. This does not mean that excitation of the chemoceptors and mechanoceptors does not in general lead to effects in the other associated system. Such effects do arise, as shown by reports in the literature and the results of the present experiments. It is a question of the comparative importance of the chemoceptors and mechanoceptors in the regulation of the respiration and circulation.

It follows clearly from this material that the effect of the mechanoceptors on respiration is small both in absolute value and by comparison with their effect on the level of the AP. Evidently Moissejeff's reflex is of very little importance in the regulation of respiration.

The question of the influence of stimulation of the chemoceptors on the circulation is rather more complicated. In response to stimulation of the isolated carotid bodies the AP is raised [5], as a result of constriction of the vessels in various organs [3, 4, 12, 9]. In these circumstances a reflex bradycardia develops [9, 10]. In hypoxemia caused by inhalation of gas mixtures deficient in oxygen, the increase in AP, which is often slight, may be replaced by a fall in AP or may be absent. In these circumstances the changes in the blood flow in different organs may take place in different directions [7]. The essential changes in vascular tone and in cardiac activity taking place in hypoxemia are associated with the hypocapnia developing in these circumstances [6, 7], with reflexes resulting from strengthening of the respiratory movements [10], and with the direct influence of oxygen lack on the central nervous system [11].

The effect of stimulation of the chemoceptors in hypoxemic conditions is thus weakened by associated and secondary influences, as a result of which the level of the AP, as demonstrated above, changes slightly in different directions.

Consequently, the mechanoceptors of the arterial system play a more important role in the regulation of the arterial pressure than of the minute volume of respiration, while the chemoceptors of this system do not possess the exclusive role in the regulation of the AP which they have in the regulation of respiration during hypoxemia.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of the first issue of this year.
