

THE MECHANISM OF AGE DIFFERENCES IN ADAPTATION OF REFLEXES ON THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS

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It was shown in a previous communication that the adaptation time of reflexes during prolonged stimulation of various receptive zones and sensory nerves increases with age. It is clear from the analysis of ideas concerning the mechanism of the processes of adaptation of reflexes that discussion is centered on two main problems: the localization of the changes associated with adaptation and the physiological processes responsible for the development of adaptation. In recent years detailed reviews of research in this field have been published [2, 3]. The object of the present study was to analyze the mechanism of the age differences in the adaptation of reflexes, paying particular attention to the relationship between the changes in the receptors and the nervous centers.

EXPERIMENTAL

Experiments were conducted on 38 young (1-1½ years) and 34 old (3½-4½ years) rabbits anesthetized with urethane (0.8 g/kg body weight). The changes in pressure in the common carotid artery and the pneumogram of the animals were recorded. The pressor reflex from the carotid sinus was evoked by compression of the common carotid arteries. The depressor reflex from this region was produced by raising the perfusion pressure from 100 to 180 mm Hg. The chemoreceptors of the isolated carotid sinus and of the intestinal vessels were stimulated by perfusion of these vessels with solutions of nicotine (10^{-4} - 10^{-5}), sodium sulfide (1% solution), acetylcholine (10^{-4} - 10^{-9}), and ATP ($1 \cdot 10^{-4}$). The nerve trunks (tibial, carotid sinus, aortic) were stimulated by a current applied from an electronic stimulator through a transformer. The transformer removed the constant component of the current supplied by the stimulator. The threshold of excitability during stimulation of the nerve to the carotid sinus was determined from the minimal voltage producing a depressor reflex.

DISCUSSION OF RESULTS

To examine the role of changes in the receptors during the formation of age changes in adaptation of the reflexes, a series of experiments was conducted on 8 old and 10 young rabbits. Electrodes were applied to the carotid nerve of the animals and the chemoreceptors and mechanoreceptors of the carotid sinus were subjected to prolonged stimulation. Before, and at various times during adaptation of the depressor reflex from the carotid sinus, the threshold of excitability was determined during stimulation of the carotid nerve.

In the young animals it was found that against the background of adaptation of the reflexes from the chemo- and mechanoreceptors of the carotid sinuses, the reflex excitability determined by the effect of stimulation of the central end of the divided carotid nerve was significantly lowered, while in the old animals the changes in the reflex excitability were not so sharply defined (see Fig. 1).

In order to continue the analysis of the role of the changes in the receptors during the development of age differences in adaptation, in the next series of experiments the effect of ATP and cysteine on the character of the reflex reactions during prolonged stimulation of the chemo- and mechanoreceptors was studied. Following adaptation

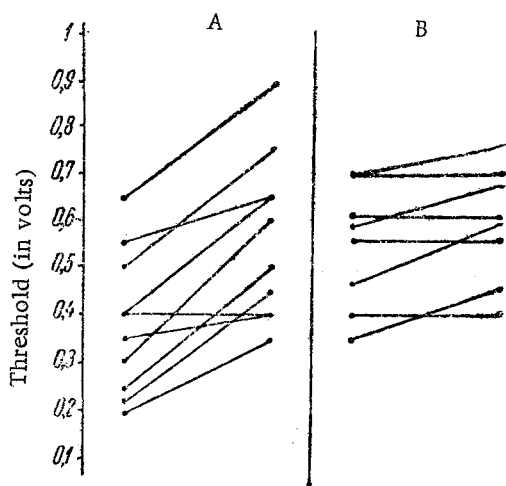


Fig. 1. Reflex excitability during stimulation of the nerve to the carotid sinus before and after adaptation of the depressor reflex in young (A) and old (B) rabbits.

the recovery period of these reflexes was doubled or trebled, and in some experiments it was increased to 40-50 min. In 18 experiments, against the background of slow recovery of the reflex, an additional strong stimulus was applied (to the respiratory tract or the rectum). In 12 cases the additional stimulus accelerated the restoration of the original magnitude of the reflex reaction.

During adaptation of the reflexes from the various receptive zones, complex changes took place in the components of the self-regulatory mechanism of the functions. In the old animals these changes developed much more rapidly. In the old animals, as also in the young, an important factor in the mechanism of weakening of the reflexes was the changes taking place in the nerve centers and the receptors. This conclusion is based on the fact that when influences are acting which by-pass the receptive zone, the time of adaptation during prolonged stimulation of the sensory nerves was shorter in the old rabbits. Meanwhile, during the adaptation of reflexes evoked by stimulation of the receptive zones, more serious metabolic and functional changes in the sensory nerve endings appeared in the old animals. The weakening of the reactions in the old animals during adaptation of the reflexes from the receptors of the carotid sinus sometimes appeared against the background of the unchanged excitability of the nerve centers. The presence of serious changes in the metabolism of the receptors was concluded from the fact that the action of ATP and cystein on the receptive zone led to a more marked effect in the old animals. The results confirm the existing views [1-3] concerning the importance of the metabolism of high-energy compounds in the mechanism of reception, and they demonstrate the role of these compounds in the development of the changes in the sensory nerve endings during the prolonged action of stimuli in old animals.

Hence, during adaptation of reflexes from the vascular receptors in old animals the changes arising in the nerve endings themselves are of essential significance.

A noteworthy feature was the sharp increase in the recovery period of the initial magnitude of the reflex in the old animals. It may be assumed that in some cases this was based on the development of a static inhibitory process. This suggestion is confirmed by the experiments in which an additional stimulus accelerated the restoration of the initial magnitude of the reflex.

LITERATURE CITED

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of the reflexes in old and young rabbits to stimulation of the chemoreceptors with nicotine, acetylcholine, and sodium sulfide, ATP or cystein was added to the perfusion fluid. It was found that ATP and cystein led to a more marked recovery of the reflexes in the old animals. Whereas usually after prolonged perfusion of the carotid sinus with nicotine solutions the original magnitude of the reaction was restored in the old rabbits within 15-40 min, the addition of ATP led to recovery of the reflex within 8-10 min. In the young animals the restorative action of ATP and cystein was less marked. The effect of ATP was observed to be similar in the case of adaptation of reflexes from the mechanoreceptors of the vessels. In all the experiments cystein potentiated the restorative action of ATP, lowering the time of recovery of the reflex to 5-8 min.

In most experiments, after adaptation of the reflexes had been attained, the period for their recovery to their original magnitude was carefully studied. In the old animals the recovery period of the reflex reactions after their depression was considerably prolonged. Whereas in the young rabbits the pressor reflex from the carotid sinus recovered after 1-2 min, and recovery after prolonged stimulation of the tibial nerve took place after 2-7 min, in the old animals in 70% of cases