PRESSOR AND DEPRESSOR STRUCTURES OF THE POSTEROLATERAL REGION OF THE HYPOTHALAMUS

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The role of the hypothalamus in the regulation of the blood pressure was demonstrated as long ago as 1909 [14]. It has subsequently been shown that stimulation of the hypothalamus causes an increase in the blood pressure in adrenalectomized and hypophysectomized animals, proving the neurogenic nature of these effects [15]. These investigations laid the foundations of extensive researches into the role of the hypothalamus in the regulation of the activity of the cardiovascular system [2, 3, 5-8, 10-13, 16-21]. Most of these studies showed that stimulation of the anterior portion of the hypothalamus evokes a depressor effect, while stimulation of the posterior hypothalamus is accompanied by a pressor reaction. The method used by these workers was to stimulate or inactivate various divisions of the hypothalamus.

Data obtained by the method of local stimulation of neurons through a microelectrode and recording of the changes in blood pressure ensuing are of considerable importance to the solution of this particular problem. The results of such investigations may give an idea of the presence and quantitative relationships between the neurons in these brain structures participating in the pressor and depressor reactions of the vascular system, and also of their functional characteristics, an essential prerequisite of the investigation of their physiological function.

In the present study this method was used to investigate the neurons of the posterolateral region of the hypothalamus, associated with the regulation of vascular tone.

EXPERIMENTAL METHOD

Experiments were conducted on 64 cats weighing from 2 to 3 kg and anesthetized with urethane. The unipolar method of stimulation was adopted, using an electric current from a thyratron peak pulse stimulator [4] or from a rectangular pulse stimulator manufactured by the firm of Diza, applied through a microelectrode. The indifferent electrode was a silver plate, 2 x 2 cm in area, placed on the animal's cervical muscles. The active electrode was a metal microelectrode, and the diameter of the point free from insulating varnish was 1-4μ. By means of a Horsley-Clark stereotaxic apparatus the electrode was inserted into the posterolateral portion of the hypothalamus according to the coordinates of the atlas of Fifkova and Marsala [9]. The changes in the blood pressure and respiration during stimulation of the neurons of the hypothalamus were recorded on a kymograph.

At the end of the experiment the position of the electrodes was verified by electrolytic destruction of the area of stimulation and subsequent examination of brain sections treated with formalin.

EXPERIMENTAL RESULTS

The results of these investigations showed that structures are present in the posterolateral region of the hypothalamus, stimulation of which causes changes in the blood pressure. Stimulation of most of the neural elements of this region of the hypothalamus which we investigated produced pressor reactions, and only in the case of a very few neurons was stimulation accompanied by depressor reactions. Furthermore some neurons were found, stimulation of which caused no change in blood pressure.

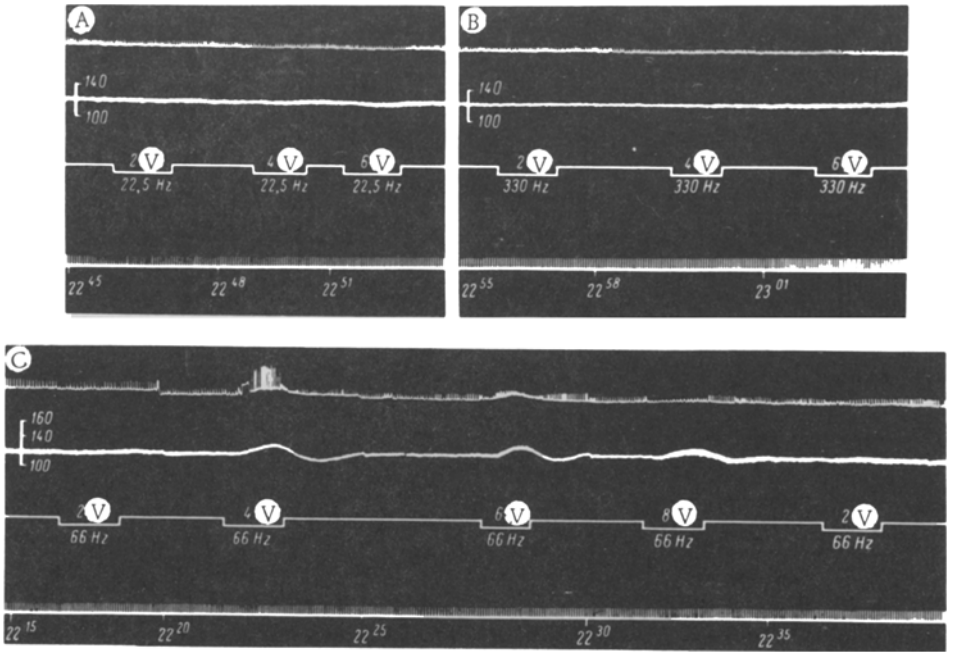

Fig. 1. Changes in blood pressure during stimulation of pressor neurons of the lateral region of the hypothalamus of a cat by pulses of current of different frequency and voltage. Coordinates of stimulated point in lateral region of hypothalamus (AHL): AP+7.5, S 3.2, V−4.0. Significance of curves (from top to bottom): respiration; blood pressure; marker of stimulation of pressor neurons of lateral region of hypothalamus; time marker (1 sec).

To investigate the functional properties of the pressor and depressor neurons, these structures were stimulated through a microelectrode with pulses of current of changing voltage (1-10 V), frequency (5-330 cps), and duration (0.1-2 millisec).

The intensity of stimulation for the threshold reaction of the blood pressure and the optimal conditions of stimulation of the pressor and depressor neurons were determined.

It is clear from Fig. 1, A that with a frequency of stimulation of the pressor point of the lateral hypothalamus of 22.5 cps, during a change in the voltage of the current from 2 to 6 V no reaction of the blood pressure was present. The same was observed with the same voltages of the current when the frequency of stimulation was 330 cps (Fig. 1, B). However, at a frequency of stimulation of 66 cps (Fig. 1, C), when the voltage of the current was 4 V, an obvious pressor reaction developed, and was well marked when the voltage of the current was 6 V and showed a decrease when the voltage was 8 V. Consequently, the threshold magnitude of the voltage of the current for stimulation of the pressor neurons of the hypothalamus in this experiment was greater than 2 V and the threshold of frequency of the pulses of current was over 22.5 cps. The optimal conditions of stimulation of the neurons evoking the pressor reaction corresponded to a voltage of 6V and a frequency of stimulation of 66 cps. With a further increase in voltage (to 8 V) and frequency of stimulation, the pressor reaction diminished, and when the frequency of stimulation was 330 cps it completely disappeared. As is clear from the accompanying kymograms, the changes in blood pressure during stimulation of the hypothalamus were usually accompanied by changes in the frequency and depth of the animal's respiration.

Our experimental results showed that the magnitude of the response reaction to stimulation of the pressor neurons of the hypothalamus was dependent, not only on the changes in the voltage and frequency of the stimulating pulses of current, but also on changes in their duration. The threshold of duration of the stimulating pulses of current for the pressor neurons in our experiments was slightly higher than 0.5 millisec, and the optimum of the reaction corresponded to 1-3 millisec. No abnormality in the character of the pressor reaction and no sign of its change into a depressor reaction was observed during a change in the parameters of the stimulating current between the above-mentioned limits.

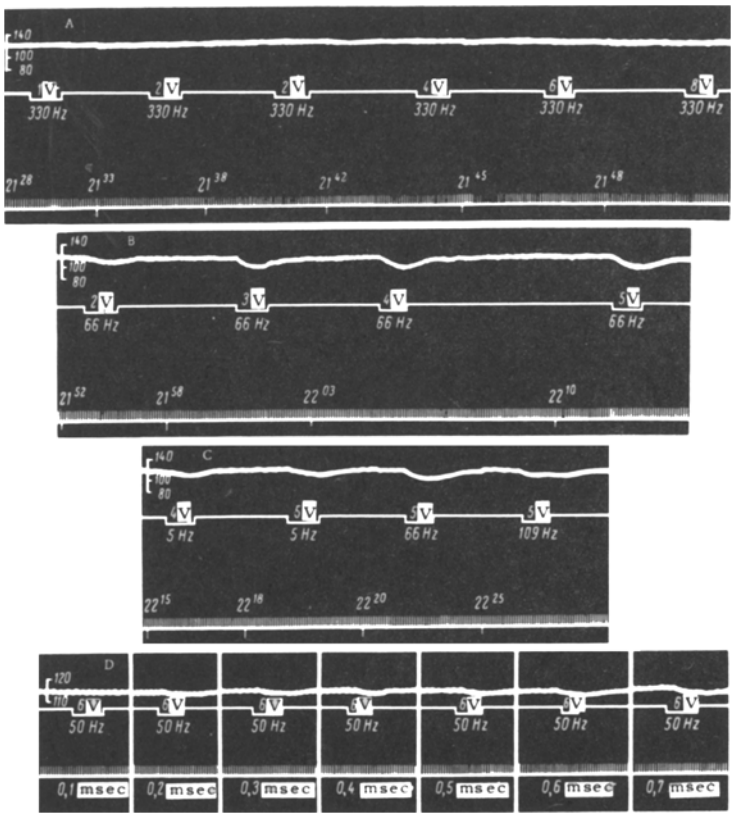

Fig. 2. Changes in blood pressure during stimulation of depressor neurons of lateral region of the hypothalamus of a cat with pulses of current of different frequency, voltage, and duration. Coordinates: AP+7.5, S 3.2, V−5.0. Significance of curves (from top to bottom): blood pressure; marker of stimulation of depressor neurons of lateral region of hypothalamus; time marker (1 sec).

During stimulation of the depressor neurons of the hypothalamus, the magnitude of the reaction was also observed to depend on the intensity of the stimulating current, although the character of the reaction remained unchanged.

It is clear from Fig. 2, A that when the depressor neurons of the lateral region of the hypothalamus were stimulated with pulses of current with a frequency of 330 cps, during a change in the voltage from 1 to 8 V no reaction took place. When the frequency of stimulation was 66 cps (Fig. 2, B), a depressor reaction began to appear at a voltage of 2 V, and it became well established at voltages of the current of 3 and 4 V. However, a reduction in the frequency of stimulation to 5 cps with the same current voltage (Fig. 2, C) sharply diminished the reaction, which became well defined again when the frequency of stimulation was increased to 66 cps. A further increase in the frequency of stimulation to 109 cps or more caused a decrease in the magnitude of the response.

The importance of the duration of the stimulating pulses of current to the development of the depressor reaction is indicated in Fig. 2, D. The kymograms show that during stimulation of the depressor neurons of the lateral hypothalamus with pulses of current of a duration of 0.1 millisec, voltage 6 V, and frequency 50 cps, no reaction took place. When the duration of the pulses of stimulating current was 0.2 millisec and the voltage and frequency of the pulses were the same, a depressor reaction developed and became well marked when the duration of the pulses was 0.7 millisec. It is clear from the accompanying kymograms that the threshold of stimulation for the depressor neurons of the hypothalamus was equal to a current with a voltage of 2 V, a frequency of 5 cps, and a duration of pulses of 0.2 millisec, and that the optimal conditions of stimulation were a voltage of 4 V and a frequency of 66 cps. With a smoother increase in the frequency of stimulation in other experiments it was demonstrated that an optimal depressor reaction may arise when the frequency of stimulation is 30 cps.

Comparison of the results of determination of the parameters of excitability of the pressor and depressor neurons of the hypothalamus shows that the depressor neurons have a lower threshold of excitability as regards the intensity, frequency, and duration of the pulses of stimulating current by comparison with the pressor neurons, and that the optimal reaction evoked by an increase in the frequency, strength,and duration of the pulses of stimulating current also develops sooner in the depressor neurons.

In an investigation by A. M. Blinova and co-workers [1], the optima of frequency and duration of the pulses of current for the depressor points of the reticular formation of the medulla also were lower than those for the pressor points. A further increase in the strength and frequency of stimulation caused a reduction in the magnitude of the reaction or, in some cases, its complete disappearance. No distortion of the reaction was observed in the course of the above-mentioned changes in the parameters of the pulses of stimulating current. The constancy of the character of the reactions evoked by stimulation of the pressor and depressor neurons of the hypothalamus during changes in the intensity, frequency, and duration of the stimulating pulses demonstrates the specialization of the function of these neurons.

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