ELECTROPHYSIOLOGICAL INVESTIGATION OF HIPPOCAMPAL-HYPOTHALAMIC CONNECTIONS IN RABBITS

R. T. Avakyan

Despite the fact that hypothalamo-hippocampal ascending connections (and the role of the hypothalamus in the activation of the function of the hippocampal formation) has occupied the center of attention of investigators during recent years [1-7], the question of descending hippocampal-hypothalamic projections has hardly been considered in the physiological literature. In recent years, a few works have appeared [8, 9] which indicate that when one stimulates hippocampal structures evoked potentials (EP) are widely present in hypothalamic formations of the cat.

The present work has been devoted to the study of the functional connections between various fields (CA1 and CA3) of the dorsal hippocampus and phylogenetically different regions of the rabbit hypothalamus.

The experiments were carried out on 25 rabbits weighing 2.5-3 kg, under acute experimental conditions. A chloralose-nembutal mixture was used for narcosis (35 mg/kg chloralose + 15 mg/kg nembutal, intravenously). Insertion of electrodes into subcortical structures of the brain was accomplished with the aid of Sawyer's [10] coordinate atlas. Steel electrodes were used for recording and stimulating: bipolar (inter-electrode distance 1.2-1.5 mm) for stimulation, and unipolar for recording. The indifferent electrode was implanted in the nasal bone. Stimulation of hippocampal strata was done with square-wave current pulses from an E-103 stimulator (from the firm of Sanei) at an intensity of 2-10 V and 0.5 msec duration (frequency 1-10 Hz). Bioelectrical potentials were put through a UBP2-03 amplifier and displayed on the screen of an SI-13 cathode oscillograph from which (with the aid of an FOR-2 photorecording apparatus) they were captured on film. At the end of the experiments, histological control was carried out in order to localize the stimulating the recording electrodes on the brain sections (60-90 μ thick, carmine stain).

It has been established that during stimulation of hippocampal structures, EP are most widely present in the nuclear formations of the posterior hypothalamus (supramammillary area, posterior hypothalamic area, mammilary bodies). During stimulation of field CA1 in the dorsal hippocampus, the highest amplitude EP in the supramammillary area (SMA) occurred during stimulation of medial layers of the hippocampus at a depth of 5.5 mm from the hemisphere surface - the apical dendrite layer according to Andersen's classification [11]. It should be noted that during stimulation of these hippocampal strata appeared in the form of negative-positive-negative waves which had a first-component latency of 8-10 msec (amplitude 70-80 μV, duration 100-100 μV, duration 18-20 msec; and for the third component 30-40 μV and 40-50 msec, respectively (See Fig. 1b). In approximately half of the experiments, spike-like waves were recorded on the rising part of the first component. They were 1.5-2 msec in duration and perhaps reflected activity in fibers of a hippocampal-hypothalamic path. When stimulating the deep layers of the hippocampus (level of the stratum lacunosum), a decrease in the amplitude of the EP recorded was noted. Stimulation of deeper layers of the hippocampus (6.5 mm from the hemisphere surface) led to the disappearance of the second positive and third negative large-amplitude waves.

In another series of experiments, during stimulation of field CA3 in the dorsal hippocampus EP also were found widely in the nuclear formations of the posterior hypothalamus. The maximal expressivity of EP in SMA occurred when stimulating the deep layers of field CA3 at a depth of 6.5 mm (level of the stratum moleculare). In distinction to the EP from stimulation of field CA1, during stimulation of field CA3 EP were recorded in the form of positive-negative waves (first component latency 2-3 msec). Amplitude of the pos-
Fig. 1. The nature of the evoked responses in the supramammillary area (SMA) of the hypothalamus when stimulating the dorsal hippocampus. Center: Diagram of the dorsal hippocampus according to Andersen [11]. a) EP in SMA during stimulation of field CA3 in the dorsal hippocampus at depths from the surface of the hemisphere of: 1) 5 mm, 2) 5.5 mm, 3) 6 mm, 4) 6.5 mm (str. moleculare); b) EP in SMA during stimulation of field CA1 in the dorsal hippocampus at depths from the hemisphere surface of: 1) 4.5 mm, 2) 5 mm, 3) 5.5 mm (apical dendrite stratum), 4) 6 mm (str. lacunosum); c) nature of the evoked responses during rhythmic stimulation of field CA3 in the dorsal hippocampus with a frequency of 3 Hz. In a, b: frequency 1/15 sec; superposition of 7 responses. Scales: a, b) 50 μV, 20 msec; c) 100 μV, 50 msec.

In comparison with the posterior hypothalamus, EP in the anterior hypothalamus during stimulation of the dorsal hippocampus had a lower threshold (2-3 V) and were characterized by a shorter latency (2-3 msec). In this regard it is necessary to emphasize that, in distinction to the posterior hypothalamus, EP in the anterior hypothalamus were evoked only by stimulation of field CA1 in the dorsal hippocampus. Maximal expressivity of EP during stimulation of field CA1 occurred in the medial preoptic area, where EP were recorded in the form of positive-negative waves which had a first-component latency of 2-3 msec, amplitude 160-170 μV, duration 16-18 msec; and for the second component, 100-105 μV and 55-60 msec, respectively. According to the degree of movement of the recording electrode into the lateral preoptic area, a gradual diminution of EP amplitude was noted, right up to its disappearance.

Thus, the data obtained indicate that when hippocampal structures are stimulated, EP are widely present in various hypothalamic formations. These results correlate well with neuromorphological data [12-15] which show that lesioning of the dorsal hippocampus of various mammals is accompanied by most expressed degenerative changes in the posterior hypothalamus.

A comparison of our data regarding the descending hippocampal-hypothalamic connections with the topical projections of the ascending hypothalamic-hippocampal connections in rabbits [3, 5, 6] indicates that the organization of the ascending and descending connections is different. Whereas the hypothalamic formations have broader ascending connections with different fields of the dorsal hippocampus, the descending connections are characterized by a more differentiated, topical projection.

LITERATURE CITED