MODULATING EFFECT OF ELECTROACUPUNCTURE STIMULATION ON UNIT ACTIVITY OF SPECIFIC AND NONSPECIFIC THALAMIC NUCLEI

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An important role in the pathogenesis of acute and chronic pain syndromes is played by changes in neuronal function in various brain structures [1, 2, 6, 8-10]. Methods of reflex therapy are nowadays being used on an ever-increasing scale for the treatment of acute and chronic pain, for they enable the functional state of neurons in the CNS to be selectively modified [2, 3, 7]. During the study of neuronal electrical responses in the specific and nonspecific thalamic nuclei to nociceptive and non-nociceptive stimulation, the difference in responses of spontaneously active neurons has drawn attention. Spontaneous activity is an arrhythmic, random sequence of spikes. However, three different types can be distinguished in their general structure: single, bursting, and grouped [4, 5]. The view is held that whereas continuous arrhythmic activity reflects the complexity of interneuronal connections in a system of specific afferentation, bursting and grouped activity is an indication that synchronized volleys are present, by means of which the nonspecific system maintains excitability of cortical structures [4]. During the investigation of responses of thalamic neurons in both the ventral posteromedial (VPM) and in the central medial thalamic nucleus of the parafascicular complex (CMPC), attention has been drawn to a characteristic feature: Virtually all neurons with spontaneous activity in the range from 3-5 to 60 Hz or more change their spontaneous firing rate in response to electroacupuncture stimulation. This fact suggests that the functional state of the nerve cells is modified by electroacupuncture (EAP). This paper describes an attempt to discover the neurophysiological mechanisms of the action of EAP on spontaneous unit activity in these thalamic nuclei.

EXPERIMENTAL METHODS

Acute experiments were carried out on cats immobilized with suxamethonium, artificially ventilated, and receiving a preliminary intraperitoneal injection of thiopental sodium in a dose of 25 mg/kg body weight. Unit activity was derived by glass microelectrodes (diameter of tip 1-3 μ), filled with 2 M KCl solution, extracellularly 3-4 h after injection of the thiopental sodium, so that the experiments could be done on virtually unanesthetized animals. Electroacupuncture stimulation was applied through steel needles introduced subcutaneously into the concha auriculae or into a forelimb, and the current was applied to them for 3 min (10 mA, 0.1 msec, 1-5 Hz). Unit activity was recorded on the VS-9 electrophysiological apparatus (from Nihon Kohden, Japan). The tip of the recording microelectrode was shown histologically to be present in the tissue structure. The animal's functional state was monitored by recording the EEG, ECG, and blood pressure (BP).

RESULTS

Altogether 96 spontaneously active neurons were studied: 51 of them in VPM and 45 in VPMPC. Depending on the character of their responses to EAP, these neurons were divided into two functional groups: Analysis of the traces showed that the infrequent spontaneous spikes of the VPM neuron became organized at the first minute of EAP, and were replaced by burst-like discharges (Fig. 1). The over-all spike frequency increased considerably and reached a maximum toward the end of the 3rd minute of EAP. The discharge frequency of the neuron was virtually back to its original level 5 min after the end of EAP. In this case, therefore, an effect of neuronal activation in the specific thalamic nucleus by afferentation entering the CNS during EAP of the concha auriculae was thus observed.

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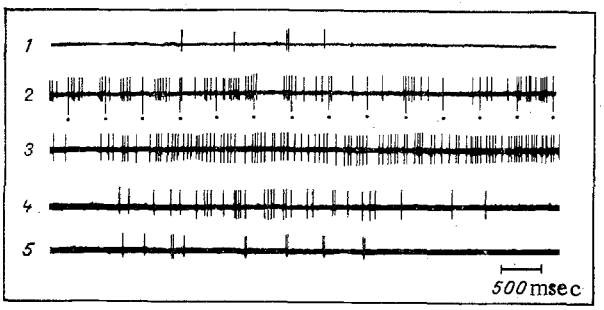

Fig. 1. Changes in unit activity in specific thalamic nucleus in response to EAP. Unit activity: 1) spontaneous, 2) after 1st minute of EAP stimulation of concha auriculae, 3) after 3 min of EAP, 4) 3 min after end of EAP, 5) 5 min after end of EAP.

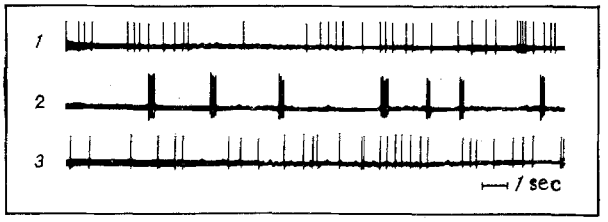

Fig. 2. Changes in unit activity in nonspecific thalamic nucleus in response to EAP. Unit activity: 1) spontaneous, 2) after EAP stimulation of concha auriculae for 3 min, 3) 5 min after end of EAP.

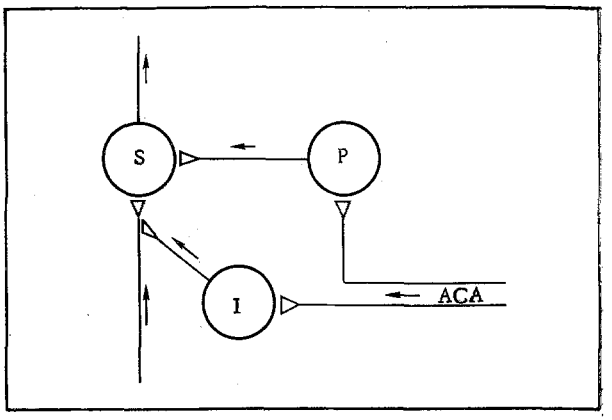

Fig. 3. Scheme of hypothetical organization of neuronal functional pool: S) spontaneously active neuron, P) pacemaker neuron, I) inhibitory interneuron, ACA) afferents from concha auriculae.

Traces of the spike discharge of a CMPC neuron are given in Fig. 2. Arrhythmic spontaneous unit activity was followed after 3 min of stimulation of the concha auriculae by distinct volleys consisting of four or five spikes. Under these circumstances, however, an inhibitory effect on unit activity was clearly visible. The initial level of spontaneous activity of the neuron was observed again 5 min after the end of EAP.

It will be noted that both EAP-activated and inhibited spontaneously active neurons were found in both thalamic nuclei studied, but the number of cells in VPM activated by EAP was much greater (by 50%) than in CPMC, whereas inhibitory responses were observed in a larger number of CMPC neurons (by 42%).

A scheme of the hypothetical organization of a neuronal functional pool, in which the phenomena observed in the experiments described above can be realized, is given in Fig. 3. The test neuron (S) possesses initial spontaneous activity. Besides afferents determining its functional role, it also evidently has inputs from trigeminal afferents of the concha auriculae, but directly, but through an interneuron (I) and a pacemaker neuron (P). Afferentation from the concha auriculae during EAP activates the inhibitory interneuron (I) which, in turn, blocks the afferent inputs of the spontaneous neuron (S), determining its spontaneous activity.

Meanwhile afferentation from the concha auriculae activates the pacemaker (P) which, becoming excited, begins to activate cell S, as a result of which rhythmic burst-like discharges are observed in the latter. It can be tentatively suggested that rhythmic volleys arising in the thalamic cell under the influence of EAP are the synchronizing volleys which, by activating the cerebral cortex, prepare the way for more adequate responses of the CNS and of the body as a whole to an acting peripheral factor. Whatever the case, the fact that the functional state of spontaneously active neurons of the specific and nonspecific thalamic nuclei changes under the influence of EAP is itself very interesting not only from the neurophysiological aspect, but also as evidence of possible modulation of the efferent flow, caused by the course of the pathological process, which is particularly important for the study and treatment of pain syndromes in clinical practice.

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