EFFECT OF ELECTROACUPUNCTURE OF NEURONAL RESPONSES OF THE CAT ORAL TRIGEMINAL NUCLEUS DURING NOCICEPTIVE AND NON-NOCICEPTIVE STIMULATION

V. G. Dolgikh and V. K. Reshetnyak

UDC 615.844.4.015.4:612.822].076.9

KEY WORDS: electroacupuncture; oral trigeminal nucleus; cat brain; nociceptive stimulation.

Interest in the oral trigeminal nucleus (OTN) in connection with the study of pain has increased considerably after the discovery of a well-marked focus of evoked activity in it during nociceptive stimulation of the orofacial receptive fields. The so-called dual representation of pain in the trigeminal complex [2] called for a close study of all features of the organization of the various nuclei of this concept (the oral, in particular), which could be responsible for their specific role in the conduction of nociceptive and non-nociceptive signals in the CNS. Despite several investigations of the organization of the afferent input and neuronal responses of OTN, only a few investigators [4] have attempted to study this problem from the standpoint of discovery of different functional types of neurons, involved in the conduction of nociceptive and non-nociceptive signals, as has been done in relation to the caudal trigeminal nucleus [8]. From this point of view it is interesting to study the character of the effect of electroacupuncture (EAP), an effective modulator of nociceptive signals.

The aim of this investigation was to study the effect of EAP on responses of neurons of different functional types in OTN to noceptive and non-nociceptive stimulation.

EXPERIMENTAL METHOD

Acute experiments were carried out on eight adult cats weighing 2.5-4 kg. The dissection was carried out under hexobarbital anesthesia (15 mg/kg, intraperitoneally), and the animals were subsequently immobilized with suxamethonium and artificially ventilated. Unit activity was recorded extracellularly by glass microelecrodes with a tip 1-3 μ in diameter, filled with 2 M KCl solution, and with a resistance of 4-10 MΩ, with the aid of a YC-10 electrophysiological complex ("Nihon Kohden," Japan). Pulsation of the brain was prevented by flooding its surface with agar-agar.

Stimulation of the dental pulp and of the lip with square pulses, 1 and 0.1 msec respectively in duration and with a strength of 0-50 mA, by means of an ÉSU-2 stimulator was used as testing stimulation. The nociceptive character of afferent stimulation of a particular intensity was determined by preliminary study of the thresholds of onset of non-nociceptive and nociceptive behavioral responses of the animals to both types of stimulation.

Depending on the character of their response to electrical stimulation of the dental pulp and lip, the neurons were divided into three groups. Neurons of group 1 responded to weak stimulation and their response was unchanged when the strength of stimulation was increased. They were regarded as non-nociceptive low-threshold neurons (LT neurons). Neurons of the second group also began to respond to weak stimulation of lip or dental pulp, but the neuron discharged more strongly when its intensity was increased. Such neurons were classed as neurons with wide dynamic range (WDR neurons). Finally, neurons of the third group responded only to intensive stimulation of the dental pulp and lip, and they were accordingly characterized as specific nociceptors (SN neurons). EAP was applied through steel needles, inserted into the lower part of the base of the concha auriculae. The duration of the pulses was 1.2 msec, their frequency 1 Hz, their intensity about 10 mA, and stimulation lasted for 5-10 min.

Research Institute of Reflex Therapy, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR G. N. Kryzhanovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 108, No. 12, pp. 646-648, December, 1989. Original article submitted December 10, 1988.

 0007-4888/89/0012-1682$12.50

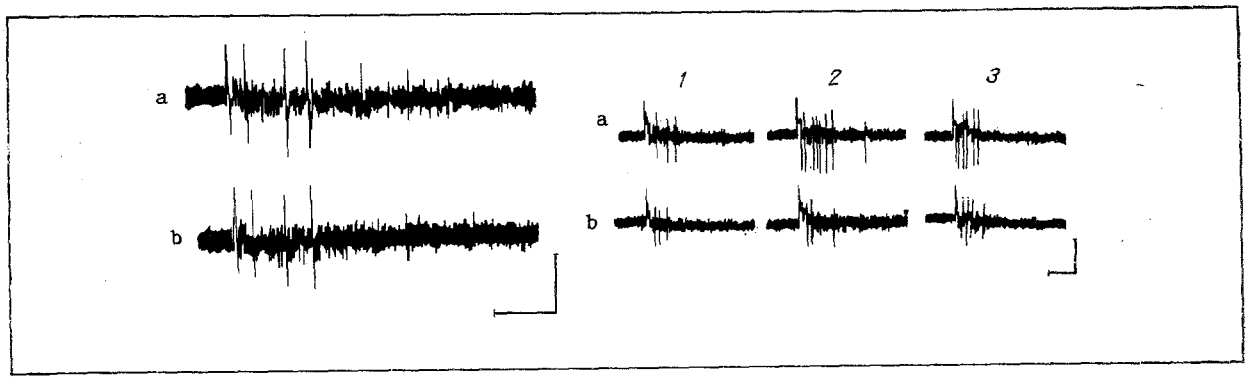

Fig. 1 Fig. 2

Fig. 1. Effect of EAP on evoked responses of LT neurons of OTN. a) Non-nociceptive stimulation of lip before EAP, b) the same, after EAP. Calibration 500 μV and 20 msec.

Fig. 2. Effect of EAP on evoked responses of WDR neurons of OTN with convergence of low- and high-threshold afferent input from dental pulp and high-threshold input from lip. 1) Non-nociceptive stimulation from dental pulp, 2) nociceptive stimulation of dental pulp, 3) nociceptive stimulation of lip; a) before EAP, b) after EAP. Calibration: 500 μV and 20 msec.

EXPERIMENTAL RESULTS

We recorded 71 neurons in OTN, of which 68% were spontaneously active; 70% of the neurons (50 neurons) responded to stimulation of the dental pulp or lip. Half (52%) of OTN neurons which responded to stimulation of the dental pulp or lip were WDR neurons. Incidentally, of 26 neurons of this type seven could be activated by weak stimulation of the dental pulp. Convergence of afferent inputs from the dental pulp and lip was observed in 69% of WDR neurons.

It was found that 32% of OTN neurons with afferent input from the dental pulp and lip were of the SN type. However, only one of these neurons was activated exclusively from the dental pulp and, consequently, was a true specific pulp nociceptor. Of the SN neurons 31% were found to have convergence of high-threshold afferent inputs from the dental pulp and lip.

Eight of the OTN neurons (16% of the total number of cells analyzed) were of the LT type. All were activated only by weak stimulation of the lip and they had no afferent input from the dental pulp.

The effect of EAP on evoked activity was tested on 34 neurons. Responses of most LT and WDR neurons to non-nociceptive stimulation of the dental pulp or lip were either unchanged or changed only a little (Figs. 1 and 2). Meanwhile, in 65% of WDR neurons, a marked and significant depression of the responses to nociceptive stimulation of both structures was observed (Fig. 2). Inhibition of responses of SN neurons was found rather less frequently (in 50% of neurons).

Attention is drawn in particular to the presence of a low-threshold non-nociceptive input from the dental pulp to some of the WDR neurons of OTN. This is further evidence that OTN may be involved in reflex responses from the dental pulp and the appearance of non-nociceptive sensations during its stimulation [5]. The morphologic substrate of this low-threshold afferent input from the dental pulp may be the thick myelinated fibers whose presence in the dental pulp has been demonstrated by both electrophysiological [6] and morphological [3] methods of investigation.

The presence of a well-marked SN-input from the dental pulp to OTN neurons must also be noted. In the coelom it composed 25.4%; among neurons responding to afferent stimulation, this was 36%; its contribution to the total afferent input from the dental pulp was 72%. True nociceptors of the dental pulp are very rare (we found a second such neuron in the marginal layer of the caudal trigeminal nucleus). These considerations explain the data relating to preservation of nocicep-

tive behavioral reactions in animals [7, 9] and painful sensations in man [10] when the dental pulp is stimulated after trigeminal tractotomy.

EAP had an inhibitory effect on nociceptive responses of OTN neurons, which was more marked in the case of WDR neurons. No significant changes were observed in responses of a large proportion of neurons to non-nociceptive stimulation. A simular effect of EAP also was observed at the level of the thalamus and cerebral cortex [1]. EAP thus leads to disinhibition primarily of the nonspecific nociceptive component of the signal at different levels of the CNS, from the primary relay to the cerebral cortex.

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