SKIN MECHANORECEPTOR FUNCTION IN ALBINO RATS DURING TRANSCRANIAL ELECTRICAL STIMULATION

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Immunocytochemical and neurophysiological methods [6, 12, 13] have shown that opioid peptides are contained in both central and peripheral parts of the nervous system, and also in other organs and tissues. It has been shown [3, 7, 10, 11, 14] that these substances possess high biological activity and are involved in the regulation of the central mechanisms of nociceptive sensitivity. At the same time, it has been demonstrated [1] that during transcranial electrical stimulation a significant increase is observed in the concentrations of endogenous opioid peptides both in brain tissues and in the cerebrospinal fluid and blood. In this connection a possible role of endogenous opioid peptides in the regulation of function of the sensory apparatus of the skin has been suggested. As we know, the latter is the initial component of the cutaneous sensory system involved in the perception of both tactile and nociceptive stimuli.

The aim of this investigation was to study the effect of transcranial electrical stimulation on cutaneous mechanoreceptor function.

EXPERIMENTAL METHOD

Experiments were carried out on male Wistar albino rats weighing 180-200 g, anesthetized with hexobarbital (0.25 g/kg). Spike activity (SA) was recorded from single fibers of the sciatic nerve, innervating the sole of the foot. IA was derived by means of a platform consisting of two adjacent cells. A silver electrode was placed in each cell. The cells were filled with Hanks' solution. Fibers dissected from the nerve trunk were placed across the septum into the neighboring cell. The skin was stimulated by means of an electrodynamic mechanical stimulator. The diameter of the rod of the mechanical stimulator was 100 μm (needle) and 1500 μm. The amplitude of the mechanical stimulus was 100-1500 μm and its duration 50 msec. Transcranial electrical stimulation was applied through steel needle electrodes. The conditions of electrical stimulation were: a combination of alternating and direct currents, frequency of stimulating pulses 70 Hz, amplitude 1.2 mA, and amplitude of direct current 0.6 mA. Fuller details of the technique of transcranial stimulation are given in [3]. Altogether 31 receptor units were studied.

EXPERIMENTAL RESULTS

In response to application of a mechanical stimulus to the surface of the skin of the lower limb, IA was recorded from the receptor units (RU; Fig. 1). The RU tested were divided by the threshold intensity of the mechanical stimulus into three main functional groups: those with low, average, and high threshold. A particular feature of RU with low and average threshold levels was that afferent impulsation appeared in them in response to mechanical stimulation (amplitude 100-300 μm), corresponding in intensity to tactile stimulation [8]. SA was observed in high-threshold RU only during the action of a mechanical stimulus (amplitude 600 μm) with maximal intensity on the skin, through the needle electrode, i.e., a stimulus with a marked algesic action.

During transcranial electrical stimulation (TES) total suppression of the response of RU to mechanical stimulation was observed, irrespective of their functional category (Fig. 1).

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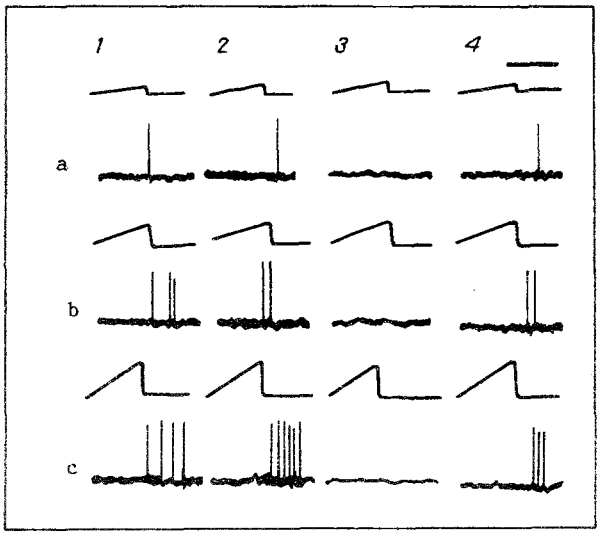

Fig. 1. Responses of mechanoreceptor units of skin under influence of transcranial electrical stimulation (TES): a) low, b) average, c) high threshold RU; 1) responses of intact RU; 2, 3, 4) responses recorded 30 sec and 19 and 10 min, respectively, after application of TES. Amplitude of mechanical stimulus (in μm): a) 150, b) 300, and c) 600 (in the last case, the stimulus was applied to the skin surface by means of a needle). Time marker 40 m sec.

The effect of total suppression of SA in the cutaneous afferents took place by the 19th minute from the beginning of electrical stimulation. The period of anesthesia and analgesia, developing as a result of the action of TES, was preceded by a period with a well-marked pain syndrome.

The most important parameter of TES, determining the development of absence of an inhibitory effect in RU, was found to be the following frequency of the stimulus. Even a very small deviation of the frequency of the stimulating pulses, toward either an increase or a decrease, led to recovery of the responses of RU and to the appearance of nociceptive responses.

A detailed study showed that the inhibitory effect develops primarily in RU with low threshold, during the first minutes of TES (Fig. 1, 1a). The initially inhibitory action of TES on low-threshold RU was expressed as an increase in the latent period of response. Later complete suppression of SA was observed. Responses of low-threshold RU disappeared completely at the end of the first minute of TES, despite a tenfold increase of stimulus amplitude. The inhibitory effect described above was observed throughout the period of TES. After the end of TES, complete recovery of the parameters of the responses of the given RU to their initial level was observed when 5 min had elapsed.

The trend of the changes in character of responses to mechanical stimulation under TES conditions in RU of average threshold was similar to that in RU of low threshold (Fig. 1: 1b). However, the time required for appearance of the effect of TES was significantly increased to 5-10 min. The duration of the aftereffect of TES also was increased, and the parameters of the responses and sensitivity of the given RU to mechanical stimulation were not restored until after 10 min. The character of response to mechanical stimulation of high-threshold RU during the action of TES varied. In 50% of RU, in the initial period of TES there was a decrease in the number of spikes in the response with a simultaneous increase in duration of the latent period and an increase in the threshold of the mechanical stimulus (Fig. 1: 1c). The other half of the high-threshold RU responded to application of TES by an increase in the number of spikes in the response to 6-12. Under these circumstances the latent period was reduced. With an increase in the duration of TES to 18 min, the latent period of response of these RU was increased. All high-threshold RU were characterized by a long duration of the recovery period: 10 min or more in individual cases. The experiments showed that against the background of preliminary injection of naloxone (0.08 mg intradermally) transcranial stimulation did not lead to any change in the parameters of responses of the RU tested.

The results are evidence that during TES total blockage of afferent impulsation is observed in response to mechanical stimulation of RU of not only low threshold, but also of average and high threshold. The mechanism of action of TES on the cutaneous afferents can be represented as follows: as a result of the action of TES central opiatergic mechanisms of the antinociceptive system are activated [2, 5], leading to release of large quantities of oligopeptides – endorphins and enkephalins [1]. The latter, on reaching the sensory endings

of the skin by the humoral route, evidently realize the effect of suppression of function of the cutaneous afferents, expressed as anesthesia and analgesia. The results of our investigations showing absence of action of TES after preliminary administration of naloxone, a specific blocker of opioid receptors, confirm the above hypothesis. It is evident that the cause of the quite considerable time interval between the beginning of action of TES and the onset of anesthesia and analgesia, can be explained from the same standpoint.

It is not yet possible to identify unambiguously the level of the receptor at which the point of application of endogenous opioid peptides is located. It is quite possible that the point of application of the active agent of opioid peptides may be equally the mechanically sensitive receptor substrate and its accessory apparatus, or the nerve fiber directly and, more accurately, its preterminal.

Views have frequently been expressed in the literature regarding the desensitizing and analgesic action of endogenous opioid peptides on nervous structures, but these statements have applied only to the central part of the nervous system [2, 4, 5, 9]. The results of the present investigation are evidence that during TES considerable but reversible changes take place in the receptor function of cutaneous afferents. Consequently, endogenous opioid peptides may participate in the regulation and formation of the afferent flow not only in the central parts of the nervous system, but also at the sensory ending level.

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