PHYSIOLOGY

Dependence of Electrical Activity of Neurons in Rostral Parts of Spinal Trigeminal Nucleus on Functional State of Trigeminal Gasser Ganglion

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Unilateral injection of 100 μl 1% lidocaine into the trigeminal Gasser ganglion of narcotized rats produced a long-term moderation of the discharge rate of neurons in the ipsilateral (relative to the side of injection) rostral area of the spinal trigeminal nucleus. Activity of neurons in the contralateral rostral area of the spinal trigeminal nucleus was not blocked. Functional state of neurons in the trigeminal ganglion determines discharge activity of ipsilateral neurons of the spinal trigeminal nucleus. Activity of neurons in the contralateral rostral area of spinal trigeminal nucleus was not inhibited. Functional state of the cells in the trigeminal ganglion determines the character of electrical activity of neurons in the ipsilateral rostral area of spinal trigeminal nucleus.

Key Words: *trigeminal ganglion; spinal trigeminal nucleus; neuronal activity; lidocaine; heart rate*

Trigeminal neuralgia belongs to the most severe pain syndromes characterized by persistent pain and aggravated course. Unfortunately, there are no efficient therapeutic approaches to the therapy of trigeminal neuralgia, because the mechanism of its development is poorly studied. It is assumed that trigeminal neuralgia results from extra pressure exerted on the trigeminal nerve (TN) by blood vessel, which sometimes leads to its demyelination [5]. Demyelination changes nerve impulse conduction and determines pathological excitability of the nerve resulting in uncontrollable pain. Other reasons of the local alterations in TN could be compression of fibers by tumor tissue or by the wall of narrowed bony canal housing TN. Demyelination provokes ectopic and ephaptic activities in the afferent portion of the trigeminal system. Abnormal nociceptive afferent firing elicits defense reactions resulting in the formation of trigeminal pain syndrome. Moreover, abnormal activity in the trigeminal system can provoke a migraine-like state [3,6]. The experimental models of this state are based on the formation of conditions, which lead to pathological hyperactivity of neurons in the spinal trigeminal nucleus (STN) [4]. In clinical practice, the blockade of receptive zones, TN fibers, and trigeminal ganglion is used for relieving trigeminal syndrome. Unfortunately, these procedures are often inefficient. Therefore, the search for causes of pain syndromes related to dysfunction of trigeminal system remains actual.

Our aim was to study regularities in the shift of electrical activity of STN neurons after microinjec-

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tions of local anesthetic lidocaine into the trigeminal Gasser ganglion.

MATERIALS AND METHODS

The experiments were carried out on male Wistar rats (n=23) weighing 280-330 g. The animals were intraperitoneally narcotized with urethane-nembutal mixture (500 and 30 mg/kg, respectively) and fixed in a stereotaxic apparatus. Cranial landmarks were set in a single horizontal plane. The STN coordinates were determined in accordance with the stereotaxic atlas. Electrical activity of STN cells was recorded in the following region: 2.3-2.8 caudal to the lambda, 2.2-2.8 lateral to the midline, and 7.5-8.5 ventral to the skull surface. Extracellular neuronal activity was recorded from the dorsal surface of the skull via a 2-mm trepanation hole. To this end, original glass-insulated tungsten electrodes (3-5 μ tip diameter) were used. To make the electrodes, tungsten wire was taped by electrolysis; thereafter it was insulated with Pyrex glass [1]. STN cells were tested by touching vibrissa or hair in supraorbital or infraorbital regions with forceps. Neuronal activity was recorded only from neurons immediately responding to the touch by increase or decrease in discharge rate.

Neuronal activity was recorded using a DAM-5 (WPI) amplifier, discriminator (the discrimination level was set by the bright mark on the oscillograph), and standard pulse generator. Conversion of the analog neuronal activity into the digital form (standard 5-20-msec pulses) made it possible to sample the response of a single high-amplitude neuron to injection of lidocaine into the trigeminal ganglion. In addition, broad (5-20 msec) standard pulses needed smaller (by 10-30 times) sampling rate for digital conversion in comparison with narrow (0.5-0.7 msec) original spikes, which resulted in smaller data files.

The rectal temperature was measured with an electrical thermometer and maintained with an electrical heater at a level of 37.0±0.5°C. Injections of 1% (100 μl) lidocaine (Curasan, Pharma AG) or 1.3 U (100 μl) lidase (BelMedPreparat) into the trigeminal ganglion was performed as follows. The rostral area of zygomatic process of the maxilla was palpated; thereafter a sterile surgical needle (0.4 mm tip diameter) was inserted via infraorbital orifice at an angle of 10° to the middle head plane. The tip of the needle was moved 20-22 mm along the infraorbital canal up to the entry into the oval orifice. After 10-min recording of initial neuronal activity, the needle was introduced into the trigeminal ganglion for 0.5 mm. At this moment, the ipsilateral mastication muscle contracted. Injection of lidocaine was performed over 2 min. In all experiments, lidocaine injections were alternated with injections of 100 μl physiological saline. The interval between injections was 1 h. At the end of the experiment, the same needle was used to inject cresyl violet used to verify the location of the needle tip within the trigeminal ganglion.

The data on neuronal activity (in analog and standard pulse form) together with the injection marks were fed into PC via 12-bit digitizer (ADC-100k/12-8, Spetzpribor). The signals were recorded and processed using InputWin standard software [2].

RESULTS

In 5 cases, unilateral injections of 1% lidocaine (100 μl) into the trigeminal ganglion virtually blocked for 5-6 min electrical activity of the neuron on the ipsilateral side (relative to injection site, Fig. 1). The discharge rate dropped few minutes postinjection, but recovered after 5-6 min. It is noteworthy that after 25-30 min electrical activity not only recovered, but also surpassed the initial level (Fig. 1). In 3 of 9 experiments, injection of lidocaine followed by injection of lidase (1.3 U, 1 h later) decreased the discharge rate by 2-3 times, but electrical activity was not entirely blocked. In 1 of 9 cases, lidocaine produced an opposite effect by increasing electrical activity of a neuron from 10.2± 0.5 to 21.1±0.8 Hz. Control unilateral injections of physiological saline (100 μl) into the trigeminal ganglion over 2 min produced no effect on electrical activity of rostral STN neurons. In 4 cases, lidocaine was not injected after control injection of physiological saline because of animal recovery from narcosis. Intraperitoneal injections of lidocaine (100 μl) produced no effect on electrical activity.

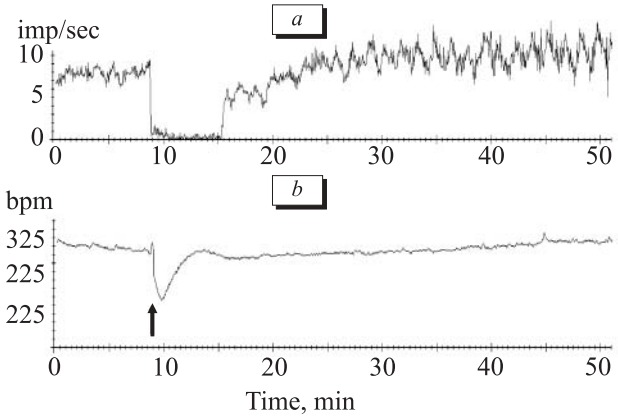

Fig. 1. Effect of unilateral injection (arrow) of 100 μl 1% lidocaine into the trigeminal ganglion on discharge rate of a single neuron in STN rostral area (*a*) and on heart rate (*b*).

In 2 cases, we could not find rostral STN neurons responding to the touch to the vibrissa or to the hair in facial part of the skull.

In 4 of 8 experiments, unilateral injections of lidocaine into the trigeminal ganglion produced no changes in activity of contralateral STN neurons. In 2 experiments we observed a short-term (5-7 min) decrease in the discharge rate from 10-12 to 7-8 Hz. In other 2 experiments, the injection needle punctured the ganglionic sheath from the dorsal side and pulmonary ventilation was arrested during injection of lidocaine. In these rats, postmortem examination showed that the tip of the needle was situated near the ventral surface of the brainstem.

Therefore, unilateral injections of 1% lidocaine (100 μl) or lidase into the trigeminal ganglion led to long-termed inhibition (up to complete blockade) of discharges in rostral STN neurons located on the ipsilateral side relative to the injection area. Under these conditions, we did not observe the inhibitory effect on the rostral STN neurons located on the contralateral side. Thus, functional state of the trigeminal ganglion neurons shapes the pattern of electrical activity of ipsilateral STN neurons.

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