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ELECTROPHYSIOLOGICAL INVESTIGATION OF CONNECTIONS OF NUCLEI OF THE MEDIAL AND LATERAL ZONES OF THE RESPIRATORY CENTER

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KEY WORDS: respiratory neurons; connections of neurons; respiratory nuclei.

The medial and lateral zones of the respiratory center differ in their neuronal composition and functional role [1, 2, 4-9]. High-frequency stimulation of inspiratory and expiratory sites of the gigantocellular nucleus [5-7] changes the state of the overwhelming majority of inspiratory and expiratory neurons of the nucleus ambiguus and nucleus retroambiguus (ventral respiratory nucleus) and nucleus of the tractus solitarius (dorsal respiratory nucleus) and evokes spike activity in them [6-8]. The presence of various mutual functional connections has been established between neurons of the inspiratory and expiratory sites of the gigantocellular nucleus and the ventral and dorsal respiratory nuclei [5-8]. No information is available on direct connections between neurons of medial and lateral zones of the respiratory center, although there are indirect data suggesting their existence. One piece of such indirect evidence is the recovery of spike activity of respiratory neurons when it has ceased during stimulation of inspiratory sites [7, 8].

The object of this investigation was to study connections of neurons of inspiratory and expiratory sites of the gigantocellular nucleus with respiratory and reticular neurons of the ventral and dorsal respiratory nuclei by analysis of latent periods of electrical responses of the neurons to equivalent stimulation of these sites.

EXPERIMENTAL METHOD

Experiments were carried out on 12 spontaneously breathing cats anesthetized with pentobarbital (40 mg/kg, intraperitoneally). The preparatory operations and the technique of conducting the observations were described in [7, 8]. Bipolar (interelectrode distance 100 μ) or glass electrodes, filled with Wood's alloy, were used for stimulation. The tips of the glass electrodes were coated electrolytically with platinum. Electrical activity was recorded on the side of stimulation from the phrenic nerve at levels C4-C5. To record integrated activity of

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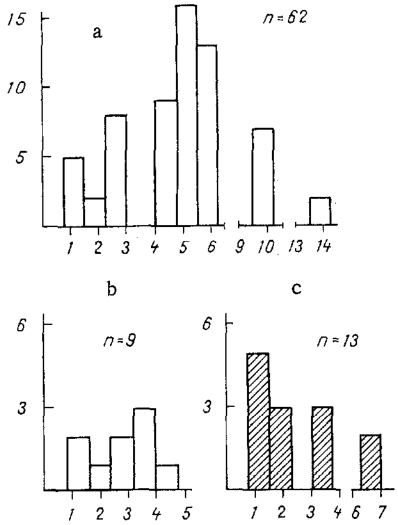

Fig. 1

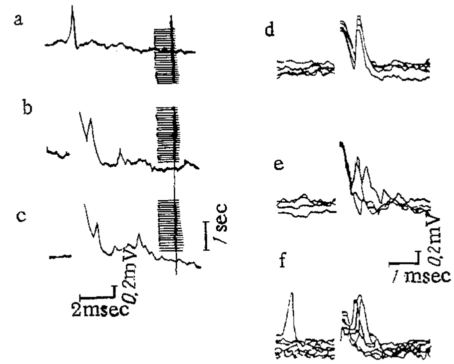

Fig. 2

Fig. 1. Histograms of synaptic responses of respiratory and reticular neurons to single stimulation of inspiratory and expiratory sites of gigantocellular nucleus. Abscissa, intervals, in msec; ordinate, number of neurons. Explanation in text.

Fig. 2. Monosynaptic responses of inspiratory neuron of ventral respiratory nucleus. Horizontally – evoked discharges of neuron, vertically – volley activity of neuron. Explanation in text.

respiratory neurons and phrenic nerve an S1-18 dual-beam oscilloscope was used. After preliminary identification of the type of the respiratory neuron, spontaneous unit activity was recorded from another oscilloscope with one beam, and discharges of the same units at different times of development of the respiratory cycle in response to single stimuli 0.1 msec in duration (negative polarity), applied from an ÉSU-2 electrical stimulator (current 3-20 μA) were recorded with the other beam. The greatest distance between the recording neurons and site of stimulation was 4 mm. The neuron responding to single stimuli was identified by the results of preliminary analysis of stable evoked unit activity and by comparing the magnitude of the discharges during natural and evoked activity.

EXPERIMENTAL RESULTS

Discharges of 67 inspiratory, 25 expiratory, and 76 reticular (with no evident connection with the phases of respiration) neurons were recorded in the region of the ventral and dorsal respiratory nuclei extracellularly. To bursts of stimulation and single stimuli of inspiratory sites in the gigantocellular nucleus, with coordinates 4 mm rostrally to the obex, 0.5 mm laterally to the midline, and at a depth of 3.5 mm from the dorsal surface, and also with coordinates 3, 2, and 4 mm respectively, evoked discharges were obtained from 62 inspiratory, 13 reticular, and 1 of the 14 expiratory neurons. Evoked responses were observed in nine of 11 expiratory neurons of the ventral respiratory nucleus in response to the same stimulation of the expiratory site with coordinates of 2.5, 1.5, and 3 mm respectively.

Histograms of latent periods of synaptic responses of inspiratory neurons to single stimulation of inspiratory sites of the gigantocellular nucleus (Fig. 1a), of expiratory neurons to stimulation of the expiratory site (Fig. 1b), and of reticular neurons to stimulation of the ipsilateral site with coordinates of 4, 0.5, and 3.5 mm (Fig. 1c), are shown in Fig. 1. The latent period of the evoked discharge in 15 of 62 inspiratory neurons was 0.7-3.0 msec. The latent period of discharges of most neurons was 4.0-6.5 msec.

Synaptic responses to single stimulation of a site with coordinates 4, 0.5, and 3.5 mm were obtained in 35 inspiratory neurons of the ventral respiratory nucleus and seven neurons of the dorsal nucleus. Two neurons recorded close to the nucleus ambiguus and one neuron close to the nucleus of the tractus solitarius gave monosynaptic responses to single stimulation.

Evoked responses of a complete inspiratory neuron are shown in Fig. 2. Variations in latent periods of evoked discharges of these neurons during the period of its discharge were noted. In the period between volleys

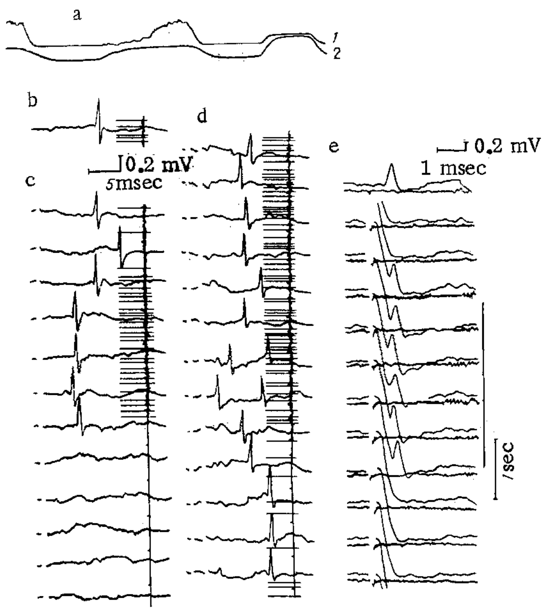

Fig. 3. Synaptic responses of inspiratory and reticular neurons of ventral nucleus. a, b) Responses to stimulation of inspiratory site of medial zone by one and two stimuli; a: 1) integrative activity of inspiratory neuron, 2) of phrenic nerve (top beam), 3) responses of reticular neuron. Top beam shows discharges of neuron, bottom beam shows electrical activity in splenic nerve. Duration of inspiration indicated on right. Just as in previous figure, movement of film is from below upward.

no electrical responses of the neurons were observed to threshold stimulation. If the stimulus arrived at the end of the second third of discharge of the neuron, the latent period was 0.7 msec, whereas if it arrived at the beginning of unit activity, it was 0.9-1.0 msec (Fig. 2b, c). The minimal latent period corresponded to a definite time of generation of respiratory discharges. Increasing the strength of the current to 1.5 to 3 thresholds led to the appearance of evoked discharges throughout the respiratory cycle or most of it (Fig. 2e). Fluctuations of latent periods of evoked discharges are explained on the grounds that the stimuli arrived at different periods of the respiratory cycle. If, however, stimulation was applied to the second third of the discharge of the neuron, evoked spike activities were superposed on one another (Fig. 2d).

Polysynaptic responses of a complete inspiratory neuron of the ventral nucleus during stimulation of the same site are represented in Fig. 3a. Stimulation by two stimuli converted volley activity of the neuron to continuous discharge (Fig. 3b). Paired stimuli caused facilitation of activity: In a series of runs at a certain moment of generation of respiratory spikes, two discharges were recorded. It must be specially noted that in every case the latent periods of the electrical responses, if they could be determined, were short but the intervolley period was always longer.

During stimulation of the inspiratory sites with coordinates of 3 mm rostrally to the obex, 2 mm laterally to the midline, and at a depth of 4 mm synaptic responses were recorded in 11 inspiratory neurons of the ventral and nine inspiratory neurons of the dorsal respiratory nuclei. In two complete inspiratory neurons of the dorsal nucleus monosynaptic responses were obtained (the latent period was 0.6-0.7 msec). The latent period of the remaining neurons varied from 2.3 to 6.5 msec. Just as during stimulation of the site described above, in most cases the shortest latent period corresponded to a particular moment of discharge of the neurons.

In 13 of the 56 reticular neurons (their spike discharge was not always connected visually with the phases of respiration), recorded in the ventral respiratory nucleus and increasing their discharge in response to high-frequency stimulation of the inspiratory site (4, 0.5, and 3.5 mm) the latent periods of the evoked discharges also were studied. A special feature of their responses was that evoked discharges in five neurons appeared only in the phase of inspiration (Fig. 3c). The latent period of ten neurons varied from 0.7 to 2.0 msec (Fig. 1c).

During stimulation of the expiratory site with coordinates of 2.5, 1.5, and 3 mm synaptic responses with a latent period of 0.7-4.0 msec were obtained in eight of the nine expiratory neurons of the ventral respiratory nucleus. The latent period in complete and late neurons was under 1.2 msec. During threshold stimulation evoked discharges of expiratory neurons were observed only in the phase of expiration, but with an increase in strength of the current, evoked activity was recorded throughout the period of the respiratory cycle. Only in one of the 19 inspiratory neurons of the ventral nucleus were evoked responses with a latent period of 6.4 msec obtained to stimulation of the expiratory site.

During stimulation of the structures described above in the gigantocellular nucleus, in some cases electrical responses of nonsynaptic origin were obtained, with a latent period of 0.3-0.4 msec, which correlated with the frequency of stimulation (up to 300 Hz).

The results thus indicate the existence of connections of a varied degree of complexity (including monosynaptic) between neurons of the inspiratory and expiratory sites of the gigantocellular nucleus and the ventral and dorsal nuclei. The latter, and also the marked facilitatory influences from these sites on the respiratory neurons of the lateral zone distinguish the sites described above [6-8] from others whose electrical stimulation switches the respiratory phases.

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ANALYSIS OF THE ACTION OF INCREASING ELECTRODERMAL STIMULATION ON VISCEROSOMATIC RESPONSES TO ELECTRICAL STIMULATION OF THE VENTROMEDIAL HYPOTHALAMUS

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KEY WORDS: hypothalamus; increasing electrodermal stimulation; naloxone; β-endorphin.

Among the various methods of increasing resistance to emotional stress, physical methods are achieving ever-increasing popularity: exposure to uhf electromagnetic fields, acupuncture, increasing electrodermal stimulation (EDS), etc. [1, 3, 4]. However, the mechanisms of action of physical factors on the course of emotional reactions still remain largely unexplained.

The aim of this investigation was to study the mechanism of the effect of increasing EDS on viscerosomatic responses to electrical stimulation of negative emotiogenic zones of the ventromedial hypothalamus (VMH). In

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