RESPONSES OF TWO OR MORE RESPIRATORY NEURONS TO STIMULATION OF INSPIRATORY AND EXPIRATORY ZONES OF THE GIGANTOCELLULAR NUCLEUS

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Electrical activity of two respiratory neurons (RN), recorded simultaneously by one electrode, has been observed by many workers [2, 3-5]. The results of their researches have shown that neurons not only of similar function, but also of different function may be intimately close together. The responses of such neurons to stimulation of inspiratory zones (IZ) located 3 mm rostrally to the obex, 2 mm laterally to the midline, and at a depth of 4-4.5 mm from the dorsal surface of the brain, and 4 mm rostrally to the obex, 0.5 mm laterally to the middline, and at a depth of 3-3.5 mm in the brain, and also to stimulation of the expiratory zone (EZ), 2.5 mm rostrally to the obex, 1.5 mm laterally to the midline, and a depth of 3 mm in the brain, all situated in the gigantocellular nucleus, were studied.

EXPERIMENTAL METHOD

Experiments were carried out on 11 cats anesthetized intraperitoneally with pentobarbital (45 mg/kg), by the method described previously [1]. Responses of 38 inspiratory (IN), 23 expiratory (EN), and three reticular (RetN) neurons, located in the lateral zone of the respiratory center in the regions of the nucleus of the tractus solitarius and the nucleus ambiguus, were studied. In 19 cases electrical activity of two neurons of functionally different groups was recorded simultaneously, and in two cases electrical activity of three neurons was recorded by the same electrode. In the other cases simultaneous recordings were obtained from two inspiratory or expiratory neurons: complete, late, and one early.

EXPERIMENTAL RESULTS

Threshold and above-threshold stimulation of IZ and EZ was carried out at different periods of development of inspiration and expiration. When IZ was stimulated during expiration, the latter ceased, and so also did the electrical activity of the recorded EN. Inspiration then began and electrical activity of the recorded IN was resumed. The number of spikes in volleys of the resumed electrical activity as a rule was less than during natural inspiration, but it could be the same or even greater. If stimulation was carried out in the course of several respiratory cycles, inspiratory apnea developed, during which electrical activity of the IN was preserved.

If EZ was stimulated during inspiration, however, inspiration was replaced by expiration. Electrical activity of the recorded IN ceased except in the case of one neuron, whose electrical activity was only reduced. Electrical activity of EN was resumed; under these circumstances the same variants of the number of spikes in the volleys were found with these neurons as in IN in which electrical activity had been induced. Stimulation of EZ for several respiratory cycles led to expiratory apnea. The results of these observations thus show that interaction between the inspiratory and expiratory neuronal systems is based on mutual inhibition in the activity of IN and EN, spreading from them to all neurons whose chains originate in these particular IN and EN.

The decrease and increase in the number of spikes in volleys from IN and EN during stimulation of IZ and EZ (compared with spontaneous activity) occurred in association with

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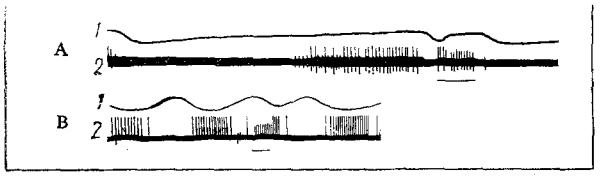

Fig. 1. Response of IN and EN to stimulation of IZ(A) and EZ(B) of gigantocellular nucleus. 1) Pneumogram, 2) unit activity; short horizontal line below is stimulus marker.

slow and fast initial discharge frequencies and also in response to stimulation at different times of development of the respiratory phases. The new firing pattern of IN and EN, evoked by stimulation of IZ and EZ, was evidently due to the different physiological properties of the responding neurons, which ultimately determine binding of the new rhythm of stimulation. The different numbers of spikes in the volleys generated by the neurons during identical artificial stimulation of IZ and EZ could be one sign of functional heterogeneity of the RN recorded. This hypothesis also was confirmed by responses of IN to stimulation of IZ during inspiration and responses of EN to stimulation of EZ during expiration. For example, in an experiment on November 17, 1977, electrical activity of a complete and a late IN was recorded simultaneously. Stimulation of IZ stopped the electrical activity of the complete IN but intensified spike generation by the late IN. In the same experiment two late IN were recorded simultaneously. During stimulation of IZ, electrical activity of one neuron ceased whereas that of the other grew stronger. In an experiment on April 18, 1978, stimulation of IZ increased electrical activity of both complete IN. The same response in the same experiment was given by a complete IN and an inspiratory—expiratory neuron in response to stimulation of IZ. In an experiment on March 31, 1979, electrical activity of one complete IN ceased, whereas that of the other, located beside it, was intensified (Fig. 1A). Similar responses also were observed in EN recorded in pairs or together with IN to stimulation of EZ during expiration. Their electrical activity could be increased or reduced in response to stimulation of EZ, despite continuing expiration. This was observed, for example, in an experiment on October 20, 1976. The difference in character of responses of EN to stimulation of EZ was particularly noticeable when two EN were recorded simultaneously by the same electrode. In an experiment on November 17, 1977, electrical activity of two complete EN was recorded. During stimulation of EZ electrical activity of one of them increased and that of the other was resumed, with a decrease in the mean firing rate in the volley. In an experiment on June 10, 1978, during stimulation of EZ electrical activity of one complete EN was increased whereas that of the other ceased (Fig. 1B). The difference between responses under identical experimental conditions and during identical stimulation indicates conclusively that in groups of complete and late neurons of the inspiratory and expiratory systems there are neurons which are not entirely identical from the functional point of view.

In experiments on May 5, 1975, and November 16, 1976, in which EZ was stimulated, one of the recorded neurons was reticular. In response to stimulation their electrical activity increased, as also did that of an EN recorded simultaneously with them. In an experiment on March 21, 1979, electrical activity of RetN ceased during stimulation of IZ. All three RetN thus responded like an EN to stimulation. These results suggest that the group of RetN present in the effector part of the respiratory center may perhaps contain a subgroup of RetN that is a part of its expiratory effector mechanism.

In conclusion it is worth pointing out that the introduction of a microelectrophysiological method of studying the functional structure of the respiratory center into practice would shed considerable light on its neuronal structure. The use of this method for simultaneous recording of electrical activity of two or more neurons in combination with stimulation of IZ and EZ provides new data on functional heterogeneity of neurons in groups of complete and late IN and EN. It is by no means everywhere that functionally unequal neurons are spatially isolated from one another, including in the nuclei of the respiratory center, but despite t' closeness, they preserve their functional features during stimulation of IZ and EZ bec e of the perfection of the isolating layer on their surface.

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