RESPONSES OF NEURONS OF THE VESTIBULAR NUCLEI TO INTEROCEPTIVE STIMULATION

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Responses of 112 neurons of the lateral and medial vestibular nuclei to adequate stimulation of mechanoreceptors of the stomach and intestine were recorded extracellularly in cats anesthetized with a chloralose-pentobarbital mixture. Depending on the response (of tonic type) to stimulation, three groups of neurons were distinguished: those responding by an increased firing rate (37), those responding by inhibition (26), and those not responding at all (49).

KEY WORDS: vestibular nuclei; visceroception; unit activity.

The study of interaction between the vestibular system, on the one hand, and the other central systems on the CNS and the autonomic nervous system, on the other hand, is important to shed light on the pathogenesis of motion sickness and the mechanisms of the somato-autonomic disorders arising in that condition.

Much research in recent years has been devoted to the study of extralabyrinthine factors in the mechanisms of onset of the vestibulo-autonomic disorders arising during exposure to radial acceleration and weightlessness [1, 6, 13].

The role of visceral afferentation in changes of reflex excitability and functional tuning of the vestibular system has been emphasized [3, 4, 10, 11, 15]. The afferent volley evoked by stimulation of visceral afferents (vagus and pelvic nerves) has been shown to reach the vestibular nuclei, in which it leads to the appearance of evoked potentials and changes in the firing pattern of the vestibular neurons [12, 15].

The responses of the vestibular neurons to stimulation of mechanoreceptors of the stomach and intestine were studied.

EXPERIMENTAL METHOD

Cats were anesthetized with a mixture of chloralose and nembutal (45 and 15 mg/kg, respectively, intraperitoneally). In many of the experiments further injections of the anesthetic mixture in 1/3-1/4 of the initial dose, were given at hourly intervals thereafter. Brain pulsation was prevented by draining the cisterna magna after division of the occipito-atlantoid membrane and by flooding the brain with 5% agar-agar solution. Unit activity of the vestibular nuclei was recorded extracellularly with glass microelectrodes prepared by the method of Tasaki et al. [22], filled with fiberglass and a 2.7 M solution of potassium chloride, and with a resistance of 5-20 MΩ. The microelectrodes were inserted into the brain structures to be investigated with the aid of the coordinates of a stereotaxic atlas [21] and with a correction for turning the animal's head through 45° to the horizontal plane [7]. Unit discharges were recorded on photographic film from the screen of a cathode-ray oscilloscope. The localization of the microelectrode tip was verified later histologically [19]. The vestibular neurons were identified on the basis of stimulation (polarization) of the labyrinth and, in some cases, of antidromic excitation of the vestibulo-spinal tracts in the cervical portion of the spinal cord.

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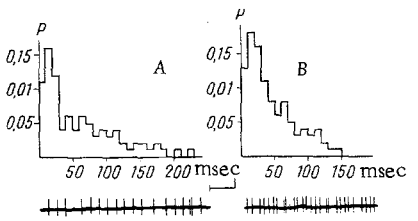

Fig. 1

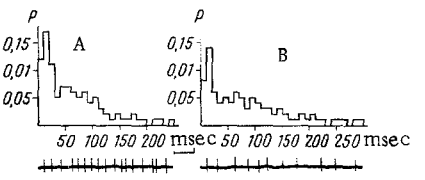

Fig. 2

Fig. 1. Unit responses of vestibular nuclei to interoceptive stimulation (activation type of response). Above: histograms of distribution of interspike intervals of vestibular neurons (combined data); below; unit activity (Deiters' nucleus). A) before; B) during stimulation of gastric mechanoreceptors (pressure 20-40 mm Hg).

Fig. 2. Unit response of vestibular nuclei to interoceptive stimulation (inhibitory type of response). Legend as in Fig. 1.

Mechanoreceptors of the stomach or large intestine were stimulated by stretching the walls with a rubber balloon inflated to a certain pressure. To analyze the spike responses of spontaneously active neurons, interspike intervals were studied for 5 sec before, during, and after interoceptive stimulation. The numerical results were subjected to statistical analysis [8].

EXPERIMENTAL RESULTS AND DISCUSSION

Unit activity of 112 neurons from the right and left vestibular nuclear complexes (mainly the lateral and medial nuclei) of the medulla was analyzed. There were 109 spontaneously active and three "silent" neurons.

The spontaneous activity of 54 neurons (48.21%) consisted of single spikes with a regular firing rate of between 2 and 60/sec. The duration of the interspike intervals of the neurons of this group averaged 34.3 ± 4.2 msec.

In 43 neurons (38.4%) with an irregular firing rate, this varied from 0.6 to 150/sec and the duration of the interspike intervals varied from 7 to 170 msec.

Twelve neurons showed a grouped type of discharge (10.71%). The firing rate varied from 4 to 40/sec and the intervals between the separate groups ranged from 100 to 2200 msec.

Three neurons (2.68%) had no spontaneous activity and they were activated only by visceral stimulation. The results of the experiments to study the character of the spontaneous unit activity of the vestibular nuclei agreed in general with those obtained by other workers [2, 9, 18].

A statistically significant (above the first threshold of probability of error-free prediction, $\beta d > 0.95$) response to visceral stimulation was observed in 63 of the 112 neurons studied (56.25%). The responses of the vestibular neurons were prolonged (tonic) in character; they were excitatory or inhibitory throughout the period of stimulation.

Neurons of the first group (37, or 33%) responded to stretching the walls of the stomach (20-40 mm Hg) or the rectal ampulla (40-80 mm Hg) by an increase in the original spontaneous firing rate (Fig. 1) by $119.5 \pm 19.77\%$ ($P < 0.001$) and also by the appearance of discharges from silent neurons (an activation type of response).

Neurons of the second group (26, or 23.21%) responded to visceral stimulation by a significant decrease in the firing rate (Fig. 2), on the average by $42.1 \pm 4.63\%$ (inhibitory type of response).

Neurons of the third group (49, or 43.7%) did not respond to stimulation of the walls of the stomach or intestine.

Among neurons of the first and second groups five responded (by excitation or inhibition) both to distension of the walls of the stomach or intestine and to their relaxation (by deflating the balloon).

The results show that the vestibular (lateral and medial) nuclei contain neurons capable of reacting to impulses arising during adequate stimulation of the mechanoreceptors of the stomach or intestine. Electrical stimulation of the visceral and somatic afferents also evokes changes in unit activity of the vestibular neurons and the intensity and character of these changes depend on the modality of the stimuli applied [5, 12, 18, 20]. It can be concluded from a comparison of these facts that the vestibular nuclei contain polysensory neurons on which vestibular, somatic, and visceral impulses converge.

The differences in the character of unit responses of the vestibular nuclei to visceral stimulation can evidently be explained by the abundance of ascending pathways along which afferent impulses from the viscera can presumably substantially modify the level of excitability and the functional tuning of the vestibular system and it may be one of the factors causing various motor and autonomic disorders.

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