EVOKED POTENTIALS IN THE RED NUCLEUS AND CENTRAL TEGMENTAL TRACT OF THE CAT DURING STIMULATION OF THE SPLANCHNIC NERVE

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The results of experimental morphological investigations of the corticofugal connections of the projection zones of the splanchnic nerve demonstrate that the terminal cortical segments of the afferent vesceral pathway are joined by a system of direct connections with the striatal complex, with certain nuclei of the thalamus, and with the reticular formations of the mesencephalon and medulla [3]. Because of this fact the suggestion has been made that the above-mentioned structures, and especially the red nucleus, may be functionally concerned with the establishment of the dynamics of formation of interoceptive signals in the central nervous system.

The red nucleus is not only a relay for the descending tracts, but also, according to recent neurophysiological investigations, it is the point of interruption of afferent pathways [6, 7]. It has also been discovered that tracts of different modalities converge on the cells of the red nucleus [7].

Yet there is no definite information in the neuroanatomical literature concerning the ascending pathway to the red nucleus. Taking into account the reticular structure of the red nucleus and the fact that it is one of the elements of the reticular complex of the mesencephalon, it might be supposed that sensory fibers enter the red nucleus from the main ascending tract of the reticular formation.

In the present investigation an attempt was made to determine, by means of the method of evoked potentials, the part played by the red nucleus in the conduction of visceral impulses, to establish the pathway along which interoceptive signals reach the red nucleus, to investigate whether the visceral and somatic pathways converge, and finally, to study the functional significance of the cortico-rubral connections arising in the projection zones of the splanchnic nerve.

EXPERIMENTAL METHOD

Investigations were carried out on 26 cats anesthetized with chloralose (80 mg/kg) and immobilized with flaxedil. The evoked potentials were recorded by a unipolar method. The diameter of the point of the active electrode was 40 μ. In some experiments a unipolar concentric electrode with an obliquely cut point was used. The indifferent electrode was fixed to the frontal bone. The active electrode was inserted into the structures of the mesencephalon with the aid of the coordinates of Jasper and Ajmone-Marsan's atlas. To stimulate the splanchnic nerve electrically in the abdomen buried electrodes were used, the interelectrode distance being 3 mm. For somatic stimulation (stimulation of the paw) needle electrodes were used, 5 mm apart. The recording part of the apparatus considted of a two-channel amplifier of biopotentials with its output fed into a type OK-21 twin-beam cathode-ray oscillograph. The transmission band of the amplifier was 0.5-1500 cps. The coefficient of amplification of each channel was 10^6 [2]. The electrical processes were recorded by means of a driven sweep on a Zorkii-6 camera. The splanchnic nerve was stimulated with single rectangular pulses with a duration of 0.5 msec, generated by a type ISE-01 electronic stimulator through a high-frequency attachment.

After the experiment the brain was perfused through the aorta with a 10% solution of neutral formalin and stained by Nissl's rapid method as modified by the authors in order to reveal the cytoarchitectonics.

EXPERIMENTAL RESULTS

The experiments showed that when a single electrical stimulus was applied to the splanchnic nerve, positive-negative bioelectrical responses with a relatively short latent period, amounting on the average to 12.8 ± 2.5 msec (10-16 msec) appeared in the red nucleus at the level of the nucleus of the posterior commissure and the central tegmental tract.

The evoked potentials were characterized by a low-voltage (40-50 μV) positive phase followed by a negative wave of comparatively high amplitude (80-100 μV) (Fig. 1). The duration of the first phase was 16-20 msec, and of the second—20-30 msec. At the same points of the red nucleus initially positive biphasic responses were recorded to somatic stimulation (Fig. 1). The latent period of the electrical reaction was 10.3 ± 2 msec (8-13 msec) and it was shorter for the ipsilateral limb. The duration of the phases of the biopotentials was indistinguishable from that in the responses to stimulation of the splanchnic nerve, while the amplitude of the potentials was slightly greater. It may be noted that the frequency of the reproduction of the electrical responses in the red nucleus to both somatic and visceral stimulation was lower than in the cortical projection zones.

In the spontaneous electrical activity of the red nucleus, besides slow waves, fast peak-like potentials were found, characteristic of conducting tracts. Their origin was evidently associated with the presence of a large number of fibrous structures in the intercellular spaces of the red nucleus and with the coarse pericellular apparatus of its macrocellular portion.

Bearing in mind the topographical peculiarities of the red nucleus, we carried out an electrophysiological investigation of the central tegmental tract (of Bekhterev) at the frontal levels (see Fig. 1) at which the conducting systems lie directly by the dorsal surface of the capsule of the red nucleus. According to V. M. Bekhterev's findings [1], these fibers take part in the formation of the dorsal portions of the capsule of the red nucleus.

The experiments showed that during stimulation of the splanchnic nerve and the limb, negative-positive bioelectrical reactions arise in the central tegmental tract.

The latent periods of the electrical responses of the conducting pathway to visceral stimulation was 7.7 ± 0.5 msec (7.0-8.5 msec), and to somatic stimulation 6.6 ± 0.2 msec (6-7 msec), and consequently they were shorter than the latent periods of the evoked electrical responses in the red nucleus. The bioelectrical waves were characterized by an initial high-voltage negative potential (150-170 μV), followed by a prolonged low-amplitude (20-30 μV) wave (see Fig. 1). The duration of the latent period shows that the observed electrical reactions reflected excitation of the ascending fibers of the tract.

The central tegmental tract of Bekhterev includes the main ascending reticular tract and descending connections. At the present time the question of the origin and ending of these fibers cannot be regarded as settled. It is claimed, however, that the ascending fibers of the tract originate in the inferior olive and terminate in the red nucleus and the other reticular formations of the mesencephalon [1, 8-10]. Furthermore, experimental morphological investigations have shown that the ascending reticular tract and the reticular structures of the mesencephalon contain only a very small number of fibers of specific pathways—the medial lemniscus [5]. It may be deduced from this last fact that the sensory rubropetal tract is formed by spino-olivary and olivo-reticular fibers. It has been shown that the spino-olivary fibers do not reach the nucleus funiculi gracilis or the nucleus funiculi cuneati and to not relay in these nuclei [4].

It may be concluded from a comparison of these findings with the neuroanatomical data that the visceral and somatic afferent impulses pass to the red nucleus along the spino-olivary tract and the ascending reticular fibers of the central tegmental tract of Bekhterev. Convergence of the visceral and somatic pathways evidently takes place not only in the red nucleus but also in the inferior olive.

When investigating the functional significance of the cortico-rubral connections aresing in the afferent zones of the splanchnic nerve, we made observations on the evoked potentials recorded in the red nucleus in response to visceral and somatic stimulation before and after division of the white matter beneath the cortex of the above-mentioned zones.

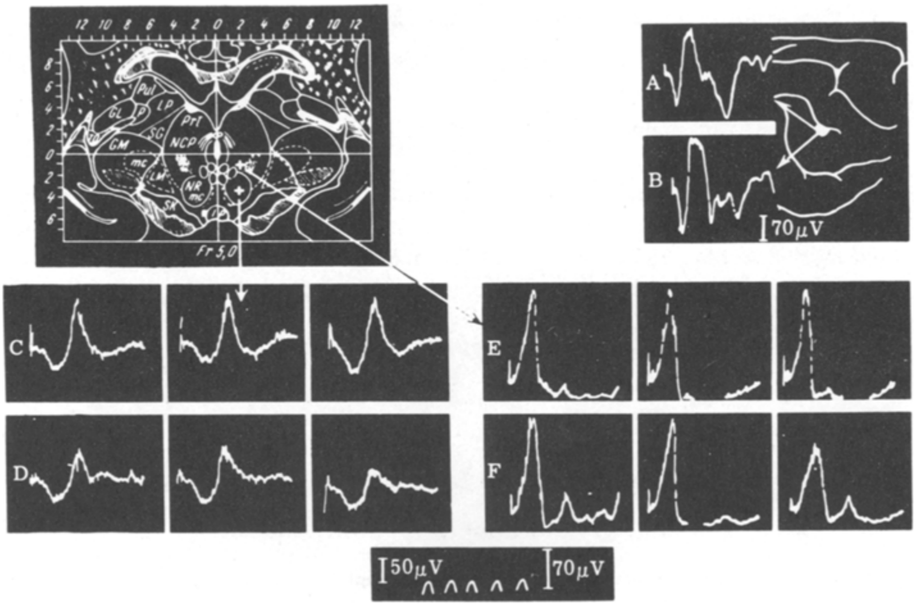

Fig. 1. Evoked potentials in the cortex of projection zone II of the splanchnic nerve (A, B), in the red nucleus (C, D), and in the central tegmental tract (E, F) during stimulation of the splanchnic nerve (A, C, E) and of the hind limb on the contralateral side (B, D, F). Time marker 20 msec; + level of recording of biopotentials.

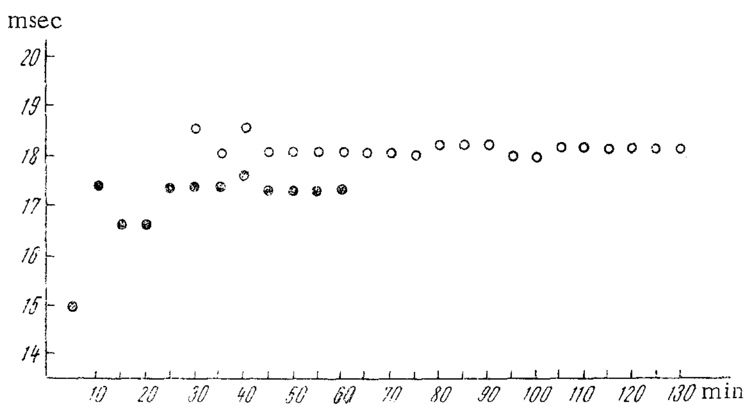

Fig. 2. Mean value of latent periods of evoked potentials in red nucleus of five experiments before (⊘) and after "undercutting" of the cortex of projection zones I (●) and II (○) of the splanchnic nerve.

The results of these experiments revealed a lengthening of the latent periods of the evoked electrical responses ($P < 0.001$). A change in the duration of the latent period of 2 msec appeared 10 min after "undercutting" the cortex of one of the projection zones. After the operation on the cortex of the other zone the latent periods were lengthened by a further 1-2 msec (see Fig. 2). No authentic changes in the amplitude and time characteristics of the responses could be established in the course of observations lasting 2-3 h.

It may be concluded from the lengthening of the latent period of the evoked electrical reactions in the red nucleus after division of the descending connections that the sensory divisions of the visceral cortex have a "facilitating" influence on the conduction of afferent visceral and somatic impulses in the red nucleus.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.