DORSAL ROOT POTENTIALS OF THE SPINAL CORD IN RATS WITH CONVULSIONS DUE TO ASCENDING TETANUS

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Dorsal root potentials (DRPs) of the spinal cord were investigated in rats with ascending tetanus at the stage of poisoning when the development of generalized convulsions in response to stimulation of nerves on the side of injection of the toxin is facilitated (the "universal departure station" phenomenon). It is shown that the DRPs of the lumbar part of the spinal cord evoked by stimulation of a cutaneous nerve of the hind limb into which the toxin was injected is greater in amplitude and, in particular, in duration and may be related differently to the strength of stimulation of the nerve from DRPs evoked by stimulation of nerves of the opposite limb and DRPs in a healthy animal. The suggestion is made that augmented DRPs arising during stimulation of nerves on the side of injection of tetanus toxin are nonhomogeneous. It is concluded that the "universal departure station" phenomenon is not due to disturbance of mechanisms of depolarization of primary afferent fibers in the spinal cord.

In animals with ascending tetanus, the development of generalized convulsions after stimulation of the limb into which the tetanus toxin was injected is facilitated [1-3,13,14]. Analysis of this phenomenon, which was found in all animals investigated, from the frog to the monkey, and described as irradiation or as the "universal departure station" phenomenon [1-7], is interesting from the standpoint of general neurophysiology. It could be considered that differences in thresholds of production of a generalized convulsive response from receptors of the "tetanized" limb and from other receptive zones, including the opposite limb, are connected with disturbance of mechanisms of depolarization of afferent endings on the "tetanized" side, restricting [12] the flow of afferent impulses into the spinal cord.

It was therefore interesting to investigate the negative electrotonic potentials of dorsal roots of the spinal cord produced in rats with ascending tetanus by stimulation of nerves of the "tetanized" and opposite limbs.

EXPERIMENTAL METHOD

Experiments were carried out on albino rats weighing 310-390 g. Ascending tetanus was produced by injecting tetanus toxin in a dose of 5 MLD into the gastrocnemius muscle of the right or left hind limb. The MLD was determined in rats weighing 200-220 g. Spread of the toxin by the blood stream was prevented by simultaneous intravenous injection of tetanus antiserum in a dose of 0.025 antitoxin unit. Dorsal root potentials were studied 4 or 5 days after injection of the toxin. On the day before the experiment, all the animals (those with tetanus and healthy animals) underwent transection of the spinal cord at the level T8-T9. On the day of the experiment tracheotomy and laminectomy (L1-S2) were performed on the animals under ether anesthesia, and the roots and nerves were dissected. The ventral roots of L2, L3, L4, and L5 and the dorsal roots of L5 were mobilized and divided bilaterally. In both limbs the sural, peroneal, and tibial nerves were dissected and divided distally, as well as all muscular branches of the sciatic nerve in the thigh. Total curarization was carried out (D-tubocurarine injected intravenously in a dose of 0.35-0.45 mg/kg) and artificial respiration applied. The DRPs of the L5 roots were amplified by means of an ac amplifier (time constant about 2 sec) and recorded from the screen of a cathode-ray oscilloscope. Stimuli were generated by an ES-103 stimulator with radiofrequency output. The duration of the stimulus was 0.1 msec. DRPs evoked by stimulation of the nerve at a strength from 4 to 40 times greater than the threshold value required to cause the appearance of a DRP (4T and 40T) were studied.

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TABLE 1. Dorsal Root Potentials in Healthy Rats and Rats with Convulsions Due to Ascending Tetanus

DRPs investigated	Threshold, in V			Amplitude (in μV)				Duration, in msec			
				4 T		40 T		4 T		40 T	
	n	$\bar{x} \pm S_{\bar{x}}$	P	$\bar{x} \pm S_{\bar{x}}$	P	$\bar{x} \pm S_{\bar{x}}$	P	$\bar{x} \pm S_{\bar{x}}$	P	$\bar{x} \pm S_{\bar{x}}$	P
In healthy rats	18	0,19±0,02	>0,05	234±30	<0,05	250±31	<0,05	60±3	<0,05	67±3	<0,05
In rats with tetanus											
On side of tetanus	19	0,20±0,01	>0,05	376±32	<0,05	422±39	<0,05	288±60	<0,05	354±50	<0,05
On side opposite injection of toxin	17	0,21±0,02		211± 21		228±23		58±2		75±8	

Legend: n – number of observations, $\bar{x}$ – arithmetical mean, $S_{\bar{x}}$ – standard error, P – probability of null hypothesis. Level of significance taken as 0.05. Difference significant when $P \leq 0.05$.

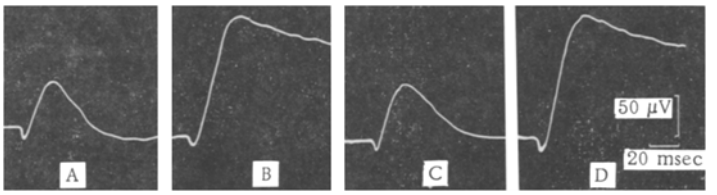

Fig. 1. Dorsal root potentials of spinal cord in a rat with convulsions due to ascending tetanus. A and C) DRPs in response to stimulation of sural nerve on opposite side to injection of toxin with strength of 4T and 40T; B and D) DRPs in response to stimulation of sural nerve on "tetanus" side with strengths of 4T and 40T.

EXPERIMENTAL RESULTS

The experimental results are shown in Table 1 and Fig. 1. In healthy rats, during stimulation of the cutaneous nerve at a strength of 4T, the DRPs almost reached their maximum, and a further tenfold increase in the strength of stimulation (up to 40T) caused only a slight increase in their amplitude and duration (Table 1). The relationship between DRP parameters and strength of stimulation of the cutaneous nerve described in cats [10] is similar. In rats with ascending tetanus (the "universal departure station" phenomenon) stimulation of the nerve on the side opposite to injection of toxin was accompanied by the appearance of DRPs differing only slightly in amplitude and duration from those in healthy rats (Table 1). Conversely, DRPs evoked by stimulation of the nerve on the side of injection of the tetanus toxin, at strengths of 4T and 40T, were appreciably greater in amplitude than DRPs evoked by stimulation of the nerve on the opposite side (Fig. 1, Table 1), and also DRPs in healthy rats (Table 1). The greatest differences were seen in the duration of the potentials. DRPs evoked by stimulation of the nerve on the side of tetanus toxin injection were several times more prolonged than DRPs caused by stimulation of the nerve on the opposite side (Table 1).

Hence, judging from the DRPs, on the side of tetanus toxin injection the effectiveness of the mechanism producing depolarization of afferent endings was not reduced, but increased, so that the facilitated development of generalized convulsions from the limb into which tetanus toxin was injected cannot be explained by suppression of this mechanism. In this respect, the action of tetanus toxin differs from the action of another convulsant, picrotoxin, which reduces the DRP [11], but is similar to the action of strychnine, which also increases and prolongs the DRP [8,9,11].

However, DRPs caused by stimulation of a nerve on the side of injection of tetanus toxin in rats with ascending tetanus differed from the DRPs in healthy rats not only in amplitude and duration, but also in the rather different character of the relationship between these parameters of the DRP and the strength of stimulation. In rats with ascending tetanus, with a smooth increase in strength of stimulation of the nerve on the side of injection of toxin, the DRPs produced at first were often different from those evoked by stimulation of the nerve on the opposite side in amplitude alone. With a further increase in strength of stimulation, sometimes only a slight increase, the duration of the DRPs suddenly increased several times over, after which an increase in the strength of stimulation had no further effect on duration of the DRPs. Whereas the threshold for production of DRPs in response to stimulation of nerves on the side of injection of tetanus toxin and the opposite side were about equal, and were the same as the thresholds for production of DRPs in healthy rats (Table 1), the threshold for prolonging the DRPs varied appreciably from one experiment to another. During stimulation

with a strength of 40T all the DRPs were long, while during stimulation with a strength of 4T, some potentials were still of only short duration. These properties of the DRPs (considerable duration, relationship between thresholds for lengthening DRPs and level of excitability of the preparation while the threshold for producing DRPs remains unchanged, lengthening of the DRPs in many cases in accordance with the "all or nothing" law) suggest the nonhomogeneity of DRPs evoked by stimulation of the nerve on the side of injection of toxin in rats with the "universal departure station" phenomenon in ascending tetanus.

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