CHANGES IN EVOKED CORTICOMOTOR RESPONSES IN RATS WITH AGE AND AFTER PARTIAL DECORTICATION

I. B. Ptitsyna, A. B. Vol'nova, and D. N. Lenkov UDC 612.82:612.763

KEY WORDS: motor cortex; compensation of injury; microstimulation.

A topic of great interest in the problem of restoration of functions during compensation of cortical trauma [3] is the possibility of plastic restructuring of descending pathways from the undamaged hemisphere [2]. Research conducted by the microstimulation method into the reorganization of cortical motor zones after partial decortication [4, 6] has enabled discussion of the possible ways in which this restructuring can be brought about, but until the question of the temporal characteristics of evoked motor responses (MR) has been answered, no definite conclusion can be drawn regarding their mechanisms. Controlled experiments on intact animals of the same age (up to 1 year) also are necessary, because reorganization of the motor areas is revealed in the late stages after experimental trauma [4].

The aim of this investigation was to compare the temporal and spatial characteristics of MR evoked in rats of different ages, under normal conditions and after partial decortication.

EXPERIMENTAL METHOD

The investigation was conducted on 39 male rats aged from 3 to 16 months, on 16 of them after unilateral extirpation in the region of motor representation of the limbs (mainly the hind limbs) by aspiration of cortical tissue. After the experiments the brain was fixed in formalin to determine the precise boundaries of decortication. Monopolar intracortical microstimulation (ICMS) was carried out through a glass microelectrode with a tip 4-6 μ in diameter, filled with sodium citrate (resistance 0.5-1.5 MΩ). For ICMS series of cathodal square pulses (current $\leq$ 50 μA), with a duration of 0.2 msec and a frequency of 400 Hz, were used. The reference electrode was a silver plate with an area of about 1 cm^2. Electromyographic (EMG) responses were recorded on photographic film, using multiple derivation with the aid of bipolar needle electrodes (up to 10-15 at the same time); the presence and localization of MR of different groups of muscles were recorded on the basis of palpation and visual observations. The latent periods of the EMG responses were measured from the beginning of the first spike in the burst.

EXPERIMENTAL RESULTS

The work was done on five groups of animals: normal rats under 4 months old (group 1), normal rats over 1 year old (group 2), and three groups of rats after partial decortication: under 2 months (group 3), from 3 to 8 months (4), and from 8 to 16 months (5) after the operation.

In experiments on rats of different ages maps of cortical motor representation of the hind limb muscles in young and old intact rats showed good agreement (Fig. 1). Only minor shifting of the boundaries of the motor areas in the caudal direction was observed in the old animals, evidently due to shifting of the bony reference points (bregma) during growth of the skull.

I. P. Pavlov Department of Physiology, Institute of Experimental Medicine, Academy of Medical Sciences of the USSR, Leningrad. Group for Developmental Neurobiology, A. A. Ukhtomskii Physiological Research Institute, Leningrad University. (Presented by Academician of the Academy of Medical Sciences of the USSR N. P. Bekhtereva.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 108, No. 10, pp. 407-409, October, 1989. Original article submitted July 26, 1988.

 0007-4888/89/0010-1386 $12.50

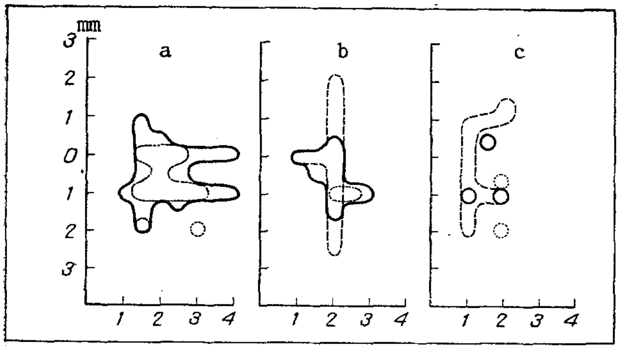


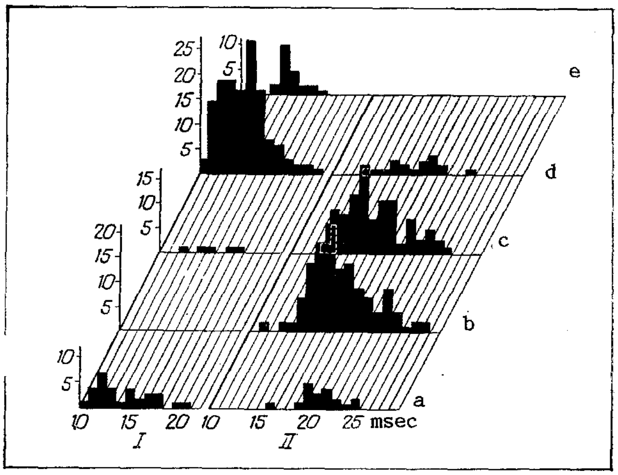
Fig. 1. Maps showing arrangement of zone of motor representation of hind limb muscles in right (intact) cerebral hemisphere according to data of intracortical microstimulation. a) Zone of evocation of responses in calf muscles, b) in thigh muscles, c) in pelvic muscles. Continuous line – boundaries of zones in normal rats under 4 months old, dotted line – in normal rats over 1 year old, broken line – in rats 8-16 months after experimental trauma. 0) Level of bregma, frontal pole of brain shown above.

TABLE 1. Latent Periods of EMG Responses to Microstimulation of Injured Hemisphere in Rats of Different Ages, under Normal Conditions and after Partial Unilateral Decortication (in msec)

Zone of recording of EMG	Group of rats	$\bar{X}$	σ	N
Forelimb:				
forearm	1	14,3	2,9	31
	3	15,2	2,1	5
	4	14,3	2,4	138
	5	14,6	1,6	23
shoulder	1	15,6	2,9	77
	3	17,5	2,6	52
Hind limb:				
foot	1	17,7	2,1	21
calf	1	21,4	2,1	19
	2	19,2	3,4	130
	3	17,8	2,9	85
	4	18,2	2,7	19
thigh	1	19,2	2,9	23
	2	19,8	3,7	17
	3	21,0	3,5	28
	3	16,5	1,9	11
Axial musculature*				
proximal segment	2	20,2	2,6	5
pelvic segment	1	19,3	1,4	17
	2	20,4	3,5	17
	2	17,2	1,8	9
	4	23,1	2,8	36

Legend. *) Data for ipsilateral EMG responses.

In the animals undergoing decortication changes were observed in the topographic organization of the motor areas of the intact hemisphere, which were not manifested until 0.5 year after the operation, and reached a maximum toward the end of the period studied. Reduction of the motor cortical representation of muscles of the distal joints took place in the rats 8-16 months after partial decortication (Fig. 1a), changes were less marked in the representation of muscles of more proximal joints (hip; Fig. 1b), and the representation of the pelvic muscles was considerably widened (Fig. 1c). Motor representation of the lumbar muscles during this period after the operation occupied the dominant position in the cortex, although under normal conditions, when ICMS is used with the same parameters, no MR were observed in these muscles.



Histograms of latent periods of EMG responses of forearm (I) and calf (II) muscles. Data given for groups of rats: a) normal rats under 4 months old (1), b) over 1 year old (2); c, d, and e) groups 3, 4, and 5, respectively, of decorticated animals. Horizontal axis, time (in msec) from first stimulus to beginning of response; vertical axis, number of observations.

As Table 1 shows, the overwhelming majority of responses to ICMS of the motor areas were contralateral; ipsilateral EMG responses were recorded from axial muscles, whose representation was discovered in the late stages after decortication.

Comparison of latent periods of EMG responses evoked in young and old normal rats, and also in rats at different times after partial decortication, revealed no significant differences in latencies of the contralateral responses (Fig. 2; Table 1). The presence of shorter latent periods among the ipsilateral EMG responses (Table 1) may indicate that they take place through cortico-bulbo-spinal pathways, for we know that the highest conduction velocities in the rubro-, reticulo-, and vestibulospinal system are higher than in the corticospinal system [5, 7, 8].

On the basis of a study of the spatial and temporal characteristics of the evoked corticomotor responses it can be concluded that the basic parameters are stable, irrespective of the animals' age (up to 1 year or more) and, on the other hand, the topographic functional organization of the cortical motor areas is changed. The process of restoration of motor function in the late stages after partial decortication includes changes in the relative detectability of MR of the different muscle groups. Besides changes in their relative number – a decrease in the fraction of zones from which MR of distal muscles are evoked, and an increase in the fraction of zones for evoking MR of proximal muscles, especially the axial muscles, the ways of realization of these responses also are changed.

Contralateral MR with the same latent periods as normally are evidently mediated through unchanged descending pathways. Ipsilateral MR of axial muscles with shorter latent periods, not normally detected, are probably realized differently – through fast-conducting fibers of supraspinal pathways. This can be explained by a change in excitability of certain groups of corticofugal neurons after partial decortication, leading to lowering of the threshold of evocation of MR of the axial muscles and to lessening of the probability of detection of distal effects.

LITERATURE CITED

1. A. B. Vol'nova and D. N. Lenkov, Zh. Vyssh. Nerv. Deyat., 32, No. 1, 122 (1982).
2. S. N. Ivanova, Mechanisms of Compensation of Motor Functions after Lateral Hemisection of the Spinal Cord [in Russian], Moscow (1980).
3. G. N. Kryzhanovskii, Determinant Structures in the Pathology of the Nervous System [in Russian], Moscow (1980).
4. I. B. Ptitsyna, A. B. Vol'nova, and D. N. Lenkov, Zh. Vyssh. Nerv. Deyat., 38, No. 3, 506 (1988).
5. S. L. Cottingham, P. A. Femano, and D. W. Pfaff, Exp. Neurol., 97, 704 (1987).

6. G. Kartje-Tillotson, E. J. Neafsey, and A. J. Castro, Brain Res., 332, 103 (1985).
7. N. K. Mediratta and J. A. R. Nicall, J. Physiol. (London), 336, 545 (1983).
8. M. Saling and J. Pavlasek, Bratisl. Lek. Listy, 86, 160 (1986).

EFFECT OF WEAK SOLUTIONS OF ALDEHYDES ON CHANGES IN THE RAT EEG

A. V. Khokhlov, I. A. Bashilov,
V. I. Tel'pukhov, and T. I. Lapkina

UDC 612.822.3.014.46:615.31:547.281

KEY WORDS: ischemia; aldehydes; EEG; CNS.

Previous investigations have shown that the safe periods of cerebral ischemia can be essentially prolonged by the use of weak solutions of aldehydes as protectors [4-6]. The protective action of aldehydes is considered to be based on inhibition of the biochemical and physiological responses. There have been many investigations of the biochemical anti-ischemic mechanisms of action of aldehydes, notably formaldehyde [2, 3, 7, 8], but little information has been obtained about physiological reactions taking place when aldehydes interact with nerve tissue. Moreover, we do not know which of these reactions may promote a favorable course of the ischemic and, in particular, the postischemic process. The aim of the present investigation was to study physiological responses of the CNS to small doses of weak solutions of aldehydes and mixtures of aldehydes.

EXPERIMENTAL METHOD

Experiments were carried out on 50 mature noninbred male rats weighing 240-280 g. Gold plated electrodes 0.4 mm in diameter were implanted into the rats' brain. The electrodes were located epidurally, bilaterally, in the medial and lateral regions of the frontoparietal cortex, according to the atlas of Paxinos and Watson [15], and were fixed by self-hardening plastics. The reference electrode was secured in the nasal bones. To apply the test solutions the right axillary artery was catheterized. Isotonic solutions of formaldehyde for glutaraldehyde, in concentrations of 0.2 and 0.02%, respectively, were injected in a dose of 0.1 or 0.2 ml/100 g body weight. A mixture of these same aldehydes in the proportion of 1:1 was used in a volume of 0.2 ml/100 g body weight. These doses of aldehydes were those which prolonged the safe period of total cerebral ischemia. As the control, the same volume of physiological saline was injected. Superficial anesthesia with hexobarbital and ether was used for the experiments. Anesthesia was induced with 1% hexobarbital solution in a dose of 0.5 ml/100 g body weight. To maintain a constant level of anesthesia, ether was inhaled. The EEG was recorded on a "San'ei" electroencephalograph (Japan). Regions of the EEG 10 sec in duration immediately before injection of the solutions and 1, 3, 5, 20, and 25 min after their injection were analyzed. In some cases, for a more detailed analysis the EEG was processed during the interval from the 5th to the 20th minute and at the 30th minute. An "Élektronika BK-0010" personal computer carried out this processing by the method of spectral analysis. The significance of differences was calculated by Cochran's test for a level of significance of $p \leq 0.05$.

EXPERIMENTAL RESULTS

Injection of physiological saline (seven experiments) caused an increase in amplitude of the EEG 20-30 sec after infusion on average by 16.3-0.7%. This change in amplitude was observed in both hemispheres in both the motor and the sensory zone of the cortex. The

Academic Group of Academician of the Academy of Medical Sciences of the USSR V. V. Kovanov, All-Union Research Center for Surgery, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR V. V. Kovanov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 108, No. 10, pp. 409-412, October, 1989. Original article submitted February 12, 1989.

0007-4888/89/0010-1389 $12.50