DURATION OF ACTION POTENTIALS OF MOTOR UNITS AFTER SPINAL CORD TRAUMA

V. I. Belyaev

UDC 616.832-001-07:616.74-009.1-073.97

The duration of action potentials of motor units (MU) of the gastrocnemius and tibialis muscles was studied in patients with spinal cord trauma by the method of local electromyography. The duration of action potentials of gastrocnemius MU was found to be reduced on average by 27%, and of tibialis MU by 38% of the age norm. The degree of shortening of the action potentials of the gastrocnemius and tibialis MU was not directly dependent on the level of spinal cord injury, the length of time after trauma, or the severity of the spastic syndrome. Changes in the duration of action potentials of MU are evidently due to differences in the degree of atrophy developing as a result of prolonged adynamia.

KEY WORDS: motor units; muscle atrophy; spinal cord trauma.

After spinal cord trauma locomotor function of the muscles of the lower limbs is absent in most patients. Prolonged hypokinesia is known to cause functional and morphological changes in several organs and systems [1, 4, 8, 11]. In patients with spinal cord lesions at the cervical and thoracic level, however, a spastic syndrome often develops and is expressed as spontaneous and uncontrollable contractions of the skeletal muscles of the lower limbs. The functional state of the muscular apparatus of these patients thus depends on the one hand on prolonged adynamia, and on the other hand on spontaneous activation of spinal motoneurons. It is thus interesting to study the functional state of motor units (MU) in relation to the level of spinal cord damage, to the time elapsing after trauma, and to the degree of severity of the spastic syndrome. The method of local electromyography, widely used in clinical practice to detect muscular dystrophy, myasthenia, myatonia [12], polymyositis [9], neurogenic atrophy [3], circulatory disturbances in the lower limbs [7], and other functional changes in the muscular system, was used for this purpose.

The object of the investigation was to study the duration of action potentials of MU of flexor (m. tibialis anterior) and extensor (m. gastrocnemius med.) muscles of the foot in patients after spinal cord trauma.

EXPERIMENTAL METHOD

Electrical activity of MU was recorded by Buchthal's method [5, 10]. Concentric needle electrodes 0.6 mm (from Medicor) and 0.4 mm (from Disa) in diameter were used. The electrodes were inserted into the belly of the tibialis anterior and gastrocnemius muscles. Action potentials of MU were recorded by the camera of a two-channel Medicor electromyograph during passive flexion and extension of the foot or during spastic contraction of the muscles. To detect more action potentials of MU, up to 5 punctures were made, and through each puncture the electrodes could be in 2 to 4 different positions. To calculate the duration of the action potentials of MU a square-pulse calibration signal was applied to the input of the myograph from a UBP-01 amplifier was used. To determine the mean duration of the MU action potentials at least 20 were counted and the average expressed as a percentage of the age norm [5, 10]. Polyphasic MU action potentials were excluded from counting. Altogether 18 patients with spinal cord injuries, aged from 17 to 54 years, were investigated. In control tests on healthy subjects results agreeing with data in the literature were obtained [5, 7, 10].

EXPERIMENTAL RESULTS

Action potentials of MU recorded during flexion and extension of the foot or during involuntary activation of MU in patients after spinal cord trauma are shown in Fig. 1a. Besides mono- and biphasic action potentials,

Department of Spinal Cord Trauma, A. V. Vishnevskii Institute of Surgery, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR M. I. Kuzin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 86, No. 9, pp. 267-270, September, 1978. Original article submitted January 20, 1978.

 0007-4888/78/8609-1130$07.50

Fig. 1

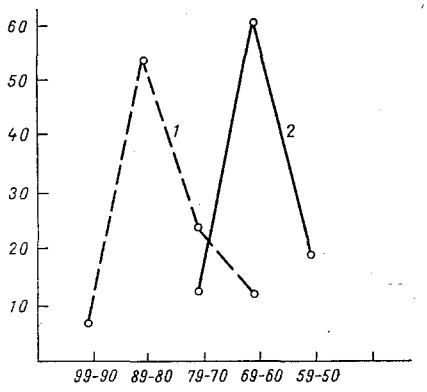

Fig. 2

Fig. 1. Action potentials of gastrocnemius and tibialis anterior MU. a) Mono- and biphasic action potentials of MU; b) polyphasic action potentials of MU. Calibration: 2.5 msec, 100 μV.

Fig. 2. Distribution of duration of averaged action potentials of tibialis anterior (1) and gastrocnemius (2) MU. Abscissa, deviation from age norm (in %); ordinate, number of cases (in %).

polyphasic action potentials of MU were recorded significantly more often in patients than in healthy subjects (Fig. 1b). Averaging of the durations of mono- and biphasic action potentials of gastrocnemius and tibialis anterior MU showed that the duration of action potentials of gastrocnemius MU was within the normal age limits in only 2 of 18 subjects studied [3, 5, 7, 10]. In 16 patients the duration of action potentials of MU of this muscle was reduced by 15-40% of the age norm (on average by 27%). The duration of MU of the tibialis anterior in all subjects was 25-48% below the limit of the age norm (on average by 38%). The difference in the duration of the action potentials of the tibialis anterior and gastrocnemius MU is shown in Fig. 2; clearly the curve of distribution of duration of action potentials of the tibialis anterior MU is shifted to the left along the ordinate relative to the corresponding curve of the gastrocnemius muscle. These results indicate that in adynamia due to spinal cord trauma the tibialis anterior muscle undergoes more severe functional changes than the gastrocnemius. This may evidently explain the pes equinus symptom so frequently observed in the patients of this category.

The results of the study of changes in the duration of the action potentials of MU were analyzed in relation to the level of spinal cord trauma, the length of time after the injury, and the severity of the spastic syndrome. Analysis of changes in the duration of the action potentials of MU of the gastrocnemius and tibialis anterior muscles in relation to the level of spinal cord trauma showed that shortening of the duration of the action potentials of MU was independent of the segmental level of the spinal cord lesion in the cervical and lumbar portions. After injury to the lumbar region of the spinal cord, as a rule flaccid paralysis was observed and reflex responses were either completely absent or sharply reduced. It was therefore impossible to induce natural discharges of action potentials from MU. A study of the times elapsing after injury (from 6 months to 12 years) likewise revealed no correlation between changes in the duration of action potentials of the tibialis anterior and gastrocnmeius MU and the duration of the posttraumatic period. A decrease in the duration of MU action potentials evidently takes place in the earlier stages after spinal cord trauma. No clear correlation likewise was discovered between shortening of the duration of the action potentials of MU and the severity of the spastic syndrome, as assessed by neurological tests.

Analysis of the results of investigation of 18 patients with spinal cord trauma thus points to the absence of any direct correlation between changes in the duration of action potentials of tibialis anterior and gastrocnemium MU and the level of spinal cord injury, the length of time after trauma, and the severity of the spastic syndrome.

Investigations of electrical activity of MU in patients with disturbances of the vascular system (endarteritis and atherosclerosis) also revealed a decrease in the duration of the MU action potentials [7]. This suggests that in patients with spinal cord trauma shortening of the duration of the MU action potentials is due to changes in the peripheral circulation and subsequent atrophy of the muscle fibers. The cause of these changes is evidently prolonged adynamia. This hypothesis is supported by the results of investigations of hypokinesia, leading to impairment of metabolism [2, 4, 6], and of anatomical changes in the peripheral vascular system [1, 8, 11].

LITERATURE CITED

1. E. A. Dyskin, E. N. Bellendir, N. M. Patlos, et al., Arkh. Anat., No. 4, 45 (1976).
2. Yu. S. Galushko, I. A. Abakumova, and I. A. Nitochkina, in: Current Problems in Space Biology and Medicine [in Russian], Moscow (1971), p. 77.
3. I. Haussmanowa-Petrusewicz, Muscular Diseases [in Russian], Warsaw (1971).
4. E. A. Kovalenko, Kosmich. Biol., No. 1, 3 (1976).
5. R. S. Person, Electromyography in Human Investigations [in Russian], Moscow (1959).
6. S. M. Peregontsev, Voen.-Med. Zh., No. 11, 63 (1972).
7. N. D. Platonov and L. S. Romanova, Byull. Éksp. Biol. Med., No. 8, 18 (1975).
8. Yu. M. Shtykhno and V. I. Udovichenko, Byull. Éksp. Biol. Med., No. 4, 403 (1975).
9. F. Buchthal and P. Pinelli, Neurology, 3, 426 (1953).
10. F. Buchthal, An Introduction to Electromyography, Copenhagen (1957).
11. A. Chobanion, R. Lille, A. Tereyak, et al., Circulation, 49, 551 (1974).
12. P. Pinelli and F. Buchthal, Neurology, 3, 347 (1953).

MONOAMINE CONTENT IN THE MOTOR CORTEX AFTER INJURY TO THE OPPOSITE MOTOR CORTEX

P. V. Rutsai

UDC 616.831-001-031.4-07:616.831.31-008.932.33-031.74-07

In chronic experiments on eight cats a spectrofluorometric study was made of the serotonin, dopamine, and noradrenalin content in the sigmoid cortex of the left cerebral hemisphere 2, 3, 4, and 5-8 days after removal of the symmetrical cortex of the right hemisphere. A decrease in the dopamine content and a tendency for a decrease in the noradrenalin and serotonin content were observed on the 2nd day, at the time of maximal disturbances of locomotor function. On the 3rd-4th and 5th-8th days, during the period of recovery of motor activity, the serotonin level increased, the dopamine content remained low, whereas the noradrenalin level rose considerably. The role of biochemical changes in the motor cortex in the mechanisms of recovery of locomotor function after injury to the symmetrical cortical region is discussed.

KEY WORDS: injury to the motor cortex; biogenic amines.

Compensation and restoration of functions of the injured brain have for a long time engaged the attention of clinicians and experimental scientists [1-3]. Published work has shown that after injury to the brain changes are observed in the monoamine content in its structures [8, 9]. It is accordingly particularly interesting to study the neurohumoral mechanisms of recovery, for this offers the prospect of being able to influence the course of compensation of disturbed brain functions through the action of physiologically active substances [4, 6].

The object of the present investigation was to study changes in the content of serotonin, dopamine, and noradrenalin in the motor cortex of the same animal after removal of the symmetrical cortex from the opposite hemisphere and in the course of recovery of the disturbed locomotor function.

Laboratory of Pathophysiology of Neurohumoral Regulation, Institute of General Pathology and Pathophysiology, Academy of Medical Sciences of the USSR, Moscow.

(Presented by Academician of the Academy of Medical Sciences of the USSR A. M. Chernukh.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 86, No. 9, pp. 270-271, September, 1978. Original article submitted March 27, 1978.

0007-4888/78/8609-1132$07.50