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RECOVERY OF MOTOR FUNCTIONS AFTER DIVISION OF THE SPINAL CORD OR CAUDA EQUINA

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Partial recovery of motor functions in 8 patients with division of the spinal cord at the mid-thoracic level or of the cauda equina at the lumbar level is described. During attempts by all patients at voluntary movement, electromyography revealed the development of activity in the trunk muscles and m. gluteus medius, as well as the appearance and development of activity in muscles of the thigh and leg. The level of rehabilitation in the patients was relatively high: They could walk with suitable support, they could work at their own trades, and they could care for themselves. Recovery of motor functions took place more rapidly after trauma at lower levels, although complete rehabilitation was achieved in two patients with trauma at a higher level. The mechanism of restoration of functions is based on the compensatory development of activity in the trunk muscles and the ability of the distal segment of the spinal cord to form new motor reflexes with the participation of the limb muscles.

KEY WORDS: recovery of motor functions; electromyogram; distal segment of the spinal cord.

The study of reflex activity of the spinal cord after division in dogs has shown that it differs considerably from normal [1]. The spinal cord "returns," as it were, to phylogenetically older forms, so that atypical motor responses can be formed in the animals. In dogs receiving extra afferent stimulation partial recovery of the motor functions of the hind limbs was observed.

In patients with complete transection of the spinal cord at the level of the thoracic vertebrae or at the lumbar level (cauda equina) remedial gymnastics and pyrogenal therapy can also lead to partial recovery of motor functions. Eight such cases are described below.

EXPERIMENTAL METHOD

In six patients the diagnosis was established at laminectomy and it was confirmed in all eight patients by the results of neurological and electromyographic investigation [2]. The patients have been trained for different lengths of time by Doctor A. N. Trankvillitati.* Besides physical therapy, pyrogenal therapy also was given [3, 4]. During training the limb volume was investigated and the electromyogram (EMG) of the trunk and lower limb muscles was recorded during attempts at voluntary movement. The movements concerned were drawing up the lower limb by tilting the pelvis towards the shoulder, and also supporting the foot on a board placed by it. The EMG was recorded in the prone and supine positions. The method of

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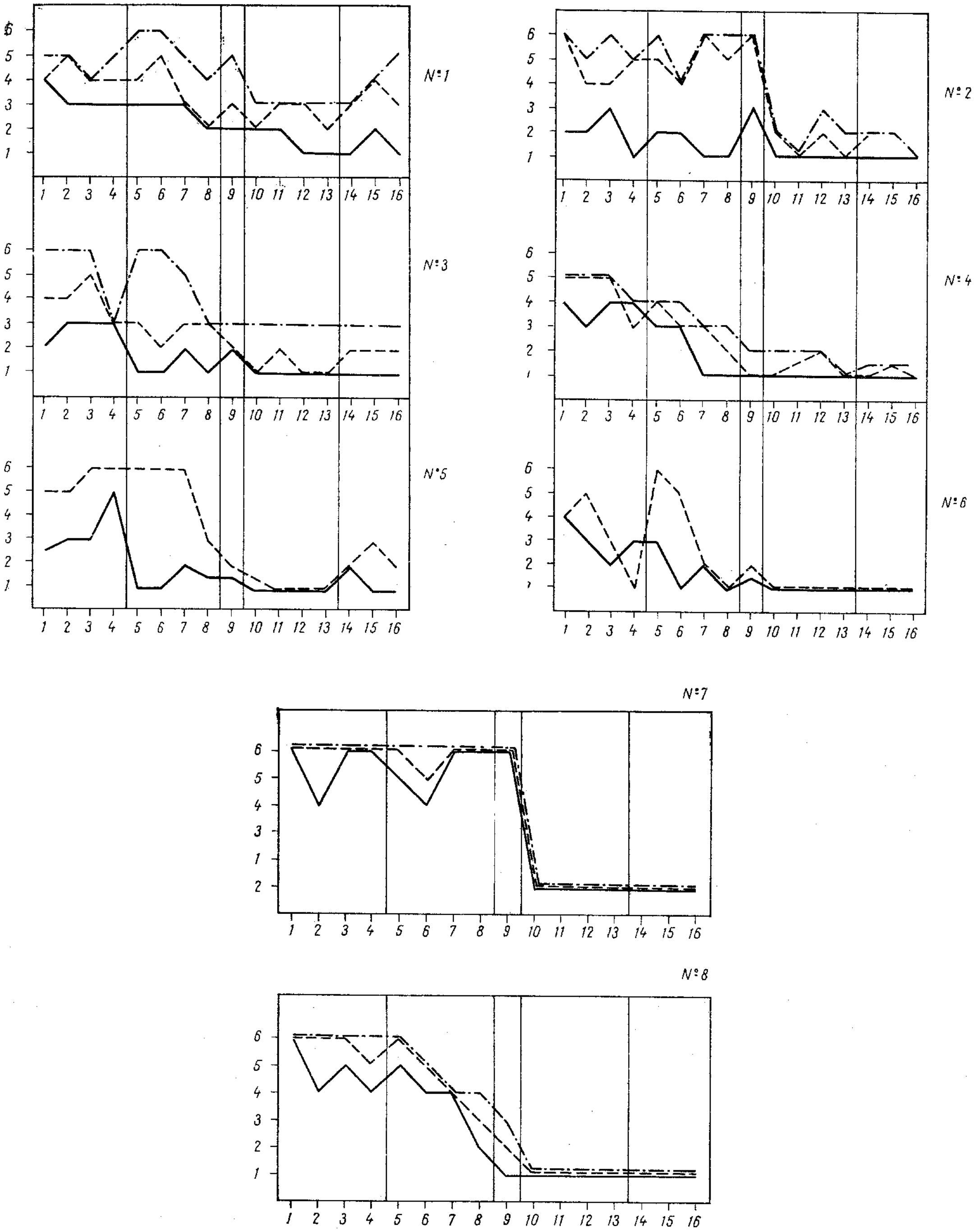

Fig. 1. Dynamics of electrical activity of muscles during treatment. Abscissa, muscles tested: 1) upper regions of m. latissimus dorsi, 2) m. longissimus dorsi, 3) m. obliquus abdominis extrenus, 4) m. rectus abdominis, 5-8) lower parts of these same muscles, 9) m. gluteus medius, 10) m. vastus lateralis, 11) m. rectus femoris, 12) m. biceps femoris, 13) m. semitendinosus, 14) m. tibialis anterior, 15) m. gastro cnemius, 16) m. soleus. Ordinate, assessment of activity of muscles, in points. Numbers on vertical axis denote patients.

recording was described previously [2]. The EMG was analyzed by a six-point system: 6) normal EMG of high amplitude, 5) normal EMG of average amplitude or slow EMG of high amplitude, 4) normal EMG of low amplitude or slow EMG of average amplitude, 3) slow EMG of low amplitude or repeated short volleys of low or average amplitude, 2) very low activity of the noise type or activity of single motor units, 1) electrical silence. An amplitude of 200 μV or more was regarded as high, of 100 to 200 μV as average, and below 100 μV as low.

For visual assessment of the changes in these processes a chart was kept for each patient on which the test muscles were recorded along the horizontal axis in the order corresponding to their position (from the upper part of the trunk downward to the leg), and the activity of the muscles in points was recorded along the vertical axis. The line connecting the points obtained in one investigation characterized the state of the patient's motor apparatus at the time of testing, and comparison of the curves indicated progress of recovery.

The first EMG was recorded in all patients in the chronic period of trauma (from 1 year to 9 years after injury). It was repeated in all patients except No. 6 at intervals of 1 to 3 years (in No. 6 after 1 month).

EXPERIMENTAL RESULTS

The six patients who were under observation for 5-6 years evidently attained the most complete possible recovery of their function. Later, one of them (No. 8), after attaining considerable recovery of his motor functions, died from pylonephritis. Five patients (Nos. 1-4, 7) can get up with supports on crutches and walk, moving the lower limbs forward alternately and raising them from the floor. They can go up and down staris, walk several kilometers, and three of them can drive a car. All work in their special trades and can look after themselves. One of the patients gave birth to a child and cared for it herself.

Two of the patients received physical therapy and massage for 1 (No. 6) and 6 (No. 5) months. The last patient was lifted on to his feet and began to move about. These results are given as an indication of improvements in muscular activity which can be obtained after a short period of treatment.

After a period of observation lasting 5-6 years the circumference of the limbs measured at different levels in patients Nos. 1-4 and 7 increased by 1-18 cm, and in patients Nos. 5 and 6 by 0.5-2 cm.

The results of the electromyographic investigation showed that during treatment the activity of several muscles increased in all patients (Fig. 1). The greatest improvement was found in the activity of the upper parts of the long muscles of the trunk, innervated from the spinal cord proximally to the level of division. In patients Nos. 1, 2, and 5 with trauma at the level of the lower thoracic and lumbar vertebrae, the lower parts of the same muscles were activated almost simultaneously with the upper parts. After only one month of intensive training in the hospital, patient No. 6 developed good activity in the lower parts of the spinal muscles. A high degree of activity of the long muscles of the trunk was the first and principal compensatory adaptation during recovery of motor functions.

Activity in the lower parts of m. obliquus abdominis externus and m. gluteus medius, responsible for drawing up the lower limb — an essential movement during walking in orthopedic appliances — is of the utmost importance to the organization of walking in the spinal patient. During training activation of these muscles usually took place fairly quickly after trauma at a low level, for they can contract voluntarily. In the case of lesions at the upper or middle thoracic level the lower part of m. obliquus abdominis extremus also becomes activated quickly during training because of its plurisegmental innervation. When it contracts, this muscle moves the skin above m. gluteus medius, which lies alongside it and is attached to the same iliac crest, and during repetition of its contraction it may thus activate this latter muscle. A high degree of activity in the trunk muscle and in m. gluteus medius, observed in patient No. 7 from the beginning of training, can be explained by the fact that he was injured in childhood and compensated his motor defect during growth.

Activity in the thigh and leg muscles appeared last of all and not in every patient. Activation of the thigh and, in particular, the leg muscles after trauma at a low level, it must be emphasized, is a no less difficult task than in patients with trauma at a high level, for in both cases activation of these muscles is achieved by repeated passive-active displacements of the lower limb by movement of the trunk and upper limbs, thereby facilitating formation of reflex limb movements. Activity of the thigh and leg muscles in patients Nos. 1-4 was achieved by a long period of training with support; no significant difference between them can be observed. Nearly all the patients described began intensive training during the chronic period of trauma as outpatients. Only patient No. 4 began his treatment early, but it was complicated by the fact that trauma occurred at two levels and by the development of myositis ossificans in the region of the hip.

These investigations showed that after complete division of the spinal cord or cauda equina, even in the chronic period of trauma considerable recovery of the patient's motor function can be achieved [5]. Recovery is based on the ability of voluntarily contracting muscles to take over additional motor functions. Movements controlled by the distal segment of the spinal cord can be triggered by the motor apparatus of the sound part of the body, by the formation of new motor reflexes and by the involvement of new muscles in the movement, in much the same way as was observed in spinal dogs. The second and no less important factor is the use of intensive physical thereapy and massage: the prevention of dystrophic changes in the spinal reflex apparatus [1].

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MECHANISMS OF THE PRIMARY RESPONSE OF THE ADRENAL CORTEX TO PAIN STRESS IN DOGS

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A sharp decrease in the glucocorticoid content accompanied by an increase in the free cholesterol and a decrease in the content of esterified cholesterol were observed in the adrenal cortex of dogs 10-15 sec after nociceptive stimulation. The blood concentrations of the hormones were increased, mainly due to the protein-bound hydrocortisone fraction. The next phase of the response (30-60 sec after stimulation) was marked by activation of synthetic processes, leading to considerable accumulation of hormones in the gland. The blood glucocorticoid level was doubled, the original ratio of hydrocortisone to corticosterone was restored, and the transcortin depot was replenished. The role of the adrenal and transcortin depots of glucocorticoids in the feedback mechanism during stress is discussed.

KEY WORDS: stress; adrenal cortex; glucocorticoids.

Despite extensive literature on the manifestations of stress and its pathogenetic mechanisms, the initial factors of the stress response, leading to activation of synthesis and secretion of hormones of the pituitary—adrenocortical system have not yet been adequately explained. It was therefore decided to study the earliest stages of the response of the adrenal cortex to stress.

EXPERIMENTAL METHOD

Noninbred mature male dogs were used. For several days the animals were adapted to the experimental situation. A state of pain stress was produced by one-stage mechanical injury to the thigh, not sufficient to produce shock. The animals were decapitated during the 10-15 sec after nonciceptive stimulation. The adrenals and blood from the inferior vena cava from the region where it receives the lumboadrenal veins were used as the test material.

Hydrocortisone, cortisone, costicosterone, and cholesterol and its esters in the adrenocortical tissue were investigated by thin-layer chromatography [1-2]. The levels of hydro-

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