ELECTROMYOGRAPHIC ASSESSMENT OF DAMAGE TO THE INJURED SPINAL CORD*

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The possibility of assessing the degree of damage to the spinal cord by electromyography in the early stage of treatment was demonstrated. The following indices obtained during attempts at movement are evidence of the absence of anatomical loss of continuity of the spinal cord: 1) in the case of injury at level D_5–D_{10}, absence of delay in activation of the lower segments of the long muscles of the trunk compared with their upper segments; 2) in the case of trauma at the level D_{10}–L_1, the presence of activity in the thigh and leg muscles, even if recordable only as single potentials of low amplitude; 3) whatever the level of trauma, the appearance of activity in symmetrical muscles of one lower limb during the attempt to move the opposite limb. In most cases, even if only one index is positive, the patient's motor functions will be restored by restitution.

KEY WORDS: spinal cord; trauma; electromyography.

Restoration of motor functions in patients with injury to the spinal cord has proved impossible mainly because of the development of degenerative changes [2, 3]. Only by the use of massive loads in the course of special remedial gymnastics has any significant degree of regeneration been obtained in vivo [5, 7]. If some fibers of the spinal cord are preserved, substantial and, in some cases, even complete restoration of motor functions can be observed [4]. In the case of anatomical loss of continuity of the spinal cord, any restoration of motor functions that may arise is compensatory in type.

The difference in the course of recovery in these cases makes the early assessment of the severity of spinal cord damage important. The methods of diagnosis used (laminectomy, neurological investigation) do not always determine the severity of injury sufficiently reliably.

This paper gives the results of an electromyographic investigation of muscle activity during attempts at movement by patients with spinal cord damage, at different stages of restorative therapy, from which indices characterizing the severity of trauma were obtained.

EXPERIMENTAL METHOD

Altogether 50 patients with injury to the spine and spinal cord at the level D_5–L_1 were studied. Restoration and maintenance of functions of the spinal reflex system were carried out by remedial gymnastics and by injections of pyrogenal [5, 7]. The patients underwent a periodic neurological examination, their movements were examined, and the electromyograms (EMGs) of the trunk and limb muscles during attempts to move were recorded by the use of surface electrodes, 8 mm in diameter, with an interpolar distance of 1.5–2 cm. The muscle potentials were led to a UBP1-01 amplifier and recorded on an N_{102} loop oscillograph, with a film winding speed of 50 mm/sec and calibration 50 μV = 2.5–4 mm. The activity

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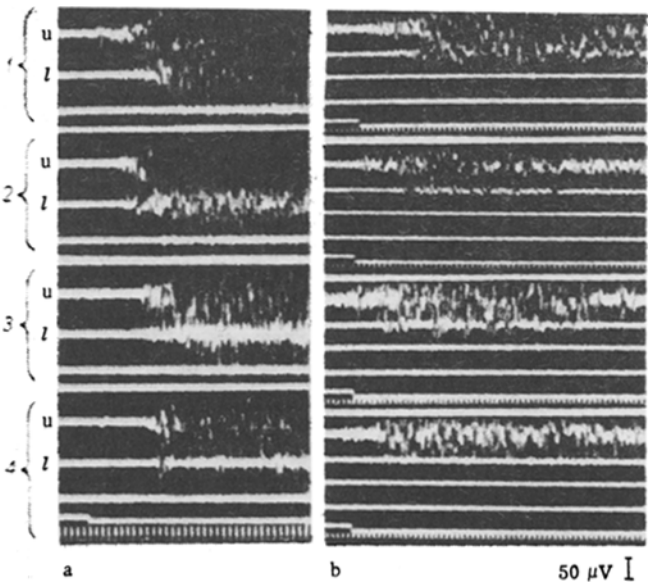

Fig. 1. Activity in trunk and limb muscles during attempts by patients with injury at level D_5-D_{10} to draw up the lower limb: a) absence of delay in activation of lower segments of long trunk muscles compared with upper segments (patient with trauma at the level D_8); b) presence of delay in activation of the same muscles (patient with trauma at the level D_5-D_6). From top to bottom, in a: 1) m. lat. dorsi (u—upper, *l*—lower segment), m. gl. max.; 2) m. long. dorsi (upper and lower segments), m. vast. lat.; 3) m. obl. abd. ext. (upper and lower segments), m. glut. med.; 4) m. rect. abd. (upper and lower segments), m. biceps fem.; in b: 1) m. lat. dorsi (upper and lower segments), m. semitendinosus, m. soleus; 2) m. long. dorsi (upper and lower segments), m. vast. lat., m. gastrocnemius; 3) m. obl. abd. ext. (upper and lower segments), m. glut. med., m. rect. fem; 4) m. rect. abd. (upper and lower segments), m. biceps fem., m. tibialis ant.

of initially 3 and later 4 muscles was recorded simultaneously. The principal movement during recording was drawing the straight lower limb toward the shoulder girdle while lying in the supine position. This movement is the basic element in the patient's step and it can be carried out by the muscles of the shoulder girdle and the upper segments of the long trunk muscles.

EXPERIMENTAL RESULTS

The first sign indicating that excitation is being conducted across the region of trauma is absence of delay in the time of activation of the lower segments of the long trunk muscles compared with their upper segments. Observations were made on 21 patients with trauma between D_5 and D_{10} and with flacoid paraplegia; anatomical loss of continuity of the spinal cord was diagnosed in 11 of them and partial interruption in 10. If activity in the lower segments of the long trunk muscles appeared simultaneously with activity in the upper segments of the same muscles at the first or second examination, preservation of conduction between the two parts of the spinal cord could be assumed. If the lower segments of the muscles were activated indirectly, through a new reflex arc and, consequently, with delay, then loss of continuity was present.

In 11 patients of this group absence of delay in activation of the lower segments of the long trunk muscles compared with the upper was observed (Fig. 1a). In 10 patients the delay in activation varied between 100 and 300 msec (Fig. 1b).

The second index of integrity of some of the spinal cord fibers was the appearance of activity in the thigh or leg muscles (even though recorded only as single low-amplitude potentials) at the beginning of or before treatment (Fig. 2). Of the 50 patients investigated, in 21 of whom anatomical loss of continuity of the spinal cord was established at laminectomy and eight of whom did not undergo laminectomy, slight

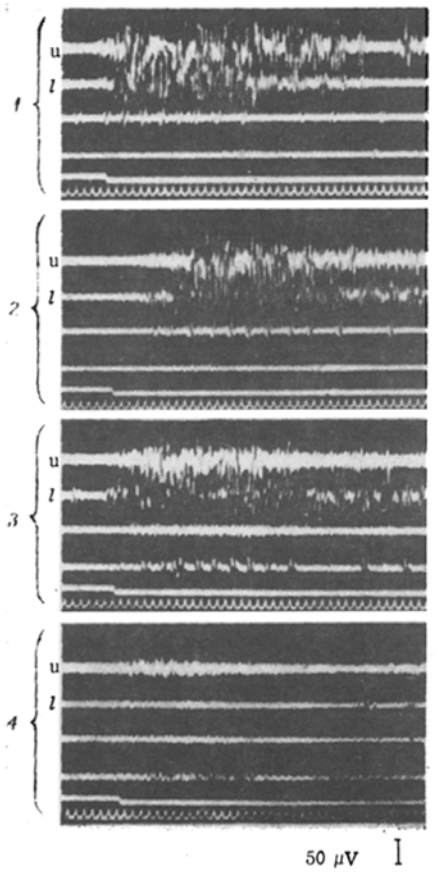

Fig. 2

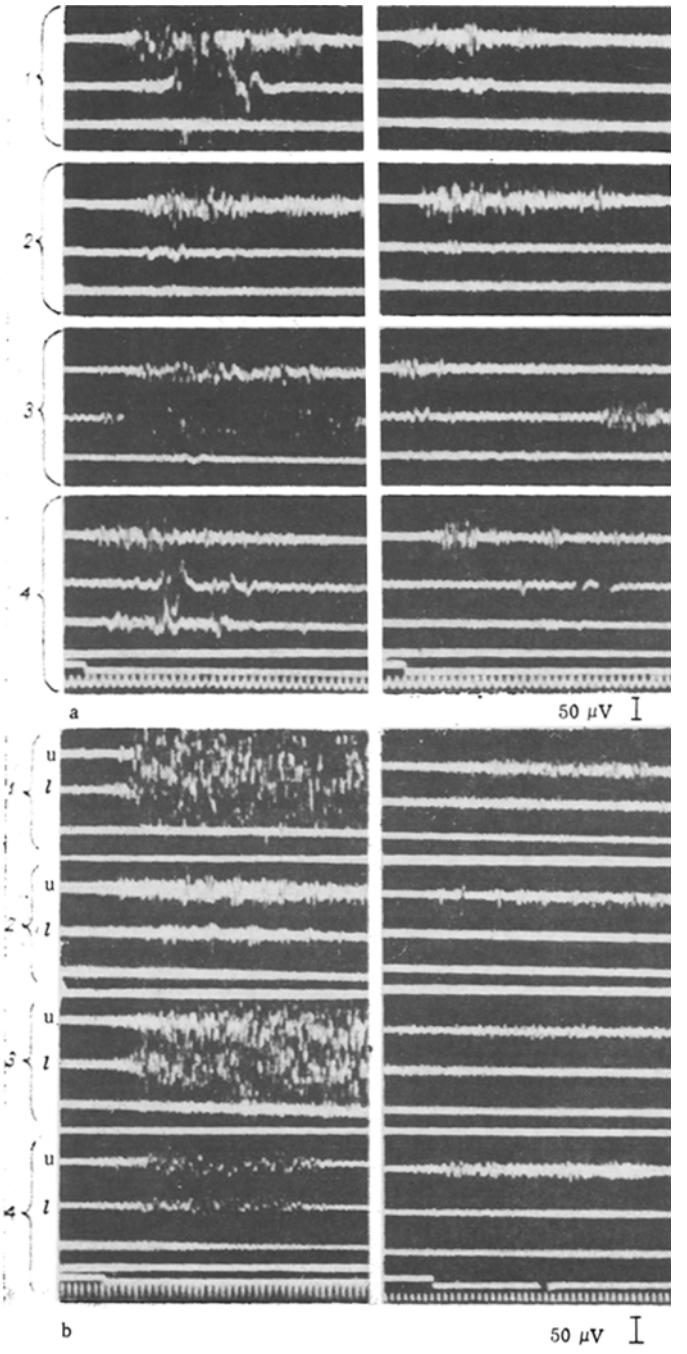

Fig. 3

Fig. 2. Activity in trunk and limb muscles during attempt by patient with trauma at level D_{12} to draw lower limb upward. Legend as in Fig. 1b.

Fig. 3. Activity in symmetrical muscles: a) presence of synergism in limb muscles (patient with trauma at level D_{11}-D_{12}); b) absence of synergism in limb muscles (patient with trauma at level D_{12}). In a and b: on the left, activity in muscles of ipsilateral limb; on the right, in muscles of the contralateral limb. In a: 1) m. lat. dorsi, m. gl. max., m. biceps fem., 2) m. long. dorsi, m. vast. lat., m. gastrocnemius; 3) m. obl. abd. ext., m. glut. med., m. rect. fem. 4) m. rect. abd., m. sartorius, m. tibialis ant.; in b: 1) m. lat. dorsi (upper and lower segments), m. gl. max., m. long. dorsi (upper and lower segments), m. vast. lat.; 3) m. obl. abd. ext. (upper and lower segments), m. glut. med.; 4) m. rect. abd. (upper and lower segments), m. biceps fem.

activity in some thigh or leg muscles was observed in 34, although most of them had difficulty in drawing up the lower limb and could do so only very slightly. In the other 16 patients, activity in the thigh and leg muscles was absent at the first or second examination. Only in eight of these could activity eventually be recorded 2-3 years later, in the form of grouped potentials of low (under 50 μV) and average (from 50 to 200 μV) amplitude.

The third indicator of residual continuity of the spinal cord was the appearance of activity in symmetrical muscles of one limb during attempts to draw up the other limb, i.e., a synergistic response assisting with the movement. It began simultaneously with activity in the working muscle or preceded it, preparing the muscular system for movement [1]. In the case of anatomical loss of continuity, as a rule such activity was absent. Even if it did appear in a few such cases, delay in its appearance in the muscles of the contralateral limb was observed [6]. In 30 of the 50 patients, activity consisting of an EMG of low amplitude was recorded at the first examination in the symmetrical muscles of the opposite lower limb (Fig. 3a). In four patients it appeared at the second examination. Activity of this sort was absent at both examinations in the 16 patients in whom no activity was recorded in the thigh and leg muscles or delay of activation of the lower segments of the trunk muscles was observed (Fig. 3b).

In all 16 patients with negative results of assessment of motor activity in accordance with the suggested indices, the functions were restored entirely by compensation; in no case was recovery of voluntary limb movement observed. Activity of the muscles responsible for walking appeared only as a result of the development of new reflex responses.

Signs of restitution of functions were observed, however, in most of the patients in whom at least one of these indices was positive.

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