FUNCTIONAL CHANGES IN THE PERIPHERAL MOTOR APPARATUS OF THE HUMAN ASSOCIATED WITH THE PAIN SYNDROME

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Changes that occur in the organism in connection with the action of nociceptive stimuli are one of the intrinsic characteristics of a pathological process. However, up until now they have not been adequately studied. Changes in the central nervous system related to pain are reflected most directly in the state of the peripheral motor apparatus. The literature contains evidence that pain may accompany an elevation in the tonus of certain muscle groups [1, 9], so called algal or reflex contractures [3, 4], as well as diffuse, subordinate or adaptive-trophic changes in the neuromuscular units.

The purpose of this work was to investigate the functional changes in the motor apparatus associated with pain, and not demonstrated by the usual clinical observations.

EXPERIMENTAL METHOD

In this project we used two procedures: 1) electromyographic investigation of the activity of muscles related, in their innervation, to the focus of pain impulsation, and 2) investigation of the subordinate changes in the excitability of muscles not linked with the site of the pain.

Three groups of patients underwent the electromyographic investigation: 1) patients with lumbar pains (mainly secondary lumbosacral radiculitis); 2) patients with joint pains (in the majority of cases, polyarthritis); 3) patients with headaches (sequelae of cerebral arachnoiditis and residual symptoms of tubercular meningitis). Control investigations were carried out on healthy, adult individuals. In each case, we studied the electrical activity of those muscles which were most closely related to the focus of the pain impulsation in their innervation, namely the sacrospinalis muscles in the case of lumbar pain, the muscle antagonists of the painful joint in the case of extremity joint pains, and the occipital, frontal, and trapezius muscles in the case of headaches.

The electrical activity of these muscles was studied at various positions of the body, using all poses which, under normal conditions, are not accompanied by activity of these muscles. Specifically: the electromyogram of the sacrospinalis muscles was recorded with flexion of the torso in the standing position, of the antagonist muscles of a painful joint, with slight, active shift in the position of the extremity; and of the head and neck muscles, with no facial expression or masticatory movement in the lying and standing position and with the head and torso bent.

The muscle potentials were conducted by superficial electrodes (100 microvolt amplification, corresponding to 18 mm) and recorded on a loop oscillograph.

EXPERIMENTAL RESULTS

The activity of the sacrospinalis muscles was investigated in 41 patients complaining of lumbar pain, and in 13 healthy subjects.

The bioelectric activity of these muscles was recorded in the standing position both in the patients and in most of the healthy individuals. Marked differences appeared in the electromyogram of the patients and healthy subjects when they held the position with flexion of the torso. In this pose, there was no electrical activity of the sacrospinalis muscles in 12 out of the 14 healthy people (Fig. 1a). Out of the 41 patients, in the flexed pose, 36 showed

electrical activity of the sacrospinalis muscles. Thus, with lumbar pains we observed an inversion of the coordination relationships during movement of the vertebral column: with flexion of the vertebral column, there was either the appearance, or the strengthening, of activity in the extensors of the vertebral column. Electrical activity of the sacrospinalis muscles in the flexed torso position was absent in only 5 patients, and in those cases, they did not complain of pain at the time of the investigation.

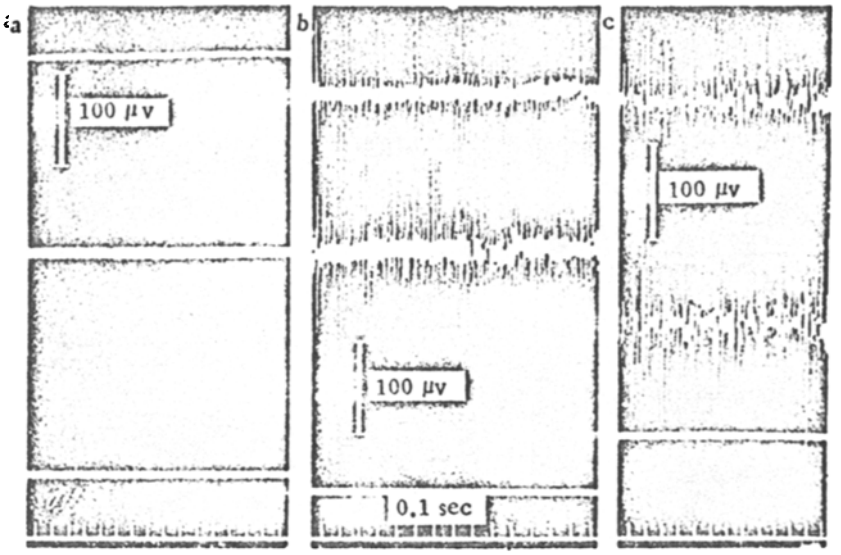

Fig. 1. Electric activity of the sacrospinalis muscles with flexion of the torso. a) In healthy woman D.; b) in patient C.; c) in patient P. Meaning of the curves (from above downward): electromyogram of the right sacrospinalis muscle; electromyogram of the left sacrospinalis muscle; zero line; time markings (0.1 second).

In the patients with lumbar pains, certain characteristics in the electromyogram of the sacrospinalis muscles were noted in a number of cases, which were absent during voluntary action of these muscles in the healthy subjects; in particular, their activity sometimes appeared like needle-shaped bursts of the fasciculation type against the background of normal, asynchronous activity of lower amplitude (Fig. 1b); not infrequently the activity appeared in volleys, i.e. involved alternation of groups of impulses with periods of bioelectric inactivity (Fig. 1c); in a number of the cases it was possible to distinguish wavelike fluctuations in the amplitude of the impulses, at a rhythm of 3-6 fluctuations per second (see lower curve in Fig. 1b).

The electromyographical investigation of the muscles functionally related to the painful joints (18 patients and 9 healthy subjects) demontrated that in many patients the muscle antagonist manifests electrical activity even with slight shifts of the pose which are normally not accompanied by this activity. Instruction to increase the movement resulted, in a number of the patients, in intensification of the activity within the antagonist; in this case, the antagonist's electrical activity was usually diminished. We often noted characteristics in the electromyogram that were analogous to those described in association with the lumbar pains.

Electromyographic investigation of the occipital, frontal and trapezius muscles in 25 patients who had suffered cerebral arachnoiditis, and in 23 patients with residual symptoms of tubercular meningitis, showed the electrical activity of these muscles to be quiet in the majority of patients (34 of 38) that complained of headaches during the investigation (Fig. 2b, c and d). There was no bioelectric activity with these muscles at rest in any of the healthy subjects (Fig. 2a), nor in 7 of the 10 patients that did not complain of headache during the investigation. We often observed a definite parallel relationship between the intensity of the headache and the magnitude of the investigated muscles' electrical activity. Thus, with increase in the pain related to flexion of the head, the amplitude of the biocurrents in the electromyogram of the occipital or frontal muscles was seen to increase (see Fig. 2b). Also, if during an attack of headaches there was electrical activity in the occipital muscle, then several days after cessation of the attack the electrical activity of this muscle disappeared (see Fig. 2c).

With the headaches, we often observed the same characteristics of the electromyogram as those which distinquished the corresponding tracings of the electrical activity in the sacrospinalis muscles during lumbar pains, and in the muscles of the extremity during joint pains.

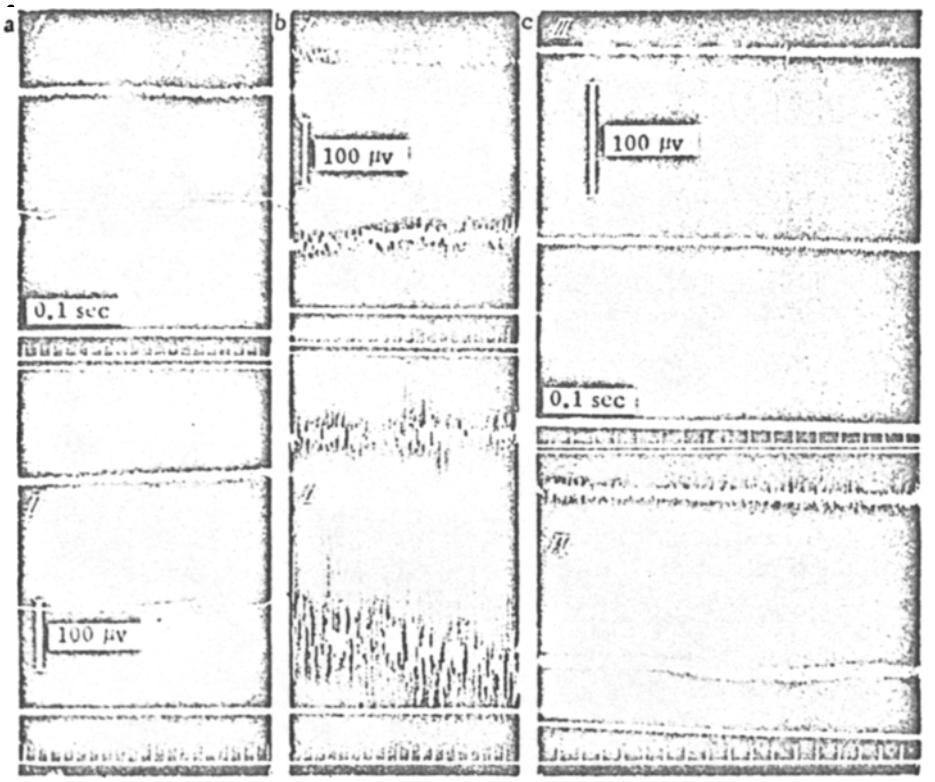

Fig. 2. Electrical activity of the occipital and trapezius muscles. a) In healthy woman D.; b) in patient Ch.; I) in the lying position; II) with flexion of the head and torso; c) in patient R.; III) not during an attack; IV) during an attack. Meaning of the curves (from above downward): electromyogram of the occipital muscle; electromyogram of the trapezius muscle; zero line; time markings (0.1 second). In Fig. 2a, the electromyogram of the trapezius muscle is not shown.

Thus, muscles that are related to a focus of pain impulsation by their innervation manifest electrical activity in those positions in which such activity is not observed in healthy subjects. In a number of the cases, this activity may be regarded as an electrical expression of defense reflexes, securing a painless position.

The electromyogram characteristics noted above, similar to those described in the literature with diseases of the motor centers [8], probably indicate an alteration in the functional state of the motor neurons, which, in these patients, may be a result of constant pain impulsation.

It can be postulated that in the origin of the characteristics of electrical activity, noted in the pain syndrome, in muscles related to the focus of injury, a decisive role is played by the change in the functional state of the nerve centers, particularly the centers connected to the focus of the lesion and the investigated muscle group in a single reflex circuit.

In the second series of experiments, we investigated the subordinate changes in the excitability of the peripheral neuromuscular apparatus, arising secondary to pain and reflected in muscles that are not connected to the anatomical region of the pain site, i.e. with lumbar pains and joint pains, we investigated the subordinate changes in excitability of one of the wrist muscles.

After the baseline strength-duration curve was determined for the abductor brevis muscle of the thumb, we applied the so called pain dose (i.e. movement, which in the case of a marked pain syndrome caused pain; this

was flexion of the vertebral column or the LaSegue test with lumbo-sacral radiculitis, movement of the painful joint with polyarthritis, etc.), and then immed-ately after reassumption of the initial pose we again determined the strength-duration curve.

In this series of experiments, we investigated 35 patients with lumbar and joint pains, and 14 healthy subjects.

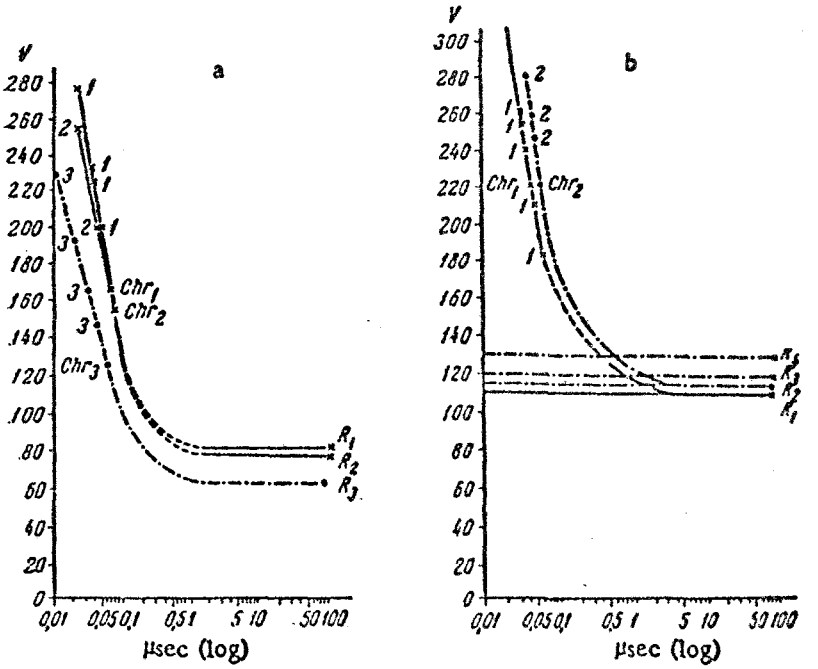

Fig. 3. Effect of an adequate "pain dose" on the strength-duration curve (endogenous pain). 1) Baseline curve of the abductor brevis of the thumb; 2, 3, etc) curves of the same muscle in consecutive moments after application of the "pain dose". Strength of the stimulatory current is shown on the ordinate; the abscissa shows time on a logarithmic scale; a) in patient K. (secondary lumbo-sacral radiculitis with moderate pain syndrome); b) in patient Z. (polyarthritis with mild pain syndrome).

In the healthy individuals, the movement serving as the "pain dose" did not cause threshold changes exceeding 2-4 v. With the marked pain syndrome, we always observed more significant shifts in the strength-duration curve. In 86% of the cases, they were directed downward and to the left (Fig. 3a). With mild pain syndrome, some cases did not show any marked changes in the thresholds, while in others the shift in the curve was directed upward and to the right (Fig. 3b).

A supplementary series of experiments with the effect of artificial pain stimulation of varying intensity (pressure on the shoulder of the arm not being used for the excitability determination, using the cuff of a tonometer, for 1-3 minutes), performed on healthy subjects, showed that a weak pain stimulus (pressure of 190-210 mm Hg was regarded as "painful") caused an elevation of the thresholds; stronger stimulation (pressure of 300 mm Hg – "very painful") was accompanied by lowering of the thresholds. Thus, these experiments definitely supported our hypothesis on the relationship of direction of the threshold changes to the severity of the syndrome.

Comparing the data pertaining to the direction of the subordinate shift in muscle excitability, associated with varying degrees of severity of the pain syndrome, with the data in the literature on the character of subordinate shifts in the motor chronaxis seen with these or other changes in the functional state of the nerve centers [2, 6, 8, 10], it may be concluded that, in our observations, the motor analyzer in the case of marked pain syndrome was in an excitatory process as a result of the "pain dose;" while in the case of the mild pain syndrome, it was in a state of inhibition. The basis of this fact is probably the following. With weak pain or the absence of painful sensation, our pain dose had to act as an indifferent stimulus of average strength, causing external inhibition or, in other words simultaneous negative induction in the larger mass of nerve cells [5]; this probably caused the lowering of the muscular

excitability (threshold elevation) under the influence of the "pain dose," seen with the weakly manifested pain syndrome. Elevation of the excitability (lowering of the thresholds) of the peripheral motor apparatus with the marked pain syndrome was probably related to the fact that the "pain dose" in this case caused excitation of the reticular formation, which resulted in a general elevation in the excitability of the cerebral cortex. This conforms with the changes observed by P. K. Anokhin et al. in the activity of the reticular formation subsequent to the action of a painful stimulus.

It was characteristic that a decrease in thresholds under the influence of the pain doses occurred in the majority of cases, specifically, in those patients whose electromyograms showed an increase in the activity of the sacrospinalis muscles in the bent vertebral column position, as well as the structural peculiarities in the tracings that were described above.

Thus, marked pain syndrome, as a rule, was accompanied by diffuse elevation of the peripheral motor apparatus excitability, a change in the coordination relationships, and alteration of the electromyograms from muscles related to the focus of pain impulsation by their innervation.

SUMMARY

Electric activity was detected (in a number of cases with peculiarities of the electromyogram, connected according to literature data with disturbed functional state of corresponding motor centers) in the sacro-spinosus muscles of patients with lumbar pains, in the occipital muscles of patients with headaches, and in the muscles-antagonists of extremities in cases with articular pain (in positions, which in usual conditions are not associated with the activity of these muscles). In cases with pain in the lumbar region and joints a study was made of subordinate shifts occurring in the curve strength – duration of the peripheral motor apparatus under the effect of "pain test" (movements causing pain in cases with a marked pain syndrome). The pain test was accompanied by a threshold reduction in 86% of cases with marked pain syndrome, whereas in mild pain syndrome the thresholds either increased or remained unchanged in 88% of cases.

LITERATURE CITED

1. A. M. Grinshtein, Vrach. delo, No. 19, col, 1411; No. 20, col. 1505 (1927).
2. O. A. Mikhaleva, Theses from the Reports of the 5th Conference on Physiological Problems [in Russian]. Moscow-Leningrad, p. 54 (1939).
3. D. A. Novozhilov, Some Questions on Problems of Pain in Traumatology and Orthopedics [in Russian]. Leningrad (1958).
4. L. A. Orbeli (edit.), Collected Articles on Military Medicine [in Russian]. Moscow-Leningrad, No. 2 (1945).
5. I. P. Pavlov, Lectures on the Work of the Greater Hemispheres of the Brain [in Russian]. Moscow-Leningrad, (1927).
6. A. F. Popova, citing Yu. M. Uflyand, Theoretical and Practical Aspects of Chronaximetry [in Russian). Leningrad (1941).
7. Yu. S. Yusevich, Electromyography in the Clinical Handling of Nerve Disorders [in Russian]. Moscow (1958).
8. B. Chauchard, B. Chauchard, and P. Chauchard, in the book: Problems in Biology and Medicine [in Russian]. Moscow-Leningrad, p. 50 (1935).
9. C. Göpfert, Dtsch. Zahnärztl. Z., Bd. 11, S. 76 (1956).
10. M. C. R. Lapique, Soc. Biol. Vol. 111, p. 957 (1932).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
