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The Effectiveness of Electrical Muscle Stimulation in Peripheral Neuropathies of the Upper and Lower Limbs

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Abstract: This article is devoted to the study of the effectiveness of electrical stimulation of muscles in peripheral neuropathies of the upper and lower limbs. The article discusses effective methods of identifying patients with electrical stimulation of muscles and their treatment, identifies problems and shortcomings.

Keywords: Muscle stimulation, limbs, stimulation methods, electrical stimulation, nerve trunks.

Introduction

Restoration of the functionality of the limb, as well as the treatment of pain syndromes caused by trauma to the peripheral nerves, still remains a difficult, unresolved issue. “In recent years, along with the improvement of surgical treatment of patients with lesions of peripheral nerves, stimulation methods are increasingly being used, including direct electrical stimulation of nerve trunks” [2, p. 118]. “The problem of restoring the working capacity of patients in recent years has acquired not only great clinical, but also social significance” [1, p. 522]. “In this regard, we can talk about the need to develop and implement new methods for the treatment of peripheral nerve injuries” [3, p. 86].

Materials and methods

Treatment of traction and traumatic injuries of the peripheral nerves of the upper and lower extremities by implanting epidural and epineural electrodes for subsequent electrical stimulation. In the postoperative period, combined simultaneous electrical stimulation was performed using electrodes and skin leads in the zone of autonomic innervation. The method allows you to install electrodes to stimulate the nerve trunks simultaneously with the implementation of osteosynthesis of bone fragments. Courses of electrical stimulation with low-intensity alternating electric current using the installed electrodes were performed daily for 14 days, 2 times a day for 15 minutes. The electrodes were removed in the dressing room after the end of the course of electrical stimulation. The dismantling of the Ilizarov apparatus was carried out during the consolidation of bone structures. Control examinations were carried out during the first year after discharge once every six months, then once a year.

Electroneuromyographic studies were performed using the Viking IIe digital system (Nicolet, USA). A number of "indicator" muscles were tested - muscles innervated by the affected nerve and reflecting the current functional status of the conduction structures. A bipolar type of lead with

standard electrodes was used. The indicators "average amplitude" (SA-EMG) and "repetition frequency" (FFR) of the total EMG were analyzed. Functional test - "maximum voluntary tension" in conditions of contraction of the examined muscle, close to isometric. The SA-EMG calculation was carried out using the MVA-test (Motor Voluntary Activity Test) program, which provides automated calculation of the MRV (Mean Rectified Voltage) indicator from fragments of EMG screen copies fixed in the computer memory with a duration of 0.2 s, registered at the peak of the development of the maximum arbitrary effort. Each muscle was tested when the patient performed two or three motor tests, while taking into account the maximum value of MVR, which was then multiplied by "2" in order to bring this indicator to the average amplitude of the total EMG not subjected to full-wave rectification. The oscillation repetition rate was determined by the visually calculated number of unidirectional peaks of the total EMG in 1 second. In addition, the method of stimulation electromyography was used - registration of M-responses of "indicator" muscles. "Motor responses" of the muscles were recorded unipolarly ("belly-tendon" lead). The stimulus duration was 1 ms, the intensity was supramaximal. The analyzed indicator is the amplitude of the M-response (A-MO), estimated "peak to peak".

From 2011 to 2022, 330 people with traumatic injuries of peripheral nerves were treated in the neurosurgical department, who underwent puncture direct electrical stimulation (I group of patients). Patients with traumatic damage to the peripheral nerves of the upper extremities 228 (69.09%) prevailed. 102 (30.91%) patients had neuropathies of the nerve trunks of the lower extremities. The age of the patients varied from 5 to 75 years, patients of working age aged 18-60 years (67.58%) prevailed, including 238 men (72.12%), 92 women (27.88%).

There were 97 patients (29.40%) with complete conduction disturbance according to the classification developed at the Military Medical Academy named after S.M. Kirov, these patients are classified as type 2 - neuropraxia (according to the classification of I.N. Shevelev (1990), based on the proposed classification of H. Seddon (1942), with partial conduction disturbance in 233 patients (70.61%) according to classification C .M. Kirov, patients with deep conduction disturbances prevailed, in whom muscle strength was estimated at no more than 1-2 points (according to the international six-point scale proposed by R.B. Zachaty, W. Holmes, 1946), electrophysiologically in these patients, in some leads, insignificant potentials, the "intensity-duration" curve determined the reaction of muscle degeneration.In case of partial conduction disturbance, 94 (28.48%) patients complained of pain in the affected limb.In 93.03% of cases (307 patients) patients complained of decreased sensitivity from anesthesia in the zone of innervation to hypesthesia and hyperpathia (S0 - S3 according to the classification

R.B. Zachaty, W. Holmes). All patients were concerned about the limitation of active movements on the part of the injury.

In group II patients (80 people) with combined damage to the nerve trunk and tubular bone, electrode implantation was performed simultaneously with osteosynthesis. Among the patients, persons of working age from 18 to 60 years prevailed. There were 31 (38.75%) patients with complete conduction disturbance, 49 (61.25%) with partial conduction disturbance. The degree of damage to the nerve trunk was assessed according to MRI/CT. Patients of this group also complained of pain, weakness and limitation of active movements in the arm or leg in the side corresponding to the fracture. Decreased sensitivity bothered 76 (95%) patients, 34 (42.5%) patients complained of pain in the affected limb upon admission (the score corresponded to group I).

Discussion and results

The results of treatment were studied in the control period of 6 months to 8 years after treatment. After treatment, an assessment of the neurological status in patients of group I showed that the pain syndrome was completely relieved in 92 of the 94 patients who had previously noted pain, 209 people (63.33%) noted increased paresthesia in the area of nerve innervation after electrical stimulation; sensory disorders in the innervated dermatome were assessed by the presence of hypesthesia without hyperpathy (S4 according to the classification of R.B. Zachaty, W. Holmes). The intensity of the pain syndrome according to the visual analogue scale (VAS) before the start of

treatment was estimated by patients at 7.7; as a result of the therapy, the intensity of the pain syndrome decreased to 1.6.

The dynamics of muscle strength was assessed using the R.B. Zachaty, W. Holmes. Complete regression of movement disorders (M5) was noted in 178 patients (53.94%), 76 patients (23.02%) had moderate limitation of movements (M2-M3) and 70 patients (21.21%) had a slight limitation of the volume of active movements (M4), without dynamics - 6 patients (1.83%). When characterizing the motor function, the angles of movements in the joints, the deficiency of flexion, extension, and the performance of various types of grip were studied. The study of sensory changes was based on the assessment of tactile, pain, temperature and muscle-articular feelings.

In the analysis of EMG with neuropathies of peripheral nerves before surgery, the amplitude of M-responses, which depends on the number of activated muscle fibers and the synchronism of their excitation and reflects the degree of preservation of the conduction of excitation along the motor fibers of the peripheral nerve, was reduced on average in the considered leads from the "indicator" muscles of the affected limb by 81.1±4.2% (in the range of 14.4-99.7%; $p<0.001$) of the normative level. The average amplitude of the total EMG, proportional to the magnitude of the voluntary effort developed by the muscle, was reduced by 73.6±3.5% (20.0-98.5%; $p<0.001$), and the frequency of oscillations, which determines the so-called . "EMG pattern", by 49.5±3.7% (10.4-86.9%; $p<0.001$). Qualitative analysis of arbitrary EMG revealed that in cases of maximum reduction in the frequency response, myograms already belonged to the “reduced EMG” type. It should be noted that evoked and/or voluntary muscle bioelectrical activity was absent in a number of patients in some leads. At the end of the course of treatment, the amplitude of motor responses of the muscles of the affected limb increased by an average of 36.0%, SA-EMG increased by 21.2% ($p<0.001$), and the oscillation frequency increased by 24.8% ($p<0.001$) . In a number of cases, the appearance of a minimal arbitrary myogram (20-60 μV) was noted in leads in which there was no initial bioelectrical activity.

During the first year after completion of treatment, the amplitude of M-responses was characterized by pronounced positive dynamics - up to a 4-fold increase ($p<0.01$) of the indicator. The SA-EMG values increased by 180.1% compared to the previous period of examinations ($p<0.001$), and in relation to HR at this stage, signs of stabilization of the indicator were noted. In addition, in some leads and during these periods of examination, the appearance of the minimum amplitude of voluntary and evoked (M-responses) bioelectrical activity was recorded, which could not be recorded before the patient was hospitalized and immediately after the end of the rehabilitation course, which also indicates the increasing effect of this method of electrical stimulation. months after completion of treatment.

In the long-term period, during the second year after the completion of the course of treatment (“control 2”), multidirectional dynamics of the parameters under consideration was observed, consisting both in a continuing increase in values, and in their stabilization or decrease. The results were considered good when sensory disorders disappeared, motor function was restored, pain syndrome was stopped, the appearance of paresthesia was noted, and patients returned to their professional activities. Satisfactory - results with incomplete recovery of motor function and discrimination sensitivity, patients changed working conditions or profession. In the absence of pronounced positive dynamics after treatment, the results were assessed as unsatisfactory. Good results of treatment were obtained in 76.96% of cases, unsatisfactory - in 23.04%. Unsatisfactory results are associated with the severity of damage to the peripheral nerve (type 3-5 according to the classification of I.N. Shevelev), patients with unsatisfactory results of treatment were offered a delayed nerve suture, various options for autoplasty

Conclusion

The results obtained allow us to conclude that direct electrical stimulation of nerve trunks with low-intensity alternating electric current with a combined effect on damaged structures is effective.

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