DIRECT ELECTROSTIMULATION AND HYPERBARIC OXYGENATION IN SURGICAL TREATMENT OF NERVE-INJURED PATIENTS

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Purpose: The results of surgical treatment of the nerve-injured patients frequently remain unsatisfactory, especially in combined nerve and vessel damage. To improve the quality of axons regeneration and functional restoration of the extremity direct electrical stimulation and hyperbaric oxygenation were carried out.

Methods: Hyperbaric oxygenation was exerted for 40 minutes with the oxygen pressure within the camera increasing to 1.7 to 1.9 ata (1).

Dynamic nerve blood flow was studied using hydrogen clearance method (2,3). For this purpose a platinum microelectrode was implanted subepineurally during the operation using the operation microscope. The electrode was fixed to the epineurium with a thin thread and passed through a special hole onto the skin. An indifferent silver electrode was placed subcutaneously. Proximal ends of both the electrodes were left above the dressing. To study the nerve blood flow both the electrodes were joined to the polarograph. The patient inhaled the air mixed with hydrogen for 2 to 3 times. Hydrogen was moved towards the platinum electrode by blood flow, which was recorded by the polarograph as a rise of the curve. Tissue hydrogen clearance is ruled by the exponential law and determined by blood flow velocity. Using the nerve tissue hydrogen clearance curve, the nerve blood flow can be calculated as ml/min/100 g.

To evaluate nerve conduction we used a 5-point method of clinical estimation of sensitivity of corresponding cutaneous areas, and strength of corresponding muscles (4). This method has been successfully used in Russia for a long time, both for clinical and scientific purposes. All the patients demonstrated the syndrome of considerable nerve conduction disturbances preoperatively, which served the indication for surgical intervention, i.e. neurolysis. Besides, the patients were subjected to electrical diagnostic studies comprising the estimation of muscular electrical excitability and the intensity over duration curve. Presence of muscular electrical excitability served the indication for surgery. Absence of excitability means total replacement of muscular tissue by the connective one that no operation on the nerves can help. Never the less, 15 patients in whom muscular electrical excitability was absent were subjected to hyperbaric oxygenation procedure followed by repeated electrophysiologic study that revealed the presence of electrical excitability, previously not obvious. This served the indication for surgery.

Electrical stimulation was performed bipolarly via the same pair of platinum electrodes implanted to estimate blood flow. The following current characteristics were used: impulse frequency - 20 to 50 Hz, impulse duration - 1 to 5 msec, strength of the current was determined according to the patient's sensation (the
threshold of pain sensitivity), 5 mA usually. The duration of a session was 10 minutes, once a day.

Results: Direct electrical stimulation exerted opposite influences upon blood flow. The analysis of this effect revealed that if the basic blood flow was low, electrical stimulation resulted in the increase of the latter, if it was high - in its decrease. The results of the study were processed mathematically, and mean basic blood flow was found for each stimulated patient for the entire period of the study. Then the effect of stimulation was estimated for low basic blood flow (lower than mean) and high (higher than mean). The results obtained demonstrated that in low basic blood flow electrical stimulation resulted in the increased blood flow in all the nerve portions (Fig. 1), with maximal effect in the neuroma area.

![Fig 1.](image1)

In high basic blood flow the stimulation resulted in decreased blood flow (Fig 2). Thus, electrical stimulation appeared to be of "normalising" influence.

![Fig 2.](image2)

After the complex treatment comprising surgery (neurolysis of the injured nerve), direct electrical stimulation, hyperbaric oxygenation and traditional therapy, i.e. group B vitamins, proserin, vascular dilatation drugs, all the patients demonstrated amelioration of nerve conduction by 1 to 3 point, which helped gain functionally useful results. The control group patients (35 cases) were subjected to
trunk neurolysis followed by traditional therapy, i.e. group B vitamins, proserin, vascular dilatation drugs. Neither electrical stimulation, nor hyperbaric oxygenation were performed. In this group nerve conduction ameliorated by 1 to 2 points in 32 of 35 patients. Statistical analysis revealed restoration of nerve conduction to a fuller extent in the main group of the patients as compared to the control one (Fig 3).

Fig 3.

Thus, hyperbaric oxygenation and direct electrical stimulation make it possible to improve the results of surgery for nerve injury. Ameliorated blood flow in the injured nerve trunk seems to be a possible mechanism of electrical stimulation influence. Blood flow velocity was compared in the nerves with conduction restored to 1 to 2 points and to 4 to 5 points (fig 4), which revealed a higher blood flow in the latter (4 to 5 point) (p < 0.05).

Fig 4.

We may suppose that hyperbaric oxygenation as if makes the muscle ready to contract by mobilising the contractile resources due to ameliorated microcirculation, tissue respiration and metabolism in the intact muscular fibers. This can be proved by the "hidden" electrical excitability of the denervated muscles. Besides, we consider that hyperbaric oxygenation, as well as direct electrical stimulation, can ameliorate microcirculation in the injured nerve trunk.
Reference.
REHABILITATION OF NEUROSURGICAL PATIENTS USING PHYSICAL STIMULATION

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Functional disturbance as the complication in neurosurgical patients is conditioned by the disease, proper, and by surgical intervention often deteriorating pre-existing neurologic deficit. Absence of adequate rehabilitation measures result in increased severity of denervation and prolonged, "flacid" period of (5). Time-taking process of neural regeneration requires optimized therapeutic measures, with a greater range of physical therapy procedures (2). Perspective are: electric stimulation (6), magnetic stimulation (3), laser therapy (4), extremely high frequency therapy (1). Yet, stimulation of the lesioned fragment of the nervous analyzer cannot mobilize the reserves of regeneration totally.

We have elaborated a rehabilitation program for neurosurgical patients suffering different-level neural lesions using physical stimulation ensuring more complete earlier restoration of the disturbed functions due to optimized technology of utilization of therapeutic physical factors.

321 neurosurgical patients aged 1 to 63, suffering traumatic (155 cases), vascular (64 cases), oncologic (58 cases), and others (44 cases) nervous system diseases served the material. According to the level of the lesion and the character of the main neurologic deficit the patients were grouped as follows: functional orbital nerve disturbance - 30 cases, mimic paresis - 23 cases, bulbar paresis - 5 cases, spastic hemiparesis - 57 cases, lower paraparesis - 45 cases, flacid extremity monopareses - 78 cases, aphasias - 22 cases, epileptic syndrome - 61 cases.

Multilevel magnetic and electric stimulation was used to rehabilitate 194 patients with palsies and pareses, aphasias, and functional orbital nerve disturbances. The method comprised acupuncture drug injection of the denervated organ to correct excitability-contractility followed by apparatus stimulation. The first level
- magnetic stimulation of the lesioned cortical centers, the second level - magnetic stimulation of the spinal cord neurons and nerves (spinal, cranial) in the osteofibrous tunnels. The third level - electric stimulation of the peripheral portion of the lesioned neural analyzer and denervated organ, particularly of the distal portions of the related organ (the right wrist in aphatic patients) using sinusoidal modulated current, the parameters chosen considering the state of excitability of the neural-receptory apparatus. This kind of stimulation makes it possible to mobilize the resources of excitability and conductivity of the disturbed neural analyzer within its whole length, and contractility of the paretic muscles, desimpede the areas of functional asynapsia in the central nervous system.

Scanning laser stimulation was used to ameliorate metabolism and to fill up the energy expenditure in the conditions of restricted reserves in rehabilitation of 164 patients with palsies and pareses, aphasias and functional orbital nerve disturbance. He-Ne laser was used (3 mm beam diameter, 0.63 mkw wave length, 20 mW power), scanning frequency 0 to 200 Hz within the figures adapted to the form of the surface irradiated, upon the cutaneous projections of the nerves and vessels, and the distal receptory fields. The figures of scanning, such as "Lissague", The spiral of Archimedes", "Standing line" were modulated. The scanning laser influence upon the adapted fields with the frequency physiologic for the neuroreceptor apparatus elicited the desired stimulation effect to ameliorate trophic processes, to myelinize nerve conducters, to increase neural growth factor production.

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months, restoration of distal muscular function and minor finger movements - within 6 to 12 months.

Millimeter radiowave stimulation was used to rehabilitate 61 patients suffering epileptic syndrome and disturbed bioelectric brain activity. Both the palmar and both the plantar surfaces were influence by extremely high frequency electromagnetic field (5.6 and 7.1 mm wave length), energy stream density 10 mW/sq.cm under electroencephalographic monitoring. Clinical diminution of number and intensity of epileptic seizures, control of asthenic syndrome were demonstrated. Considerable reorganization of bioelectric brain activity was observed in the process of treatment and during several months after it, with diminution of paroxysmal phenomena and complete disappearance of them, restoration and normalization of the main rhythm absent before the treatment. Epileptic syndrome was controlled clinically. The rest of the patients demonstrated similar results, as well as amelioration of related motor and speech disturbances.

Thus, the program of rehabilitation of neurosurgical patients using the methods of physical stimulation proposed by us can help shorten the period and increase the quality of treatment of the patients with different level lesions of the nervous system. Nervous tissue regeneration was stimulated and metabolic and energy resources were ensured through the influence by specific physical factors upon the lesioned neural analyzer throughout its length, from the forming centers to the denervated organ, as well as the use of corrective possibilities of each factor and specific fields of influence.

Reference.