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Use of Information and Communication Technologies in Motor Rehabilitation of Patients with Stroke

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ABSTRACT

Stroke is an acute violation of cerebral circulation, which is one of the main causes of disability and mortality in the population. In addition to its unconditional medical and social significance, a stroke also brings colossal economic damage. For example, in the United States, costs associated with the treatment and rehabilitation of patients with stroke, as well as economic losses associated with disability, amount to 6.5-11.2 billion dollars per year. The problem of stroke is especially urgent in the Russian Federation, where 450 thousand cases of strokes are registered annually and for every 100 thousand of the population there are 600 patients with the consequences of stroke, of which 60% remain disabled [2, 9].

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INTRODUCTION

Currently, significant advances have been made in the prevention, diagnosis, treatment and prevention of ischemic stroke, which have made it possible to significantly reduce mortality and improve the prognosis of recovery. The concept of pathogenetic heterogeneity of ischemic stroke has become the basis for a differentiated approach to treatment and primary / secondary prevention. Treatment of patients with ischemic stroke includes the following aspects: general measures, reperfusion therapy, secondary prevention and rehabilitation, symptomatic therapy, relief of complications [4, 8].

All patients who have had an ischemic stroke or a transient ischemic attack are shown secondary prevention of recurrent cerebrovascular accidents [16]. The specific list of preventive measures depends on the subtype of stroke. In all cases, correction of risk factors is necessary, first of all, normalization of blood pressure, compensation of diabetes , lifestyle changes (cessation of smoking, alcohol abuse, adequate diet, etc.) [10]. Currently, the postponed ischemic stroke is considered as a direct indication for the initiation of statin therapy [11]. Antiplatelet agents, in particular acetylsalicylic acid, are currently the basis of secondary prevention [5]. Dipyridamole or clopidogrel is prescribed for intolerance to acetylsalicylic acid, as well as if a stroke develops while taking it. In the case of cardioembolic stroke, the use of indirect anticoagulants (warfarin) is permissible [7, 14, 15, 19].

The basic principles of rehabilitation of patients who have suffered a stroke include the early start of rehabilitation measures with the activation of the patient, a multidisciplinary organized approach, continuity, consistency and continuity at all stages of its implementation. In most cases (more than 80%), movement disorders (hemiparesis, monoparesis) determine the degree of disability, disability and impairment of everyday activity [17]. Rehabilitation of patients after a stroke is not limited to measures to restore only motor functions. Other disorders that necessitate rehabilitation include speech disorders (various aphasias) and other higher cortical functions, sensory disorders, dysphagia, visual impairments, etc. [22].

The neurophysiological mechanisms that allow the restoration of motor functions in patients with stroke are complex and diverse. In the early period (the first days and weeks after a stroke), the main importance is the restoration of the functional activity of morphologically preserved, but temporarily disorganized neurons located perifocal in relation to the lesion focus. This is possible due to such phenomena that develop in the first weeks after a stroke, such as resolution of edema, development of the collateral circulation system and restoration of perfusion of the affected area of the brain. In the future, the

neurophysiological basis of recovery is the processes of cerebral plasticity associated with the reorganization of normal physiological relationships between various brain structures involved in the implementation of this function. Collateral sprouting (proliferation of damaged fibers with the formation of new synapses), denervation hypersensitivity (receptors become more sensitive to neurotransmitters or increase in number), unmasking, in which resting neuronal connections are inhibited, but are activated after damage [21, 22].

ROBOTIC MECHANOTHERAPY IN THE REHABILITATION OF MOTOR FUNCTION

To robotic devices:

- for upper limb restorative treatment include:
  - MIT-MANUS
  - ARM Trainer
  - mirror-image motion enable (MIME) robot
  - Armeo
- to restore the lower limb:
  - Erigo
  - Lokomat
  - Lokohelp
  - Rehabot
  - Gait Trainer
  - Lopesandetc.

The most studied are the robotic systems Erigo and Lokomat (Hocoma, Switzerland). In order to facilitate the process of mobilization of patients with severe motor impairments, Hocoma (Switzerland) has created an Erigo upright table, which, unlike classic rotary tables, is equipped with an integrated robotic orthopedic device, which simultaneously allows the patient to be vertically aligned (from 0 to 80 degrees) to carry out intensive movement therapy in the form of passive dynamic movements of the lower extremities with the possibility of cyclic load on them. Intensive movements prevent the accumulation of venous blood in the lower extremities and prevent the development of orthostatic reactions during verticalization of patients. patient to increasing physical activity, increases muscle strength, reduces pathological tone and begins the process of formation and restoration of the physiological walking pattern (Domashenko M.A., Chernikova L.A. 2008; Muller F. 2009). This simulator is a quick rehabilitation start, preparing patients for extended rehabilitation, as well as training on the Lokomat system, which is a weight-relieving treadmill with a robotic walking mechanism.

Currently, there have been many studies evaluating the effectiveness of robotic mechanotherapy in the rehabilitation treatment of motor function in comparison with conservative rehabilitation therapy.

Among the Russian studies, one can single out the works of KochetkovA.V. and co-authors, Makarova M.R., Preobrazhensky V.N., Lyadova K.V. (2008); ChernikovaL.A. and coauthors (2008); as well as our own studies (Daminov V.D. Rybalko N.V., Kuznetsov A.N., 2009), confirming the effectiveness of robotic systems in the rehabilitation of patients with CNS lesions [4, 6-8].

Mayr A, Kofler M, (2007) studied the effects of using the Lokomat system in 16 patients with post-stroke hemiparesis no more than 1 year old with different localization of the lesion and different etiology. The main group (8 patients) received 3 weeks of training on the Lokomat system, then for 3 weeks - the usual traditional therapy, and then again for 3 weeks - therapy using the Lokomat system. In the control group (8 patients), the sequence of application of traditional therapy and the Lokomat system was different. During the first 3 weeks, the patients received traditional rehabilitation, then within 3 weeks - the Lokomat system, and finally - again 3 weeks of traditional rehabilitation. The effects of the treatment were assessed using point scales and by such indicators of the Lokomat system as walking speed, the degree of unloading of body weight and the degree of decrease in the control effort by the Lokomat. A comparative study revealed the advantage of automated training on the Lokomat system in relation to traditional rehabilitation in terms of clinical indicators of gait assessment. The authors believe that training on the Lokomat system is especially useful in the early stages of recovery, when there are problems with balance, severe paresis, and instability of muscle tone [18].

The study Hidler J., Nichols D., (2009) evaluated the effectiveness of therapy using the Lokomat system in 30 patients with post-stroke hemiparesis with a stroke duration of 28 to 200 days. In addition to the generally accepted clinical scales, the assessment of walking was used using the Paromed Neubeuern system (Germany), the bioelectrical impedance of the soft tissues of the body was analyzed, muscle tone was assessed using the Ashforth scale and the activity of daily life using the Bartel index. The study showed that patients who received training on the Lokomat system increased the duration of single support on the paretic leg, which contributed to a more symmetrical gait, increased muscle mass and decreased the percentage of fat in the studied tissues. At the same time, there were no statistically significant differences in other measurements [14].

A multicenter study examined the effect of using the Lokomat system on the state of functional mobility in 20 patients with the consequences of a spinal cord injury 2 to 17 years old. The study was conducted in 5 rehabilitation centers (USA, Germany and Switzerland) for 2 years. It should be noted that, prior to training with the Lokomat system, 16 out of 20 patients could walk at least 10 m using walking aids. The workouts continued for 8 weeks 3-5 times a week for 45 minutes a day. The study showed that the use of the Lokomat system in patients with the consequences of spinal cord injury led to a significant increase in walking speed, endurance and improved performance of functional tasks. At the same time, no correlations were found between

the increase in walking speed and the degree of paresis and spasticity. It should also be noted that 4 patients who could not move before the start of training on the Lokomat system and did not regain the ability to move after the end of the 8 week training course.

Thus, robotic devices are currently beginning to occupy a certain important place in the complex rehabilitation of neurological patients with severe motor disorders of various etiologies, however, it seems that further research is required as to study effects, as to develop methods for using robotic systems. Most authors using robotic devices note that training on this system does not in any case replace the traditional healing gymnastics, should be applied in a complex with other rehabilitation methods. At the same time, it is emphasized that robotic mehanotherapy has significant advantages in teaching skills to walk patients with severe pares of various etiology [9,13,15].

One of the ways of improvement is a combination of robotic technologies with other methods of activation of neuroplasticity mechanisms (functional neuromuscular electrostimulation and stimulation methods of treatment affecting various levels of CNS).

The use of virtual reality technologies, simulating real conditions using computer techniques, makes it possible to achieve greater training efficiency against the background of sensory feedback. With the help of MRI, the reorganization of the activity of the motor cortex was confirmed when using virtual reality technologies for training walking [20,21].

REHABILITATION METHODS FOR NEUROLOGICAL PATIENTS

Physiotherapy is one of the main components of the complex of rehabilitation measures in the rehabilitation neurological department, one of the most important and effective methods of medical rehabilitation, which is widely used in diseases of the nervous system of various etiologies with various clinical syndromes, both in neurological and neurosurgical practice. This is determined, on the one hand, by the breadth of the effect of therapeutic physical exercises on various functional systems of the body: cardiovascular, respiratory, musculoskeletal, nervous, endocrine, and, on the other hand, by the training and restorative effect of these exercises in case of deficiency or insufficiency of various body functions.

Exercise therapy tasks can be divided into general and specific. Regardless of the nature of the disease, the complex of physiotherapy exercises includes exercises that have a general tonic effect on the patient's body, his emotional-volitional sphere, to improve the function of the central nervous system, blood circulation, respiration, trophics (general tasks). Particular tasks are determined by the nature of the disease, clinical syndrome, features of a functional defect, and the level of compensatory capabilities.

The main means of physiotherapy exercises are physical exercises used for therapeutic purposes. They are divided into gymnastic, sports (walking, running, swimming, etc.), exercises and games (sedentary, active, sports). Physiotherapy exercises also include work exercises and ideomotor (imaginary) movements with the mental sending of impulses to the limb.

Acupuncture, Su-Joktherapy. Acupuncture refers to reflex therapy methods. This is one of the oldest methods of influencing the biological active points of acupuncture. Acupuncture is based on a therapeutic effect on strictly localized, biologically active microzones (acupuncture points, BAP) located in the integument of the body. The essence of acupuncture lies in the effect on the body with a therapeutic purpose of different strength, nature and duration of irritations applied to the BAP. Acupuncture has a regulating effect on the functional state of the central nervous system, increases the excitability of nerve centers, improves the conduction of nerve impulses along peripheral nerves.

Electromyographic Biological Feedback Control Method. The EMG-biofeedback method represents a new direction in the complex of restorative measures for various neurological defects in patients with the consequences of stroke, TBI and other pathological conditions. The method is based on the conditioned reflex associative principle of formation of temporary connections in the brain and the formation of a new dynamic stereotype. The formation of new motor acts is accompanied by a restructuring of the biorhythmological activity of the brain with the creation or enhancement of the alpha rhythm and decreases the representation of the theta rhythm. The use of EMG-biofeedback contributes to an increase in the role of conscious control of the impaired function, which was not previously controlled.

Mechanotherapy. Mechanotherapy is a form of physiotherapy exercises, which is a system of functional treatment using various devices. Mechanotherapy devices are a variety of simulators specially designed in accordance with the biomechanical characteristics of movements in the joints, with the help of which it is possible to achieve directed motor tactics. The advantage of these simulators lies in the possibility of more accurate dosing of the load than when performing ordinary gymnastic exercises, as well as in limiting the dispersion of power actions, which ensures the concentration of efforts in the desired direction.

Virtual reality training aims to create a supportive environment for learning motor skills. The complex for creating virtual reality, in addition to a computer, includes numerous motion and position sensors, glasses with a liquid crystal monitor, where the image is directly transmitted. Exercises are carried out in specially designated rooms. Most often, using virtual reality, rooms with household furnishings and corridors are simulated, along which it is necessary to mix. The effectiveness of using the developed

systems for creating a virtual system in the process of rehabilitation of post-stroke patients and after craniocerebral trauma has been shown in small pilot studies, but they have not been tested in well-controlled clinical trials. Today's virtual reality systems are mostly based on visual effects, although future systems will also allow for tactile sensations. Some researchers prefer to use non-immersive (non-directional) training in virtual reality because of the easier tolerance and lower risk of side effects such as dizziness and nausea. For this reason, training in a virtual environment should be aimed at compensating for certain motor skills, since studies on healthy people have shown a loss of the effectiveness of complex exercises in virtual reality with the development of side effects [26].

Neuromuscular activation (NEURAC). Exercise on Redcord suspension systems also consists in restoring an optimal motor stereotype. This type of therapy is characterized by the performance of movements without pain, in the volume and at the level that is free for each individual patient, subject to the activation of deep muscles [23,24]. The method makes it possible to act practically in isolation on the muscle concerned (for the purpose of both relaxation and activation), gradually (stepwise) facilitate or complicate the performance of movements along the progression ladder (min → max → ∞). The work of the medical staff is facilitated, since no special physical efforts are required to fix the patient in any plane. The patient can independently perform movements (during individual and group training), but provided that the kinematically correct movement is maintained [23]. The main distinctive features of intangible assets in Redcord suspension systems (RSS): exercises in closed kinematic chains; unstable support created by suspension systems; three-dimensional training (3D training). One of the main elements used in the NMA method with the use of RSS is exercises in closed kinematic chains, in which a functionally appropriate load is used, multi-segment movements based on the stability of the trunk, and the cooperative work of the muscles of agonists and antagonists. These exercises activate a large number of motor units, due to which they act globally on the muscular system. Unstable support gives dynamic stability to the joints, stimulates mechanoreceptors and enriches motor development programs. Three-dimensional learning combines movements in all planes, forming functional motor stereotypes, improving coordination, balance and sense of one's own body [24,25,26].

Functional electrical stimulation. Various results have been obtained in the study of the effectiveness of functional electrical stimulation to improve motor functions after stroke. Both meta-analyzes and systematic reviews have found evidence of the effectiveness of functional electrical stimulation in the form of increased muscle strength in patients after stroke. A more definitive and large clinical trial is needed to prove the feasibility of using functional electrical stimulation in this category of patients. Functional electrical stimulation has also been combined with electromyographic biofeedback with quite successful results. When using this method, surface electrodes were placed over the muscles of interest, which recorded electromyographic activity, and electrical stimulation provided the necessary muscle tone for muscle contraction and "completion" of movement. Functional electrical stimulation was also combined with positional biofeedback: when a certain articular angle was reached, muscle stimulation occurred [17,26].

Transcranialmagneticstimulation. Currently, transcranial magnetic stimulation (TCMS) is considered as one of the promising methods of restorative treatment in patients with CNS pathology, including motor and other disorders after stroke.

The impact of rhythmic TCMS has the following therapeutic effects: directly activates intact motor neurons of the precentral gyrus, probably contributes to the formation of new synaptic connections; reduces the maladaptive effect of transsynaptic functional deactivation; causes a transient increase in regional cerebral blood flow; helps to reduce spasticity [10].

Botulinum toxin (Botox). Botox not only relieves wrinkles - it helps with migraines, nervous tics and sweating. For most of us, Botox is a way to get rid of wrinkles. Few people know that botulinum toxin type A (botulinum toxin, also known as Botox, Lantox, Xeomin, Dysport) is a drug that has been successfully used for several decades for the treatment of various diseases. Moreover, they began to use it not at all in cosmetology, but in neurology. What is botulinum toxin? Botulinum toxin is a purified toxin from a specific bacteria that causes botulism (severe damage to the nervous system). In fact, the main effect of this toxin is used in medicine - this substance disrupts the transmission of impulses from the nerve cell to other cells. Unlike botulism, with therapeutic injections, botulinum toxin has only a local effect, i.e. blocks impulses pointwise.

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