Conference Paper

Justification of a New Solution in the Field of Stroke Rehabilitation

B.S. Gareev and A.N. Kulemin

Ural Federal University named after the first Russian President B.N. Yeltsin, Russia, 620002, Ekaterinburg, street Mira, 19

Abstract

This research consists in the creation of a hardware-software complex for the rehabilitation of stroke patients. The device is designed for rehabilitation of patients after acute disorders of cerebral blood circulation with severe neurotraumas. The device is based on two existing rehabilitation technologies: the method of transcranial brain stimulation with the help of a magnetic neurostimulator, and the development of hand motility with the help of gloves. The combination of these two methods will allow patients to recover effectively, even at home, after they was suffering from neurotrauma.

Keywords: stroke, ischemic, rehabilitation, biofeedback, paresis, brain, computer, mechanized glove, hardware, and software complex, CNS diseases, integration, TMS, magnetic neurostimulator

Corresponding Author:
B.S. Gareev
Bogdangareev196@gmail.com

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1. Introduction

According to the World Health Organization, between 100 and 300 strokes are registered annually for every 100,000 people. In Russia, this figure is 250-300 cases among the urban population and 150-170 cases among the rural population. According to European researchers, for every 100,000 people, there are 600 patients with stroke consequences, of whom 360 (60%) are disabled.

Stroke ranks first among all causes of primary disability of the adult population (32 per 100,000 population). The most frequent consequences of strokes are motor disorders, which affect the mobility of patients and worsen their quality of life. More than 60% of people are unable to fully restore their arm and hand despite having completed rehabilitation courses), which leads to difficulties in everyday life [1].

Rehabilitation of patients with post-stroke motor disorders is one of the most difficult medical and social problems. Today, research on the use of new methods of recovery after a stroke, which is based on the use of the mechanism of neuroplasticity - the ability of nervous tissue to structurally and functionally reorganize [1], [2] - is becoming extremely relevant. At the same time, they have been shown to be effective in teaching

patients ”new motor skills” on the basis of individual plastic capabilities. There are data on the successful rehabilitation of patients with motor disorders using hardware-software complexes [3].

However, the question arises, which of the current methods are the most effective and accessible to patients. This article discusses the possibility of creating a universal concept that concentrates the best methods to achieve greater effect.

2. Overview of Scientific Sources

The purpose of this paper is to provide a scientific and technical review of publications on stroke rehabilitation with supporting elements, on the basis of which an innovative development will be put forward in the future, which in turn is also aimed at solving the problems of neurorehabilitation. This development, based on proven methodologies, will help a person who has had a stroke to recover more effectively.

To date, a person who has had a stroke has to face a number of limitations. First of all, it concerns the technical staffing of hospitals and clinics. Most of the medical facilities are unable to provide comprehensive rehabilitation due to outdated technologies and equipment, which makes treatment of such patients extremely ineffective. Only a few clinics are able to carry out rehabilitation on expensive foreign devices, but the cost of these courses is much inflated. Also, it is worth noting that one of the common problems is the lack of beds, and as a consequence, the inability to admit a patient to the hospital [4]. In addition, one should not forget about the late recovery period, when the patient is transferred to home treatment. In this period, the patient should be maintained after the course to avoid the possibility of a relapse. Accordingly, in order to maintain a person’s condition, it is necessary to use modern devices and technologies.

The following technologies were identified in the course of the scientific and technical review:

-robotic mechanotherapy;

-Biological feedback;

-Virtual reality;

-Neurostimulation;

Robotic mechanotherapy. One of the most common devices for human recovery after stroke is robotic mechanotherapy. The essence is that simulators allow passive development of movements in the upper and lower extremities. A clear advantage of such rehabilitation is the reduction of the burden on medical personnel. It has also been

proven that robotic mechanotherapy improves the muscular strength of the proximal parts and the functional outcomes of the upper limb [5]. However, it should be noted that the disadvantage of this technology is the lack of advantages over the same physical therapy as such.

Biological feedback. Biological feedback is one of the most popular technologies in neurorehabilitation. Thus, a person who makes certain movements of the hand in a sensory glove can control a computer game, thus training the point movements of the hand. The use of visual feedback significantly increases the efficiency of hand motor recovery [6]. But it is worth noting that even biofeedback is used in collaboration with other techniques.

Virtual reality. Immersion in the game by means of VR-devices allows making training more interesting. In various studies, their high efficiency was revealed [7]. In practice, biofeedback and virtual reality technologies are combined with robotic therapy. However, it should be noted that this collaboration is only of a superficial nature since only the brush's own motor skills are developed using these devices.

Neurostimulation. Neurostimulation is one of the most breakthrough and effective technologies for stroke rehabilitation, as it allows to influence the brain areas responsible for lost functions. Currently, the efficacy of transcranial magnetic stimulation (TMS) in a number of diseases is demonstrated. This is a non-invasive effect of a high-intensity (magnetic induction of more than 1.0 Tesla) pulsed magnetic field on the nervous system, accompanied by a pronounced response from brain structures and associated effectors. According to the literature, when exposed to a high-intensity magnetic field on the brain, in addition to improving the state of cells in the normalization of brain perfusion after 10-14 days, there are plastic regenerative changes of nervous tissue, and new synapses are formed. This method is based on the following therapeutic effects: activation or inhibition of cortical neuronal axons, change of cerebral blood flow, change of brain functional structures, an increase of neuroplasticity, activation of the limbic system. The efficacy of TMS has also been proved in the treatment of hemiparesis, neuropsychological abnormalities, speech restoration and swallowing [8].

However, it should be noted that the development of limbs requires not only a non-invasive effect on the brain area but also movements that accompany the development of the skill. Then, with the formation of new neural connections in the brain under the influence of the coil in certain areas, there will be stimulation of neuronal growth, which will provide further progress in rehabilitation.

Therefore, several conclusions can be drawn from all of the above methods:

- Many of the technologies are more effective if considered in collaboration with each other, as the properties of each of them can make a greater contribution to the recovery of the patient.

- An important aspect without which recovery is impossible is training, not only during the main period of rehabilitation but also afterward for further support in order to avoid relapse.

- Proceeding from the conclusions drawn and from the above-mentioned technologies, we can propose an innovative concept that will be really effective in rehabilitation after the trauma.

3. Development of a Hardware-software Complex for Stroke Rehabilitation

Today the world produces a huge amount of funds for rehabilitation of patients after a stroke. Among the total number of devices produced, at least two technologies stand out - the impact on the brain with the help of magnetic neurostimulator (TMS), as well as the restoration of fine hand motility using a glove-type neuro trained. The efficacy of transcranial magnetic stimulation (TMS) in a number of diseases has now been proven. This is a non-invasive effect of pulsed magnetic field on the nervous system, accompanied by a pronounced response from brain structures and associated effectors. Based on the data, acting in this way on the brain during the rehabilitation period, plastic regenerative changes of nervous tissue are observed and new synapses are formed. Active reorganization of the cortical motor representation is observed. The following therapeutic effects served as pathogenetic justification for the application of this method: activation or inhibition of cortical neuronal axons, change in cerebral blood flow, changes in the functional structures of the brain, increase in neuroplasticity. The efficacy of the recovery of fine hand motor skills using a glove-type has also been proved. Observational data show that restoration of fine hand motor skills sharply increases the level of use of the paretic limb, which has a positive effect on functional recovery and daily activity due to the increased intensity and duration of passive movements of the limb itself. For the first time, we will create a hardware-software complex, which combines the advantages of applying the effects of magnetic stimulation (TMS), as well as the restoration of fine hand motility using a glove. (Fig.1a, Fig.1b.)

After carrying out scientific researches, it was possible to design the design of the hardware-software complex, which can be used in home rehabilitation. A combination of two elements - a trainer for the development of motor skills, transcranial magnetic

Figure 1: Combined device consisting of a coil (TMS) and a training glove

stimulator, and formation of biologically active bonds, resulting from the collaboration, will allow people to recover more effectively and faster. Robotic devices will allow increasing, first of all, the intensity and duration of passive movements, and stimulation by means of biofeedback promotes restoration of brain integrative activity [9]. In addition, similar studies with a similar design were carried out by scientists from Canada in 2019, as a result of which it was found that this collaboration really helps people in recovery [10].

4. Conclusion

On the basis of the studies conducted, it can be argued that the combined use of the two technologies contributes to the regression of motor deficiency, improving daily activity. TMS reduces cognitive impairment, while mechanized therapy develops arm motor skills and biofeedback, which contributes to the formation of new neural connections. These two technologies are the most important link in the complex of neurorehabilitation activities as a method of restoring motor function.

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