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Correction of post-stroke cognitive impairments using computer programs

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ABSTRACT

Neurorehabilitation of poststroke cognitive impairments is an important medical problem. The purpose of the present study was to estimate the efficacy of new methods of restoration of impaired cognitive functions using computer correction programs. 43 poststroke patients aged 57–69, (male — 23, female — 20) were randomized into two groups. First group patients have been treated with the standard methods and supplementary neuropsychological computer training for 14 days, 25–35 min of duration per day. Control group received standard treatment according to Federal and local medical recommendations. Initial and achieved levels of cognitive functioning were estimated with the use of Mini Mental State Examination, Frontal Assessment Battery, the Clock Drawing Test, the Montreal Cognitive Assessment, Schulte's test, Hospital Anxiety and Depression Scale. We found that including the computer correction programs into the complex protocol of rehabilitation of post-stroke patients confirmed their efficacy in both clinical aspects and the Patient Global Impression Scale. Although the results are encouraging, further studies are required with larger samples and longer follow-up to identify characteristics of those patients who are most likely to benefit from computer training of cognitive functions.

1. Introduction

Stroke makes a serious problem for the aging population worldwide. It is associated with vascular dementia, and is considered to be the second main cause of dementia [1]. The risk of dementia development increases 12 times after the acute stroke [2,3]. Association of the poststroke non-dementia cognitive impairments and a poor functional outcome has been previously reported.

The diagnosis of poststroke dementia is possible, when the presence of dementia symptoms appears during 3 months after primary or repeated stroke [4]. Post-stroke dementia prevalence among the patients who have suffered a primary or repeated stroke varies from 6% to 31.8% [5]. The most frequent manifestations of vascular cognitive impairment are attention insufficiency, executive disturbance, and memory impairments [4]. Cognitive function in post-stroke patients decreases despite the primarily preserved level of higher cortical functions. This observation is principal for the recovery of altered functions [6]. Robertson et al. have shown that presence of sustained attention function by 2nd month after a stroke is a positive predictor for full restoration of cognitive functions [7]. Nys [8] has proved that the degree of cognitive function impairments in one week after a stroke is a predictor of life quality in 6 months (according to Stroke Impact Scale), thus, presence of a unilateral visual-spatial neglect is statistically significant. According to other authors, attention deficit also plays a role in the disturbance of body balance and daily functioning, as well as physical and social aspects. Attention deficit is connected with the considerable functional disorders and falls in post-stroke patients living in the community [9]. At the same time, vascular cognitive impairments usually have slow rate of progression ("the stable response to placebo") [10].

The main goals in treatment of vascular cognitive impairments are: 1) symptomatic improvement of cortical functions (cognitive disorders, level of activity of daily living), 2) slowing the progression; and 3) treatment of neuropsychiatric symptoms (depression, psychic tension, agitation) [10]. Several approaches for the treatment of vascular dementia have been proposed including anti-thrombocytic drugs, nootropics, analogs of thyrotropin-releasing hormone, extract of gingko biloba, hyperbaric oxygenation, antioxidants, serotonin and histamine receptor antagonists, vasoactive substances, xanthines, calcium channel blockers [11]. However, efficacy of the above-mentioned approaches is relatively low, probably, due to small number of observations, short period of treatment, absence of uniformity in both diagnostic criteria and primary end-points. Memantine [12] and anticholinesterase agents [13] have shown their effectiveness. Anyway, there is no any proven symptomatic therapy of vascular cognitive impairments for the present time.

K. Cicerone et al. [14] summarized the recent studies of attention remediation. Most of them were devoted to attention rehabilitation in patients with traumatic brain injury (TBI). Several studies investigated

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attention remediation after stroke. A class I study [15] utilized an automated, computerized training program to treat adults who had sustained a stroke 1 to 3 years earlier. The treatment protocol required home use of computer software, completing 90 trials (taking about 40 min) daily, 5 days a week for 5 weeks. When compared with an untreated control group, participants who completed the computerized intervention demonstrated improvements on untrained working memory and attention tests, as well as a decrease in self-rated cognitive symptoms. Authors of review [14] noted, although improvements in attention-executive functioning have been related to self-reported improvements in attention and memory, there is a limited evidence of improvement in everyday functional activities after attention training.

In a randomized controllable study of 84 patients who survived a stroke, the estimation of attention training was carried out with to restore the ability for driving a car. Research concentrated on elimination of visual neglect had no sufficient statistical significance [16].

Efficacy of attention retraining for the improvement of attention, neglect, and speed (evaluated with an on-road driving evaluation, visual perception tests, and the test of everyday attention) has been demonstrated in 16 post-stroke patients [17]. Unfortunately, this study was small, not randomized, and was not confirmed with a comparable control group. Use of the computerized programs for attention training was evaluated in randomized controllable study in 27 patients with unilateral hemisphere injury mostly caused by the insult. Training improved selectivity and vigilances of attention, but, unfortunately, the group was small, quality of life was not estimated, and patients with a traumatic brain injury were included, therefore results could not be accepted. Cochrane review which is based on two small controlled studies of attention training after the stroke has led to the conclusion that enough sampling and blinded randomized protocols are required [18].

According to ESO2008 recommendations, efforts aimed at correction of anosognosia (spatial neglect) improve a patients' status, but effectiveness for ADL has not been shown [19]. Some studies estimated effectiveness of the procedures aimed at visual disorders and apraxia, but confirmed that conclusions have not been made [16].

At present, there is no better practice to correct the cognitive disorders than application of specially developed computer tasks. Results found by Otfinowski et al. [20] prove a potential of computer games for complex rehabilitation and increasing the motivation for motor exercises. However, differentiated computer programs had not been used for cognitive stimulation so far. It motivated us to develop special programs based on tasks for neuropsychological testing for computer correction of the cognitive disorders where variants and complexity of tasks can be changed according to the patient's abilities.

The purpose of the present study was to estimate efficacy of new methods of cognitive neurorehabilitation with the use of computer correction programs.

2. Subjects and methods

2.1. Patients

43 patients with cognitive impairments after a hemisphere stroke, ranging from mild cognitive impairments to mild dementia, without significant speech pathology and epilepsy in the acute and early restorative period of a stroke, were randomized into the intervention and control groups. The intervention group is represented by 24 patients at the age of 60–72 (Median = 61 [57; 69]), control group — 19 persons at the age of 60–72 (Median = 66 [61; 69]). Individuals were excluded if they could not give informed consent; experienced severe cognitive deficits precluding participation (Mini Mental Status Exam [MMSE] <20), were medically unstable, were not fluent in Russian as required for standardized assessment, or had another condition that could impact results (e.g. aphasia). Stroke survivors were approached within 2 weeks after stroke.

2.2. Procedure

2.2.1. Diagnostics methods

In addition to detailed clinical-neurological examination, neurologic status of all patients was assessed according to the scale of stroke NIHSS. The NIHSS allows estimating the basic spheres of the neurologic status: general brain symptoms, function of craniocereberal nerves, motor, sensory and coordinatory systems, as well as a speech status. Intensity of symptoms fluctuates from 0 to 3–4 points, from normal rates to complete loss of function. The internal consistency and re-testing reliability were proved in a number of studies (Goldstein J.C. et al., 1989).

Validation of localization and character of the brain lesion focus was carried out by method of the routine MRI. Absence of epileptiform activity was established by the results of computer electroencephalography.

Randomization was performed with the use of method of letters. Cognitive assessment was conducted on the day of inclusion into the study; assessments were repeated on day 14–16 by a trained assessor blind to randomization. Estimation of the cognitive status was performed with the use of the standard batteries of tests: MMSE as a widespread test used for screening of patients and estimation of dementia severity; FAB as a test for estimation of cognitive disorders of mainly subcortical and subcortical-frontal type; Clock drawing test which is used to detect disorders of optical-spatial gnosis and executive functions; and Montreal Scale of Cognitive Assessment (MoCA) — as a means of fast estimation in the case of moderate cognitive dysfunction. The estimation of attention deficit has been done with the Schulte's tables. This test is a validated technique for estimation of concentration and switching of attention. The table consists of 25 cells arranged in a five-by-five square, each cell contains a number from 1 to 25 in a random order. A patient is offered to find and show, as soon as possible, all the numbers in an increasing order. Standard values of full completion correspond to 40–45 s, while persons with attention deficit demonstrate extend time of the test performance.

Estimation of mood disturbances has been done according to HADS scale which is a simple questionnaire revealing the signs of anxiety or depression. The estimation of daily activity has been performed with the IADL scale which allows assessing of basic manifestations of life activity — ability of independent walking, feeding, travelling, carrying out hygienic procedures, shopping etc.

Satisfaction with the results of treatment has been estimated with the CGIS scale by a medical specialist: 1 — symptoms have worsened, 0 — without changes, 1 — limited improvement, 2 — considerable improvement, 3 — symptoms disappeared completely. Also the PGIS scale for assessment of patient's satisfaction with results of treatment was used and the same questions were answered by a patient.

The study protocol was approved by Ethics Committee of Krasnoyarsk State University. Written informed consent was obtained from all patients included in the study. Patients were provided with full information about all procedures in the study and differences of intensity of training for cognitive impairments in interventional and control groups.

2.3. Treatment methods

In addition to standard treatment at the in-patient rehabilitation department, the intervention group received up to 15 h of individual training with the use of computer programs (every day, 30 min per day, 2 weeks). Patients in the control group received standard treatment at the in-patient rehabilitation department only.

2.3.1. Description of the training method

2.3.1.1. Training of attention with the use of computerized Schulte's tables. Original method of restoration of cognitive functions has been developed by our group. We focused on four aspects of attention (sustained, selective, divided, and alternating ones), and the method