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The effectiveness of the correction of cognitive impairment using computer-based stimulation programs for patients with coronary heart disease after coronary bypass surgery

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ABSTRACT

We evaluated effectiveness of using copyrighted computer-based stimulation programs in the correction of cognitive function in patients with coronary heart disease after coronary bypass surgery.
A total of 74 patients were examined, all the patients underwent a course of drug therapy, 37 patients underwent a course of rehabilitation in addition to medical therapy using computer-based stimulation programs (1 time per day for 20 min within 10 days). A course of rehabilitation using computer-based stimulation programs in patients with coronary heart disease after coronary bypass surgery was proved to be an effective way of correcting cognitive function.

1. Introduction

Coronary heart disease (CHD) has a leading position among the cardio-vascular diseases (CVD) due to both mortality and disability rates of the working population of Russia. Treatment of coronary heart disease has improved significantly in recent years; more efficient drugs have been available for patients, which resulted in improving the quality and span of their lives.

Coronary artery bypass graft surgery (CABG) is one of the most radical ways to treat coronary artery disease. The main outcome of CABG is to improve the quality of life of patients. However, this intervention, especially with the use of cardiopulmonary bypass (CB) is associated with developing complications, including neuropsychological cognitive impairment of short and long term memory, concentration, and mental abilities. Literature analysis reveals that the use of cardiopulmonary bypass during cardiac surgery is a common cause of neuropsychological complications (from 5.6% to 90%) [13,23]. Thus, the frequency of cerebral complications such as stroke and encephalopathy (including delirium) is relatively small and is from about 2% to 5% and from 10% to 30%, respectively [3,16]. However, cognitive dysfunction with clinical manifestations such as impairment of memory, attention, psycho-motor reactions, and visual–spatial orientation is detected more often [5].

Damage to the nervous system after cardiac surgery occurs in spite of the improvement in surgical techniques and the implementation of neuroprotective strategies. Endovascular treatment being more widespread, it is usual for patients to be admitted to surgery with multivessel, critical, often diffuse coronary disease, usually with a long case history of coronary heart disease and a range of comorbidities.

Prevalence of diagnosed cognitive dysfunction varies considerably from 50% to 70% in the first week after the operation and decreases from 30% to 50% after 2 months [11,19]. Fontes and colleagues [11] reported that 45% of patients 6 weeks after CABG developed postoperative

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cognitive dysfunction (POCD). According to the authors, catamnesis registered complete regression of these disorders 1 year after surgical treatment of CHD.

In a research performed on patients six years after surgery, cognitive function in patients with CABG and in control groups similar in age were comparable. In addition, a connection was revealed between the degree of cognitive impairment and the progression of major cardiovascular disease [23].

Recent studies have shown that postoperative cognitive dysfunction may be transient in nature [10]. Short-term cognitive decline after CABG usually refers to changes in cognitive performance observed up to several weeks after surgery. L. Evered and his colleagues [10] reported that patients who had CABG also had significantly higher incidence of POCD (43%) 7 days after the surgery, compared with patients who had hip replacement surgery with general anesthesia (17%). However, after 3 months there was no significant difference according to the test results in both groups.

To understand the alterations in the cognitive sphere it is relevant that a significant portion of patients with coronary heart disease before surgery have cognitive disorders of varying severity. Frequency of preoperative cognitive impairment cases, according to the literature, ranges from 20 to 46%, depending on the age, the presence or absence of hypertension, cerebrovascular disease, genetic predisposition and educational background [13,22]. The results of brain MRI in the preoperative period also showed a high prevalence of vascular small focal and diffuse changes in the white matter [17].

The mechanisms of POCD are multifactorial, including cerebral microembolism and hypoperfusion. There is some evidence for the role of systemic inflammatory response associated with cardiopulmonary bypass. A connection was revealed between the levels of inflammation markers (proinflammatory cytokines, C-reactive protein) and the results of cognitive research.

In addition, some researchers put forward the hypothesis about significant effects of non-specific effects of extensive surgery, including postoperative pain, sedation, sleep disturbances [1,12,15]. The phenomenon of selective sensitivity of hippocampus to damaging influences of proinflammatory cytokines, ischemia, hypoxia and metabolic stress is widely described in the literature.

Fontes and colleagues [11] in their study showed that a more intensive daily activity within 6 weeks after the operation was a significant predictor of recovery of cognitive function. In addition, aerobic exercise can help prevent or even help reduce cognitive decline in the elderly. These data indicate that stimulation of the brain after cardiac surgery reduces the cognitive disorders. There also is a neuroprotective effect of control over modifiable risk factors - hypertension, diabetes, hyperlipidemia [11,21]. Thus, the development of POCD in patients with CABG by means of artificial circulation is an urgent medical and social problem. There is no clear data on the mechanisms, factors and the need for early POCD rehabilitation and approaches to it in such patients.

There have been some publications on surveys devoted to the rehabilitation of cognitive impairment in cerebrovascular pathology, including K. Cicerone et al. [8]. Several major studies are devoted to the application of computer training of memory, attention and visual gnosis [8]. Employees of the department of nervous diseases with a course of medical rehabilitation of KrasSMU named after prof. V.F. Voino-Yasenetsky developed a method of correction of cognitive impairment in cerebrovascular disease using computer-based stimulation programs (patent number 2438574, 2012). [4,18].

They include sets of structured, standardized and well-designed tasks, provide a choice of exercises with a given level of difficulty and time, allow the patient to provide immediate feedback on the results of the task and may be done at home. They are also available for patients with severe physical defects. It is proved that rehabilitation using computer-based stimulation programs within 10 days 1 time per day (duration of one lesson — 20 min) is an effective way of correction of cognitive impairment of vascular genesis [4,18]. Considering the general features of the pathogenesis of vascular and postoperative cognitive decline, computer training, with a specific modification of the classes has a potential of application in patients after CABG.

The aim of the study was to evaluate the effectiveness of using computer-based stimulation programs in the correction of cognitive impairment in patients with coronary heart disease after coronary bypass surgery.

2. Materials and methods

A total of 74 male and female patients with coronary heart disease were examined on the premises of the Federal centre for cardiovascular surgery (Krasnoyarsk).

The inclusion criteria for the treatment group included:

1. Age up to 70 years.
2. Prescheduled coronary bypass surgery.
3. Signed Informed Consent.

The exclusion criteria comprised:

1. The presence of chronic obstructive lung disease, chronic renal failure, and oncopathology.
2. Combination of coronary heart disease with valvular disease, diabetes mellitus of any type, atrial fibrillation, brachiocephalic arterial occlusive disease or acute cerebrovascular accident in past medical history.
3. Less than 24 pre-operative indices on the Mini Mental State Examination scale and/or less than 11 pre-operative indices of the Frontal Assessment Test Battery.
4. Patient's refusal to participate in the study.

According to the research objective all the patients were divided into two groups. The main group ($n = 37$) included patients who underwent a course of rehabilitation with the use of computer-based stimulation programs (1 time per day for 20 min. Within 10 days) in addition to usual medical therapy. The course was started within the second twenty-four hours after coronary bypass surgery. The control group included 37 patients who underwent a course of post-operative rehabilitation getting usual medical therapy. The average age of main group patients made 60.0 ± 6.42 years with a median value of 61 years [57; 65]; the average age of the control group patients made 60.5 ± 6.42 years with a median value of 61 years [55; 66] ($p > 0.05$).

The pre-operative examination comprised general somatic examination, methods of functional diagnostics (echocardiography, duplex scanning of brachiocephalic arteries), neuropsychological testing.

The diagnosis of coronary heart disease was confirmed based on the WHO criteria, the presence of anginal thoracalgia or its equivalent, patients' medical history and instrumental methods of analysis. The estimation of the functional class of angina was made following the Canadian Cardiovascular Society Angina Classification (CCS, 1976). To reveal the stage of cardiac failure (CF) the classification after N.D. Strazhesko and V.H. Vasilenko (1935)was used. The estimation of the functional class of CF was made following the New York Heart Association (NYHA, 1964) classification. The severity of angina corresponded to the II–III functional class (see Table 1).

The patients were examined with the use of a standard scheme for neurological examination.

We used the following testing battery for the diagnostic of cognitive impairment:

- MMSE as a widespread test used for screening of patients and estimation of dementia severity (Folstein, Folstein, McHugh, 1975) [2];

- FAB as a test for estimation of cognitive disorders of mainly subcortical and subcortical–frontal type (Dubois et al., 1999) [9];

-Clock drawing test is used to detect disorders of optical–spatial gnosis and executive functions (Brodaty H., 1997) [6];

- The estimation of attention deficit was carried out with the use of Schulte's tables (Zakharov V., 2005) [2]. The table consists of 25 cells