Cognitive Functioning of Patients with CHD After Coronary Artery Bypass Grafting with Cardiopulmonary Bypass

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Introduction

According to WHO, about 16.7 million people in the world die every year from cardiovascular diseases, including coronary heart disease (CHD). CHD is a leading disease in incidence and mortality in the general population [1,2]. One of the most important treatments of coronary heart disease is coronary artery bypass grafting (CABG), which's been one of the most commonly performed surgeries for more than 30 years. The main purpose of the operation includes: extending the patient's life, reducing the somatic symptoms associated with CHD, and improving the quality of life. However, CABG patients frequently experience neurocognitive complications as a result of the surgery. The current level of development of cardiac technology has resulted in a significant reduction of severe neurological complications. At the same time, mild postoperative neurological disorders (primarily, cognitive decline) remain a widespread problem [3].

In general, a cognitive decline means a subjectively and/or objectively detectable reduction of cognitive functions (attention, memory, gnosis, praxis, speech, thought, etc.). This reduction affects the efficiency of learning, professional, consumer, and social activities. The problem of a cognitive decline after CABG has been under the great attention recently. Let's have a look on previous researches.

First, previous studies, which evaluate the effect of CABG on cognitive abilities, mostly consider long-term effects of the operation [4]. However, the studies of cognitive functioning in the early postoperative period are very controversial. For instance, some studies [5] describe a reduction of cognitive functioning in the early postoperative period. Some authors report on the absence of changes and even on an improvement [6] of cognitive functioning after CABG. Second, recent studies have shown severe neurocognitive complications in cardiac patients after surgery. At the same time, mild cognitive dysfunction remains outside the scope of research because of difficulties in diagnosing. The situation is also complicated by the fact that mild cognitive dysfunction is less realized by the patients than by clinicians. In addition clinicians frequently reject subjective complaints about cognitive decline from patients and their relatives [7]. Third, the vast majority of current studies mostly considers negative changes in cognitive functioning, while positive changes are neglected. Finally, most studies only state the presence of some cognitive disorders, accompanying cardiac pathology, whereas the underlying mechanism leading to cognitive decline is still unclear.

The present research aims at a comprehensive study of the characteristics and disorders of cognitive functions in patients with CHD undergoing CABG. The work focuses on studying the dynamics of the main indicators of cognitive functioning, including active attention, psychomotor speed, memory, and thinking abilities.

Materials and methods

70 patients undergoing coronary artery bypass grafting with standard cardiopulmonary bypass technique in Federal Almazov Medical Research Centre (Saint-Petersburg, Russia) have been studied. Cardiopulmonary bypass (CPB) is a technique that temporary takes over the function of the heart. CPB is commonly used in heart surgery because of the difficulty of operating on the beating heart. CPB is

well known to contribute to cognitive decline. The informed consent was obtained from all patients. Among them there were 58 (82.9%) men and 12 (17.1%) women; the average age of the patients was 59 years. 48.6% of the patients were employed before the operation, 54.3% of patients were planning to return to their work after the operation. According to clinicians, the majority of the patients had no contradictions to come back to work three months after the surgery. But in fact, only 20.5% returned.

The examination was performed in three stages: a day or two before CABG, immediately before discharge from a hospital (12-14 days after CABG), and three months after CABG.

The methods used in the current study were selected with regard to the bio-psycho-social approach in modern clinical psychology and in accordance with the «Statement of Consensus on Assessment of Neurobehavioral Outcomes after Cardiac Surgery» [8].

The study of cognitive functions of patients with CHD undergoing CABG was performed with the use of the following methods.

(1) Verbal learning test «10 words» was used in studying short- and long-term verbal memory.
(2) The method «Remembering stories» was used in studying logical memory.
(3) «The Benton Visual Retention Test» was used in studying visual perception and visual memory.
(4) The subtest «Similarities» of the Wechsler Adult Intelligent Scale (WAIS) was used in studying abstract verbal reasoning.
(5) The «Simple analogy» method was used in studying verbal-logical thinking.
(6) The subtest «Block Design» of the Wechsler Adult Intelligent Scale (WAIS) was used in studying spatial thinking.
(7) The Trail Making Test (TMT Parts A and B) was used in studying psychomotor speed, attention switching and mental flexibility.
(8) The Stroop Color-Word Test (SCWT) was used in studying two indicators: processing speed, as well as selective attention and resistance to cognitive interference.

The results obtained were processed with the use of standard statistical techniques included in SPSS and Excel. We used Wilcoxon signed rank tests for a comparative analysis of the preoperative and postoperative variables of cognitive functioning. The scores obtained vs normative scores were analysed by using the t-tests. Differences were considered significant at $p<0.05$.

Results

The investigation was started by asking every patient whether they had had any problems in cognitive functioning. 58.6% of the patients answered positively and declared memory complaints.

In accordance with the purposes of the research, the dynamics of the main indicators of the cognitive functioning of patients with CHD during the rehabilitation after CABG was studied (Table 1).

Table 1. Indicators of cognitive functioning of patients undergoing CABG

The main indicators of cognitive functioning	The first stage (before CABG)	The second stage (12-14 days after CABG)	The third stage (three months after CABG)
	M ± m	M ± m	M ± m
Short-term verbal memory («10 Words»), the number of reproduced words after 5 presentations	7.97 ± 1.58	8.05 ± 1.46	7.24 ± 1.87
Long-term verbal memory («10 Words»), the number of reproduced words after 1 hour of presentation	5.44 ± 2.09	5.78 ± 2.05	3.20 ± 1.84
Visual memory (Benton test), score	6.64 ± 1.76	7.03 ± 2.05	7.96 ± 1.56
Logical memory («Remembering Stories»), score	3.98 ± 1.17	4.35 ± 1.06	4.64 ± 0.99
Abstract verbal reasoning (subtest «Similarity»), score	15.72 ± 4.29	17.20 ± 3.88	17.32 ± 3.84
Verbal-logical thinking («Simple Analogy»), score	7.68 ± 2.13	8.27 ± 1.78	8.04 ± 2.28
Spatial thinking (subtest «Block Design»), score	29.82 ± 10.47	29.43 ± 11.17	32.0 ± 12.47
Psychomotor speed (TMT-A), score	5.18 ± 2.93	5.05 ± 3.33	6.50 ± 3.23
Attention switching and mental flexibility (TMT-B), score	5.17 ± 3.0	4.57 ± 3.41	6.0 ± 3.46
Processing speed (SCWT), score	7.21 ± 2.16		8.29 ± 2.31
Selective attention and resistance to cognitive interference (SCWT), score	2.97 ± 2.87		5.26 ± 3.67

The short- and long-term verbal memory was investigated by the verbal learning test «10 words». The indicator of the short-term verbal memory span is statistically significantly higher before CABG than three months after. Moreover, 12-14 days after the operation the short-term verbal memory span is also larger than three months after the operation. As to the long-term verbal memory span the same statistically significant trend was observed.

On the contrary, the visual memory indicator increases during the whole period of observation (from the first to the third stage). The logical memory improves during both the hospital treatment period (from the first to the second stage of the study) and the whole period of the observation (from the first to the third stage of the study).

Thus, the reduction in the verbal memory span and improvement in the visual and logical memory as a result of CABG were demonstrated.

Verbal-logical thinking, spatial thinking and abstract verbal reasoning of the patients were also studied in this research. The indicator of verbal-logical thinking is higher 12-14 days after CABG than before it. However, we have observed no significant changes in verbal-logical thinking between the second and the third stages of the research. The indicator of abstract verbal reasoning shows exactly the same dynamics. It is also higher 12-14 days after CABG than before it. The dynamics of spatial thinking was positive as well. The indicator measured three months after the surgery is higher than the preoperative one. This data suggests that CABG can have a positive impact on the thinking abilities of patients with CHD.

The psychomotor speed, as well as attention switching and mental flexibility, was studied by the Trail Making Test. The changes in the psychomotor speed are not statistically significant. However, the indicator of attention switching and mental flexibility is statistically significantly lower after the surgery than before.

The indicators of processing speed, selective attention and resistance to cognitive interference were measured by the Stroop-test. The changes in the processing speed are not statistically significant. At the same time, the indicator of selective attention and resistance to cognitive interference statistically significantly improves during the treatment. These facts show a reduction in the attention switching and in the tendency to interfere during mental work, as well as an improvement in functioning under the influence of external stimuli.

Conclusion

The present research demonstrates significant and stable changes in the cognitive functions of patients with CHD undergoing CABG with cardiopulmonary bypass. In agreement with previous results [9,10], we observed negative changes in both short- and long-term memory. At the same time, a positive trend was discovered in the visual and logical memory, active attention, and thinking activity. This positive dynamics can be a result of the coronary revascularisation and improved cerebral blood flow. The reason for postoperative cognitive dysfunctions is yet unknown. Possible reasons include conditions and consequences of the surgery, normal ageing, brain injury at the time of coronary surgery, or a combination of these and other factors. The results obtained can be used in diagnosing cognitive impairments and in developing and improving rehabilitation programs for patients undergoing CABG.

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