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The effects of coronary artery bypass graft on selective attention, shifting attention, and sustained attention

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ABSTRACT

Almost five decades have passed since open-heart surgery was used as a method for improving coronary arteries. The research carried out in the past has shown the emergence of cognitive impairment and/or cognitive dysfunction in many patients after coronary artery bypass graft (CABG), but more recent research mentions a minor dysfunction after surgery and the reason for this difference is considered to be the advances in anesthetic and surgical techniques, differences in methodologies, or the precision of the applied neuropsychological instruments. In the present research we have specifically examined attention in its selective, shifting, and sustained dimensions in order to determine the effect of CABG on these variables. Attention was assessed by comparing two groups of 30 patients with coronary artery disease. One of the two groups underwent surgery while the control group was on the waiting list. Thus, the methodology of the present research is pretest-posttest with a control group. The instruments include Stroop test for assessing selective attention, SAT for shifting attention, and CPT for sustained attention. The first group performed the neuropsychological tests one month after surgery, and the control group performed them once when they were admitted and a month later when they were hospitalized. Mann-Whitney U test was applied for data analysis. The results showed that there is no significant difference between the two groups in any of the tests, though considerable differences were observed in comparing the means of the two groups.

Keywords: Coronary arteries bypass graft, cognitive function, selective attention, shifting attention, sustained attention.

INTRODUCTION

After the introduction of coronary artery bypass graft (CABG) to the world and the prevalence of this therapeutic method for improving blood vessels, complications were gradually observed in patients, leading researchers to identifying them. One of these complications that emerged in patients after surgery is cognitive impairment which made researchers interested in finding its dimensions and causes. The focus was initially on the emergence of basic cognitive impairments, but research over the past 6 years, which will be discussed later in the text, primarily focus on damages that can be regarded more as complaints rather than impairments—personal complaints of patients of the negative influences of surgery on their lives, jobs, and education. Memory loss and poor executive function are examples of these damages that directed the line of research toward follow-up of patients for many years after surgery in order assess the extent to which these damages progress or improve. Despite the advances in anesthetic and surgical techniques, delirium and cognitive impairment still exist as the side-effects of surgery. Cognitive impairment and delirium occur temporarily in a large number of patients that have undergone surgery, although these early cognitive alterations may forever remain in few patients. Hudtez (2010) believes difficulty in concentrating, short-term memory loss, and inability to process information are the typical schema of cognitive dysfunction [14].

The risk of cognitive impairments is prevalent and may amount to 8% of the world's population. The symptoms include memory loss or attention deficit and reduced motor and psychological reaction speeds. Although these issues have been briefly studied and modified after a few months, recent research shows that these cognitive impairments may persist [6]. Some studies have reported the early cognitive damages such as damages to memory, psychomotor speed, executive function, and the visual ability. From the viewpoint of the patient and their family members, most complaints involve changes in focus and memory. Since the cognitive complaints of the individual are not always concomitant to the function of the cognitive test, some researchers have ignored them as the secondary effects of depression [3]. Thus, attention which is the basis of all cognitive functions and is considered as the gate letting information into the brain was specifically assessed in the present research in shifting, selective, and sustained forms. Attention is the clear focus of the mind on one or more objects or a chain of stimuli that occur concurrently. In other words, attention is disregard to some stimuli in order to inspect others. Generally, the components of attention include the following:

1. Ability to maintain attention beyond time
2. Ability to maintain attention on a specific stimulus among other distracting stimuli
3. Ability to shift attention from a task or stimulus to another
4. Ability to divide attention between more than two ongoing stimuli or processes [2].

Many stimuli simultaneously affect individuals, but what can be perceived at a certain moment is limited. What is practically perceived not only depends on the stimuli, but also on the cognitive processes that reflect the tendencies, goals, and expectations of the person at that moment. In other words, besides the physical characteristics of the stimulus, cognitive processes (perception, attention, analysis, etc.) also play a categorical role in selective attention [6].

Shifting attention is the ability to consciously reallocate attentional resources from one stimulus to the other. Selective attention is the ability to maintain attentional resources on a certain stimulus and ignoring distracting stimuli. Finally, sustained attention is the ability to maintain attentional resources on a specific stimulus in a long time interval (more than 10 minutes) [10].

Researchers arrive at new findings by changing neuropsychological instruments, methodologies, groups, assessment intervals, and short-term and long-term follow-ups. Identifying the pathological causes after CABG is the basis of the research aiming to prevent postoperative cognitive impairment. The major shortcoming of the extant literature is in the procedures of the relevant studies as well as the inefficiency of the measurement instruments in distinguishing between various dimensions of cognitive dysfunction. Using modern instruments along with novel software methods can overcome this major flaw. The present study can introduce a new approach to examining the dimensions of cognitive impairment and rehabilitation in patients with open-heart surgery. Thus, the different dimensions of cognition including attention and the brain regions involved in it—different parts of the prefrontal cortex—are studied in order to come up with compensatory ways for minimizing such damages.

MATERIALS AND METHODS

Participants

The participants of the research are all the patients referring to Tehran Heart Center for coronary artery bypass graft (CABG). The interval that defined the population was from March to August, 2011. The samples were selected using convenience sampling and were divided into two groups of 30 subjects.

Instruments

1- *Stroop Test:* Selective attention is assessed using Stroop Test. Stroop test is a common test for the function of the frontal lobe. In this test, the name of color (e.g. green) is printed in a color not denoted by the name (e.g. red).The person is asked to tell the color of the word instead of reading the word. Each participant spends a longer time naming the color of the word in comparison with the color of a geometrical figure [4]. The present research uses the computerized version of Stroop test. Thus, instead of reading the word, the subject clicks the button of the same color on the computer screen. The indices assessed in this test are: commission errors (pressing the button for an irrelevant stimuli) and mean response time of the subject for correct responses. Stroop test is an experimental model for assessing selective attention. Measuring regional blood flow during this test using PET is accompanied by increased activation of the anterior cingulate gyrus (medial prefrontal cortex) [10].

2- *SAT:* This test is a scale for measuring shifting attention. The computerized version of the test is used in the present research. The test is performed in two stages:

1) A circle is presented to the person as the base with two different shapes under it, a circle and a square or triangle. The person is asked to choose the figure that resembles the base figure by clicking on the respective button on the screen regardless of the color of the shapes. 2) The same circle with the same color is presented to the person and the first figure is a random figure (circle, triangle, or square) with the same color as the base circle and the second figure is another random figure (circle, triangle, or square) with a different color. In this stage the person is asked to choose the option that has the same color as the base figure regardless of their shapes by pressing 1 or 2 on the keyboard. The indices assessed in this test are: the number of correct responses and mean reaction time of the participant for correct responses.

3- *Continuous Performance Test (CPT):* This test is applied for evaluating sustained attention. A series of numbers appear with a certain interval, two stimuli are determined as target stimuli, and the subject must quickly press the respective button upon seeing the number. The variables of this test are: omission errors (failure to press the button for a stimulus), commission errors (pressing the button for a non-target stimulus), and correct response reaction time (mean reaction time of correct responses in milliseconds). Imagery research has demonstrated the activation of the frontal lobe during the continuous performance test [5].

4- *Spielberger State Trait Anxiety Inventory:* An inventory with 20 items that includes statements people use for describing themselves. The patient marks the choice that best describes their feeling at that moment. In the original form of the inventory, each item includes four options: never, sometimes, often, and always on a scale of 1 to 4. In the revised version—STAI-Y—12 items from the total number of 40 items changed, that is 30% of the items, and thus the psychometric characteristics of both state and trait anxiety scales ameliorated [14]. The scoring of this inventory is as follows: 20-31 slight situational anxiety, 32-42 moderate-to-low situational anxiety, 42-53 moderate-to-high situational anxiety, 54-64 relatively intense situational anxiety, 65-75 intense situational anxiety, and above 76 very intense situational anxiety [7]. This questionnaire has a considerable validity and reliability. In the present research, due to the importance of state anxiety in the test results, this inventory has been used for evaluating and comparing the state anxiety of the patients while taking the tests.

5- *Mini Mental Status Examination (MMSE):* This questionnaire was developed by Marshal Folstein and colleagues in 1975 and is used for evaluating the cognitive function of patients. It includes several sections and evaluates 6 items: orientation, registration, attention and calculation, recall, language, and drawing.

Procedure

The studied patients were divided into two groups: the first group or the control consisted of patients who referred to the hospital in prearranged dates, were under 60 years old, and had minimum literacy for reading and writing. These patients underwent the tests after being hospitalized in the ward. First, an interview was conducted to determine their psychological disorders and if there were no disorders, the MMSE test would be conducted to screen for cognitive impairments; after verifying their cognitive health, they would enter the testing process. In this stage, the patients filled out Spielberger's STAI in order to evaluate their state anxiety which was probably due to hospitalization and operation they were about to undergo, and then some explanations were provided for them regarding the neuropsychological tests and their procedures. The second stage of testing was conducted one month after the surgery when the patients referred to the clinic for postoperative follow-ups. As before, first the interview and MMSE were conducted and after filling out Spielberger's STAI, the neuropsychological tests were again performed. The second group included patients who referred to the hospital to set a time for hospitalization. These patients were selected from those whose hospitalization was due a month later, who were below 60 years, and had minimum literacy to read and write. After filling the consent form, they underwent psychological and cognitive interviews similar to the patients in the first group so as to enter the testing stage in case of being healthy. These patients also filled Spielberger's inventory and then prepared for neuropsychological tests after some explanations were provided for them regarding test procedures. The second stage of testing was conducted one month later when the patients referred back to the hospital for surgery.

Data Analysis

Descriptive statistics including mean, median, range, variance, and standard deviation were used for data analysis. For inferential analysis, Mann-Whitney U test was applied due to the non-normal distribution of the data.

RESULTS

The demographic indices of the patients that underwent surgery and those who did not were separately calculated. The data for each group is presented in the following table.

Table 1. Demographic data by groups

Total	Gender		Education				Occupation			Marital Status		Age		
	M	F	Elementary	High-School	Diploma	Higher Education	Employee	Freelancer	Retired	Married	Divorced	Min	Max	Mean
Surgical Patients	6	24	4	9	12	5	4	11	15	29	1	45	59	51.83
Non-Surgical Patients	9	21	6	8	8	8	5	7	18	28	2	42	59	53.70

As can be seen in table 1, the majority of patients in both groups are men and although the mean age of the two groups is almost the same, the age range is different. Most patients are married and have high-school diploma or higher education.

The Effect of CABG on Selective Attention of the Patients

Mann-Whitney U test was applied to examine and compare the significance of differences in the number of correct responses and reaction time of the both groups in the first, second, and third stages of Stroop test. The results are presented in the following table.

Table 2. Correct responses and reaction time of the both groups in the first, second, and third stages of Stroop test

Variable	Groups	Total	Mean	Stan Dev	U-Statistic	Z-Statistic	Sig.
Correct Responses (First Stage)	Surgical	30	0.26	1.17	384	-1.272	0.203
	Non-Surgical	30	0.36	1.82			
Reaction Time (First Stage)	Surgical	30	0.28	0.44	381	-1.020	0.308
	Non-Surgical	30	0.38	0.50			
Correct Responses (Second Stage)	Surgical	30	0.26	1.65	437.5	0.332	0.704
	Non-Surgical	30	0.20	1.06			
Reaction Time (Second Stage)	Surgical	30	0.03	0.37	372	-1.153	0.249
	Non-Surgical	30	0.09	0.39			
Correct Responses (Third Stage)	Surgical	30	-1.40	4.77	405	-0.675	0.500
	Non-Surgical	30	-0.53	3.15			
Reaction Time (Third Stage)	Surgical	30	0.64	1.46	414	-0.532	0.595
	Non-Surgical	30	0.66	1.05			

According to the table 2, the results indicate that there is no significant difference between the two groups in the number of correct responses in the first, second, and third stages ($\alpha = 0.05$). Moreover, no significant difference was observed between the two groups in reaction time in the first, second, and third stages.

The Effect of CABG on Shifting Attention of the Patients

Mann-Whitney U test was applied to examine and compare the significance of differences in the number of correct responses and reaction time of the both groups in the first, second, and third stages of SAT. The results are presented in table 3.

Table 3. Correct responses and reaction time of the both groups in the first, second, and third stages of SAT

Variable	Groups	Total	Mean	Stan Dev	U-Statistic	Z-Statistic	Sig.
Correct Responses (First Stage)	Surgical	30	1.03	19.79	425	-0.370	0.712
	Non-Surgical	30	0.03	17.28			
Reaction Time (First Stage)	Surgical	30	1.20	11.58	443	-0.104	0.917
	Non-Surgical	30	1.46	10.18			
Correct Responses (Second Stage)	Surgical	30	0.26	1.65	437.5	0.332	0.704
	Non-Surgical	30	0.20	1.06			
Reaction Time (Second Stage)	Surgical	30	0.43	0.35	448	-0.030	0.976
	Non-Surgical	30	0.89	0.86			

According to the above table, the results indicate that there is no significant difference between the two groups in the number of correct responses and reaction time in the first and second stages of SAT ($\alpha = 0.05$).

The Effect of CABG on Sustained Attention of the Patients

Mann-Whitney U test was applied to examine and compare the significance of differences in the commission errors, omission errors, and reaction time of the both groups in CPT. The results can be seen in table 4.

Table 4. Correct responses and reaction time of the both groups in the first, second, and third stages of CPT

Variable	Groups	Total	Mean	Stan Dev	U-Statistic	Z-Statistic	Sig.
Correct Responses Number of Commission Errors	Surgical Non-Surgical	30 30	0.03 0.20	1.90 4.74	379	-1.065	0.287
Reaction Number of Omission Errors	Surgical Non-Surgical	30 30	0.40 2.70	8.13 6.25	384.5	-0.971	0.332
Reaction Time	Surgical Non-Surgical	30 30	0.007 0.005	0.05 0.03	413	-0.547	0.584

According to the above table, the results indicate that there is no significant difference between the two groups in the number of commission errors, omission errors, and reaction time in CPT (α = 0.05).

DISCUSSION AND CONCLUSION

In the present research we aimed to examine attention as the basis for all cognitive functions and a gate letting information into the brain. The differences in scores of selective, shifting, and sustained attention were evaluated using the computerized version of Stroop test, SAT, and CPT. Thus, the possible impairments and the brain regions involved in them that lead to decline of cognitive function and affect the job and education of the patients were specifically identified. Accordingly, necessary measures need to be taken in order to incorporate cognitive and physical rehabilitation and facilitate the recovery of patients to normal conditions using proper cognitive tasks. Moreover, since the major shortcoming of the extant literature is due to the procedures and inefficacy of the measurement instruments in distinguishing between different dimensions of cognitive dysfunction, it is necessary to make use of novel instruments for specific assessment of attention as the fundamental dimension of cognition. For examining selective attention, the results of speed (reaction time) and error were analyzed using Stroop test in three stages. The results showed that there is no significant difference between the two groups in the number of correct responses and reaction time in the first, second, and third stages (α = 0.05). Selnes et al. (2007) used Mini Mental Status Examination before and at 3, 12, and 36 months after the operation. They compared patients undergoing CABG and that did not and found no significant difference between the two groups. Rosengart et al. (2006) evaluated attention using Digit Span from the Wechsler Adult Intelligence Scale (third edition) and compared two CABG groups and healthy controls before and three weeks after the operation and did not come to a significant difference. The CABG group did not exhibit any considerable change in the baseline scores and the scores after three weeks. Van Dijk et al. (2008) also evaluated selective attention using Stroop test and compared two CABG groups with a healthy control group before and 5 years after surgery. They arrived at no significant differences between groups.

The results of the present research also showed that in both levels of SAT there is no significant difference between the two groups in the number of correct responses and reaction time (α = 0.05). Sweet et al. (2008) compared a healthy group and a CABG group three weeks after operation and found no clear pattern of group differences or change. Tournay-Jetté et al. (2011) showed that intraoperative cerebral oxygen desaturation is associated with early and late POCD in elderly patients. Further, to examine continuous attention, the results of CPT were analyzed with respect to commission errors, omission errors, and reaction time and no significant between-group differences were observed. Chernov et al. (2006), after 10-14 days and 6 months postoperative follow-ups in CABG patients, found a relationship between cognitive malfunction and reduced cerebral perfusion. The results of the present research are consistent with the findings of Chernov et al. (2006) who reported that on-pump CABG is followed by neurocognitive impairment. There is a consensus among many research studies that there may be a difference in mean cognitive scores before and after surgery, yet this difference is very little and statistically insignificant. As an explanation for this result it can be argued that coronary artery disease is associated with mild damage to some cognitive functions even if no surgery is done [9]. That is, cardiovascular risk factors are weak predictors of performance in neuropsychological tests [13]. In conclusion, it must be noted that even if statistical analyses suggest no significant difference, personal differences and the results of each individual are of utmost importance can be further examined.

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