Cognitive Outcomes and Functional Performance for Patients After Open Heart Surgery

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ABSTRACT

Context: Open heart surgery is a lifesaving procedure for patients who need coronary artery bypass graft (CABG) and heart valve replacement or repair (HVR). However, it also carries a risk of cognitive and functional performance injuries. Between 30% to 60% of patients undergoing open heart surgery worldwide are at high risk of cognitive and functional performance injuries.

Aim: The study aimed to assess cognitive outcomes and functional performance of patients after open heart surgery.

Methods: A descriptive exploratory design was applied to achieve the aim of this study on a purposive sample of 103 adults who were scheduled for elective open-heart surgery (CABG and valve replacement or repair). Montreal Cognitive Assessment (MOCA); Physical Self-Maintenance Scale (Activities of Daily Living) (PSMS) tests were used to determine the effect of cardiac surgery on cognitive outcomes and functional performance abilities of patients undergoing cardiac surgery. Both scales were used twice for each patient (preoperative and postoperative).

Results: The current study shows a statistically significant deterioration in all cognitive functions (visuospatial &executive function, naming, short-term memory recall task, attention, language, abstraction, orientation) (p=0.000). A total cognitive score reveals that 68% of the patients had normal cognitive function before open heart surgery, significantly decreasing to 55.3% after surgery. The functional outcomes measured by the assessment of activity of daily living shows that 100% of patient were independent before open heart surgery and significantly decreased to 74.8% postoperatively.

***Conclusion*:** It can be concluded that open heart surgery impacts cognitive functions, particularly in domains of visuospatial and executive function, memory, and attention. Besides, the everyday functional performance includes toileting, feeding, dressing, grooming, physical ambulation, and bathing). Instrumental activities of daily living (IADL), which include the ability to use the telephone, shopping, food preparation, housekeeping, laundry, away for transportation, responsibility for following their medication regimens, and ability to handle finances, were also affected. Nurses caring for patients undergoing open heart surgery should consider cognitive limitations when giving them health education and discharge instruction, their readiness to learn should be considered before any educational event. Further studies should be carried out to identify the factors that may contribute to the impairment of cognitive function and functional performance for patients undergoing cardiac surgery.

Keywords: Cognitive outcomes, functional performance, open heart surgery

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1. Introduction

Cardiac surgery has undergone rapid and extraordinary development since the mid-1940s. As of 2016, an estimated one million patients undergo cardiac surgery throughout the world every year. Neurological impairment is a well-known complication of cardiac surgery, resulting in longer hospitalizations, increased costs, and an escalation in morbidity and mortality. The neurological complications vary and can include peripheral neuropathy, encephalopathy, cognitive impairment, and stroke *(Veluz & Leary, 2017).*

Open heart surgery is a lifesaving procedure. Common open-heart surgeries are coronary artery bypass graft (CABG) and heart valve replacement or repair (HVR). All these surgeries appear to impact cognition and functional performance. On-pump is a term that refers to the use of a cardiopulmonary bypass (CPB) during open heart surgeries. During CPB, blood is rerouted through a heart-lung machine to be oxygenated and pumped into the body to maintain perfusion *(Abrahamov et al., 2017).*

Other surgical techniques of CABG include off-pump or beating-heart surgery. This procedure involves surgery on the beating heart using special equipment to stabilize the heart area the surgeon is working on. This type of surgery is challenging because the heart is still moving. It is not an option for everyone *(Benetti & Scialacomo, 2017).* Off-pump CABG surgery has historically been considered an option to reduce cognitive dysfunction. However, comparisons between on and off-pump CABG surgery have not shown this to be an effective or significant option in reducing cognitive impact *(Shroyer et al., 2017).*

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Heart valve surgery is a procedure to treat heart valve disease. Heart valve disease involves at least one of the four heart valves not working properly. Surgeon repairs or replaces the affected heart valves. Many surgical approaches can repair or replace heart valves, including open-heart or minimally invasive heart surgery. Treatment depends on several factors, including age, health, the affected heart valve's condition, and the patient's condition severity *(Roth, 2020).*

Coronary artery bypass graft (CABG) and heart valve replacement or repair (HVR) improve cardiac function. However, cognitive function or functional performance deficits may also develop in over one-third of the population receiving these surgeries. The cognitive deficits present after open heart surgery are typically determined by tabletop neuropsychological test batteries *(Shaikh, 2020).*

Postoperative cognitive dysfunction (POCD) is a decline in cognitive function after surgery and anesthesia from the preoperative baseline level. It can affect cognitive domains such as attention, memory, learning, visual spatial, motor skills, and executive functions. Behavioral changes may also accompany it. Clinical suspicion of POCD may be confirmed with neuropsychological testing completed several weeks after surgery and compared with baseline tests performed preoperatively. POCD occurs in 20% of patients undergoing cardiac surgery *(Ji et al., 2017).*

POCD can be sub-classified into the short-term and long-term. Short-term POCD is usually transitory and is defined as cognitive decline lasting up to six weeks post-surgery. It occurs in 20–50% of cardiac surgery patients. However, POCD can be long-term, defined as a subtle deterioration in cognitive function six months after surgery. It occurs in 10–30% of cardiac patients *(Ji et al., 2017).* Postoperative cognitive dysfunction after cardiac surgery predicts long-term cognitive outcome deterioration six years after the operation, particularly in executive functioning and delayed memory *(Relander et al., 2020).*

Patients appear to have a poorer cognitive function after HVR surgery compared to patients after CABG surgery, as individuals undergoing HVR surgery are at greater risk of embolic phenomena than those who were undergoing CABG (embolization carries a risk of cognitive and functional performance injuries) *(Kastaun et al., 2016).* Aortic valve surgery, performed more commonly in older adults, entails a greater risk of early cognitive dysfunction within the first month after surgery than mitral valve surgery, especially in patients with aortic stenosis as these patients have calcified aorta *(Oldham et al., 2018).*

The cognitive deficits present after open heart surgery are typically determined neuropsychological testing that reveals much about cognitive deficits, it is costly and time-consuming. Recommendations have been made to develop and use brief screening tools to effectively reveal cognitive deficits in patients after open heart surgery and identify patients at risk preoperative *(Evered et al., 2016).*

Functional performance means the level of ability to perform activities of daily living (ADL) and instrumental activities of daily living (IADL). The ADL include toileting, feeding, dressing, grooming, physical ambulation, and bathing; and the IADL includes ability to use telephone, shopping, food preparation, housekeeping, laundry, away for transportation, responsibility for following their medication regimens, and ability to handle finances *(Correa et al., 2017).*

Nurses are expected to perform comprehensive and systematic physical assessments. The nurse should be particularly astute to neurologic assessment in the pre and postoperative period. The goals of nursing care for the patient after cardiac surgery are addressing the palliative care needs of patients, including implementing family-centered care, ensuring families that core nursing care will be maintained, enhancing the quality of life by managing symptoms, integrating spiritual care, and providing a support system for patients and caregivers *(Zhou et al., 2019).*

2. Significance of the study

The world health organization indicates the prevalence of cardio-vascular-disease in adults ≥ 20, accounting for 46% of the total deaths in 2018 in Egypt. Patients who need open-heart surgery account for 20% of patients who suffer from cardiovascular disease. Patients who receive open heart surgery account was 270, 293 in 2018 in Egypt *(Hassanin et al., 2020).* The most common etiology of cardiac diseases was ischemic heart disease which needs CABG surgery, and the most common valvular abnormality in all regions of Egypt was mitral regurgitation *(Hassanien et al., 2020).*

Researchers have tracked cognitive changes after open heart surgery and found that deficits may last as long as five years, caregivers recognize deficits more readily than patients themselves, and these deficits are associated with poor satisfaction with the performance of activities of daily living (ADL) *(Kastaun et al., 2016).* So, this study will size up the problem in one of the main Egyptian cardiac centers to inform the current nursing practice and improve the nursing care and education provided for that wide patient sector.

3. Aim of the study

This study aimed at assessing cognitive outcomes and functional performance for the patient after open heart surgery through:

- Assessment of cognitive outcomes for the patient after open heart surgery.
- Assessment of functional performance for the patient after open heart surgery.

3.1. Research question

Is there a change in cognitive outcomes or functional performance among adults who undergo open heart surgery (CABG and HVR or repair) postoperatively?

3.2. Operational definitions

Cognitive outcomes mean different cognitive domains which include (visuospatial skills, executive skills, naming, memory, attention, language, abstraction, and orientation).

Functional performance mean performing activities of daily living (ADL) and instrumental activities of daily living (IADL). The ADLs include toileting, feeding, dressing, grooming, physical ambulation, and bathing. The IADLs include the ability to use the telephone, shop, food preparation, housekeeping, laundry, away for transportation, responsibility for following their medication regimens, and ability to handle finances.

4. Subjects & Methods

4.1. Research Design

A descriptive exploratory research design was used in carrying out this study. Exploratory-descriptive designs, usually field studies, provide the least control over variables. The data collected either contribute to the development of theory or explain phenomena from the perspective of the persons being studied *(Brink & Wood, 2012).*

4.2. Study setting

This study was conducted at the Open-heart Care Unit and outpatient clinic in the National Heart Institute at El Giza city. It is a 360-bed teaching hospital that offers a full range of cardiac health care services for all people in Egypt. These services include cardiac surgery. There was cardiac surgery department for the adult and pediatric cardiac surgery department. Five catheterization laboratories serve 1500 diagnostic and therapeutic cases every month. They have two computed tomography scans, an Interferon therapy unit, an emergency department, a pediatric, adult, and urgent care cardiac emergency center, and an outpatient clinic.

4.3. Subjects

A purposive sample of 103 patients who are scheduled for elective open-heart surgery (CABG and valve replacement or repair).

Inclusion criteria

Adults aged 18 and more, of both genders, can read and write, free from neurological impairment like (dementia, stroke, previous brain injury with residual cognitive deficits or intellectual disability), and free from auditory and visual disabilities.

The sample size was calculated according to the following equation as

$$n = \frac{N}{1+N(e)2}$$

n=sample size
N=population size
e=co-efficient factor *(Yamane, 1967*).

The values were calculated according to the previous equation as
n = 140/1 + 140 (0.05)2
n = 140/1.35 = 103 subjects
n: (sample size)
N:(population size)
e: error (alpha) = 0.05

4.4. Tools of data collection

Data were collected using three tools: Patient Assessment Record, Montreal Cognitive Assessment (MOCA), and Physical Self-Maintenance Scale (PSMS).

4.4.1. Patient Assessment Record

The investigator developed it after reviewing the relevant and most recent literature. This tool consisted of two parts:
The first part aimed to gather patients' characteristics, such as age, gender, level of education, and marital status.
The second part was the patient assessment record, aimed at recording the current medical diagnosis, date of admission, body mass index (BMI), surgical intervention, previous cardiac surgery, and assessing patients' risk factors before cardiac surgery as the past medical history of diabetes mellitus, hypertension, smoking; history of atherosclerosis of ascending aorta, cerebrovascular disease (transient ischemic attack or stroke), history of small subcortical vessel ischemic disease (carotid stenosis).

4.4.2. Montreal Cognitive Assessment (MOCA) Test

It aimed to assess the cognitive status of patients before and after cardiac surgery. This tool was adopted from *Nasreddine et al. (2005).* The (MOCA) test assesses several cognitive domains as follows: Visuospatial/executive function that includes clock-drawing task, cube-copy, trail making; naming task for three animals; short term memory recall task with two trials of five nouns and delayed recall after five minutes; attention including reading a list of digit (1 digit/sec forward and backward), tapping (read the list of letters), serial seven subtraction starting at 100; language including repetition of two syntactically complex sentences and verbal fluency such as naming a maximum number of words in one minute that begin with the letter F (number of words ≥11); abstraction that includes describing the similarity between two things like (Banana and orange); orientation for a date, month, year, day, place and city.

Scoring system

The MOCA was scored according to the following scoring system:

- Visuo spatial abilities: Clock-drawing task scored with 3-points, Cube-copy scored with 1-point, Trail-making task scored with 1-point. Total visuo spatial (5 points).
- The naming task of three animals (lion, cat, camel), with a score of (3 points).
- Short-term memory recall task (5 points).
- Attention: Read a list of digits forward and backward scored as 1-point for each, read a list of letters (Tapping), scored 1 point, and the subtraction task, with a score of 3 points. Total attention (6 points).
- Language: Repetition of two syntactically complex sentences, with a score of 2 points, and verbal fluency was scored as 1-points. Total language (3 points).
- Abstraction with a sore of (2 points).
- Orientation for the date (1 point), month (1 point), year (1 point), day (1 point), place (1 point), and city (1 point) with a total orientation of 6 points.

The score of each cognitive dimension was classified as follows: A score (86% to 100%) from the total score of each dimension is considered normal, and a score of 4 marks (76% to 85%) from the total score of each dimension is considered mild cognitive dysfunction, a score of (55% to 75%) from the total score of each dimension is considered moderate cognitive dysfunction, and a score of ≤54% from the total score of each dimension is considered severe cognitive dysfunction.

The total score of MOCA was classified as follows: A score of 26 to 30 is considered normal, a score of 23 to 25 is considered mild cognitive dysfunction, a score of 22 to 17 is considered moderate cognitive dysfunction, and a score of ≤16 is considered severe cognitive dysfunction *(Rosenzweig et al., 2020).*

4.4.3. Physical Self-Maintenance Scale (PSMS)

It aimed to assess the functional performance of patients before and after cardiac surgery. This tool was adopted from *Lawton and Brody (1969).* PSMS used to assess activities of daily living and instrumental activities of daily living. Activities of daily living include toilet, feeding, dressing, grooming (neatness, hair, nails, hands, face, clothing), physical ambulation, and bathing. Instrumental activities of daily living assess the patient's ability to use the telephone, shopping, food preparation, housekeeping, laundry, away for transportation, responsibility for own medications, and ability to handle finances.

Scoring system

Each activity on the ADLs scale was scored against five points to describe the patient's ADL limitation. Activities of daily living scale (ADLs), total score range from 6 to 30, which range from total independence to total dependence, as a six score indicates total independence, while higher scores indicate greater dependence.

Instrumental activities of daily living scale (IADLs) scored as flowing: Ability to use the telephone (3 points), shopping (4 points), food preparation (4 points), housekeeping (5 points), laundry (3 points), away for transportation (4 points), and responsibility of own medication (3 points), and ability to handle finances (3 points) with a total score from 8 to 31 which range from total independence to total dependence, as eight scores indicate total independence while higher scores indicate greater dependence.

4.5. Procedures

Preparatory phase: A review of the literature was done, including current and past relevant literature covering the various aspects of the study variables using textbooks, articles, periodicals, and internet search, to be aquatinted with and oriented about the aspect of the study.

Tool validity and reliability: Patient assessment record, which was constructed by the investigator and revised by a panel of seven medical and critical care nursing experts, to ensure clarity, completeness, objectivity, and relevance of the study tool and to establish the content and face validity of this tool. Content validity was done to identify the degree to which the used tool measured what was supposed to be measured and to determine whether the included items were clear and suitable to achieve the aim of the current study, MOCA test was adopted from *Nasreddine et al. (2005)* and reported a sensitivity and specificity of (MOCA) for detecting mild cognitive impairment were between 90% and 87%. PSMS test was adopted from *Lawton and Brody (1969)* and reported a correlation of 0.62 with a physician rating of functional health and 0.61 with an (IADL) scale and reliability (quantitative) by Pearson correlation of 0.87. Inter-rater reliability of 0.91 has also been reported. Aguttman reproducibility coefficient of 0.96 was also reported.

Ethical considerations: Ethical approval was obtained from the Scientific Research and Ethical Committee of the Faculty of Nursing, Ain Shams University. An official letter requesting permission to conduct the study was directed from the dean of the Faculty of Nursing, Ain Shams University to the medical and nursing directors of the National Heart Institute at Embaba to obtain their approval to carry out this study. These letters included the aim of the study and photocopy of data collection tools to get permission and help for the data collection. Verbal consent was taken from patients or responsible relatives to participate in the study after explaining the study's aim. The participants in the study were informed that they had the right to withdraw from the study at any time without penalties. The participants were assured of confidentiality and anonymity of information gathered that will be used only for the study.

A pilot study was conducted on ten percent of the total study subject. The aim of the pilot study was to examine the feasibility, objectivity, and applicability of the study tools. Based on the result of the pilot study, no modifications were done. The pilot sample was included in the actual study sample.

Fieldwork started after the official permission from the responsible authority at National Heart Institute, Embaba. The researcher visited the study setting and met the patients to collect demographic data from the patient to identify the patients who matched the inclusion criteria. Each participant was assessed for cognitive functions and functional performance abilities by using MOCA tests and PSMS before and one month after surgery, then compared between the results of preoperative and postoperative tests to assess the cognitive outcomes and functional performance of patients undergoing cardiac surgery.

Data were collected over six months, from August 2020 to the end of January 2021. Data were collected three days a week from Wednesday to Friday at morning, afternoon, and night shifts. Infection control precaution against Covid-19 was strictly applied according to the Egyptian Ministry of Health guidelines.

4.6. Data analysis

Statistical analysis was done using the SPSS program (version 20) (SPSS inc. Chicago,IL); relevant statistical analysis was used to test the obtained data. Descriptive statistics were applied, quantitative data were (e.g., mean, standard deviation). qualitative data were expressed as, frequency, percentage. Fisher exact test and Chi square test were used to test the association between different qualitative variables. McNemar and Marginal Homogeneity tests were used to test relation between before and after surgery for qualitative data. Statistical significance was considered at a p-value ≤0.05.

5. Results

Table 1 shows that the mean age of studied patients was 52.82±10.42, and 61.2% were above 50 years of age, 65% of them were males, 56.3% of them had high education, and 86.4% of patients were married.

Table 2 clarifies that 36.9% of patients had moderate obesity. 41.7% of studied subjects underwent CABG (coronary-artery-bypass graft) (on-pump) and 49.5% of studied subjects were smokers.

Table 3 shows all dimensions of cognitive functions pre and post-open heart surgery. Visuospatial abilities show that 47.6% of the patients had a normal level before surgery vs 36.9% postoperative. Besides, no one patient had severe visuospatial disabilities preoperatively compared to 9.7% postoperatively. The naming function shows that 62.1% of patients had a normal function before surgery and 55.3% after surgery. Short-term memory reveals a similar result 12.6% of patients had normal level preoperative vs. 9.7% postoperative, no severe deficit postoperative, and 16.5% had severe deficit postoperative.

Attention function reveals that 51.5% of the patients had normal attention before surgery vs. 45.6% after surgery. At the same time, 3.9% had severe attention deficit before surgery, converted to 22.3% postoperatively. The language was also affected as 60.2% of the patients had a normal function before surgery vs. 48.5% after surgery, with 5.8% having severe language dysfunction before surgery, which turned 23.3% after surgery. Abstraction also shows a similar deficit, as 85.4% of the patients were normal before surgery vs 71.8% after surgery, with 15.5% of patients showing severe abstraction deficit postoperatively compared to no one preoperatively. Orientation reveals that 14.6% of the patients were normal after surgery compared to 21.4% postoperatively.

Table 4 reveals the relation between the total score of cognitive domains before and after surgery. The table shows a statistically significant deterioration in all cognitive functions postoperatively compared with the patients' preoperative levels.

Table 5 shows deterioration in cognitive functions after open heart surgery than before, as 17.5% of the patients deteriorated to a severe deficit after surgery vs. no one before surgery.

Table 6 reveals the relation between the total cognitive score (MOCA) before and after surgery. The table shows a statistically significant deterioration in cognitive functions postoperatively compared with the patient's preoperative levels (p=0.000).

Table 7 shows deterioration in the activity of daily living after surgery among 25.2% of patients who became dependent as measured by the ADL scale compared to no one before surgery. There is deterioration after surgery among patients as 23.3% became dependent as measured by the IADL scale compared to no one before surgery.

Table 8 shows deterioration in the total ADL after open heart surgery as 25.2% became dependent as measured by the PSMS scale.

Table 9 shows the relationship between the type of surgery and open-heart surgery outcomes. The table shows that the CABG (off-pump) has the least complication among the other type of surgery with no severe or moderate level of cognitive dysfunction, while the 7% moderate dysfunction in on-pump CABG patients and so in AVR (9.1%), and MVR (3.4%) post open heart surgery although the difference was not statistically significant. The table also shows a statistically significant relationship between the ADL and the type of surgical intervention with the CABG off-pump group was no complication on ADL compared to 25.6% CABG on-pump, 27.3% AVR, and 41.4% MVR were dependent postoperatively.

Table (1): Frequency and percentage distribution of demographic characteristics of the studied patients (N = 103).

Variables	N	%
Age		
18-30 years	4	3.9
>30-50 years	36	35.0
>50 years	63	61.2
Mean±SD	52.82±10.42	
Gender		
Male	67	65.0
Female	36	35.0
Educational level		
Illiterate	0	0.0
Read & write	2	1.9
Essential Education	7	6.8
Diploma	36	35.0
High education	58	56.3
Marital status		
Single	9	8.74
Married	89	86.4
Widow	3	2.92
Divorced	2	1.94

Table (2): Frequency and percentage distribution of studied patients' medical data (n=103).

Variables	N	%
BMI		
Under normal (<18)	2	1.9
Normal (18 - 24.9)	14	13.6
Overweight (25 - 29.9)	33	32.0
Moderate obese (30 - 35)	38	36.9
Severe obese (35 - 40)	15	14.6
Very severe obese (>40)	1	1.0
Surgical intervention		
CABG (coronary-artery-bypass graft) (on pump)	43	41.7
CABG (coronary-artery-bypass graft) (off-pump)	20	19.4
AVR* (Aortic-valve-replacement or repair)	11	10.7
MVR** (heart-valve-replacement or repair) (MVR)**	29	28.2
Previous cardiac surgery	4	3.9%
Past medical history		
Diabetes milletus	41	39.8
Hypertension	43	41.7
Smoking	51	49.5
Previous cardiac surgery	4	3.9
History of atherosclerosis of ascending aorta	0	0.0
History of cerebrovascular disease (transient ischemic attack or stroke)	0	0.0
History of carotid stenosis	0	0.0

**AVR: Aortic valve replacement/repair, ** MVR: Mitral valve replacement/repair.*

Table (3): Comparison of patients' cognitive dimensions pre- and post-open heart surgery (n=103).

Cognitive dimensions	Pre		Post	
	N	%	N	%
Visuospatial abilities				
Normal	49	47.6	38	36.9
Mild	54	52.4	48	46.6
Moderate	0	0.0	7	6.8
Severe	0	0.0	10	9.7
Naming				
Normal	64	62.1	57	55.3
Moderate	39	37.9	45	43.7
Severe	0	0.0	1	0.9
Short-term memory recall task (STMRT)				
Normal	13	12.6	10	9.7
Mild	65	63.1	56	54.4
Moderate	25	24.3	20	19.4
Severe	0	0.0	17	16.5
Attention				
Normal	53	51.5	47	45.6
Mild	34	33.0	24	23.3
Moderate	12	11.7	9	8.7
Severe	4	3.9	23	22.3
Language				
Normal	62	60.2	50	48.5
Mild	0	0.0	0	0.0
Moderate	35	34.0	29	28.2
Severe	6	5.8	24	23.3
Abstraction				
Normal	88	85.4	74	71.8
Moderate	15	14.6	13	12.6
Severe	0	0.0	16	15.5
Orientation				
Normal	22	21.4	15	14.6
Mild	81	78.6	87	84.5
Moderate	0	0.0	1	1.0
Severe	0	0.0	0	0.0

Table (4): Relation between total score of cognitive domains before and after open heart surgery (n=103).

Cognitive dimension (post)	Total cognitive score (pre)								Test*	P
	Normal		Mild		Moderate		Severe			
	N	%	N	%	N	%	N	%		
Visuospatial abilities (post)										
Normal	38	77.6	0	0.0	0	0.0	0	0.0	4.562	0.000
Mild	7	14.3	41	75.9	0	0.0	0	0.0		
Moderate	2	4.1	5	9.3	0	0.0	0	0.0		
Severe	2	4.1	8	14.8	0	0.0	0	0.0		
Naming (post)										
Severe	0	0.0	0	0.0	0	0.0	1	1.6	2.183	0.029
Mild	0	0.0	0	0.0	0	0.0	0	0.0		
Moderate	0	0.0	0	0.0	38	97.4	7	10.9		
Normal	0	0.0	0	0.0	1	2.6	56	87.5		
Short-term memory recall task (STMRT) (post)										
Normal	7	53.8	0	0.0	3	12.0	0	0.0	3.411	0.001
Mild	2	15.4	52	80.0	2	8.0	0	0.0		
Moderate	1	7.7	6	9.2	13	52.0	0	0.0		
Severe	3	23.1	7	10.8	7	28.0	0	0.0		
Attention total score (post)										
Normal	47	88.7	0	0.0	0	0.0	0	0.0	4.080	0.000
Mild	0	0.0	23	67.6	1	8.3	0	0.0		
Moderate	0	0.0	0	0.0	9	75.0	0	0.0		
Severe	6	11.3	11	32.4	2	16.7	4	100.0		
Language score (post)										
Normal	47	75.8	0	0.0	3	8.6	0	0.0	3.575	0.000
Mild	0	0.0	0	0.0	0	0.0	0	0.0		
Moderate	3	4.8	0	0.0	26	74.3	0	0.0		
Severe	12	19.4	0	0.0	6	17.1	6	100.0		
Abstraction (post)										
Normal	6	40.0	10	11.4	6	40.0	10	11.4	4.243	0.000
Moderate	9	60.0	4	4.5	9	60.0	4	4.5		
Severe	0	0.0	74	84.1	0	0.0	74	84.1		
Orientation test score (post)										
Normal	15	68.2	0	0.0	0	0.0	0	0.0	2.828	0.005
Mild	7	31.8	80	98.8	0	0.0	0	0.0		
Moderate	0	0.0	1	1.2	0	0.0	0	0.0		
Severe	0	0.0	0	0.0	0	0.0	0	0.0		

**Marginal Homogeneity test was used.*

Table (5): Comparison of total Montreal cognitive assessment score for the studied patients before and after open heart surgery (n=103).

Cognitive levels	Pre		Post	
	N	%	N	%
Total cognitive score				
Normal	70	68.0	57	55.3
Mild	28	27.2	25	24.3
Moderate	5	4.9	3	2.9
Severe	0	0.0	18	17.5

Table (6). Relation between total cognitive functions of patients with open heart surgery before and after cardiac surgery (N = 103)

Level of cognitive functions	Total cognitive score (pre)								Test*	P
	Normal		Mild		Moderate		Severe			
	N	%	N	%	N	%	N	%		
Total cognitive score (post)										
Normal	57	81.4	0	0.0	0	0.0	0	0.0	4.383	0.000
Mild	4	5.7	21	75.0	0	0.0	0	0.0		
Moderate	0	0.0	0	0.0	3	60.0	0	0.0		
Severe	9	12.9	7	25.0	2	40.0	0	0.0		

**The marginal Homogeneity test was used.*

Table (7): Frequency and percentage distribution of activity of daily living in the studied patients before and after open heart surgery (n=103).

ADLs levels	Pre		Post	
	N	%	N	%
The activity of daily living				
Independent	103	100.0	77	74.8
Dependent	0	0.0	26	25.2
The instrumental activity of daily living				
Independent	103	100.0	79	76.7
Dependent	0	0.0	24	23.3

Table (8): Frequency and percentage distribution of total activity of daily living in the studied patients before and after open heart surgery (n=103).

Total activity of daily living level	Pre		Post		P*
	N	%	N	%	
Independent	103	100.0	77	74.8	0.000
Dependent	0	0.0	26	25.2	

**Fisher Exact test*

Table (9): Relation between the open-heart surgery outcomes and the type of surgical intervention pre and postoperative (n=103).

Open heart surgery outcomes	Surgical Group								Test	P
	CABG (on pump)		CABG (off pump)		AVR		MVR			
	N	%	N	%	N	%	N	%		
Cognitive functions (pre)										
Normal	28	65.1	14	70.0	9	81.8	19	65.5	Fisher exact 3.845	0.695
Mild	12	27.9	6	30.0	1	9.1	9	31.0		
Moderate	3	7.0	0	0.0	1	9.1	1	3.4		
Severe	0	0.0	0	0.0	0	0.0	0	0.0		
Cognitive functions (post)										
Normal	22	51.2	14	70.0	6	54.5	15	51.7	Fisher exact 12.423	0.129
Mild	13	30.2	6	30.0	1	9.1	5	17.2		
Moderate	1	2.3	0	0.0	1	9.1	1	3.4		
Severe	7	16.3	0	0.0	3	27.3	8	27.6		
The activity of daily living (pre)										
Independent	43	100.0	20	100.0	11	100.0	29	100.0	--	--
Dependent	0	0.0	0	0.0	0	0.0	0	0.0		
The activity of daily living (post)										
Independent	32	74.4	20	100.0	8	72.7	17	58.6	X^2 10.781	0.013
Dependent	11	25.6	0	0.0	3	27.3	12	41.4		

6. Discussion

Neurological complications secondary to cardiac surgery encompass a variety of disorders, including stroke, postoperative delirium (POD), and postoperative cognitive decline (POCD). Postoperative cognitive dysfunction (POCD) occurs in 25% to 50% of patients after cardiac surgery. These neurological complications are associated with increased mortality and decreased quality of life *(Liu et al., 2019)*. The current study aimed to assess cognitive outcomes and functional performance of the patient after open heart surgery.

The patient demographic characteristics show that nearly one-third of the study sample was above fifty years of age, males, more than half of the study sample had high education, and most of them were married. This age is commonly affected by cardiovascular disorders. In addition, being male is another factor. This result was in the same line as *Hassanien et al. (2020)*, who studied “Demographics, clinical characteristics, and outcomes among hospitalized heart failure patients across different regions of Egypt,” and found that the mean age of studied subjects who suffer from cardiac diseases which usually need cardiac surgery ranged from 52.2 to 62.8 years and males were more than females (68% vs. 32%). This finding is in concordance with *Gao et al. (2019)*. They studied gender differences in cardiovascular disease and found that men usually have a two-fold higher incidence of coronary heart disease and more related mortality than women.

The current study reveals that patients’ body mass index (BMI) shows various degrees of obesity. Obesity is one of the risk factors that might induce coronary artery disease, hypertension, and diabetes milletus. *Aboulghate et al. (2021*), in a study about "The burden of obesity in Egypt,” reported a prevalence of obesity that has increased in adults in Egypt to reach about 40% according to a 100million health survey, 2019 compared to the 36% estimate of 2017 STEPwise survey. Obesity is more prevalent in Egyptian females than males (about 50% and 30%, respectively). This finding could probably be attributed to cultural factors, as females in Egypt are less likely to be involved in physical activities than males *(WHO, 2017; Alebshehy, 2016).*

The result of the current study agreed with *Bakhtiyari et al. (2022)*. They studied the contribution of obesity and cardiometabolic risk factors in developing cardiovascular disease and found that general obesity increased the risk of incident cardiovascular diseases (CVDs) by 68%.

Regarding the distribution of type of surgery for patients on cardiac surgery, nearly two-thirds of the studied patient in the current study had CABG surgery (off-pump or on-pump), and nearly half of them were on-pump. In addition, more than one-fourth of the study subjects underwent mitral valve replacement/repair. This finding might be the cause behind the cognitive deficit due to microinfarctions. This finding is agreed with *Hassanien et al. (2020)*, who found that the most common etiology of cardiac diseases was ischemic heart disease which needs CABG surgery and reported that the most common valvular abnormality in all regions was mitral regurgitation.

The assessment of cognitive outcomes among adults who undergo open heart surgery over time as measured by the Montreal Cognitive Assessment (MOCA) test in the current study shows a statistically significant impairment of cognitive functions of patients after open heart surgery in domains of visuospatial and executive function, naming, short term memory, attention, language, abstraction, and orientation. This finding might be referred to many factors, namely patient factors, anesthesia, and surgical technique (either on-pump or off-pump) *(Kamel, 2019).* This finding was evident in the current study as the CABG off-pump had the least complication regarding cognitive functions compared with the other types of surgical techniques and so for ADL.

The result of the current study is in the same line as *Kureshi et al. (2016)*. They studied the effect of open-heart surgery on the cognitive outcomes of patients undergoing open-heart surgery. They found that between 30% and 60% of patients undergoing CABG surgery develop deficits in cognitive function. Patients after heart valve repair or replacement (HVR) surgery is developing cognitive dysfunction compared to patients after CABG surgery, possibly due to more particulate air emboli from the valve itself or increased cerebral air micro embolism from the open cardiac chambers during surgery.

Similar findings were reported by *Relander et al. (2020)*. They studied “Postoperative cognitive change after cardiac surgery predicts long-term cognitive outcome" and found that one week after surgery, 71% of patients showed a cognitive decline, as compared to preoperative results. Three months post-surgery, the decline was observed in 47% and improvement in 25% of patients. Executive functioning and delayed memories were the most sensitive domains to decline and improvement. Postoperative dysfunction predicted long-term cognitive deterioration six years after the operation, particularly in the domains of executive functioning and delayed memory.

However, the findings of the current study differ from what was reported by *Knipp et al. (2017)*, who studied neurologic complications after cardiac surgery and showed that the course of cognitive performance after valve surgery and CABG was similar with early postoperative decline followed by subsequent recovery. Although silent small brain infarcts were present in about half of all patients, they did not impact cognitive performance either early or during long-term follow-up. The difference with the current study might be due to different surgical techniques and patient characteristics.

Regarding assessing functional performance among patients who undergo open heart surgery over time as measured by the physical self-maintenance scale (activities daily living) (PSMS), the current study shows an increased dependency after open heart surgery compared to preoperative levels of PSMS (either ADL, IADL) in about one-fourth of the studied patients. This finding might be due to the patient fear of doing activities, anxiety, or depression due to the extended recovery period.

Oxlad et al. (2006); Parker and Adams (2008) in their studies have linked factors such as depression and anxiety to the observed suboptimal outcomes. In patients who had undergone coronary artery bypass grafting (CABG), depression and anxiety were associated with higher hospital readmission rates. The result of the current study was in the same line as *Niemeyer-Guimaraes et al. (2016)*. They studied the course of functional status in elderly patients after coronary artery bypass surgery: 6-month follow-up. They found a significant decline in functional performance directly after CABG surgery that did not return to baseline by six months.

Also, the result of the current study is in concordance with *Benjamin et al. (2018)*. They studied neurologic complications after cardiac surgery and found that stroke is one of the most devastating complications after cardiac surgery that entails permanent disability.

7. Conclusion

The current study concluded that open heart surgery impacts both cognitive functions, particularly in domains of visuospatial and executive function, naming, short-term memory, attention, language, abstraction, and orientation, and everyday functional performance, indicating that patients may require assistance to perform both activities of daily living (ADL and IADL), which include toileting, feeding, dressing, grooming, physical ambulation, and bathing. Besides, instrumental activities of daily living (IADL) include the ability to use the telephone, shopping, food preparation, housekeeping, laundry, away for transportation, responsibility for following their medication regimens, and the ability to handle finances.

8. Recommendations

In the light of the results of this study, the following recommendations were suggested:

- Nurses caring for patients undergoing open heart surgery should consider cognitive limitations when planning health education and discharge instructions. They should consider their readiness to learn when planning for educational sessions, emphasizing that most health instruction should be given mostly in the preoperative period, and slowly, repetitively postoperatively according to patient cognitive affection. They should also consider their functional performance limitation on a short and long term.

- Preoperative screening for patients undergoing open heart surgery to examine the high-risk patients for cognitive and functional deficit.
- Further studies should be carried out to identify the factors that may contribute to the impairment of cognitive function and functional performance for patients undergoing cardiac surgery. Developing ideas to facilitate the education of those patients.
- Replication of the study on a larger probability sample selected from different geographical areas in Egypt is recommended to obtain more generalizable data.

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