



Research Paper

Evaluating Quality of Life and Cognitive Impairment in Post-cardiac Operation



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ABSTRACT

Background: Cardiovascular disease can affect the quality of life and postoperative cognitive dysfunction (POCD) following cardiac operation.

Objectives: The current study aimed to evaluate POCD along with underlying factors in patients after cardiac operation to improve the quality of life, duration of hospitalization, resulting in better prognosis with lower mortality rates.

Materials & Methods: This descriptive cross-sectional study was conducted on 183 patients who underwent cardiac operation. In this study, patients completed the mini-mental state examination (MMSE) questionnaire about cognitive disorders before the operation and after recovery. Quality of life was also measured using the SF-36 questionnaire, which the patients completed before and 6 months after the operation.

Results: This study showed a positive correlation in MMSE scores before and after the operation ($P=0.006$). Also, there was a significant decline in MMSE score after the operation (from 24.91 to 9.67). MMSE score decline after the operation was negatively related to smoking habit ($P=0.011$), time of hospitalization at ICU, cerebral oximetry indexes $<50\%$, ejection fraction (EF) index $<35\%$ and on-pump blood pressure less than 50 mm Hg ($P=0.00$). Also, all eight items in the SF-36 questionnaire had improved significantly after the operation compared to counterpart items before the operation ($P=0.001$). We found no significant relationship between the demographic characteristics of patients and the SF-36 score.

Conclusion: This study showed that the MMSE score declines after cardiac operation, and quality of life improves significantly.

Keywords: Mental status and dementia tests, Postoperative cognitive complications, Quality of life, Cardiac surgical procedures

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Highlights

- Anesthesia administration has a long-term effect on brain functions.
- Anesthesia administration renders the development of postoperative cognitive disorders.
- Cognitive decline was observed following cardiac operation.
- Increase in blood pressure and decrease in cerebral oximetry index are observed after cardiac operation.
- Time of hospitalization affects cognitive disorders in patients after cardiac operation.
- The quality of life has been improved after cardiac operation.
- The mini-mental state examination score declines, whereas the SF-36 score improves after cardiac operation.

Introduction

Hearth diseases have caused a global concern and accounts for a lot of mortality, about 18 million people annually. The rate of mortality is considerably higher in developing countries, with about 82% death rate [1]. Factors contributing to cardiac diseases are overweight, lack of physical activities, excessive alcohol intake, lack of proper nutrition, family history, hypertension, diabetes, high cholesterol, as well as some psychiatric issues such as depression, tension, anxiety, fear, and anger [2]. Cardiovascular diseases affect people's quality of life, not to mention burdening patients and society with a lot of expenditure.

Quality of life is associated with maintaining good physical and mental health status, proper social communications, moderate economic status, job satisfaction, and education, as well as having a sense of security, freedom, and authority in making a decision. It also relates to the quality of the environment in which a person lives [3]. Additionally, health-related quality of life is a person's social, emotional and physical health status following medical intervention, which is associated with a person's characteristic and interdisciplinary aspects of life [4]. Various psychological manifestations, such as anxiety, fatigue, rigidity and annoyance, are directly related to how a person deals with the current situation and improve the quality of life. So, patients' lifestyle and physical status would be significantly related to the development of cardiac complications, indicating the effect of psychological features on the occurrence of physical disease. So, the management of psychological aspects should be considered as a prophylactic consideration [5].

Studies conducted on patients who underwent cardiac operation from 2009 to 2015 indicated the high prevalence of perioperative loss of health-related quality of life. However, administration of cardiac rehabilitation could improve the mental and physical status of patients 30 and 180 days after coronary operation [6].

Additionally, older patients are confronted with postoperative cognitive dysfunction (POCD) following cardiovascular operation owing to the administration of anesthesia [7]. The POCD is characterized by a long-term or short-term loss of attention, memory, and concentration, which can persist 6 weeks to 6 months, and even several years after cardiac operation [8]. The type of operation, either cardiac or non-cardiac operation, could affect the incidence of POCD; patients who underwent coronary artery bypass graft (CABG) are more prone to POCD one week after the operation (37.6%) or three months after the operation (20.08%) [9]. Old age; history of cardiac, vascular, and neurological complications; alcohol consumption; and gender are considered a predictive factor of PCOD. The prevalence of POCD is higher in patients aged 60-69 and over 70 years, as well as in the female gender, in which the level of creatinine and the rate of bleeding is increased after cardiac operation [10].

The exact mechanism of POCD has not been discovered yet. However, various studies indicate the effect of cerebral microemboli as a result of the accumulation of β -amyloid, a neurotoxic protein, contributing to the production of N-acetylcholine (NAC) released in the central nervous system. The outcome of NAC synthesis is blocking nicotine acetylcholine receptors, a significant neurotransmitter related to memory, learning, and consciousness regulation [11, 12].

An updated narrative review about POCD following cardiac operation from 2015 to 2022 indicates that inflammation, cerebral hypoperfusion, anesthesia, glycaemia, and microemboli are underlying factors of PCOD. However, dexamethasone and NIRS administration would relatively attenuate the inflammation and cerebral desaturation [13].

Considering the occurrence of POCD in the patients after cardiac operation along with the health-related quality of life, the current study aimed to evaluate the quality of life and POCD and underlying factors in patients after cardiac operation to improve the quality of life, duration of hospitalization to achieve better outcomes with lower mortality rate.

Materials and Methods

This descriptive, analytical, and cross-sectional study was conducted on 183 patients referred to Rajaei Heart Hospital, Tehran City, Iran, within 6 months follow-up who underwent elective cardiac operation (coronary, valvular, and congenital operation). The informed consent was obtained from all patients before the study. A questionnaire was prepared to record the clinical manifestations of the patients before and after the operation. The patients completed the mini-mental state examination (MMSE) questionnaire about cognitive disorders before the operation and after recovery. The standard MMSE questionnaire was translated into Persian and was validated for Persian patients. It constitutes questions about orientation, attention, concentration, naming, verbal memory, and visuospatial skills [14]. Furthermore, quality of life was also measured using the SF-36 questionnaire [15], translated to the Persian from its original one and validated by Montazeri et al. It contained 36 questions evaluating the quality of life regarding physical function, body pain, social functioning and general and mental health issues [16]. The patients completed it before the operation and then 6 months after operation. Patients with emergency operation, patients who underwent emergency aneurysm operation and dissection, as well as patients who expired after the operation have been excluded from the current study.

Statistical analysis

Descriptive statistical analysis was performed using variance analysis and t-test. The Pearson correlation and 2-tailed t-test were performed to find the correlation between study variables. SPSS software, version 23 was applied for analysis.

Results

A total of 183 patients who underwent cardiac operation were enrolled in this study. The mean age of the patients was 53.61 ± 15.36 years (range: 17 to 97 years), with a higher prevalence of male patients than females (69% vs 30.6%, respectively). The demographic characteristics of patients are listed in Table 1. The study population was relatively younger than 55 years old, and the prevalence of diabetes was above 30%, indicating a high-risk factor for cardiac complications.

After cardiac operation, we evaluated patients' clinical manifestations and risk factors to determine the possible relationship between risk factors and cognitive loss in the patients. According to the results presented in Table 2, we observed lower mean blood pressure (<50 mm Hg), decreased oxygen saturation in the brain (cerebral oximetry) and an ejection fraction (EF) $<35\%$ (Table 2).

Cognitive function scoring based on MMSE model compared with demographic characteristics

The cognitive function of patients was evaluated using the MMSE before and after the operation, and any alteration in cognitive function was assessed in relation to age, sex, weight, education, hypertension, diabetes, history of brain and heart stroke, addiction, and smoking. The Pearson correlation analysis showed a positive correlation in the MMSE score before and after operation ($P=0.006$). Also, there was a significant decline in MMSE score after the operation (from 24.91 to 9.67), indicating the increase in cognitive complications after operation (Table 3).

Furthermore, we evaluated the correlation between MMSE score and cognitive score decline with patients' risk factors after operation, including time of operation, on-pump operation time, aortic clamp time, time of hospitalization at ICU, smoking and other clinical and laboratory risk factors. Based on the Pearson correlation test, MMSE score decline after the operation was negatively related to smoking habit, time of hospitalization at ICU, cerebral oximetry indexes less than 50%, EF index $<35\%$, and on-pump blood pressure <50 mm Hg (Table 4).

Quality of life evaluation before and after the cardiac operation

The quality of life was assessed using the SF-36 score considering physical functioning, social functioning, role limitation due to physical health and emotional problems, body pain, vitality (energy/fatigue), emo-

Table 1. Demographic characteristics of patients enrolled in the study

Characteristics		Mean±SD/(%)
Age (y)	Range: 17-97	53.61±15.336
Weight (kg)	Range: 32-114	76.68±14.8
Gender	Female	30.6
	Male	69.4
Education	Uneducated	14.8
	Diploma	70.5
	BS	9.8
	MS	4.9
	PhD	0
Diabetic		30
Hypertension		32.8
Arrhythmia		13.1
History of brain stroke		2.2
History of heart stroke		4.4
Addiction		8.8
Smoker		27.9
Type of operation	CABG	91.3
	ASD/VAD	4.9
	Mixed	3.8

CABG: Coronary artery bypass graft; ASD/VAD: Atrial septal defect/ventricular assist device.


Table 2. Clinical manifestations after heart operation

Characteristics	Mean±SD/ %	Range
On-pump operation time (min)	96.63±37.85	23-316
Aortic clamp time (min)	60.30±26.09	17-208
Operation duration (h)	5.37±1.16	1-12
Base Hb (dL/g)	13.25±1.53	9-19
Intubation time (h)	18.28±4.16	7-48
Hospitalization at ICU (d)	4.14±1.47	2-10
Blood pressure increase to more than 50 on on-pump operation	76	-
Cerebral oximetry indexes >50%	82.5	-
Ejection Fraction >35%	82.2	-



Table 3. MMSE score before and after the operation

MMSE Score		Mean±SD	95% CI	The Pearson Correlation	P
Operation	Before	24.91±5.55	24.10–25.71	0.204	0.006
	After	9.67±1078	8.09–11.25		



tional well-being and general health perception before and after the cardiac operation. According to Table 5, all eight items in the SF-36 questionnaire had improved significantly after operation compared to counterpart items before the operation. The results of the SF-36 questionnaire were evaluated using demographic characteristics and medical history before and after the operation using the Pearson correlation test. We found no statistically significant relationship between the demographic characteristics of patients and the SF-36 score. However, duration of operation negatively correlated with SF-36 score after operation (the Pearson correlation=-1.19, P=0.012) and on-pump Hct positively correlated with SF-36 score (the Pearson correlation=0.182, P=0.015). Additionally, the EF score had improved to more than 35% in 85% of patients, indicating a better recovery and quality of life after heart operation (P<0.05).

SF-36 scores variation in pre and post-operation

We further evaluated the percentage and mean score of SF-36 items in pre- and post-operation (Table 4). Most items increased with some exceptions (vitality and general health). Although their scores increased after the operation, but in 20.8% and 35% of cases, they remained

unchanged. Furthermore, physical functioning, role limitation due to physical functioning and due to emotional problems, emotional well-being, and social functioning scores dramatically increased compared to pre-operation (Table 6).

Discussion

Annually, more than 2 million heart operations are performed worldwide, whose patients are at higher risk of POCD. It is defined as an impaired functional mental activity, including concentration, attention and loss of memory due to neurological complications after cardiac operation [17]. As a consequence, nowadays, the attention toward physical and mental recovery after cardiac operation has increased.

The current study was conducted on 183 patients who underwent cardiac operation with a mean age of 53.6 years. We found a higher prevalence of diabetes, hypertension, and smoking habits in these patients. The cognitive function decline has been observed on MMSE scores following cardiac operation, with the majority on CABG operation, which is associated with smoking habit, time

Table 4. Correlation between intraoperative data and MMSE score

Intraoperative Data	The Pearson Correlation	P
Smoking	-0.188	0.011*
On-pump operation time (min)	0.030	0.60
Time of operation	0.026	0.72
Aortic clamp time	0.013	0.86
Time of hospitalization at ICU	-0.344	<0.001**
Intubation time (min)	0.002	0.97
Cerebral oximetry indexes <50%	-0.378	0.000**
Ejection fraction index <35%	-0.366	0.000**
On-pump mean blood pressure <50 mm Hg	-0.554	0.000**

*Correlation is significant at 0.05 level (2-tailed), **Correlation is significant at 0.01 level (2-tailed).



Table 5. The SF-36 Mean±SD scores before and after the operation

SF-36 Items	Mean±SD		P
	Before the Operation	After the Operation	
Physical functioning	31.15±14.67	68.49±24.63	<0.001
Role limitations due to physical health	29.43±19.36	48.66±29.03	<0.001
Role limitations due to emotional problems	48.79±28.95	61.71±31.78	<0.001
Energy/fatigue	39.55±24.28	49.62±26.94	<0.001
Emotional well-being	62.96±28.33	67.97±24.11	0.01
Social function	53.81±20.74	74.13±28.76	<0.001
Pain	51.48±26.9	66.68±28.35	<0.001
General health	39.37±16.61	52.47±21.23	<0.001


Table 6. The frequency of decrease, increase, or stable scores of sf-36 items in pre-operation and post-operation

Post-operation SF-36	No.	Decreased		No Change		Increased	
		No. (%)	Mean Difference	No. (%)	Mean Difference	No. (%)	Mean Difference
Physical functioning	183	32(17.5)	-16	19(10.3)	132(72.2)	39.9	
Role limitations due to physical health	182	36(19.8)	-17.8	23(12.6)	123(67.6)	32.6	
Role limitations due to emotional problems	180	48(26.6)	-19.6	11(6.1)	121(67.2)	23.1	
Energy/fatigue	183	59(32.2)	-23.3	38(20.8)	86(47)	16.4	
Emotional well-being	182	46(25)	-16.4	7(3.8)	129(71.2)	20.8	
Social function	181	52(28.7)	-14.9	19(10.5)	110(60.8)	29.7	
Pain	180	39(21.6)	-21.6	29(16.1)	112(62.3)	34.4	
general health	183	21(11.5)	-42.9	64(35)	98(53.5)	36.7	



of hospitalization at ICU, cerebral oximetry indexes <50%, EF index <35%, and on- pump blood pressure <50 mm Hg. The main objective of the current study was to assess cognitive complications and quality of life after operation while patients were discharged from the hospital. According to MMSE scoring, the cognitive score before the operation was 24.9, which decreased significantly after the operation to 9.67. Neurological complications are the most prevalent complications that occur after cardiac operation. These complications are classified into type I and type II neurological impairments. Delirium and cognitive defects are classified as type II neurological impairments, according to the American

College of Cardiology and American Heart Association [17, 18]. POCD is characterized by decision-making ability, attention, speaking, motor skills and visuospatial interpretation, consistent with the DSM-5 definition regarding the terminology of neurological disorders [19, 20]. It was observed that in older people, excessive bleeding and higher levels of creatinine are significantly related to POCD [21]. Additionally, the rate of cognitive complication is directly related to the age and time of the post-operation period. POCD is more prevalent in patients aged 60-69 owing to cerebral hypoperfusion, cerebral inflammation, and ischemic damage [10, 22, 23].

Timothy et al. evaluated the effect of chronic smoking habit with neurocognition and brain neurobiology using cohort studies. Results of the literature review reveal that chronic smoking contributes to brain atrophy and neurodegenerative complications, which are associated with decision-making ability, general intellectual function of the brain, learning and memorizing skills, and cognitive tensile, especially at older ages [24]. The current study confirms the previous findings about cognitive decline following heart operation. The mean age of the enrolled patient was 53.6 years, which was relatively younger than earlier reports, and according to MMSE scoring, the cognitive decline was closely related to smoking habits ($P=0.011$).

During cardiac operation, patients receive anesthetic agents, which make them lose consciousness, which may have a long-term effect on brain functions, including the development of POCD. Administration of volatile agents would have a better cognitive outcome following cardiac operation, which could reduce the risk of brain ischemia occurring in CBP with cardioplegic arrest [25]. The type of anesthetic agents was not clarified in our research.

According to one cohort study conducted on neurological complications after cardiac operation, intraoperative blood pressure and oxygen saturation maintenance during heart operation are closely related to neurological outcomes. Thus, having a sustained amount of hemoglobin of at least 7.5 g/dL is claimed to be adequate for cardiac operation. Maintenance of blood pressure and cerebral oximetry index is paramount in cardiac operation. The hypotension status may lead to impaired blood clearance and an increased risk of emboli, especially in the brain. In contrast, hypertension contributes to post-operative delirium and cognitive decline [26, 27]. Also, hemoglobin should be maintained at adequate levels to provide oxygen supply. Mazer et al. [27] declared that the amount of Hb under 7.5 g/dL would be sufficient for oxygen supply; hence, more research should be performed to confirm this claim [28]. We found no statistical correlation between cognitive decline and Hct level after the operation.

It has been shown that blood pressure fluctuation and brain hypoxia are probable causes of cognitive decline after heart operation, especially at older ages. Our brain's function is strictly associated with blood and oxygen supply, as moderate hypoxia renders the impaired cholinergic system, releasing the neurotransmitters and damaging the brain [29]. Also, low hypotension negatively affects the clearance of the embolus and brain function.

Based on data obtained from a systematic review of risk factors of cognitive decline after heart operation, the effect of low blood pressure on delirium and brain stroke after heart operation and maintenance of blood pressure is an essential criterion for brain function [30]. Accordingly, we observed an increase in blood pressure in 76% of patients and an improvement of cerebral oximetry index by more than 50% in 82.5% of patients, which negatively correlated with MMSE score decline after operation (Table 4) ($P=0.000$).

The association between hospitalization and cognitive decline has been indicated in various studies, although the exact reason for poor cognition results remains unclear. There are some possible risk factors, including diabetes, metabolic syndrome, smoking, and depression, which may contribute to cognitive decline during hospitalization. The intensive care units where most patients with operation, acute respiratory distress syndrome, and delirium have been hospitalized gain the most interest in terms of cognitive impairment occurrence. Owing to the lack of long-term follow-up, it is unclear whether the duration of hospitalization contributes to cognitive changes or whether it is the underlying factor for the development of neurodegenerative complications [31]. One study conducted on patients aged over 65 years old with normal cognitive functioning before hospitalization (MMSE score ≥ 20) showed impaired and progressive cognitive decline at the time of hospitalization but improved 6 months after discharge. It was hypothesized that the highest time and surgical procedures and patients with dementia would worsen the cognitive decline following hospitalization after cardiac operation [32]. Accordingly, we observed a negative correlation between hospitalization duration at the ICU and cognitive decline, indicating that less hospitalization time renders a better cognitive outcome in patients after heart operation.

In the next step, we evaluated the quality of life in patients who underwent heart operation using the SF-36 health assessment tool. The quality of life has improved significantly following heart operation; the pre-operative SF-36 scores ranged from 29.43 for role limitation due to physical health to 62.96 for emotional well-being items because of waiting for heart operation. The CABG type of operation was the most prevalent in this study (91.3%).

Overall, patients who have a poor pre-operative health status and lower role limitation score show higher mortality rate 6 months after CABG operation [33]. Nevertheless, comparing mean SF-36 items scores before and after operation indicated a noticeable increment in

the quality of life after cardiac operation (Table 3). The most noticeable changes have been observed in physical function, emotional well-being, role limitation due to physical function, role limitation due to mental health problems, and pain (72.2%, 71.2%, 67.6%, 67.2% and 60.8%, respectively). Comparing cognitive and physical items of the SF-36 questionnaire in patients who underwent myocardial revascularization revealed that the health-related quality of life of survivors 6 months after operation was mainly determined by pre-operative health status [34].

It has been shown that weight loss, reduction of alcohol consumption, smoking reduction, and maintaining depression and anxiety problems would positively affect health-related quality of life improvement. Also, patients underwent severe pain during hospitalization at the ICU following heart operation, including CABG, should be considered [35]. The time of operation was negatively associated with the quality of life (the Pearson correlation=-1.19), whereas on-pump Hct was positively related to better quality of life (the Pearson correlation=0.182).

Also, the EF improved >35% in about 85% of patients, indicating a better recovery and an increment in patients' quality of life. To the best of our knowledge, there was no data regarding the effect of time of operation and on-pump Hct on the quality of life and this study is the first report. Furthermore, our finding was exclusive in term of evaluation both cognitive complications and quality of life assessment in patients with a mean age of 53.6 years who underwent the CABG operation which could take into consideration for improvement of patient's life style after cardiac operation.

Conclusion

This study shows that cognitive impairment increases after cardiac operation, and by reducing the risk factors shown in this study, cognitive disorders after operation can be reduced. Also, the quality of life improves significantly after operation, which shows that cardiac operation effectively improves patients' physical and mental performance.

Study limitations

The main limitation of current research is a lack of long-time follow-up and evaluation of the cognitive changes and quality of life assessment in fixed time intervals, and it should be considered for further study.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Rajaie Cardiovascular Medical and Research Center (Code: IR.RHC.REC.1399.072). The study process was in compliance with the ethical guidelines of the Declaration of Helsinki 2013.

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Authors contributions

Conceptualization, visualization, supervision, project administration, review and editing, funding acquisition and revising: Maryam Ghadimi and Yasamin Chaibakhsh; Formal analysis: Maryam Ghadimi; Investigation: Fatemehshima Hadipourzadeh, Ali Sadeghi and Rasool Ferasatkish; Resources: Roxana Rastravan, Javad Jamalian and Fatemeh Eftekhari; writing—original draft: Maryam Ghadimi, Roxana Rastravan, Javad Jamalian, and Fatemeh Eftekhari; Methodology: Fatemehshima Hadipourzadeh, Ali Sadeghi Rasool, Rasool Ferasatkish, Roxana Rastravan, Javad Jamalian and Fatemeh Eftekhari; Final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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