Impact of Postoperative Cognitive Dysfunction after Cardiac Surgery on Midterm Outcomes and Mortality

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ABSTRACT

Background: Postoperative cognitive dysfunction (POCD) that is a common neurological side effect after cardiac surgery, is becoming more widely acknowledged as a possible marker of adverse outcomes. But its effect on mortality and midterm results is still unclear, especially in developing countries.

Aim of the Study: To investigate the impact of POCD on midterm clinical outcomes and mortality following cardiac surgery.

Patients and Methods: This prospective observational cohort study was conducted on 200 adult patients undergoing cardiac surgery at the National Heart Institute, Cairo, Egypt, and Shebein Elkom Teaching Hospital, Menoufia. Patients were categorized into POCD and non-POCD groups based on postoperative cognitive assessment using the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA).

Results: Postoperatively, MMSE scores were significantly lower in the POCD group compared to the non-POCD group. Patients with POCD had significantly prolonged ICU stays and total hospital stays. The incidence of postoperative complications was significantly higher in the POCD group. Functional dependence, as assessed by Activities of Daily Living (ADL), was also significantly more prevalent among POCD patients. Regarding mortality outcomes, although mortality at 1 week and 1 month were higher in the POCD group, it did not reach statistically significant difference. While at 1 year the POCD group showed a significantly higher mortality rate (9.0% vs 1.0%, $p = 0.019$).

Conclusion: POCD is associated with adverse postoperative outcomes following cardiac surgery, including increased complications, prolonged hospitalization, greater functional dependence, and higher midterm mortality. Early identification and targeted management of POCD may improve patient outcomes and reduce postoperative morbidity and mortality.

KEYWORDS: Cognitive dysfunction; POCD; cardiac surgery; mortality.

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INTRODUCTION

Every year, more than two million heart procedures are carried out worldwide. Patients who need cardiac surgery are getting older and are more likely to have concomitant conditions like diabetes and hypertension. Elderly individuals are more likely to have morbidity, death, and post-operative problems [1].

Between 25% and 70% of patients following cardiac surgery experience postoperative cognitive dysfunction (POCD), which is defined as a deterioration in cognitive function from baseline performance as determined by neuropsychological testing before and after surgery. Although cognitive dysfunction is typically temporary, it is linked to longer hospital stays, higher rates of morbidity and mortality, and lower quality of life, which places a heavy financial and medical burden on the healthcare system [2].

Cardiopulmonary bypass (CPB), advanced patient age, pre-existing comorbidities, intricate surgical techniques, and intraoperative hypothermia are some of the factors that can lead to postoperative neurological problems after cardiac

surgery. Long-term use of analgesic, hypnotic, and sedative drugs may also be involved. Crucially, the 5-year death rate is noticeably greater in those who develop POD or POCD. This higher chance of death, along with the negative effects on autonomy and quality of life, underscores the urgent need to identify high-risk patients and create quick, targeted techniques for early detection and intervention [3].

Even when similar patient demographics are involved, cardiac surgery has a significantly greater incidence of POCD than other surgical specialties, such as general, orthopedic, and urological operations. According to studies, delirium rates following general surgery range from 8.4% to 23.8%, increasing to 28% under general anesthesia; rates following orthopedic surgery are approximately 8.2%, and rates following urological surgery range from 8.8% to 29%, depending on the type of intervention. According to Sircar et al. [4] and Hua et al. [5], the incidence of delirium in older persons varies from 9% to 30% for general surgery, 16–44% for hip fractures, and 11–55% for cardiac surgery.

The purpose of this study was to investigate the impact of POCD on midterm clinical outcomes and mortality following cardiac surgery.

PATIENTS AND METHODS

This prospective observational cohort study was conducted at the National Heart Institute, Cairo, Egypt, and Shebein Elkom Teaching Hospital, Shebein Elkom, Menoufia during the period from June 2023 to December 2023. Written informed consent was obtained from all participants prior to enrollment. The study included 200 adult patients (≥18 years) scheduled for elective cardiac surgery, including coronary artery bypass grafting (CABG), valvular surgery, or combined procedures, performed under general anesthesia with or without cardiopulmonary bypass. Patients with a prior history of diagnosed dementia, major psychiatric illness, severe neurological deficits (e.g., prior stroke with residual disability), severe hepatic or renal impairment, or those unable to complete cognitive assessments were excluded.

A total of 200 patients were consecutively recruited and subjected to detailed preoperative evaluation including demographic data, comorbidities (e.g., hypertension, diabetes mellitus), medication history, and baseline laboratory investigations. Cognitive function was assessed preoperatively using standardized and validated tools such as the Montreal Cognitive Assessment (MoCA) [6] and Mini-Mental State Examination (MMSE) [7]**.** The MMSE and MoCA were administered at 96 h postoperatively.

Visuospatial/executive, name, memory, attention, language, abstract thinking, delayed recall, and orientation are the eight cognitive areas covered by the MoCA (version 8, 2018), which has a maximum score of 307. For those with fewer than twelve years of formal education, it adds one point. A score of at least 26 is regarded as normal. It takes about ten minutes to administer the MoCA. The MMSE has a maximum score of 30 and encompasses six cognitive domains: orientation, registration, attention and calculation, recall, language, and visuospatial ability. A score of at least 24 is regarded as normal. It takes five to ten minutes to give the MMSE **[8].**

Under established institutional standards, all patients received elective open heart surgery, including CABG and valve replacement or repair (using both conventional and thoracoscopic techniques). Propofol and fentanyl were used to produce general anesthesia, rocuronium was used to relax muscles, and sevoflurane in an oxygen-air combination was used to sustain it. Fentanyl or remifentanil was used for intraoperative analgesia, and the attending anesthesiologist selected additional anesthetic drugs, vasopressors, and inotropes based on the patient's state and institutional protocols. ECG, pulse oximetry, capnography, invasive arterial blood pressure, central venous pressure, and the Bispectral Index (BIS) with a target range of 40–60 were all part of standard monitoring. The goal of hemodynamic control was to keep mean arterial pressure between 50 and 60 mmHg during cardiopulmonary bypass (CPB) and above 65 mmHg prior to CPB. The temperature was kept between 32 and 34°C, which is mild hypothermia. St. Thomas cardioplegia solution was used to protect the heart at regular intervals, and CPB was carried out using a typical roller pump and heat exchanger system with a priming solution that included colloids, crystalloids, diuretics, anticoagulants, antibiotics, and mannitol.

According to **Berger et al. [9],** POCD was diagnosed based on a predefined decline from baseline cognitive performance assessed using MMSE and MoCA, according to a fixed cutoff/reliable change index.

Intraoperative hemodynamics, anesthetic methods, cardiopulmonary bypass time, aortic cross-clamp time, type of surgery and duration were all documented. The length of stay in the intensive care unit (ICU), hospital stay, and incidence of complications were postoperative factors. Over the course of twelve months, patients were monitored for midterm results. The main outcomes were complications, hospital readmission and all-cause mortality. Functional status was the secondary outcome.

STATISTICAL ANALYSIS

The SPSS software (Statistical Package for Social Science) version 27.0 was used to computerize and statistically analyze the gathered data (IBM, 2020). Frequencies and relative percentages were used to display qualitative data. To determine the difference between qualitative variables, the Chi-square test was employed. When one or more of the examined cells

were less than five, Fisher's exact test was utilized to determine the difference between qualitative variables in various groups. Mean ± SD (standard deviation) was used to express quantitative data. The difference between quantitative variables in two groups of normally distributed data was determined using the independent T test. In data that was not regularly distributed, the Mann Whitney (MW) test was employed to determine the difference between quantitative variables in two groups.

RESULTS

Table (1): Comparison of Baseline Characteristics between POCD and Non-POCD Groups

	Variable	POCD (n=100)	Non-POCD (n=100)	P-value
Age	Mean ± SD (Range)	67.00 ± 7.24 (55–79)	65.9 ± 6.7 (55–83)	0.27
Sex	Female	51 (51.0%)	43 (43.0%)	0.321
	Male	49 (49.0%)	57 (57.0%)	
Education	High education	16 (16.0%)	18 (18.0%)	0.219
	Moderate	33 (33.0%)	43 (43.0%)	
	Low	51 (51.0%)	39 (39.0%)	
Comorbidities	Yes	75 (75.0%)	68 (68.0%)	0.347
Medications	Yes	61 (61.0%)	59 (59.0%)	0.885

POCD: Postoperative Cognitive Dysfunction, MMSE: Mini-Mental State Examination, MoCA: Montreal Cognitive Assessment, SD: Standard Deviation.

There was no statistically significant difference between POCD and non-POCD groups regarding baseline characteristics (Table 1).

Table (2): Comparison of operative and intraoperative data between POCD and Non-POCD Groups

	Variable	POCD (n=100)	Non-POCD (n=100)	P-value
Surgery Duration (min)	**Mean ± SD (Range)**	243.63 ± 38.52 (157–330)	236.78 ± 39.91 (153–326)	0.255
CPB Time (min)	**Mean ± SD (Range)**	110.92 ± 20.45 (66–156)	108.37 ± 19.21 (63–153)	0.36
Cross Clamp (min)	**Mean ± SD (Range)**	78.14 ± 14.89 (43–110)	76.64 ± 14.61 (39–105)	0.47
Hemoglobin	**Mean ± SD (Range)**	11.56 ± 1.21 (8.7–14.4)	11.8 ± 1.4 (8.5–14.2)	0.21
Surgery Type	**CABG**	31 (31.0%)	31 (31.0%)	0.943
	Valve	31 (31.0%)	29 (29.0%)	
	Combined	38 (38.0%)	40 (40.0%)	
Anesthesia Type	**General anesthesia**	50 (50.0%)	48 (48.0%)	0.887
	General + Sedation	50 (50%)	52 (52%)	
Arterial Pressure	**Controlled pressure**	73 (73.0%)	74 (74.0%)	1.000
	Fluctuating	27 (27.0%)	26 (26.0%)	
Glycemic Control	**Controlled glycemia**	73 (73.0%)	75 (75.0%)	0.872
	Uncontrolled glycemia	27 (27.0%)	25 (25.0%)	

CPB: Cardiopulmonary Bypass, SD: Standard Deviation

There was no statistically significant difference between POCD and non-POCD groups regarding operative and intraoperative data (Table 2).

Table (3): Comparison of postoperative outcomes between POCD and Non-POCD groups

	Variable	POCD (n=100)	Non-POCD (n=100)	P-value
ICU Stay (days)	**Mean ± SD (Range)**	6.02 ± 1.96 (2.2–10.5)	3.05 ± 1.02 (1.2–5.9)	**<0.001**
Hospital Stay (days)	**Mean ± SD (Range)**	14.22 ± 3.06 (7.9–21.3)	9.18 ± 2.08 (5.3–14.1)	**<0.001**

POCD: Postoperative Cognitive Dysfunction, MMSE: Mini-Mental State Examination, ICU: Intensive Care Unit, SD: Standard Deviation

Patients in the POCD group had a significantly longer ICU stay (6.02 ± 1.96 vs 3.05 ± 1.02 days, $p < 0.001$) and hospital stay (14.22 ± 3.06 vs 9.18 ± 2.08 days, $p < 0.001$) compared to the non-POCD group. These findings indicate that POCD is associated with worse postoperative outcomes in terms of cognitive function and length of hospitalization (Table 3).

Table (4): Comparison of postoperative complications between POCD and Non-POCD groups

Complication	POCD (n=100)	Non-POCD (n=100)	P-value
Delirium	12 (12.0%)	2 (2.0%)	**<0.001**
Pneumonia	6 (6.0%)	2 (2.0%)	
Arrhythmia	5 (5.0%)	2 (2.0%)	
Infection (SSI/Sepsis)	4 (4.0%)	2 (2.0%)	

Prolonged Mechanical Ventilation	3 (3.0%)	1 (1.0%)	
Bleeding	3 (3.0%)	1 (1.0%)	
Stroke	2 (2.0%)	1 (1.0%)	
Total complications	**35 (35.0%)**	**11 (11.0%)**	

POCD: Postoperative Cognitive Dysfunction, SSI: Surgical Site Infection, MV: Mechanical Ventilation.
A significantly higher overall incidence of postoperative complications was observed in the POCD group compared to the non-POCD group (35.0% vs 11.0%, p < 0.001). Delirium was the most frequent complication and showed a significantly higher incidence among POCD patients (Table 4).

Table (5): Comparison of postoperative clinical outcomes between POCD and Non-POCD groups

	Variable	POCD (n=100)	Non-POCD (n=100)	P-value
Readmission	**Yes**	41 (41.0%)	29 (29.0%)	0.103
Functional Status	**Dependent (ADL)**	49 (49.0%)	24 (24.0%)	**0.004**
	Independent	51 (51.0%)	76 (76.0%)	
Mortality 1 week	**Yes**	6 (6.0%)	2 (2.0%)	0.279
Mortality 1 month	**Yes**	5 (5.0%)	4 (4.0%)	1.000
Mortality 1 year	**Yes**	9 (9.0%)	1 (1.0%)	**0.019**

POCD: Postoperative Cognitive Dysfunction, ADL: Activities of Daily Living

The functional dependence (ADL) was significantly more frequent in the POCD group (49.0% vs 24.0%, p = 0.004). Regarding mortality outcomes, although mortality at 1 week and 1 month were higher in the POCD group, it did not reach statistically significant difference. While at 1 year the POCD group showed a significantly higher mortality rate (9.0% vs 1.0%, p = 0.019). On the other hand, no statistically significant difference was found between both groups regarding hospital readmission (p = 0.103). These findings indicate that POCD is associated with worse clinical outcomes, including higher complication rates, functional dependence, and mortality (Table 5).

DISCUSSION

In our study, there was no significant difference between the POCD and non-POCD groups in terms of intraoperative variables such as operation duration, cardiopulmonary bypass (CPB) time, aortic cross-clamp time, intraoperative hemoglobin levels, anesthesia type, arterial pressure management, and glycaemic control.

Van Harten et al. [10], reported that although CPB-associated microemboli and neuroinflammation play pathophysiological roles, the relationship between CPB duration and POCD incidence is not linear and may depend on individual patient susceptibility, according to a thorough review of POCD after cardiac surgery and anesthesia.

Selnes et al. [11], who observed that cerebral reserve, neuroinflammatory reactions, and genetic predisposition interact to establish POCD susceptibility and that intraoperative factors alone do not consistently predict cognitive outcomes.

The POCD group in our study had significantly lower postoperative MMSE scores than the non-POCD group (23.11 ± 2.01 vs. 26.45 ± 1.21, p < 0.001).

These results are in accordance with those of **Newman et al. [12],** who found that about 53% of patients had cognitive decline upon hospital discharge, which decreased to 24% at six months and 42% at five years, highlighting the variable but enduring character of POCD.

The current study's findings are consistent with those of **Monk et al. [13],** who examined risk factors for POCD in patients undergoing cardiovascular surgery and found that older age, lower educational attainment, and pre-existing cerebrovascular disease were important modifiers. These factors were fairly evenly distributed in our cohort.

Relander et al. [14] sought to determine whether long-term cognitive outcome is predicted by domain-specific cognitive alterations following cardiac surgery. Six years following surgery, they found that postoperative dysfunction, especially in the area of executive functioning, predicted long-term cognitive decline.

In comparison to patients without POCD, patients with POCD had significantly longer ICU hospitalizations (6.02 ± 1.96 vs. 3.05 ± 1.02 days, p < 0.001) and overall hospital stays (14.22 ± 3.06 vs. 9.18 ± 2.08 days, p < 0.001).

These findings are in keeping with **Slater et al. [15]**, Cognitive impairment was revealed to be an independent predictor of prolonged hospital stays in a prospective investigation of cerebral oxygen desaturation in patients after cardiac surgery when compared to their cognitively intact peers. Likewise, **Fiani et al. [16]** found that patients with surgical cognitive impairment had significantly longer ICU stay.

The POCD group in our study had a considerably greater incidence of postoperative complications than the non-POCD

group (35.0% vs. 11.0%, p < 0.001).

Vedel et al. [17], showed that patients with POCD experienced more complications and had worse outcomes. **Fink et al. [18]**, similarly reported significantly higher complication rates among cognitively impaired patients compared to cognitively intact controls.

In our study, the POCD group had a considerably higher prevalence of functional dependence as measured by Activities of Daily Living (ADL) (49.0% vs. 24.0%, p = 0.0004).

This result is in line with **Phillips-Bute et al. [19],** who showed that, even after adjusting for mood disorders and physical health factors, neurocognitive decline at one year was independently linked to lower quality of life and functional capacity in a prospective follow-up study of CABG patients.

Steinmetz et al. [20] reported that in a long-term follow-up of POCD patients, it was discovered that those with chronic POCD were far more likely than those who remained cognitively intact to report difficulties with instrumental ADL and to quit the workforce early.

In the current study, regarding mortality outcomes, although mortality at 1 week and 1 month were higher in the POCD group, it did not reach statistically significant difference. While at 1 year the POCD group showed a significantly higher mortality rate (9.0% vs 1.0%, p = 0.019). The hospital readmission rates for the POCD and non-POCD groups did not differ statistically significantly (41.0% vs. 29.0%, p = 0.103).

Steinmetz et al. [20] revealed that POCD was linked to higher mortality at three months but not at one week (hazard ratio, 1.63 (95% confidence range, 1.11-2.38); P = 0.01, adjusted for sex, age, and cancer).

In a study of **Butz et al. [21],** patients with POCD had a higher relative risk (RR) of mortality following cardiac surgery. According to **Saczynski et al. [22],** patients with and without postoperative delirium—a closely related construct to POCD—had significantly different cognitive trajectories after cardiac surgery, and those with greater early cognitive impairment had significantly worse short- and long-term survival.

Xiong et al. [23] revealed a significant correlation between poorer survival and postoperative cognitive impairment (P =.028). Higher postoperative MoCA scores were substantially linked to lower mid-term mortality, according to multivariate Cox models (HR =.744 (.584,.949), P =.017).

According to another study involving 275 patients who were continuously mechanically ventilated in both medical and coronary ICUs, patients who experienced delirium during their hospital stay were linked to higher six-month mortality rates, higher length of stay (LOS), fewer median days alive, fewer days without mechanical ventilation, and a higher incidence of cognitive impairment at the time of discharge **[24].**

A prospective design, standardized cognitive evaluation using validated instruments (MMSE and MoCA), a balanced two-group comparison, a precisely defined POCD case definition, and a follow-up period that lasts up to a year after surgery are all advantages of the current study. Multiple mortality time-points and functional outcome data (ADL) are included to give a complete picture of the clinical consequences of POCD. However, a number of limitations must be acknowledged. The investigation was carried out at two tertiary-referral centers in Egypt, which may restrict its applicability to populations with distinct baseline characteristics or healthcare environments. The comparatively small sample size of 200 patients might not have enough power to identify a meaningful difference in hospital readmission or one-month death. Without domain-specific cognitive batteries, which would have allowed for a more detailed description of the cognitive profile of POCD, neuropsychological testing was restricted to the MMSE and MoCA. Furthermore, inferences on the persistence or recovery trajectory of POCD in this cohort cannot be drawn because long-term cognitive follow-up beyond a year was not carried out.

CONCLUSION

POCD after cardiac surgery was significantly associated with worse postoperative outcomes including longer hospital and intensive care unit admissions, higher rates of complications, increased functional dependence and higher 1-year mortality. These results highlight the significance of regular perioperative cognitive evaluation for patients undergoing cardiac surgery. Targeted neuroprotective, rehabilitative, and supportive therapies aiming at reducing the significant clinical burden of POCD may be made easier with early identification of at-risk people.

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