

ORIGINAL ARTICLE

Neurological Complications in Patients Undergoing Cardiac Surgery: A Tertiary Care Experience

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This article may be cited as:

Niazi AK, Mahmood MM, Mikrani B, Sarwer MM, Akram S, Yaqoob Z; Neurological Complications in Patients Undergoing Cardiac Surgery: A Tertiary Care Experience. Pak J Med Health Sci, 2025; 19(12):16-22.

Received: 02-07-2025

Accepted: 26-12-2025

Published: 30-12-2025



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**ABSTRACT**

Background: Morbidity related to neurology complications continues to be a major issue after cardiac surgery. Postoperative stroke and delirium contribute to prolonged hospital ICU stay and increase in cost as well.

Methods: Prospective observational study conducted at Mayo Hospital Lahore in Cardiac surgery Department from July 2024 to June 2025. A total of 210 adult patients undergoing cardiac surgery participated in the research. Demographic factors, comorbidity, variables of surgery and neurological outcomes were examined. The patterns of occurrence of the neurological complications by the type of procedure and high-risk groups were assessed. Predictors of postoperative neurological complications were identified by using multi-variable analysis.

Results: The risk of neurological complications depended on the complexity of the procedures performed with high incidence of strokes being reported in Mitral and Aortic valvular surgeries and in both CABG + valvular surgeries in comparison to isolated Coronary Artery Bypass Grafting CABG. Postoperative delirium was strongly predictable by advanced age, high scores in surgical risk, previous cerebrovascular pathology, and a decrease in cerebral oxygen saturation.

Conclusion: Multi-factorial neurological complications after Cardiac Surgery procedures are dependent and affected by patient factors, the complexity of procedures and physiological events. Early risk factors evaluation and perioperative management in cardiac surgery should be optimised to enhance the neurological outcome.

Keywords: Cardiac surgery; Delirium; Stroke; Cerebral oxygenation, Double valve replacement (DVR).

INTRODUCTION

Cardiovascular diseases, particularly Coronary Artery Disease and Valvular Heart Disease, remain leading cause of mortality and morbidity worldwide, with a

disproportionately high burden in Low and Middle income countries^{1,2}. With the advancement in medical science cardiac surgery plays a critical role in the treatment of advanced coronary and valvular heart disease¹. Currently, it is estimated 1.5 million cardiac surgeries are being

performed in a year across the world. Despite improvement in surgical techniques and perioperative care neurological complications remain among the most serious postoperative events²⁻³.

Postoperative delirium (POD) with the incidence rate of 25% to 52% is an acute consequence of the brain malfunction that is manifested by oscillating variations in both the consciousness and awareness and is most common that has been linked to extended Intensive Care Unit (ICU) and length of hospitalization and high mortality. The pathophysiology is also complicated but the intraoperative cerebral hypoperfusion and hypoxia have often been proposed as the major factors⁴⁻⁶.

In addition to delirium, perioperative stroke is another complication that happens in about 1.5% to 17% of patients who have undergone any cardiac surgery procedures. Factors attributed to stroke are the manipulation of the aorta, atheroembolism or intraoperative hypotension with mean arterial pressure less than 60 mmHg⁶⁻⁷.

3.8% patients with coronary artery bypass grafting (CABG), 8.8% with mitral valve surgeries and 10% with double valve replacement (DVR). Stroke differentiated into early and late. The early stroke mainly are associated with the manipulation of the aorta and later atheroembolism during the time of cross-clamping or cannulation. On the other hand, late stroke, following the neurologic recovery of a patient who has gone through anaesthesia, are also linked with postoperative arrhythmias, such as atrial fibrillation, hypercoagulability, or underlying cardiac pathology. Haemodynamic goal while performing surgery is to maintain mean arterial pressure (MAP) 60mmHg during cardiopulmonary bypass^{7,8,9}.

MATERIAL AND METHOD

Study Design and Setting: The study was a prospective observational cohort study, conducted in Tertiary Cardiac Centre, Mayo Hospital Lahore. The research was carried out in one year from July 2024 to June 2025.

Study Population: The study population included adult patients undergoing Cardiac Surgery procedures. The total participants that were registered determines 210 who entered the study once met the eligibility requirement. Recruitment of patients was done in the Cardiac Surgery unit and were followed up through the entire perioperative period up to the discharge.

Inclusion Criteria

The patients were selected on the following:

- Age ≥ 18 years
- Elective, urgent, or emergency cardiac surgery requiring median sternotomy, including:

- Isolated coronary artery bypass grafting (CABG)
- Isolated valve surgery (aortic, mitral, or tricuspid valve replacement/repair)
- Combined CABG and valve procedures
- Informed Consent Given

Exclusion Criteria

- Pre-existing neurological or psychiatric illness that would confound delirium assessment (e.g., dementia, Parkinson's disease, psychosis, severe depression)
- Traumatic brain injury or intracranial surgery within the preceding 6 months
- Severe communication or hearing impairment precluding reliable cognitive assessment
- Active central nervous system infection
- Known intracranial pathology (tumor, arteriovenous malformation)
- Refusal to provide informed consent

Sample Size and method of sampling.

The sample was 210 patients, which was calculated using the expected incidence of postoperative neurological complications as 20-30% of patients who went through cardiac surgery, the level of confidence of 95, and a margin of error of 5-7. The study used a consecutive non-probability method.

Data Collection Procedure

A structured data collection proforma that has been specially prepared to carry out the study was used to collect data. Patient medical records, anaesthesia charts, surgical notes, ICU monitoring records, and personal assessment of a patient were used as sources of information.

Cognitive-assessment:

Baseline cognition assessed using Mini-Mental State Examination (MMSE).

MMSE ≤ 24 defined as cognitive impairment.

Outcome

- Postoperative delirium
- Perioperative stroke

Stroke

New focal neurological deficit lasting >24 hours confirmed by CT/MRI.

Delirium

Assessed using CAM-ICU or CAM.

Medications Medical comorbidities (hypertension, diabetes mellitus, dyslipidaemia, chronic kidney disease,

chronic obstructive pulmonary disease, previous stroke or transient ischemic attack)

The nature of the Cardiac surgery procedures (CABG and Valvular)

- Length of cardiopulmonary bypass
- Duration of surgery
- Aortic cross-clamp time
- Intraoperative haemodynamic parameters

Epileptic fits or other Acute Vascular albums.

The level of postoperative delirium involved the Confusion Assessment Method of the ICU (CAM-ICU) in ventilated patients and the traditional Confusion Assessment Method (CAM) in patients who were not on ventilators. The assessments conducted were every two hours in the initial five days of the postoperative or until ICU discharge.

There were secondary outcomes such as:

- Duration of ICU stay
- Total length of stay of the hospital
- Opioid use and postoperative pain
- Detection of predictors of postoperative delirium that are independent.
- Assessment of High-Risk Population.

Statistical Analysis

The analysis of data was done by Statistical Package of Social Sciences (SPSS) version 26. The continuous variables were depicted as mean standard deviation (SD) of the normally distributed data and median and interquartile range of the non-parametric data. The nominal variables were in the form of frequencies and percentages.

To determine causes of predictors of postoperative neurological complications, a multivariate logistic regression analysis was used to question the presence of independent variables. It was reported as adjusted odds ratios (OR) with 95 percent confidence interval (CI). The value of p below 0.05 was deemed to be statistically significant.

Ethical Considerations

Institutional Review Boards (IRB) of Mayo Hospital Lahore had to be reached out to and ensure their ethical approval before starting the study. Informed consent was done through written documents of all subjects or their legally authorised representatives.

RESULTS

In the Table 1 the demographic features of the study sample represent the characteristic of the cardiac surgery cohort of middle-aged and aged persons with approximately half of the participants aged between 41

and 60 years. Men made up about 2/3 of the cohort and is in accord with higher incidence of cardiovascular disease among men of South Asian populations. The average age of about 58 years also confirms the fact that cardiac surgical intervention is more prevalent among older patients who already have cardiovascular risk factors.

The distribution of patients with overweight and obesity was great which explains the increasing load of metabolic syndrome among such patients. The most common comorbidities included hypertension, diabetes mellitus, and dyslipidaemia representing the tendency to cluster cardiovascular risk factors that is typically seen among patients undergoing cardiac surgery. The existence of past stroke in a section of patient groups further signifies a higher neurobiological vulnerable level in the group.

Almost half the patients had a smoking history, which is a significant modifiable risk factor that leads to the development of cardiovascular diseases as well as perioperative complications. The most popular procedure done was coronary artery bypass grafting, followed by valve surgeries and combined surgeries which also conforms to the international trends in cardiac surgical procedures.

Neurological complications rates depended significantly on the nature and the complexity of cardiac operations. The incidence of overall perioperative stroke on all the cardiac surgeries was 4.6% which correlates with literature in the past. The incidence of stroke among patients undergoing isolated coronary artery bypass grafting (CABG) was relatively lower (3.8%), but in patients who had undergone mitral valve, and multiple valves operations, insidious neurological complications were high (8.8 and 9.7% respectively). It is interesting to note that surgical aortic valve replacement followed by intensive neurological attention had the highest reported incidence of stroke (17%), which could also represent procedural complexity as well as enhanced identification by serial neurological studies.

The rate of postoperative delirium (POD) in the patients under sim READ cardiac surgery was 25-52 percent, and the pooled meta-analysis estimate under 17 percent as well. Such results suggest that neurological complications have not yet been eradicated in spite of the improvements of surgical and perioperative treatment procedures and complex nature of the performed procedures is one of the most influential factors that can contribute to the risk size.

Predictors of Postoperative Delirium as independent predictors

Multivariate analysis also came up with a number of independent predictors which were significantly linked with the postoperative delirium. The history of stroke in the

past was the most predictive, and patients with a history of stroke had almost sixteen times more likelihood to develop delirium, showing the role of the already present cerebrovascular disease in the preoperative susceptibility of the nervous system. Delirium was also linked to greater absolute changes in postoperative in regional blood cerebral oxygen saturation that was also statistically significant to the hypothesis delirium is associated with impaired cerebral oxygen delivery to contribute to the pathophysiology of postoperative cognitive dysfunction.

The values of EuroSCORE II were higher as the likelihood of delirium, which is a neurological complication, in patients who require higher surgical or systemic risk burden is more likely. The advancing age indicated that age was strongly correlated with POD, which is in line with less neurocognitive reserve and increase in physiological deterioration. On the other hand, protective effects were shown in higher baseline cognitive functioning in the form of higher preoperative MMSE scores and discourages vulnerability to delirium. In addition, postoperative delirium was also linked with a higher risk of mortality hence indicating its clinical importance as a significant prognostic factor and not a complication to pass.

By and large, these results demonstrate that the load of neurological risks in critically unwell populations is significant and must be improved with respect to creating better neurological surveillance methods in the above groups.

Table 1: Demographic and Clinical Characteristics of Study Participants (N = 210)

Variable	Frequency (n)	Percentage (%)
Age Group		
≤40 years	28	13.3
41–60 years	98	46.7
>60 years	84	40
Mean Age (± SD)	57.9 ± 11.8	—
Gender		
Male	142	67.6
Female	68	32.4
Body Mass Index		
Normal	70	33.3
Overweight	86	41
Obese	54	25.7
Comorbidities		
Hypertension	132	62.9
Diabetes Mellitus	96	45.7
Dyslipidemia	88	41.9
Previous Stroke/TIA	18	8.6
Chronic Kidney Disease	24	11.4
COPD	26	12.4
Smoking Status		
Current/Former Smoker	96	45.7
Non-smoker	114	54.3
Type of Surgery		
CABG	120	57.1

Table 2. Incidence of Neurological Complications Following Cardiac Surgery

Procedure Type	Complication	Incidence (%)
All Cardiac Surgeries (overall cohort)	Perioperative Stroke	4.6
Isolated CABG	Perioperative Stroke	3.8
Mitral Valve Surgery	Perioperative Stroke	8.8
Double Valve Surgery	Perioperative Stroke	9.7
Surgical Aortic Valve Replacement (with serial exams)	Perioperative Stroke	17
All Cardiac Surgeries (Meta-analysis)	Postoperative Delirium	17
General Cardiac Surgery (reported range)	Postoperative Delirium	25–52

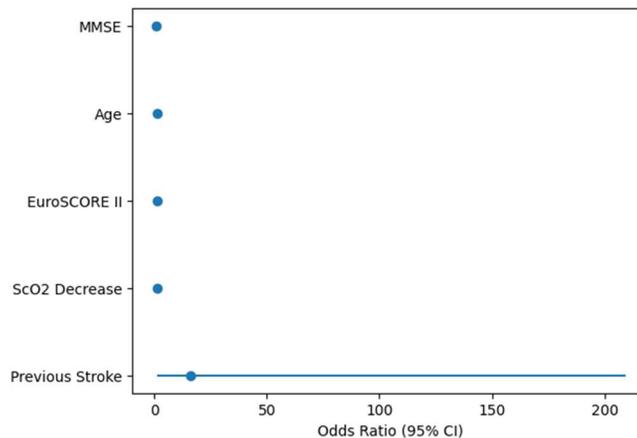


Figure1: Independent Predictors of Postoperative Delirium

Table 3. Independent Predictors of Postoperative Delirium (POD)

Variable	Odds Ratio (OR)	95% Confidence Interval	P-value
Previous Stroke	15.97	1.22 – 209.2	0.035
Postoperative Sc t O ₂ Absolute Decrease	1.19	1.03 – 1.38	0.019
EuroSCORE II	1.23	1.02 – 1.49	0.03
Age (per year increase)	1.15	1.01 – 1.31	0.029
Preoperative MMSE Score	0.8	0.64 – 0.99	0.047
POD Impact on Mortality	2.77	1.86 – 4.11	<0.001

DISCUSSION

This paper compared the incidence, predictors, and clinical burden of neurological complications in the postoperative phase of cardiac surgery among one tertiary care unit. The results indicate that the clinically problematic issues of neurological complexity persist even following the improvement of the perioperative care, and postoperative delirium and stroke are the most prevalent manifestations. The trends in incidence among the observed types of procedures get to the point that the more complex the surgery is, the more at risk the patient is, and the risks of valve and combined procedures are the highest as it has been previously noted in the literature. This may be due to the increased manipulation of the aorta, longer cardiopulmonary bypass, and increased embolic load leading to the higher risk with the complex surgeries.

Old age was determined as a significant risk factor of postoperative neurological susceptibility. The decreased cerebral autoregulatory capacity, microvascular integrity and neuronal reserve are age related factors that are likely to predispose elderly patients to delirium and ischemic events in the stress perioperative procedure. Likewise, preoperative cognitive impairment evidenced a close relationship with postoperative delirium, which also proves that the neurocognitive status before the operation is one of the key determinants with respect to postoperative neurological outcomes¹⁰⁻¹³. This evidence upholds the need to implement cognitive screening in the normal preoperative evaluation procedures^{7,9,12}.

The neurological complications were also found to have a significant relationship with surgical risk (measured by EuroSCORE II) and demonstrated that the systemic physiological burden is significant in causing postoperative neurological dysfunction. The more the patients are at a higher risk and the more the co morbidities, lesser cardiac reserve, and impaired end-organ perfusion often appear, which makes them prone to cerebral injury¹³. The relationship between the decreases in the saturation of the regional cerebral oxygen and the development of delirium after the operation was one of the most clinically significant discoveries. The pathophysiology of delirium has been largely implicated in cerebral hypoperfusion, and oxygen imbalance and our results confirm the hypothesis that

postoperative stages can be a period of neurological vulnerability. This is an indication that further cerebral observation was necessary after the intra operative stage¹⁴⁻¹⁵.

The demographic characteristic of the study population indicated a high status of cardiovascular risk factors such as hypertension, diabetes mellitus, dyslipidemia, and obesity. These co morbidities play a role in promoting endothelial dysfunction, systemic inflammation and cerebrovascular pathology that could further predisposed the patient to the development of neurological complications after surgery. The fivefold higher number of male subjects in the study group indicates the established epidemiological trends of cardiovascular disease among South Asians^{12,15-18}.

CONCLUSION

Post cardiac surgery neurological morbidity is a major etiological factor in patients at high risk and the elderly group. Factors that make postoperative neurological dysfunction relevant are procedural complexity, underlying cerebrovascular disease and worsened cognitive functioning. Early detection of high-risk patients, perioperative care optimisation, and surveillance interventions could have a beneficial effect on neurological outcomes and decrease postoperative morbidity.

Clinical Implications

- Cognitive assessment is a regular preoperative procedure that needs to be a part of cardiac surgical assessment.
- Cerebral oxygenation can be used in detecting patients with potential neurological problems.
- The risk stratification instruments like Euro SCORE II will help to predict the neurological susceptibility.
- Improved perioperative management measures can minimise postoperative morbidity in the neurological aspect.

Recommendations

- Institute systematic neurological observational procedures in cardiac operating units.
- Adopt multimodal approach of perioperative optimisation as a way of minimizing cerebral hypoperfusion.
- Normalise the best practices of enhanced recovery.
- Deliver specialised care channels among the aged and high-risk patients.
- Enhance haemodynamic management in the peri-operative period to achieve sufficient cerebral perfusion.

Limitations

This research has a number of weaknesses.

- The observational design makes it impossible to prove causal relations between predictors with neurological outcomes.
- Data were collected in few tertiary care centres which could have impact on generalisability.
- The long-term neurological outcome was not evaluated, which did not allow analyzing the presence of persistent cognitive impairment after discharge.
- Differences in intraoperative management and monitoring availability would have provided some measurement bias.
- The possible confounders of the study like inflammatory biomarkers and anaesthetic depth were not assessed.

Future Research

Future research needs to concentrate on multicentre cohorts that are larger in size to confirm these results besides enhancing generalisability. Randomised controlled trials that explore the intervention to optimise cerebral oxygenation and haemodynamic stability are justified. Long-term cognitive outcomes and quality-of-life results after timing cardiac surgery are also suggested as the topic of research to be conducted longitudinally to give important information on the continuing effects of neurological complications. Also, research on biomarkers related to neuroinflammation and cerebral injury can help to detect it in advance and provide individual treatment.

DECLARATION

The authors gratefully acknowledge the patients and their families for participating in this study. We thank the nursing staff of the Cardiac Surgery ICU and ward at Mayo Hospital for their assistance with data collection and patient care. We appreciate the support of the Department of Anesthesiology and the Division of Neurology for their collaborative contributions.

Conflict of Interest Statement

The authors declare no conflicts of interest related to this work.

Funding Source

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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