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INCIDENCE OF NEUROLOGICAL COMPLICATIONS IN CORONARY ARTERY BYPASS GRAFTING VERSUS VALVE SURGERY (AORTIC, MITRAL, TRICUSPID); SINGLE CENTRE STUDY

Raja Umer Ejaz[1], Brig Nasir[2], Amna Akbar[3]*

[1*]Resident Cardiac Surgery, AFIC/NIHD, Rawalpindi, drumerejaz@yahoo.com
[2]Prof Cardiac Surgery, AFIC/NIHD, Rawalpindi, MBBS, FCPS Gen Surgery, FCPS Cardiac Surgery, drnasirali48@gmail.com
[3]Female Medical Officer, District Headquarter Hospital, Hattian Bala, AJK, Pakistan, amna.akbar1324@gmail.com, https://orcid.org/0009-0009-6560-5493

***Corresponding Author: -** Amna Akbar
*Female Medical Officer, District Headquarter Hospital, Hattian Bala, AJK, Pakistan, amna.akbar1324@gmail.com, https://orcid.org/0009-0009-6560-5493

Abstract

Introduction: Cardiac surgery continues to be a procedure with poor prognosis and compromised recovery, sometimes necessitating emergency department (ED) intervention for postoperative problems. Neurological complications mostly include neurocognitive dysfunction, stroke, seizures, delirium, and, in rare cases, coma.

Methodology: We observed 49 cases of cardiac surgery at our hospital over a period of six months and recorded the adverse neurological events. The data was analyzed on SPSS version 25.

Results: There were 18 cardiopulmonary bypass surgery and 31 Valve Surgery cases among which, male female ratio was 11/7 and 17/14 respectively. There were three incidents of stroke and there was no significant relationship ($p > 0.05$).

Conclusion: Although the literature suggests that there is difference between cardiac surgery procedures in terms of neurological complications, but our study could not establish it due to small data.

Keywords: cardiac surgery, valve surgery, neurological complications, aortic, mitral, tricuspid

Introduction

Neurological Complications, after heart failure, are the second most common cause of illness and death following cardiac surgery. Having neurological problems considerably raises the chances of needing long-term care. Encephalopathy refers to the significant neuropsychiatric abnormalities which occur following heart surgery. These abnormalities mostly include neurocognitive dysfunction, seizures, delirium, and, in rare cases, coma. Cardiac surgery, specifically aortic valve replacement and repair of an ascending aorta, can lead to supranuclear gaze palsy. Common coexisting abnormalities include spastic dysarthria, emotional lability, and gait disorder (1).

CABG surgery continues to be a procedure with bad prognosis and poor recovery, sometimes necessitating emergency department (ED) intervention for postoperative problems. Annually 200,000 coronary artery bypass graft (CABG) procedures are conducted in the United States. Out of these, up to 14% of patients experience post- operative problems including stroke and require emergency department (ED) care within 30 days after discharge (2). There is a possibility of harm to the adjacent nerves and organs as complications of mitral valve replacement (MVR) and nerve and/ or organ impairment in aortic valve replacement (AVR) (3). Transcatheter aortic valve replacement (TAVR) is a modern medical procedure that provides a hopeful alternative to surgical aortic valve replacement for patients who have a high or intermediate risk for surgery (4). Stroke is a severe consequence that can occur during aortic valve replacement in cases with calcific aortic stenosis, whether it is done through transcatheter implantation (TAVR) or surgical replacement (SAVR). Recent studies indicate a decrease in stroke rates following TAVR compared to the rate of previous rate and SAVR. Cerebral lesions were found in 68 – 93 % of patients after TAVR and 38-54 % after SAVR (5).

Following CABG, the incidence of brachial plexus injury ranges from 2 to 15 percent, while the occurrence of stroke ranges from 0.4 to 14 percent. Society of Thoracic Surgeons (STS) reported incidence of permanent stroke to be 1.4 % in CABG patients, 1.3% in AVR, 2.3% in MVR. Combined open MVR and CABG procedures had a stroke incidence of 3.1% and combined AVR and CABG procedures reported 1.9% incidence of stroke. Ophthalmologic complications are observed in 0.1 to 25 percent of cases, with angiography being necessary in all instances. Cognitive impairment includes disruptions in memory, executive function, motor speed, attention, and other cognitive abilities. Delirium occurs in 3 to 32 percent of cases, while subtle cognitive issues are percent in 10 to 79 percent of cases. The occurrence of intracranial hemorrhage is less than 0.1 percent, and seizures are observed in 0.6 percent of cases (1). In a study of 451 cases, the occurrence of neurological problems was 4.9%, with major neurological events accounting for 1.5% and minor neurological events accounting for 3.3% (6). Brain computed tomography (CT) or magnetic resonance imaging (MRI) scans can predict the risk of postoperative stroke after CABG (7). We conducted this study aiming at determining the prevelance of neurological complications in CABG surgery or valve surgery patients.

Methodology

This prospective study aimed to investigate the incidence and risk factors of neurological complications in patients undergoing various cardiac surgery procedures, including coronary artery bypass grafting (CABG), valve surgery (aortic, mitral, tricuspid), and other related interventions. The study design is observational and prospective, allowing for the collection of data from participants before and after their cardiac surgeries. The study included adult patients (age 18 and older) who were scheduled to undergo cardiac surgery at our tertiary care hospital. Patients were recruited based on their surgery schedules, and informed consent was obtained from each participant before the study began.

The induction of patients was done through consecutive sampling over a period of six months and 49 patients were inducted. Baseline demographic information age, gender, race, and comorbidities were noted down. Clinical history of any preexisting neurological conditions, cognitive impairment, and history of stroke was recorded. Cardiac health information like indications for surgery, type of surgery performed (CABG, valve replacement etc.), and other relevant cardiac factors were all noted in electronic database. Intraoperative details or specifics of the surgical approach, on-pump or off-pump CABG, aortic clamping, and other relevant surgical details were sought from the surgeon and anesthesiologist. Information on type of anesthesia used, including the use of anesthetic preconditioning when applicable was also obtained from anesthesiologist.

Neurological complications: Monitoring was done for complications such as stroke, transient ischemic attacks (TIA), delirium, visual disturbances, seizures, and other neurological events. Imaging studies: Brain computed tomography (CT) or magnetic resonance imaging (MRI) scans to detect brain lesions and assess their nature and extent. Cognitive assessment was done using standardized tests to evaluate cognitive function before and after surgery. Assessment of patients'

functional independence in activities of daily living was done. Participants were followed up for a specified period, typically up to 12 weeks after surgery, to assess the long-term impact of neurological complications on their quality of life, cognitive function, and overall recovery. Patient evaluation was done on third day and day 30th and incidence of neurological complications (e.g., stroke, TIA, delirium, visual disturbances, seizures, etc.), cognitive function scores (preoperative and postoperative) were noted down. Initial descriptive statistics were calculated for all variables. This includes mean, median, standard deviation, and frequency distributions for continuous and categorical variables. The primary analysis was focused on calculating the incidence rates of neurological complications for different types of cardiac surgery procedures (CABG, valve replacement) and the overall incidence for the entire cohort. The rates were reported with 95% confidence intervals. To identify significant risk factors associated with neurological complications, potential predictors, including surgery type, demographics, comorbidities, and surgical details, were included in the analysis.

Results

The male to female ratio was 11/7 in CABG and 17/14 in valve repair surgeries with an average age of 65.7 years.

Table 1: General characteristics and Clinical classification of patients

		CABG (n=18)	Valve Repair Surgery (n=31)	p value
Gender (male/female)		11/7	17/14	>0.05
Age (years)		65.7±6.4	65.7±6.4	>0.05
Course of disease (years)		6.2±2.4	6.2±2.4	>0.05
Comorbid	Diabetes	8	9	>0.05
	Hypertension	7	6	
	Hyperlipidemia	6	7	
ASA classification	Class I	25	26	>0.05
	Class II	20	19	
	Class III	8	9	
	Class IV	5	4	

Diabetes, hypertension and hyperlipidemia, although present in a sizeable number of individuals in the data set, were not associated with the neurological events. ASA classification also did not provide any significant results.

Table 2: Incidence of adverse reactions in both groups (n, %)

Groups	Dizziness	Nausea and vomiting	Insomnia	Total incidence Rate
CABG	3	4	3	10 (17.24%)
Valve repair	6	4	10	20 (64.5%)
Aortic	3	1	3	7
Mitral	2	3	5	10
Tricuspid	1	0	2	3
χ^2			1.91	
p			>0.05	

Table 3: Incidence of neurological complications in both groups (n, %)

Groups	Stroke	Visual impairment	Loss of attention	Total incidence Rate
CABG	2	3	3	8
Valve Repair	1	0	8	9
Aortic	1	0	3	4
Mitral	0	0	2	2
Tricuspid	0	0	3	3
χ^2			2.06	
p			>0.05	

The adverse mild neurological dysfunctions (MND) were measured as dizziness, nausea and vomiting and insomnia while other neurological complications were recorded as stroke, visual impairment and loss of attention.

Discussion

Neurological complications following heart surgery result in longer hospital stays, increased mortality rates, and even in patients who do not show any signs of stroke on radiological imaging. Additionally, doing repeat surgeries further raises the likelihood of experiencing postoperative neurological problems. Neurological damage during heart surgery is a significant problem in terms of both clinical outcomes and cost-effectiveness. Neurological impairments can manifest as mild neurological dysfunctions (MND) after minimal invasive mitral valve surgery (MIMVS). These are transient neurological deficits with negative computed tomographic scans and apparent full recovery before discharge. MND occurs more frequently than strokes during the postoperative period (6). Mild neurological dysfunctions (MND) incidents were 20 related to valve repair in our study population. Among these 7 incidents happened in aortic, 10 in mitral and 3 in tricuspid valve repair. Insomnia was the most common mild symptom and we tried that it gets resolved before the patient is discharge otherwise the patient would need medications.

Both CT scan and MRI can be used but MRI is more efficient in diagnosing mild to moderate encephalopathy cases, MRI revealed lesions resembling those previously documented strokes in 3 out of 4 cases. Among the remaining three patients, who exhibited severe encephalopathy, magnetic resonance imaging (MRI) revealed widespread cortical necrosis. These images have the potential to enhance clinicians' comprehensions of the etiologic, pathophysiologic clinical and prognostic features of these neurologic sequels (8). In our study we used both CT scan and MRI.

The Diagnostic and Statistical Manual of Mental Disorders (DSM V) defines postoperative delirium (POD) as a fluctuating disturbance in attention and awareness that occurs shortly after surgery and deviates from the individual's normal state. This condition is accompanied by impaired cognition or perception and is typically not caused by an existing neurocognitive disorder or extremely low levels of arousal. Seizures occur in approximately 1% of patients after heart surgery and up to 8% of critically sick patients experience non-convulsive seizures which can hinder their recovery (9). Paraplegia is an unforeseeable neurological complication that can occur during coronary artery bypass grafting (CABG) surgery. It is an uncommon yet lethal condition, and the underlying mechanism remains unclear. Preoperative cognitive impairment was observed in 19% and post-operation delirium was observed in 18% of patients who after CABG. Dementia exhibited in 7% of patients at 5-7 years after undergoing surgery (10). In our study, loss of attention occurred in 3 CABG cases and 8 valve repair cases.

The occurrence of unfavourable neurocognitive outcome, such as stroke, postoperative cognitive dysfunction (POCD), and delirium in the intensive care unit (ICU) following Endoscopic coronary artery bypass grafting Endo-CABG, is infrequent (1.72% stroke and 8.6% POCD and 8.6% delirium at 3 months) and like that observed with percutaneous Coronary Intervention (PCI) (1.67% stroke and 10% POCD at 3 months) (11). In a cohort of 20,582 patients, 0.7% of the sample experienced a stroke and more than 50% cases occurred during the first 72 hours. Patients who experienced a stroke after CABG surgery had a significantly worse long-term survival rate compared to those who did not (long-rank $p < 0.001$) (12). Percutaneous coronary intervention (PCI) has a lower procedural risk of stroke compared to coronary artery bypass grafting (CABG) although CABG may provide superior long-term survival rates in specific subgroups of patients. The progress in surgical techniques, optimization of medical therapy, neurologic risk stratification, stent technology, and pharmaceutical treatment is constantly enhancing outcomes (13). In cohort of 1022 patients 3.5% reported stroke after CABG, with most of them experiencing multiple strokes, and in many cases, these effected both sides of brain. Stroke patients had higher prevalence of peripheral arterial disease and carotid stenosis, but they were less inclined to have pre deployment balloon aortic valvuloplasty ($p=.005$). Stroke patients exhibited a higher incidence of postoperative complications, such as prolonged breathing

(p<.001), significant vascular problems (p<.001), and new-onset dialysis (p<.001). The mortality rate was higher in stroke patients compared to non-stroke patients (p<.001). Additionally, the 1-year Kaplan-Meier estimates showed a decline in survival rates for stroke patients (log-rank p=.002) (14). In our study stroke was found in a total of 3 cases, CABG related cases were 2 and one case of stroke occurred in aortic valve repair.

The occurrence of postponed cognitive impairment was independent of the kind or position of the implanted prosthetic heart valve in patients (n =115) who underwent elective replacement or repair surgery. Postoperative cerebral dysfunction characterized by stroke and symptomatic delirium was identified in 40.9% of patients (OR 4.47), 45.5% in the aortic and 55% in the mitral and 20% in multiple places. The occurrence of symptomatic delirium during the early postoperative phase was more frequent after the replacement with a biological prosthesis (p=0.047) (15). The profound influence of problems related to TAVR on the ultimate clinical result and death rate underscores the importance of promptly identifying and managing them in patients undergoing TAVR (4). TAVR is now strongly recommended as a first-line treatment for symptomatic patients with severe aortic stenosis (AS) who are at high risk for surgical aortic valve replacement (SAVR). It is also recommended as a second-line treatment for intermediate-risk patients (16). Preoperative cardiovascular diagnostic testing before transcatheter aortic valve replacement (TAVR) does not accurately forecast the occurrence of stroke during the patients' hospital stay is within 30 days after the procedure (17). Given the projected rise in the number of patients undergoing TAVR in the future, it is crucial to examine the occurrence and causes of stroke following SAVR and TAVR. Modifications in the surgical approach for SAVR, as well as the use of devices to prevent embolic events during TAVR, have not shown a substantial decrease in occurrence of strokes after the procedure (18). According to literature available at present both transcatheter aortic valve replacement (TAVR) and surgical aortic valve replacement (SAVR) carry comparable stroke risks for patients with intermediate risk, suggesting that neither technique is inherently safer than the other (19). In our study the patients underwent surgical valve repair and there was one stroke event in aortic valve repair.

Patients undergoing transcatheter aortic valve replacement (TAVR) are not often assessed for depression and cognitive dysfunction (CD), and the relationship between these conditions and post procedural outcomes is not well comprehended, Initially, a prevalence of 19.6% for depression and 31.8% for CD was recorded (20). After a median follow-up period of 16 months, it was found that POD (second day prevalence 13.4%) continued to be a significant predictor of mortality in patients who underwent transfemoral TAVR compared to those who underwent non trans femoral TAVR (21). The occurrence of stroke and encephalopathy at an early stage led to a higher mortality rate at 12 months in both SAVR and TAVR therapy cohorts. Patients who experienced early strokes showed an earlier improvement in their quality-of-life following Transcatheter Aortic Valve Replacement (TAVR), with a notable difference observed at the 30-days follow-up. However, the quality of life became comparable between the two groups at 6 and 12 months (16). Stenosis was found in either carotid artery in over 90% of stroke patients in population with 9.5% prevalence of stroke after TAVR (17). Stroke prevalence after TAVR at 30-days (1.3%) and 6-month stroke (2.4%) is low yet poses significant impact on survival (22). The pooled incidents (in 42 studies) of POD following TAVR as found to be 10.5 %. The occurrence of POD was seen to be thrice following non-transfemoral (non-TF 25.3 %) TAVR in comparison to trans femoral (TF 9.3%) TAVR (23). Age, peripheral arterial disease, re-exploration for bleeding, perioperative myocardial infarction, and year of surgery were identified as independent predictors for stroke by multivariate logistic regression analysis (24). Additionally, increased functional impairment and a history of stroke were identified as risk factors for long-term neurological events. Individuals with pre-existing atrial fibrillation or those who develop new-atrial fibrillation after undergoing a transcatheter aortic valve replacement (TAVR) face a fourfold higher risk of experiencing strokes during their hospital stay and in the long term. From a procedural perspective, the use of balloon following dilatation of the valve has been linked to an elevated risk of stroke (18) also alternative access technique and a history of transient ischemic attack

(14). TAVR procedure is still not commonly used in Pakistan, so we did not include any patient undergoing TAVR in our study. But this technique, with promising neurological outcomes can become very affective in future, so it is discussed here.

Aortic Valve pre-dilatation, diabetes, and left ventricle ejection fraction <50% were independent predictors of 30-day stroke, whereas diabetes, pre-existing neurological dysfunction, bicuspid valve, and critical status were predictive of 6-month stroke (22). Risk factors for substantial hemorrhage include big infarcts, anticoagulant therapy, and the existence of a preexisting hemorrhagic infarct. Endocarditis causes cerebral hemorrhage while ischemic optic neuropathy causes visual loss. Preexisting organic mental disorders (such as stroke or dementia), a history of heavy alcohol consumption, advanced age, intracranial cerebral artery disease, renal failure, hepatic failure, thyroid abnormalities, or stroke are risk factors for delirium. Hypoxemia, metabolic imbalances (such as hyponatremia and hypoglycemia), medication toxicity (including lidocaine and procainamide), and structural brain damage like stroke pose risk for seizures. Coma seldom occurs as a complication of heart surgery and is caused by widespread global anoxic injury, major hemispheric or brainstem strokes, multifocal infarcts, intracerebral hemorrhages, convulsions, or server metabolic abnormalities (1). There is a strong correlation between a low oxygen delivery index (DO2i) during cardiopulmonary bypass and the occurrence of postoperative delirium in individuals undergoing coronary artery bypass grafting (CABG). Age, pre-existing cognitive impairment, preoperative renal disease, and cross-clamp time were independent risk factors for delirium. The findings also demonstrated that elderly individuals exhibited greater sensitivity to a decrease in DO2i (25). Major vascular complications/bleeding, stroke, acute kidney injury, aerial fibrillation, and infectious disease combined with complicated TAVR results in longer stay at hospital. The factors that were shown to be associated with an increased risk of postoperative delirium (POD) were non trans femoral (transapical/transaortic) access, current smoking, carotid artery disease, atrial fibrillation, age (21), stroke (23), prior anxiety and depression (26). In our study the comorbid conditions (diabetes, hypertension and hyperlipidemia) were not significantly associated with the outcomes of the surgery. Patients who receive percutaneous treatment for mitral or tricuspid valve regurgitation frequently present at an advanced age, are weak, and have other comorbidities, which increases their susceptibility to developing postoperative delirium (POD) (27). Associations were reported between prevalence of visual hallucinations and level of nicotine consumption, as well as the duration of aortic clamp/extracorporeal circulation (28). Paraplegia following CABG was associated with spinal cord ischemia (29). Silent brain infarcts (SBIs) are commonly detected following transcatheter aortic valve implantation (TAVI) when patients undergo screening using diffusion-weighted magnetic resonance imaging (DW-MRI). It is still unclear how useful SBIs are for predicting outcomes after TAVI. The prevalence of strokes cases with localized neurological impairments was 3%. The presence of diabetes, chronic renal disease, the use of 3-Tesla MRI, and pre-dilation were all linked to a higher risk of silent brain infarction (SBI). The occurrence of early POD became more common throughout time. The utilization of cerebral emboli protection devices (CEPDs) seemed to reduce the size of silent brain infarctions (SBI); however, it did not affect their overall occurrence. Although there is evidence suggesting that an increased number of new SBIs have a negative impact on early neurocognitive outcomes (30). The overall occurrence rate of new brain lesions was 20.1%, with only one symptomatic patient in a previous cohort. In patients with brain lesions, 61.9% had on-pump coronary artery bypass grafting (CABG) and 52.4% underwent aortic clamping. The Katz Index of independence in Activities of Daily Living was notably reduced in individuals with brain injuries, those who had several new lesions were shown to experience postoperative cognitive dysfunctions (POCD), whereas those with a larger maximum lesion size were considerably more likely to have POCD (31). The incidence silent brain infarcts SBI after transcatheter aortic valve implantation was 0.71(RR 0.10), 0.44 after aortic valve replacement (RR 0.22), 0.39 after mixed cardiothoracic surgery (RR 0.15), and 0.25 after CABG (RR 0.10). For percutaneous coronary intervention (RR 0.06), the incidence was 0.14 and 0.14 for off-pump CABG (RR 0.21). The elevated occurrence rate of SBI in

comparison to strokes emphasizes the significance of documenting this substitute metric in cardiac interventional research (32). No brain infarcts were noted in our study group.

The presence of ischemic brain lesions caused by embolized particles can result in cognitive impairment. Aortic Valve Implantation (TAVI) can have beneficial impacts on cognitive function due to its ability to enhance the amount of blood pumped by the heart and the flow of blood to the brain (33). The findings of cognitive tests in individuals undergoing on-pump and off-pump coronary artery bypass surgery have been inconsistent. The precise mechanisms of postoperative cognitive impairment after coronary artery bypass grafting remain unclear. It is imperative to conduct a comprehensive investigation into the dual effects of aesthetics, namely their neuroprotective and neurotoxic properties. The diagnosis should rely on a thorough cognitive assessment using neuropsychiatric tests, brain biomarker inspections, and electroencephalographic examination. Cognitive impairment ban be managed through either preventive or therapeutic techniques. Implementing preventive measures such as altering surgical facilities and practices can effectively reduce the occurrence of postoperative cognitive impairment. Experimental therapies may provide innovative approaches to treatment. anaesthetic preconditioning may be beneficial for enhancing the improvement of this disorder (34). The off- pump coronary artery bypass grafting (CABG) without aortic manipulation had the lowest occurrence of neurological complications (0.7%) when compared to other revascularizations procedures (35). Postoperative stroke (3.4% vs 9.8%) and delirium (4.2% vs 11.5%) was less prevalent in off-pump CABG. The neurological outcomes are collectively referred to as “Major Adverse Neurological Events” (MANE), the composite outcome MANE was 20.3% in the on-pump group and 7.6% in the off-pump group (36). Individuals in the on-pump CABG group experienced temporary visual hallucinations while the off-pump group reported no such hallucinations ($p=0.020$) (28). Neuroserpin shows potential as a reliable indicator of type 2 neurological problems and can promote neuro regeneration following off-pump CABG (37). The utilization of off-pump coronary artery bypass (OPCAB) and the implementation of single aortic clamping in the on-pump coronary artery bypass (ONCAB) group were correlated with a decreased occurrence of postoperative stroke in a cohort of 7,231 patients (38). Transcatheter mitral valve replacement (TMVR) results in a notable enhancement in cognitive function, exercise capacity, and quality of life in patients suffering from severe mitral regurgitation (MR) within a three-month follow –up period. The evaluation of cognitive function in 72 individuals with Euro Score II of 4.4% revealed a noteworthy enhancement in the overall score of the Montreal Cognitive Assessment MoCA-Test ($p<0.01$), with notable modifications observed in the executive ($p<0.001$), attention ($p<0.001$), abstraction ($p<0.001$), and memory ($p<0.001$) subcategories (39). In our study all the cardiac surgery procedures were done on-pump so we cannot compare the difference between an off-pump and on-pump cardiac surgery.

Conclusion: There are huge volumes of literature showing that the surgical procedure or technique matters when it comes to neurological complications after cardiac surgery. But our data did not show any relationship between the procedure and the adverse neurological events. The data was small and follow-up duration was short so we cannot establish the relationship. Furthermore, the literature suggests that TAVR is a better option that harms lesser. The neurological symptoms are fewer in TAVR than the SAVR. In Pakistan, TAVR is under trail, and we could not include any case of TAVR is this study.

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