

*Original Research Article*

# Risk Factors for Early Neurological Complications after Coronary Artery Bypass Graft *versus* Valve Replacement Surgery: Regional Cardiac Center Study

Shahswar Arif<sup>1</sup>, Zarina Brady<sup>1</sup>, Georgi Bachvarov<sup>2</sup>, Mariya Negreva<sup>3\*</sup>

## Abstract

<sup>1</sup>Medical University of Varna, Varna, Bulgaria

<sup>2</sup>Department of Cardiovascular Surgery and Angiology, University Hospital "St. Marina" Varna, Bulgaria

<sup>3</sup>Department of Cardiology, University Hospital "St. Marina" Varna, Bulgaria

\*Corresponding Author's E-mail: [mnegreva@abv.bg](mailto:mnegreva@abv.bg)  
Tel: +359 888 478 303

Data on the early neurological injuries following coronary artery bypass graft (CABG) and valve replacement surgery are scarce and conflicting, especially those evaluating risk factors for their appearance. That gave us a predisposition to analyse and compare the early neurological complications following these two types of heart surgeries and find significant risk factors for their development. A retrospective observational study was conducted at the cardiac surgery of the University hospital "St. Marina" – Varna, Bulgaria for the period July 2019 – June 2020. 152 patients who underwent CABG operation and 100 patients with valve replacement operation were included consecutively in the study and followed during the early postoperative period (up to the 7<sup>th</sup> day after the operation) for the manifestation of the neurological complications: a psychomotor excitement, a delirium, cognitive deficit and a stroke. Patient demographic and clinical characteristics, as well as intraoperative variables were analysed as risk factors for these complications. For statistical analysis unpaired t-test was used. A p-value <0.05 was considered statistically significant. A total of 48 / 252 (19%) patients suffered postoperative neurological complications following cardiac surgery, 30 patients with CABG operation and 18 with valve replacement surgery. Although cognitive deficit (20% vs 5.6%), delirium (3% vs 0%) and psychomotor excitement (63.3% vs 61.1%) were higher in CABG cohort (versus valvular), differences were not statistically significant (p>0.05). However, post-operative stroke rate was significantly higher in valvular surgeries (13.3% vs 33.3%, p<0.05). Regarding risk factor evaluation, in the CABG cohort, older age, peripheral artery disease, diabetes mellitus, family history of stroke and atrial fibrillation were all statistically significantly linked to neurological complications. In the valvular cohort, dyslipidaemia, family history of stroke and longer operation time were all statistically significant (p<0.05) risk factors. Family history of stroke was recorded to be a statistically significant risk factor for stroke following both CABG and valve replacement surgery. All patients undergoing CABG/valve surgeries should be given adequate information on potential postoperative neurological complication risks, and postoperative care staff should be aware of the additional risk and be clinically equipped to deal with such complications effectively.

**Keywords:** Coronary artery bypass graft, Neurological complications, Risk factors, Stroke, Valve replacement surgery

## INTRODUCTION

Cardiac surgery gives millions of people chance to live, especially after the improvement of surgery and

anesthetic management. The survival after the procedure has increased dramatically because of significantly

reduced rate of complications (Berger et al., 2018; Selnes et al., 2012). Although the overall postoperative morbidity and mortality has improved dramatically, neurological complications are still a critical event (McKhann et al., 2006; Kowalewski et al., 2017; Kowalewski et al., 2016). Serious clinical manifestation involves mainly central nervous consisting of great variety with most clinical attention paid to cognitive-behavioural disturbances, impaired consciousness, deficit in neurological function and most devastating stroke (Newman et al., 2001; Raffa et al., 2018; Gozdek et al., 2018; Raffa et al., 2016). There is a large body of data, presenting cognitive disturbances after coronary bypass graft (CABG) or valve replacement surgery with a great variation of presentation from 66% to 15% before discharge (Mahanna et al., 1996; Bucerius et al., 2003). Their typical clinical manifestation is deterioration in memory, attention, (psycho) motor speed, and visuospatial ability. Many of these cognitive disturbances are not permanent, but in almost 40% of patients they have been still present at 5 years after the operation. The overall incidence of symptomatic stroke (stroke with clinical signs) is recorded to be much lower to 1.2 – 6% and the rate is higher in elderly patients (Raffa et al., 2019). The incidence has been largely unchanged for years, despite the improvement of surgical techniques (Whitlock et al., 2014). Still the burden of stroke is a major limitation to cardiac surgery success.

Several articles have analysed neurological consequences following surgeries and risk factors for their presentation; however, results have been varied, or incomplete mostly due to a minute number of interferences. Some publications have identified the link between prolonged cardiopulmonary bypass and the development of postoperative stroke, whereas others have been sceptical of its importance (Baker et al., 2005; Almassi et al., 1999; Floyd et al., 2006). The scarce and inconclusive character of the results determined our purpose to study was the rate of neurological complications and their risk factors in cases of cardiac surgery at our regional cardiac surgery center.

## MATERIAL AND METHODS

A retrospective observational study was conducted in the cardiac surgery center of the University hospital “St. Marina” Varna covering the period July 2019 – June 2020. From all patients admitted to the center during this period, only patients undergoing coronary artery bypass graft (CABG) operation or valvular surgery were consecutively selected for the purpose of the study. Complex cardiac surgeries (CABG plus valvular surgeries), minimally invasive procedures, revision surgeries or patients with inconclusive/insufficient data were excluded from the final review list. CABG cohort included patients with on-pump CABG operation and off-

pump CABG operation. Valve replacement group included patients with one or more than one valve replaced. Neurological complications were defined as psychomotor excitement, a delirium, cognitive deficit and a stroke and they were assumed in the study if only were objectively present in the medical history of the patients. For the study, early postoperative neurological complications were defined as complications that were recorded up to the 7<sup>th</sup> day after the cardiac surgery. Patient demographic and clinical characteristics like age (years), gender, BMI and co-morbidities (peripheral artery disease, diabetes mellitus, dyslipidaemia, hypertension, familial history of stroke, coronary artery disease, atrial fibrillation, significant carotid artery stenosis), as well as many intraoperative variables as average operation time (minutes), average cross-clamp time (minutes), average extracorporeal time (minutes) were recorded and analysed as risk factors for the neurological complications. Quantitative variables were compared using the unpaired t-test. *p*-value <0.05 was considered statistically significant.

## RESULTS

A total of 252 patients were consecutively selected for the study. Of them, 152 patients undergone CABG operation and 100 patients were selected for the group with valve replacement operation. 48 / 252 (19%) patients suffered early postoperative neurological complications (psychomotor excitement, a delirium, cognitive deficit or a stroke), of which 30 were from the CABG group and 18 belonged to valve replacement surgery group. The rest 204 patients (122 patients with CABG operation and 82 with valve replacement surgery) had no clinical signs of neurological complications during the early postoperative period.

In the CABG group, neurological complication evaluation revealed that older age (72.8 years vs 66.4 years), peripheral artery disease (10% vs 5.7%), diabetes mellitus (43.3% vs 35.3%); family history of stroke (20% vs 8.2%) and atrial fibrillation (13.3% vs 6.6%) were all statistically significantly linked to neurological complications (*p*<0.05); whereas in the valve replacement cohort, male gender (61.1% vs 51.1%), family history of stroke (16.7% vs 6.1%) and average operation time (320.8 min vs 262.2 min) were deemed statistically significant risk factors for the appearance of early neurological complication after valve replacement surgery (*p*<0.05) (Table 1).

Although psychomotor excitement (63.3% vs 61.1%), cognitive deficit (20% vs 5.6%) and delirium (3% vs 0%) were higher in CABG cohort (versus valve replacement group), differences were not statistically significant. However, post-operative stroke rate was significantly (*p*<0.05) higher in valve surgery group (33.3%) than in CABG surgery group (13.3%) (Table 2).

**Table 1.** Demographic, clinical and intraoperative variables as risk factors for neurological complications

Variables	CABG Surgery (152 patients)			Valve Replacement Surgery (100 patients)		
	Subgroup with neurological complications	Subgroup without neurological complications	p-value	Subgroup with neurological complications	Subgroup without neurological complications	p-value
Patients, n	30	122	-	18	82	-
Average Age (years)	72.8	66.4	<0.05	61.9	62.3	>0.05
Male gender(%)	20/30(66.7%)	86/122 (70.5%)	>0.05	11/18 (61.1%)	46/82 (56.1%)	<0.05
BMI(kg/m2)	26.8	30.1	>0.05	27.1	28.2	>0.05
Peripheral artery disease, n (%)	3/30 (10%)	7/122 (5.7%)	< 0.05	1/18 (5.6%)	0 (0%)	-
Diabetes Mellitus, n (%)	13/30 (43.3%)	43/122 (35.3%)	<0.05	4/18 (22.2%)	21/82 (25.6%)	>0.05
Dyslipidaemia, n (%)	23/30 (76.7%)	98/122 (80.3%)	>0.05	6/18 (33.3%)	27/82 (32.9%)	>0.05
Hypertension, n (%)	29/30 (96.7%)	119/122 (97.5%)	>0.05	13/18 (72.2%)	69/82 (84.1%)	>0.05
Previous history of stroke, n (%)	6/30 (20%)	10/122 (8.2 %)	<0.05	3/18 (16.7%)	5/82 (6.1%)	<0.05
Atrial Fibrillation, n (%)	4/30 (13.3%)	8/122 (6.6%)	<0.05	3/18 (16.7%)	24/82 (29.3%)	>0.05
Significant Carotid Artery Stenosis, n (%)	1/30 (3.3%)	6/122 (4.9%)	>0.05	0 (0%)	1 (2.3%)	-
Average Operation time (min)	242.8	256.2	>0.05	320.8	262.2	<0.05
Average Cross-Clamp time (min)	59	58.2	>0.05	106.8	93	>0.05
Average Extracorporeal time (min)	92.7	105.2	>0.05	169.2	142.2	>0.05

**Table 2.** Rate of postoperative complications following CABG operation and valve replacement surgery

Postoperative complication	CABG group	Valve replacement group	95 % CI	p-value
Psychomotor excitement	19/30 (63.3%)	11/18 (61.1%)	-2.49 to -1.91	>0.05
Cognitive deficit	6/30 (20%)	1/18 (5.6%)	-14.61 to -14.19	>0.05
Delirium	1/30 (3%)	0 (0%)		n.a.
Postoperative stroke	4/30 (13.3%)	6/18 (33.3%)	-19.76 to 20.24	- <0.05

## DISCUSSION

Age is one of the most vigorously tested variables in respect to the link with stroke (Andersson et Asperg, 2021; Boehme et al., 2017; Kim et al., 2018; Roy-O'Reilly et McCullough, 2018; Yousufuddin et Young, 2019).

In spite of the elderly cohort appearing to preserve cerebral autoregulation, they are at an elevated risk of stroke, specifically in the presence of major aortic atherosclerosis and occult cerebrovascular disease

(Berger M et al., 2018; Gaudino et al., 2019). The older cohort are at a higher risk to have limited baseline cognitive processing, hence, a relatively minute decline can have a major effect on living independently (Arrowlish et al., 2000). Our results show that older age is a significant factor for early postoperative neurological complications following a CABG operation that is in accordance with previous studies.

Some studies have analysed the effect of gender on postoperative neurological outcome (Sabzi et Asadmobini, 2020). The major reason for this is that

number of males significantly higher than females in the adult cardiac surgical cohort. In our study, males undergoing valvular surgeries had a higher rate of neurological complications, however, such a correlation was not established in CABG cohort. More specifically, females were linked an improved five-year survival. Oestrogens have a crucial function in neuronal development, cognitive function and survival (Nikolini et al., 2016; Dixon et al., 2021). Studies have analyzed the link between stroke and surgical intervention and stenosis, which is which occur through either artery to artery or via hypoperfusion (Hirotani et al., 2000; Ascher et al., 2001). Hirotani et al. (2000) suggested that carotid artery stenosis is the single independent risk factor of postoperative stroke. Very few studies have evaluated such a relationship. The link between calcifications of the aortic arch and coronary artery disease has been discussed (Irribaren et al., 2000). In asymptomatic cases, the carotid intima media thickness, and not the degree of stenosis may predict stroke risk as well as other coronary ischemic events (Lin et al., 2011; Lorenz et al., 2007; Barnnet, 2004). Bilateral carotid artery stenosis is a critical result, and showcased diffuse atherosclerosis, more particularly, morphological characteristics and anatomical location of cranial lesions indicate embolism mechanism from manipulation of ascending aorta and aortic arch (Irribaren et al., 2000; Eigenbrodt et al., 2013).

Patients with a familial history of stroke or transient ischaemic attack are more vulnerable to a postoperative stroke (Li et al., 2019; Pourasgariet Mohamadkhani, 2020; Yiet al., 2020). In our experience, patients with a familial history of stroke were more likely to have a postoperative neurological complication after CABG operation, as well as valve replacement operation.

McDonagh et al. (2014) reported that patients with cardiac related symptoms more 24 weeks or more were more susceptible for a post coronary artery surgery neurological injured. However, another study revealed that cardiac arrhythmias nor congestive heart failure were linked with postoperative neurological complications (Ngaage et al., 2008). In our experience, in the CABG cohort, neurological evaluation revealed that atrial fibrillation (13.3% vs 6.6%) was statistically significantly linked to neurological complications ( $p < 0.05$ ); whereas in the valve replacement surgery cohort, atrial fibrillation was not a statistically significant risk factor ( $p > 0.05$ ).

Diabetes mellitus has been reported as a risk factor for postoperative neurological complications in cardiopulmonary bypass surgeries (Lauruschkatet al., 2008; Ram et al., 2020; Santos et al., 2016). There are suggestions that concurrent illnesses such as hypertension, renal, and vascular abnormalities as a result of diabetes could be the reason behind postoperative neurological complications in patients with diabetes mellitus. From our experience, in the CABG cohort, neurological complication evaluation revealed that diabetes mellitus (43.3% vs 35.3%) was statistically

significantly linked to neurological complications ( $p < 0.05$ ); whereas in the valvular cohort, such a correlation was not established.

There is a suggestion that in cardiopulmonary bypass surgery, operation time and postoperative neurological complications are linked (Abou-Arab et al., 2020; Bronster, 2006; Celmetaet Miceli, 2022; Gilbey et al., 2022; Zabala et al., 2005). However, some studies have not found such a correlation (Liu et al., 2019). It is critical to note that CABG time could be increased due to various reasons, leading to a higher rate of neurological complications postoperatively. Certain surgeries such as combined valvular surgeries or CABG + valvular surgeries, any intraoperative challenges or technical issues are all potential reasons behind longer operation time. In our experience, longer operation time was statistically significantly linked with neurological complications, however a similar relationship was not established in CABG cohort.

## CONCLUSION

Postoperative neurological sequelae after cardiac surgeries are linked with increased burden on the patients, staff, and the national health service. This study showcased that among co-morbidities, family history of stroke was statistically significant risk factor in both CABG and Valvular cohorts. In regard to the comparison between CABG and valvular, surgeries, valvular surgeries increased the risk of postoperative neurological complications more significantly than CABG surgeries. Relevant patients, postoperative care staff should be well experienced in dealing with potential complications effectively.

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