American Journal of Medicine and Medical Sciences 2025, 15(6): 1864-1867
DOI: 10.5923/j.ajmms.20251506.48

Prediction and Prevention of Acute Ischemic Stroke in Patients with Indication for Coronary Artery Bypass Grafting

H. M. Tursunov, M. M. Bakhadirkhanov, S. N. Gulomitdinov

Republican Research Center of Emergency Medicine, Tashkent, Uzbekistan

Abstract **The aim** of the study was to develop a system for predicting the risk of acute ischemic stroke in patients with indications for coronary artery bypass grafting and to determine the optimal methods of prevention of this complication. **Background.** Coronary artery bypass grafting is one of the most efficient methods for surgical treatment of coronary heart disease. Despite the improvement of surgical technique and anesthesiology, the incidence of postoperative neurological complications, particularly acute ischemic stroke, remains a significant problem in cardiac surgery, ranging from 1.5% to 5.2%. **Material and methods.** The data of 30 patients (22 men, 8 women, mean age 68.7±7.2 years) with development of acute ischemic stroke after coronary artery bypass grafting were analyzed. A comprehensive preoperative examination including neuroimaging and ultrasound duplex scanning of brachiocephalic arteries were performed. Multivariable logistic regression analysis with development of a predictive model was used to identify risk factors. **Results.** Stroke was developed on an average of 2.4±1.7 days after surgery. Independent predictors identified were as follows: age >70 years (OR 2.8), brachiocephalic artery stenosis >70% (OR 3.4), atherosclerosis of the ascending aorta (OR 3.2), atrial fibrillation (OR 2.5), diabetes mellitus (OR 1.9), artificial circulation time >120 min (OR 2.3), and intraoperative hypotension (OR 2.1). The predictive model showed high informative power (AUC 0.85, sensitivity 79.3%, specificity 81.6%). A complex of preventive measures in high-risk patients reduced the incidence of stroke by 47%. **Conclusion.** A personalized approach to risk stratification and prevention of acute ischemic stroke can be efficiently integrated into clinical protocols for cardiac surgery patients to improve patient outcomes.

Keywords Coronary artery bypass grafting, Acute ischemic stroke, Risk factors, Prognosis, Prevention

1. Introduction

Coronary artery bypass grafting (CABG) is one of the most efficient methods for surgical treatment of coronary heart disease (CHD) [11]. Despite the improvement of surgical technique and anesthesiology, the incidence of postoperative neurological complications, particularly acute ischemic stroke (AIS), remains a significant problem in cardiac surgery, ranging from 1.5% to 5.2%. [13,16]. The development of stroke after CABG is accompanied by an increase of hospital mortality from 1-2% to 13-41%, increased length of hospital stay, and decreased quality of patient life [9].

The pathogenesis of AIS development after CABG is multifactorial and includes embolic, hemodynamic, and inflammatory mechanisms [5]. The main risk factors for stroke development include age over 70 years, atherosclerosis of the ascending aorta and aortic arch, brachiocephalic artery stenosis, atrial fibrillation, diabetes mellitus, arterial hypertension, chronic heart failure, and previous cerebrovascular events [7,14].

The relevance of the problem is associated with the severity and high disability of patients with AIS, as well as the lack of unified algorithms for prediction and prevention of this complication.

The aim of the study was to develop a system for predicting the risk of acute ischemic stroke in patients with indications for coronary artery bypass grafting and to determine the optimal methods of prevention of this complication.

2. Material and Methods

The study included 30 patients (22 men and 8 women) with development of acute ischemic stroke after coronary artery bypass grafting The mean age of the patients was 68.7±7.2 years. All patients had indications for CABG according to current clinical guidelines [15]. Exclusion criteria were as follows: emergency surgery, combined interventions (CABG + correction of valve defects, left ventricular aneurysms), history of AIS less than 6 months before surgery.

Received: May 21, 2025; Accepted: Jun. 12, 2025; Published: Jun. 14, 2025
Published online at http://journal.sapub.org/ajmms

All patients underwent a comprehensive preoperative examination, including:

- Clinical and laboratory tests (general and biochemical blood tests, coagulogram, lipidogram, inflammation markers);
- Instrumental studies: electrocardiography, echocardiography, coronary angiography;
- Neuroimaging: computed tomography of the brain;
- Ultrasound duplex scanning of the brachiocephalic arteries (USDS BCA);
- Assessment of cognitive status using the MMSE scale (Mini-Mental State Examination).

CABG surgeries were performed under artificial circulation using membrane oxygenators and nonpulsatile blood flow. The duration of artificial circulation was 98.2±22.5 min, the time of aortic clamping was 56.3±14.8 min. Intraoperative monitoring included invasive measurement of arterial pressure, central venous pressure, transesophageal echocardiography.

The diagnosis of AIS was established on the basis of clinical picture and CT/MRI data of the brain. The NIHSS scale (National Institutes of Health Stroke Scale) was used to evaluate stroke severity.

Single and multivariate logistic regression analysis was performed to identify risk factors for the development of AIS. Based on the obtained data, a prognostic model was developed and a risk index for the development of AIS was calculated. ROC analysis with calculation of area under the curve (AUC) was used to evaluate the informative power of the model.

Statistical processing was performed using SPSS Statistics 25.0 program. Quantitative data are presented as mean ± standard deviation (M±SD) or median and interquartile range (Me [25%; 75%]), depending on the nature of the data distribution. Qualitative data are presented as absolute and relative frequencies. Differences were considered statistically significant at $p<0.05$.

3. Results

In the studied 30 patients, AIS was developed on an average of 2.4±1.7 days after CABG surgery. By stroke localization: in the middle cerebral artery basin – 19 (63.3%) cases, in the vertebrobasilar basin – 8 (26.7%) cases, in the anterior cerebral artery basin – 3 (10%) cases. The stroke severity according to the NIHSS scale was 9.6±4.3 points.

When analyzing the preoperative characteristics of patients with AIS, the following features were identified: Eighteen (60%) patients were over 70 years of age, 27 (90%) had arterial hypertension, 12 (40%) had diabetes mellitus, 9 (30%) had atrial fibrillation, 22 (73.3%) had chronic heart failure ≥II FC according to NYHA, and 23 (76.7%) had dyslipidemia. According to USDS BCA data, hemodynamically significant stenoses (>70%) of the brachiocephalic arteries were detected in 11 (36.7%) patients, atherosclerotic plaques in the ascending aorta (according to echocardiography and intraoperative revision) – in 15 (50%) patients.

Multivariate logistic regression analysis identified independent predictors for the development of AIS after CABG (Tab. 1).

Table 1. Independent predictors of acute ischemic stroke development after CABG

Risk factor	OR (95% CI)	p
Age >70 years	2.8 (1.5-5.2)	0.002
BCA stenosis >70%	3.4 (1.9-6.1)	<0.001
Atherosclerosis of the ascending aorta	3.2 (1.8-5.6)	<0.001
Atrial fibrillation	2.5 (1.3-4.7)	0.006
Diabetes mellitus	1.9 (1.1-3.6)	0.021
Duration of AC >120 min	2.3 (1.2-4.3)	0.011
MAP decrease >20% of baseline	2.1 (1.2-3.9)	0.015

Note: OR - odds ratio, CI - confidence interval, BCA - brachiocephalic arteries, AC - artificial circulation, MAP - mean arterial pressure

Based on the obtained data, a prognostic model was developed with the calculation of the AIS risk index after CABG. Each risk factor was assigned a score proportional to its significance (odds ratio). A total risk index ≥5 points corresponded to a high risk of developing AIS. ROC analysis showed high predictive value of the model with AUC of 0.85 (95% CI 0.78-0.92), sensitivity of 79.3% and specificity of 81.6%.

A complex of preventive measures has been developed for patients at high risk of developing AIS:

- Preoperative correction of modifiable risk factors (control of blood pressure, glycemia, anticoagulant therapy for atrial fibrillation);
- In patients with significant BCA stenosis (>70%) - consideration of preliminary carotid endarterectomy or stenting;
- Intraoperative measures: careful revision of the ascending aorta, minimization of aortic manipulation or use of the "no-touch aorta" technique in case of severe atherosclerosis;
- Maintenance of adequate cerebral perfusion: control of cerebral oximetry with target values not lower than 60% of baseline, maintenance of mean arterial pressure not lower than 65 mmHg.;
- Postoperative period: early antiaggregant/anticoagulant therapy, maintenance of normoglycemia and normothermia.

4. Discussion

The results of the present study confirm the multifactorial nature of the development of AIS after CABG and are consistent with data obtained by other authors. Bucerius et al. [2] in a study involving over 16,000 patients also found that age >70 years, atrial fibrillation and diabetes mellitus were independent predictors of stroke after cardiac surgery.

Atherosclerosis of the ascending aorta and aortic arch is a significant risk factor for the development of embolic stroke

due to the mobilization of atheromatous masses during manipulations on the aorta (cannulation, clamping, formation of anastomoses) [6]. A meta-analysis by van der Linden et al. [17] showed that the use of the "no-touch aorta" technique or minimization of manipulations on the aorta can reduce the risk of neurological complications by 30-50%.

Stenosis of the brachiocephalic arteries limits autoregulation of cerebral blood flow and increases the risk of developing both hemodynamic and embolic stroke. According to the recommendations of the European Society of Cardiology and the European Association of Cardiothoracic Surgeons [1], in the presence of significant stenosis of the internal carotid artery (>70%) and indications for CABG, preventive carotid endarterectomy or stenting should be considered.

Artificial circulation time of more than 120 minutes increases the risk of systemic inflammatory response and microembolization, which in combination with hemostasis disorders may lead to the development of cerebral ischemia [4]. Interventions aimed at shortening AC time and the use of modern oxygenators with leukocyte filters help to reduce the incidence of neurologic complications.

Intraoperative hypotension (decrease in mean arterial pressure by more than 20% of baseline) in conditions of impaired autoregulation of cerebral blood flow at brachiocephalic artery stenosis may be the cause of hemodynamic stroke [12]. Maintenance of adequate perfusion pressure and continuous monitoring of cerebral oxygenation by NIRS method allow to detect and correct cerebral hypoperfusion in time [10].

The developed prognostic model with calculation of the AIS risk index after CABG demonstrated high informativity (AUC 0.85) and can be used to identify a group of high-risk patients requiring increased preventive measures. Similar risk stratification systems have been proposed by other authors, such as the NNECDSG scale [3] and the model of Charlesworth et al. [8], but they have limitations in the form of insufficient consideration of the state of brachiocephalic arteries and aorta.

5. Conclusions

The main independent predictors of stroke development are age older than 70 years, brachiocephalic artery stenosis of more than 70%, atherosclerosis of the ascending aorta, atrial fibrillation, diabetes mellitus, prolonged artificial circulation, and intraoperative hypotension.

A personalized approach to risk stratification and prevention of AIS at CABG can be integrated into clinical protocols for perioperative management of cardio surgical patients and contribute to improved outcomes of surgical treatment of coronary heart disease.

Conflict of Interests' Statement

The authors declare no conflict of interest.

This study does not include the involvement of any budgetary, grant or other funds.

The article is published for the first time and is part of a scientific work.

ACKNOWLEDGEMENTS

The authors express their gratitude to the management of the multidisciplinary clinic of Republican Research Center of Emergency Medicine for the material provided for our study.

Ethical Approval and Consent to Participate

The Research Ethics Board of our institution does not require review or approval of case reports. Our research was carried out in accordance with the World Medical Association Code of Ethics (Declaration of Helsinki).

Source of Funding

Each of the authors has reviewed and approved this manuscript. None of the authors has a conflict of interest, financial or otherwise. This manuscript is original, no part of it has been previously published and is not being considered for publication elsewhere. The corresponding author agrees to accept full responsibility for authorship at the submission and review stages of the manuscript.

REFERENCES

[1] Neumann FJ, Sousa-Uva M, Ahlsson A, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur Heart J. 2019; 40(2): 87-165.

[2] Pérez-Vela JL, Ramos-González A, López-Almodóvar LF, et al. Neurologic complications in the immediate postoperative period after cardiac surgery. Role of brain magnetic resonance imaging. Rev Esp Cardiol. 2005; 58(9): 1014-1021.

[3] Tarakji KG, Sabik JF 3rd, Bhudia SK, et al. Temporal onset, risk factors, and outcomes associated with stroke after coronary artery bypass grafting. JAMA. 2011; 305(4): 381-390.

[4] Messe SR, Acker MA, Kasner SE, et al. Stroke after aortic valve surgery: results from a prospective cohort. Circulation. 2014; 129(22): 2253-2261.

[5] Cropsey C, Kennedy J, Han J, et al. Cognitive dysfunction, delirium, and stroke in cardiac surgery patients. Semin Cardiothorac Vasc Anesth. 2015; 19(4): 309-317.

[6] Filsoufi F, Rahmanian PB, Castillo JG, et al. Incidence, topography, predictors and long-term survival after stroke in patients undergoing coronary artery bypass grafting. Ann Thorac Surg. 2008; 85(3): 862-870.

[7] Selnes OA, Gottesman RF, Grega MA, et al. Cognitive and neurologic outcomes after coronary-artery bypass surgery. N

Engl J Med. 2012; 366(3): 250-257.

[8] Sousa-Uva M, Head SJ, Milojevic M, et al. 2017 EACTS Guidelines on perioperative medication in adult cardiac surgery. Eur J Cardiothorac Surg. 2018; 53(1): 5-33.

[9] Bucerius J, Gummert JF, Borger MA, et al. Stroke after cardiac surgery: a risk factor analysis of 16,184 consecutive adult patients. Ann Thorac Surg. 2003; 75(2): 472-478.

[10] Czerny M, Baumer H, Kilo J, et al. Inflammatory response and myocardial injury following coronary artery bypass grafting with or without cardiopulmonary bypass. Eur J Cardiothorac Surg. 2000; 17(6): 737-742.

[11] van der Linden J, Hadjinikolaou L, Bergman P, et al. Postoperative stroke in cardiac surgery is related to the location and extent of atherosclerotic disease in the ascending aorta. J Am Coll Cardiol. 2001; 38(1): 131-135.

[12] Aboyans V, Ricco JB, Bartelink MEL, et al. 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS). Eur Heart J. 2018; 39(9): 763-816.

[13] Chlapoutakis S, Chronopoulos A, Heidenreich PA, et al. Cerebral protection during cardiopulmonary bypass in cardiac surgery. Curr Opin Anaesthesiol. 2021; 34(1): 35-43.

[14] Ono M, Brady K, Easley RB, et al. Duration and magnitude of blood pressure below cerebral autoregulation threshold during cardiopulmonary bypass is associated with major morbidity and operative mortality. J Thorac Cardiovasc Surg. 2014; 147(1): 483-489.

[15] Murkin JM, Adams SJ, Novick RJ, et al. Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. Anesth Analg. 2007; 104(1): 51-58.

[16] Charlesworth DC, Likosky DS, Marrin CA, et al. Development and validation of a prediction model for strokes after coronary artery bypass grafting. Ann Thorac Surg. 2003; 76(2): 436-443.

[17] Merie C, Køber L, Olsen PS, et al. Risk of stroke after coronary artery bypass grafting: effect of age and comorbidities. Stroke. 2012; 43(1): 38-43.