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Predictors of stroke in patients undergoing cardiac surgery

Preditores de acidente vascular cerebral em pacientes submetidos à cirurgia cardíaca

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Abstract

Objective: **To determine the risk factors related to the development of stroke in patients undergoing cardiac surgery.**

Methods: **A historical cohort study. We included 4626 patients aged ≥ 18 years who underwent coronary artery bypass surgery, heart valve replacement surgery alone or heart valve surgery combined with coronary artery bypass grafting between January 1996 and December 2011. The relationship between risk predictors and stroke was assessed by logistic regression model with a significance level of 0.05.**

Results: **The incidence of stroke was 3% in the overall sample. After logistic regression, the following risk predictors for stroke were found: age 50-65 years (OR=2.11 – 95% CI 1.05-4.23 – *P*=0.036) and age ≥66 years (OR=3.22 – 95% CI 1.6-6.47 – *P*=0.001), urgent and emergency surgery (OR=2.03 – 95% CI 1.20-3.45 – *P*=0.008), aortic valve disease (OR=2.32 – 95% CI 1.18-4.56 – *P*=0.014), history of atrial fibrillation (OR=1.88 – 95% CI 1.05-3.34 – *P*=0.032), peripheral artery disease (OR=1.81 – 95% CI 1.13-2.92 – *P*=0.014), history of cerebrovascular disease (OR=3.42 – 95% CI 2.19-5.35 – *P*<0.001) and cardiopulmonary bypass time > 110 minutes (OR=1.71 – 95% CI 1.16-2.53 – *P*=0.007). Mortality was 31.9% in the stroke group and 8.5% in the control group (OR=5.06 – 95% CI 3.5-7.33 – *P*<0.001).**

Conclusion: **The study identified the following risk predictors for stroke after cardiac surgery: age, urgent and emergency surgery, aortic valve disease, history of atrial fibrillation, peripheral artery disease, history of cerebrovascular disease and cardiopulmonary bypass time > 110 minutes.**

Descriptors: **Stroke. Myocardial Revascularization. Heart Valves. Risk Factors. Cardiac Surgical Procedures.**

Resumo

Objetivos: **Determinar os preditores de risco relacionados ao desenvolvimento de acidente vascular cerebral em pacientes que realizaram cirurgia cardíaca.**

Métodos: **Estudo de coorte histórico. Incluímos 4626 pacientes com idade ≥ 18 anos submetidos à cirurgia de revascularização do miocárdio, cirurgia cardíaca valvar isolada ou cirurgia valvar associada com revascularização do miocárdio, de janeiro de 1996 e dezembro de 2011. A relação**

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Abbreviations, acronyms & symbols	
AF	Atrial fibrillation
CABG	Coronary artery bypass graft
CHF	Heart failure functional class
CI	Confidence interval
COPD	Chronic Obstructive Pulmonary Disease
CPB	Cardiopulmonary bypass
CVD	Cerebrovascular disease
DM	Diabetes Mellitus
EF	Ejection fraction
HF	Heart failure
ICU	Intensive Care Unit
NYHA	New York Heart Association
PAD	Peripheral arterial disease
POCS	Postoperative of Cardiac Surgery
SAH	Systemic Arterial Hypertension
SPSS	Statistical Package for the Social Sciences
TIA	Transient ischemic attack

entre os preditores de risco e o acidente vascular cerebral foi avaliada por modelo de regressão logística com nível de significância de 0,05.

Resultados: **A incidência de acidente vascular cerebral foi 3% na amostra total. A análise multivariada identificou como preditores de risco para o acidente vascular cerebral: idade 50-65 anos (OR=2,11 – 95% IC 1,05-4,23 – *P*=0,036) e idade ≥ 66 anos (OR=3,22 – 95% IC 1,6-6,47 – *P*=0,001), cirurgia de urgência/emergência (OR=2,03 – 95% IC 1,20-3,45 – *P*=0,008), valvulopatia aórtica (OR=2,32 – 95% IC 1,18-4,56 – *P*=0,014), fibrilação atrial (OR=1,88 – 95% IC 1,05-3,34 – *P*=0,032), doença arterial obstrutiva periférica (OR=1,81 – 95% IC 1,13-2,92 – *P*=0,014), história de doença cerebrovascular (OR=3,42 – 95% IC 2,19-5,35 – *P*<0,001) e tempo de circulação extracorpórea >110 minutos (OR=1,71 – 95% IC 1,16-2,53 – *P*=0,007). A mortalidade foi 31,9% nos pacientes que sofreram AVC e 8,5% nos sem AVC (OR=5,06 – 95% IC 3,5-7,33 – *P*<0,001).**

Conclusão: **Idade, cirurgia de urgência/emergência, doença de valva aórtica, história de fibrilação atrial, doença arterial obstrutiva periférica, história de doença cerebrovascular e tempo de circulação extracorpórea > 110 minutos foram preditores independentes para o desenvolvimento de AVC intra-hospitalar, em pacientes submetidos à cirurgia cardíaca.**

Descritores: **Acidente Vascular Cerebral. Revascularização Miocárdica. Valvas Cardíacas. Procedimentos Cirúrgicos Cardíacos. Fatores de Risco.**

INTRODUCTION

Data published by the Heart Disease and Stroke Statistical Update 2012 revealed that, in the United States, stroke is a disease of high mortality rate: approximately one of every 18 deaths is related to stroke. Every year, approximately 795,000 people have a stroke, 610,000 of them for the first time. On average, every 40 seconds someone in America has a stroke. Among 45 to 64-year-old people, 8% to 12% of the strokes are ischemic. Every year the number of women affected by stroke outweighs the number of men by 55,000, and of all these strokes, 87 % are ischemic, 10% hemorrhagic, and 3% are subarachnoid hemorrhage[1].

In Brazil, circulatory diseases were responsible for over 326,000 deaths/year (28.7%) in 2010. Ischemic heart disease and cerebrovascular diseases together account for more than 199,000 deaths/year (17.6%) of a population of 1,136 million deaths/year. Stroke is responsible for approximately 100,000 deaths recorded annually, and it is one of the leading causes of deaths in the country[2].

In cardiac surgery, changes in the central nervous system range from 20% to 83% and in stroke, from 1% to 6%[3,4]. The most common stroke in cardiac surgery is ischemic, ranging from 53% to 85%[5] and estimated mortality is between 14% and 40.4%[5-7]. The main causes of this outcome in cardiac surgery are: advanced age, calcified aorta, use of intra-aortic balloon, unstable angina, history of heavy alcohol consumption, arrhythmia of atrial fibrillation (AF) type, previous bypass, and heart failure (HF)[4], history of cerebrovascular disease (CVD), hypertension (SAH) , peripheral arterial disease(PAD)[4,8], diabetes (DM)[8], emergency surgery and cardiopulmonary bypass (CPB) time >120 minutes[7,8].

Neurological complications are cited by different authors, according to the following criteria: type I, defined by neurological deficit of stroke type, transient ischemic attack (TIA), coma, anoxic encephalopathy, and brain death; and type II, in which the impairment of cognitive and intellectual functions is more evident[6,9].

The present study aimed to determine the predictors of risk related to the development of stroke in a non-selected cohort of patients undergoing cardiac surgery. We believe that the identification of predictors for the occurrence of this outcome in our country can help in developing measures to reduce its incidence.

METHODS

We performed a historical cohort observational study from variables obtained from the database of the postoperative Intensive Care Unit (ICU) of Postoperative of Cardiac Surgery (POCS), at Hospital São Lucas. The population is composed of 4626 patients over 18 years of age who underwent coronary

artery bypass graft (CABG), heart valve surgery alone or heart valve surgery combined with CABG between January 1996 and December 2011.

The variables assessed were: age; gender (male/female); heart failure functional class (CHF) according the New York Heart Association (NYHA) stratified into two groups: group 1 (Classes III and IV) and group 2 (Classes I and II); type of valvular disease; history of AF; history of CVD; DM; PAD; SAH; Chronic Obstructive Pulmonary Disease (COPD); surgical type; heart surgery; surgical character: urgency/emergency; renal disease, defined by history of dialytic or non-dialytic renal diseases and/or creatinine ≥ 1.5 mg/dL; left ventricular ejection fraction (EF); obesity: defined by body mass index ≥ 30 kg/m^2; CPB time; surgical reintervention; return to POCS ICU in the same hospital; death; and postoperative hospitalization time.

The outcome assessed was the occurrence of stroke in the postoperative cardiac surgery (CABG, heart valve surgery alone or heart valve surgery combined with CABG) during the entire period of hospitalization. Type I neurological deficit (stroke, TIA) was classified as any new neurologic deficit persisting for more than 24 hours, confirmed by clinical examination by a neurologist and brain imaging (computed tomography or magnetic resonance imaging), as well as stupor or coma at the time of discharge.

The presence of previous cerebrovascular disease was considered by history of stroke, TIA or surgical repair (carotid endarterectomy) in anamnesis, luminal carotid artery stenosis of ≥ 50% on angiography, ultrasound or magnetic resonance angiography, or a combination thereof.

Technical procedures, such as anesthesia, techniques of cardiopulmonary bypass, and cardioplegia, were performed according to the standards of the Cardiovascular Surgery Service of Hospital São Lucas. After surgery, all patients were transferred to the POCS ICU under mechanical ventilation[10].

For statistical analysis of the data, we used mean and standard deviation for Gaussian quantitative variables as well as median and minimum and maximum values in asymmetrical situations. Categorical data were described by counts and percentages. Comparisons between means were performed using Student's *t* test or its nonparametric substitute. Categorical variables were compared using the chi-square test or Fisher exact test. For multivariable situations we used the logistic regression model that allows the assessment of the effect of both quantitative and categorical variables on a binary event. The variables considered statistically significant were those with $P<0.05$ and confidence interval (CI) of 95%. Data were processed and assessed using SPSS (Statistical Package for the Social Sciences) version 18.0.

This study did not use calculation of sample size. Failure to use the calculation of sample size for this study is justified because it used any number of patients entered into the database, except those meeting the exclusion criterion.

This study was submitted to the Research Ethics Committee of PUCRS and received their assessment and approval under protocol number CEP 11/05631.

RESULTS

We selected a total of 4626 patients divided into three surgical types: CABG, heart valve surgery alone or heart valve surgery combined with CABG. The overall incidence of stroke was 3.0%, varying among the three surgical types, with higher incidence in combined procedures (5.4%). In the overall sample, mean age was 58.9±12.6 years, and men comprised 63.4% of the patients. The occurrence of stroke was 2.8% in men and 3.5% in women, with different incidence of death between genders when comparing stroke and non-stroke groups for percentage of deaths, incidence being 24.4% and 7.8%, respectively, in men, and 42.4% and 9.7%, respectively, in women. The mean hospital stay was 10.84±9.7 days (Table 1).

In patients undergoing CABG, there was observed higher incidence of patients aged between 50 and 65 years, male, PAD, history of CVD, DM, hypertension, obese, smokers, COPD (similar to combined procedures) and patients with EF < 40%. However, these patients had lower percentages of aortic and mitral valve disease, and history of AF as well as improved CHF functional class, even with lower EF. Among the three surgical types, CABG had the lowest rates of surgical intervention, return to POCS ICU, hospitalization and death (Table 1).

In patients undergoing cardiac valve surgery alone, we found a higher percentage of young patients, aged 18 to 49 years, with the lowest average age and a higher percentage of women (43.4%). This subgroup had the highest incidence of patients with history of AF, patients undergoing heart surgery and CHF functional class III/IV (similar to combined procedures); however, it was the subgroup with the best EF. We emphasize that in isolated cardiac valve surgery patients there was lower rates of urgent/emergency surgical procedures, PAD, history of CVD, DM, smoking, COPD and postoperative stroke (Table 1).

In combined surgical procedures, we found a higher percentage of older patients with higher average age. This subgroup contained patients with higher rates of urgent/emergency surgical procedures, aortic and mitral valve disease, COPD, history of renal disease, and CHF functional class III/IV (similar to isolated valve surgery); however, this subgroup had the lowest EF. CPB time >110 minutes was present in most patients, and the average was higher than in the other groups. Combined procedure had a higher incidence of stroke, reintervention, return to POCS ICU, hospitalization and death (Table 1).

Regarding preoperative and intraoperative variables, those that showed statistical significance ($P<0.05$) in the univariate analysis are: combined procedures (OR=1.85 – 95% IC 1.04-3.29 – $P=0.035$); age 50-65 years (OR=2.69 – 95% IC 1.37-5.28 – $P=0.004$) and ≥66 years (OR=4.72 – 95% IC 2.42-9.18 – $P<0.001$); urgent/emergency surgery (OR=2.47 – 95% IC 1.52-4.03 – $P<0.001$); aortic valve disease (OR=1.92 – 95% IC

1.09-3.39 – *P*=0.034); CHF functional class III/IV (OR=1.67 – 95% IC 1.17-2.4 – *P*=0.006); history of AF (OR=1.84 – 95% IC 1.11-3.05 – *P*=0.026); PAD (OR=2.82 – 95% IC 1.82-4.34 – *P*<0,001); history of CVD (OR=4.45 – 95% IC 2.91-6.78 – *P*<0.001); DM (OR=1.64 – 95% IC 1.15-2.34 – *P*=0.008); COPD (OR=1.62 – 95% IC 1.08-2.42 – *P*=0.025); history of renal disease (OR=1.7 – 95% IC 1.08-2.66 – *P*=0.028); CPB time > 110 minutes (OR=2.03 – 95% IC 1.42-2.92 – *P*<0.001); reoperation (OR=2.62 – 95% IC 1.61-4.27 – *P*<0.001); returning to POCS ICU (OR=3.12 – 95% IC 1.89-5.16 – *P*<0.001); death (OR=5.06 – 95% IC 3.5-7.33 – *P*<0.001); and length of hospital stay (*P*<0.001) (Table 2).

After logistic regression, the present study identified eight variables associated with the development of stroke in the postoperative of cardiac surgery: age 50-65 years (OR=2.11 – 95% IC 1.05-4.23 – *P*=0.036) and ≥66 years (OR=3.22 – 95% IC 1.6-6.47 – *P*=0.001); urgent/emergency surgery (OR=2.03 – 95% IC 1.20-3.45 – *P*=0.008); aortic valve disease (OR=2.32 – 95% IC 1.18-4.56 – *P*=0.014); history of AF (OR=1.88 – 95% IC 1.05-3.34 – *P*=0.032); PAD (OR=1.81 – 95% IC 1.13-2.92 – *P*=0.014); history of CVD (OR=3.42 – 95% IC 2.19-5.35 – *P*<0.001); and CPB time >110 minutes (OR=1.71 – 95% IC 1.16-2.53 – *P*=0.007) (Table 3).

Table 1. General Patient's Characteristics.

Variables	CABG(%) n= 3318 (71.7)	Valve(%) n= 1051 (22.7)	CABG+Valve(%) n=257 (5.6)	Total(%) n=4626 (100)
Age				
- 18-49 years	551 (16.6)	395 (36.7)	17 (6.6)	963 (20.8)
- 50-65 years	1644 (49.5)	383 (36.4)	88 (34.2)	2115 (45.7)
- ≥66 years	1123 (33.8)	273 (26)	152 (59.1)	1548 (33.5)
Age (mean±SD)	60±11.2	53,7±15.3	66,84±10.4	58,93±12.6
Male	2185 (65.9)	594 (56.6)	151 (58.8)	2930 (63.4)
Urgent/Emergency surgery	228 (6.9)	53 (5.0)	20 (7.8)	301 (6.5)
Aortic valve disease	12 (0.4)	180 (17.1)	65 (25.3)	257 (5.6)
Mitral valve disease	37 (1.1)	88 (8.4)	24 (9.3)	149 (3.2)
III/IV CHF	446 (13.8)	471 (45.2)	114 (45.2)	1031 (22.8)
History of Atrial Fibrillation	94 (2.8)	221 (21)	34 (13.2)	349 (7.5)
PAD	348 (10.5)	10 (1.0)	17 (6.6)	375 (8.1)
History of CVD	223 (6.7)	49 (4.7)	15 (5.8)	287 (6.2)
Prior Cardiac Surgery	108 (3.3)	156 (14.8)	12 (4.7)	276 (6.0)
DM	988 (29.8)	58 (5.5)	49 (19.1)	1095 (23.7)
COPD	572 (17.2)	103 (9.8)	46 (17.9)	721 (15.6)
SAH	2395 (72.2)	392 (37.3)	158 (61.5)	2945 (63.7)
Obesity	407 (12.3)	52 (4.9)	20 (7.8)	479 (10.4)
Smoking	1095 (33)	234 (22.3)	68 (26.5)	1397 (30.2)
Ejection fraction <40%	655 (19.7)	83 (7.9)	44 (17.1)	782 (16.9)
Ejection fraction (mean±SD)	54±15	61±13	56±15	56±15
Prior Renal Disease	366 (11)	102 (9.7)	40 (15.6)	508 (11)
Creatinine (mean±SD)	1.17±0.83	1.11±0.73	1.22±0.71	1.16±0.80
CPB time >110 minutes	569 (17.4)	164 (15.7)	141 (55.5)	874 (19.1)
CPB time (mean±SD)	83±35	83±34	119±43	85±37
Postoperative stroke	100 (3.0)	27 (2.6)	14 (5.4)	141 (3.0)
Reintervention	175 (5.3)	75 (7.1)	36 (14)	286 (6.2)
Return to POCS	150 (4.5)	61 (5.8)	21 (8.2)	232 (5.0)
Death during hospitalization	271 (8.2)	92 (8.8)	62 (24.1)	425 (9.2)
Length of Stay (mean±SD)	10.6±9.8	11.3±8.7	12.5±12.2	10.8±9.7

N=population; CABG - cardiopulmonary bypass surgery; CVD - cerebrovascular disease; Stroke; SAH – systemic arterial hypertension; PAD - Peripheral Arterial Disease; DM - Diabetes Mellitus; CHF – Cardiac Heart Failure (as determined by the NYHA); COPD - Chronic Obstructive Pulmonary Disease; CPB – Cardiopulmonary Bypass; Prior Renal Disease – history of renal disease requiring dialysis or not and/or creatinine > 1.5 mg/dl

Table 2. Variables associated with risk of stroke.

Variables	Stroke (n=141) %	No stroke (n=4485) %	OR	IC 95%	*P*
Surgical Type					
- CABG	70.9	71.8	1	-	-
- Valve Replacement	19.1	22.8	0.85	0.55 - 1.31	0.455
- CABG + Valve Replacement	9.9	5.4	1.85	1.04 - 3.29	0.035
Age					
- 18-49 years	7.1	21.2	1	-	-
- 50-65 years	41.1	45.9	2.69	1.37 - 5.28	0.004
- ≥66 years	51.8	32.9	4.72	2.42 - 9.18	<0.001
Age (mean±SD)	64.1±10.5	58.8±12.8	-	-	<0.001
Male	58.2	63.5	0.8	0.57 - 1.12	0.224
Urgent/Emergency surgery	14.2	6.3	2.47	1.52 - 4.03	<0.001
Aortic valve disease	9.9	5.4	1.92	1.09 - 3.39	0.034
Mitral valve disease	4.3	3.2	1.35	0.59 - 3.11	0.462
III/IV CHF	32.6	22.4	1.67	1.17 - 2.40	0.006
History of Atrial Fibrillation	12.8	7.4	1.84	1.11 - 3.05	0.026
PAD	19.1	7.8	2.82	1.82 - 4.34	<0.001
History of CVD	21.3	5.7	4.45	2.91 - 6.78	<0.001
Prior Cardiac Surgery	6.4	6	1.08	0.54 - 2.14	0.975
DM	33.3	23.4	1.64	1.15 - 2.34	0.008
COPD	22.7	15.4	1.62	1.08 - 2.42	0.025
SAH	70.9	63.4	1.41	0.97 - 2.03	0.083
Obesity	12.1	10.3	1.19	0.71 - 2.0	0.594
Smoking	28.4	30.3	0.91	0.63 - 1.32	0.698
Ejection fraction <40%	18.4	16.9	1.12	0.72 - 1.72	0.704
Ejection fraction (mean±SD)	53±14.5	56.8±14.1	-	-	0.039
Prior Renal Disease	17	11.8	1.7	1.08 - 2.66	0.028
Creatinine (mean±SD)	1.17±0.39	1.16±0.83	-	-	0.817
CPB time >110 minutes	31.9	19.7	2.03	1.42 - 2.92	<0.001
CPB time (mean±SD)	97±34	84±38	-	-	<0.001
Reintervention	14.2	5.9	2.62	1.61 - 4.27	<0.001
Return to POCS	13.5	4.7	3.12	1.89 - 5.16	<0.001
Death during hospitalization	31.9	8.5	5.06	3.5 - 7.33	<0.001
Length of Stay (mean±SD)	20.4±15.3	10.5±9.36	-	-	<0.001

N=population, OR = odds ratio, 95% CI=confidence interval, P = statistical significance 95%. CABG – coronary artery bypass grafting, CVD – cerebrovascular disease, SAH – systemic arterial hypertension, PAD - Peripheral Arterial Disease; DM - Diabetes Mellitus; CHF - Cardiac Heart Failure (as determined by the NYHA), COPD - Chronic Obstructive Pulmonary Disease; CPB – Cardiopulmonary Bypass; Prior Renal Disease – history of renal disease requiring dialysis or not and/or creatinine > 1.5 mg/dl

DISCUSSION

In our study, age was an independent predictor for stroke in the postoperative period, in which the group of patients aged between 50 and 65 years had an OR of 2.11 (95% IC 1.05-4.23 – *P*=0.036) and the group aged ≥66 years had an OR of 3.22 (95% IC 1.6-6.47 – *P*=0.001). Furthermore, the average age in the group of patients affected by stroke was significantly higher (64±10.5 vs. 58.8±12.8 – *P*<0.001). This shows, as in other studies, that age is an important non-modifiable risk factor for cerebrovascular disease, confirming that the occurrence of postoperative stroke increases significantly among older patients[5,6].

In urgent/emergency surgeries, this study showed an OR of 2.03 (95% IC 1.2-3.42 – *P*=0.008) for the occurrence of stroke, with a percentage of 6.6% *vs.* 3% in the whole sample. Patients who developed stroke underwent additional urgent/emergency procedures in the ratio of 14.2% to 6.3%. It is believed that the combination of urgent/emergency surgery and stroke is linked to the severity of clinical criteria, which serves as indication for the procedure and the risks of cardioembolic events associated with them: evolving acute myocardial infarction with persistent angina or hemodynamic instability after unsuccessful percutaneous coronary intervention, mechanical complications of infarction such as free wall rupture, ventricular septal defect and rupture or dysfunction

Table 3. Analysis of Logistic Regression.

Variables	OR	CI 95%	*P*
Surgical Type			
- CABG	1	-	-
- Valve Replacement	0.78	0.44 - 1.39	0.403
- CABG + Valve Replacement	0.89	0.44 - 1.79	0.746
Age			
- 18-49 years	1	-	-
- 50-65 years	2.11	1.05 - 4.23	0.036
- ≥66 years	3.22	1.60 - 6.47	0.001
Male	0.77	0.53 - 1.10	0.154
Urgent/Emergency surgery	2.03	1.20 - 3.45	0.008
Aortic valve disease	2.32	1.18 - 4.56	0.014
Mitral valve disease	1.27	0.52 - 3.09	0.596
III/IV CHF	1.35	0.89 - 2.05	0.156
History of Atrial Fibrillation	1.88	1.05 - 3.34	0.032
PAD	1.81	1.13 - 2.92	0.014
History of CVD	3.42	2.19 - 5.35	<0.001
Prior Cardiac Surgery	1.07	0.51 - 2.25	0.849
DM	1.29	0.87 - 1.91	0.204
COPD	1.4	0.89 - 2.21	0.15
SAH	1.13	0.75 - 1.70	0.56
Obesity	1.12	0.65 - 1.91	0.69
Smoking	1.03	0.67 - 1.59	0.885
Ejection fraction <40%	0.74	0.47 - 1.19	0.216
Prior Renal Disease	1.11	0.68 - 1.81	0.67
CPB time >110 minutes	1.71	1.16 - 2.53	0.007

N=population, OR = odds ratio, 95% CI=confidence interval, P = statistical significance 95%. CABG – coronary artery bypass grafting, CVD – cerebrovascular disease, SAH – systemic arterial hypertension, PAD - Peripheral Arterial Disease; DM - Diabetes Mellitus; CHF - Cardiac Heart Failure (as determined by the NYHA), COPD - Chronic Obstructive Pulmonary Disease; CPB – Cardiopulmonary Bypass; Prior Renal Disease – history of renal disease requiring dialysis or not and/or creatinine > 1.5 mg/dl

of papillary muscle, which can lead to mitral valve prolapse and further contribute to severe hemodynamic repercussion or cardiogenic shock[11]. To Burcerius et al.[8], emergency surgery is secondary to unstable heart condition, being an independent predictor for stroke with an OR of 1.47 (95% IC 1.23 – 1.76), where unstable angina in patients with coronary artery disease and endocarditis were the main factors that indicated the need for urgent surgery. In patients undergoing urgent/emergency surgical procedures the death rate in the literature ranges from 54% to 63.8%[12,13]. In this study, death rate was 51.8% and we highlight that rate of death from stroke increased to 70%.

In the present study, aortic valve disease showed an OR of 2.32 (95% IC 1.18-4.56 - *P*=0.014) for the occurrence of the stroke. GARY Registration (German Aortic Valve Registry), which in 2011 assessed 13,860 patients who underwent isolated aortic valve replacement, aortic valve replacement combined with CABG or transcatheter aortic valve implantation, demonstrated that the occurence of cerebrovascular events was 2%, 4% and 3.5% to 3.7% respectively[14]. This was confirmed in our study, where isolated valve procedures had a smaller percentage of outcomes (2.6%) compared to combined procedures (5.4%).

History of AF is a high risk factor for ischemic stroke by thromboembolism of central nervous system and inflammatory processes related to cardiac surgery can cause episodes of AF[15]. AF with unsatisfactory control of anticoagulation, intraoperative surgical manipulation or spontaneous recovery of sinus rhythm postoperatively can cause embolism due to the formation of clots in the left atrium[16]. In this study, history of AF was an independent predictor of risk with an OR of 1.88 (95% IC 1.05-3.34 – *P*=0.032). According to a European study, about one in every five cases of stroke are related to atrial fibrillation, and paroxysmal AF carries the same risk of stroke as permanent or persistent AF[17].

PAD was correlated with stroke in our series, with an OR of 1.81 (95% IC 1.13-2.92 – *P*=0.014). PAD is interpreted as a marker of generalized atherosclerosis and a predictor of myocardial infarction and stroke[18]. There is a high association between PAD, coronary artery disease and carotid artery disease, which predisposes these patients to an increased risk

of myocardial infarction, ischemic stroke and vascular death, with the relative risk of mortality increased by three times for all causes, and by six times for vascular death, as seen by Durazzo et al.[18]. According to Rosa & Portal[19], carotid disease increases by four times the risk of perioperative stroke. PAD is more prevalent after the fourth decade of life, with the risk increasing two to three times every 10 years, and is associated with the following cardiovascular risk factors: smoking, DM, hypertension, and dyslipidemia[18,20].

In the present study, history of CVD may be an important risk factor for the development of postoperative stroke with an OR of 3.42 (95% IC 2.19-5.35 – P<0.001) in logistic regression. Different authors[8,21] mention that history of CVD is an independent predictor of perioperative stroke and postoperative cardiac surgery, confirming the results found in our study. According to Bucerius et al.[8], history of CVD can demonstrate the existence of pathological condition of the cerebrovascular system or condition of stenosis of the carotid arteries.

CPB time in our study was statistically significant with an increase in patients who developed postoperative stroke (84±37 vs. 97±34 minutes, P<0.001). CPB time >110 minutes was present in 31.9% of patients with stroke and in 19.7% of those without stroke, presenting an OR of 1.71 (95% IC 1.16-2.53 – P=0.007), similar to other studies[22], which associated stroke to a CPB time greater than 120 minutes, with an OR of 1.42 (95% IC 1.17-1.72)[8].

The association between CPB and postoperative changes in the central nervous system is potentially related to the presence of severe atheromatous disease of the ascending aorta and carotid arteries, inadequate anticoagulation during CPB, age, changes in body temperature during surgery, hyperglycemia, intraoperative acid-base correction methods, micro and macroembolization during CPB, intracardiac procedures and advanced cerebral vascular disease[23]. In this study, patients undergoing CABG combined with valve replacement showed higher mean CPB time (119±43 minutes) when compared to the average time of patients who underwent CABG (83±35 minutes) and those who underwent isolated valve replacement (83±34 minutes) and consequently increased incidence of stroke: 5.4% *vs*. 3% *vs*. 2.6%, respectively. Hedberg et al.[22] demonstrated higher rates of stroke in combined procedures, divided into early and late, such as 5.7% *vs*. 2.5 % in CABG, along with increased CPB time of 143 minutes *vs*.75 minutes. Furthermore, elderly patients with comorbidities such as hypertension and diabetes, may be at increased risk due to changes in auto regulation of cerebral blood flow[24].

According to Vicchio et al.[25], mortality rate differs between isolated aortic valve replacement (7.8%) and aortic valve replacement associated with CABG (15.2%) (P=0.019), as confirmed in this study where the mortality rate for CABG was 8.2%, 8.8% for isolated valve replacement and 24.1% for combined procedures. It was also found that the risk of death among patients increases five times in the presence of the stroke (OR=5.06 - 95% IC 3.5-7.33 – P<0.001), with the percentage of deaths being 31.9% *vs*. 8.5%. This fact was evidenced by other authors, whose studies also showed that the group of patients who developed stroke had higher mortality rates than those of the control groups, 18.6% *vs*. 2.6%[21], from 8.1% to 14.1% *vs*. 0.8%[22], and 40.4% *vs*. 2.2%[7].

We believe that the identification of predictors may make it possible to stratify patients at potential risk for the development of stroke. In addition, it may offer guiding criteria for care and special handling of these patients, minimizing the impact of the disease and supporting the design of a risk score for the development of stroke in patients undergoing cardiac surgery.

We can consider the use of a cardiac surgery postoperative unit database as a limiting factor of this study, which was not initially modeled to assess systematically and prospectively this outcome. However, we believe that this factor did not affect the validity of the results.

CONCLUSION

Stroke is still a prevalent complication after cardiac surgery in adults and occurred in 3% of the population.

The logistic regression model identified the following risk factors for the development of stroke type I, during cardiac surgery postoperative: age over 50 years, urgent and emergency surgery, aortic valve disease, history of AF, PAD, prior stroke, and cardiopulmonary bypass with time greater than 110 minutes.

Authors' roles & responsibilities	
HNS	Main author
EHM	Data analysis and writing
JCVCG	Data collection and data arrangement
NNS	Reference search
LCA	Writing and review
MAG	Data collection
JBP	Data survey
LCB	Adviser in master's degree dissertation which resulted in this article

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