ORIGINAL ARTICLE

Risk factors of neurological complications in cardiac surgery

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Abstract

Background: Postoperative complications are integral to cardiac surgery. The most serious ones are stroke, which develops in about 7.5% of the patients, and postoperative encephalopathy, which affects 10–30% of the patients. According to bibliographical data, the number of complications is increasing.

Aim: To analyse the risk factors and the types of neurological complications in patients undergoing heart surgery.

Methods: We assessed retrospectively 323 consecutive patients undergoing surgery at the Department of Cardiac Surgery, University Teaching Hospital, Medical University of Bialystok, Poland, between July 2007 and June 2008. Group 1 comprised patients without neurological complications (n = 287; 89%) and Group 2 consisted of patients with neurological complications (n = 36; 11%). Our analysis included the following: preoperative status (age, sex, co-morbidities), intraoperative course (surgery type, duration of cardiopulmonary bypass [CPB], duration of aortic cross-clamping, types of medications administered, necessity of reinfusion from the cardiotomy reservoir and the necessity of tranexamic acid infusion) and the postoperative course (time to regaining consciousness, duration of mechanical ventilation, development of complications, types of complications). The results were then analysed statistically: arithmetic means and standard deviations were calculated for quantitative variables and the quantitative and percenage distributions were calculated for qualitative variables. The between-group comparisons of the quantitative variables were carried out using the t-Student test, while the qualitative variables were compared using the χ^2 test. The variables that proved significant in the univariate comparisons were included in the multivariate model. Regression analysis was the final step of the analysis of the risk factors for neurological complications. Based on the analysis of the ROC curve we calculated the cutoff values for the continuous variables. We calculated odds ratios with their 95% confidence intervals. P values of less than 0.05 were considered statistically significant.

Results: Among the 36 patients in Group 2, postoperative encephalopathy developed in 22 patients, transient ischaemic attacks in 7 patients, ischaemic stroke in 6 patients (associated with right hemisphere damage in 3 patients and with left hemisphere damage in 3 patients) and haemorrhagic stroke in 1 patient (right hemisphere). Early mortality was 5% with 2 (0.69%) patients dying in Group 1 and 14 (38.9%) in Group 2. Univariate analysis revealed that the preoperative risk factors of neurological complications were: age > 68 years (with a cutoff value of 58.5 years), a history of stroke with paresis, atrial fibrillation (AF) and a euroSCORE of > 6 (with a cutoff value of 4.5). The peri- and postoperative risk factors included: surgery type (complex coronary and valvular surgeries aortic valve surgeries), duration of CPB of > 142 min, duration of aortic cross-clamping of > 88 min, mean perfusion pressure during CPB of < 70 mm Hg, haemodilution manifested by a haematocrit (HCT) of < 28%, perfusate supply, time to regaining consciousness of > 14.5 h and duration of artificial ventilation of > 30.5 h. Multivariate analysis revealed the following factors to increase the risk of neurological complications: long duration of ventilation, a history of stroke with paresis, AF, low HCT values and long duration of aortic cross-clamping. The Nagelkerke R^2 coefficient of determination was 0.636, the sensitivity was 74.36%, the specificity was 97.545% and the accuracy was 94.74%.

Conclusions: In patients undergoing heart surgery, the independent risk factors of neurological complications in the first 30 days include: long duration of ventilation, a history of stroke with paresis, AF, haemodilution manifested by an HCT of < 28% and long duration of aortic cross-clamping. Neurological complications are associated with high postoperative mortality.

Key words: neurological complications, risk factors, cardiopulmonary bypass

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INTRODUCTION

Despite the progress in surgical technique postoperative complications continue to be an inherent part of cardiac surgery with neurological complications being among the most serious. The most dangerous neurological complications include postoperative stroke, ischaemic in most cases, which affects about 7.5% of the patients undergoing heart surgery, and postoperative encephalopathy, which is observed in 10–30% of the patients [1–5]. Patients in the postoperative period may also develop transient ischaemic attacks (TIAs), whose manifestations may include numbness of one half of the face or body, transient hemipareses, sensory or motor aphasia. The number of patients at risk of these complications is rising [3, 6–8]. Macro- and microembolism is the underlying cause of neurological damage. In the case of on-pump cardiac surgeries the sources of microemboli may be the oxygenators, cardiopulmonary bypass (CPB) drains, suction units returning blood from the operating field to the circulation and containing air microbubbles formed as a result of cavitation, fat or cellular aggregates [2, 3, 9, 10]. The contact of blood with the artificial surface of the oxygenator leads to the activation of a number of neurotransmitters, which trigger systemic inflammatory response syndrome and lead to interstitial microdamage and dysfunction of the body's vital organs [4]. The sings and symptoms of brain damage, if any, develop within the first 24 h post-op. They include aphasia, hemiparesis, convulsions, impaired consciousness. The development of coma is associated with high mortality. The American College of Cardiology and the American Heart Association have proposed the following division of neurological complications of cardiac surgery:

— death because of stroke or hypoxic encephalopathy, non-fatal stroke, TIA, stupor or coma at discharge;
— impairment of intellectual functions, confusion, agitation, memory disorders without manifestations of focal central nervous system (CNS) injury [11].

The aim of our study was to analyse the risk factors and the types of neurological complications in patients undergoing cardiac surgery.

METHODS

We performed a retrospective review of medical records of 323 consecutive patients undergoing surgery at the Department of Cardiac Surgery, University Teaching Hospital, Medical University of Bialystok, Poland, between July 2007 and June 2008. Group 1 comprised patients without neurological complications (n = 287; 89%) and Group 2 consisted of patients with neurological complications (n = 36; 11%). Early postoperative neurological manifestations were considered complications if they developed within the first 30 days post-op. Based on the available bibliography we selected and analysed a total of 14 variables describing preoperative status: sex, age, co-morbidities (hypertension, hyperlipidaemia, obesity defined by body mass index, type 1 and 2 diabetes mellitus, persistent atrial fibrillation [AF], chronic renal failure, peripheral artery disease of the lower extremities, varicose veins, thyroid diseases, a history of percutaneous transluminal coronary angioplasty, a history of on-pump cardiac surgery, a history of stroke with or without paresis), intraoperative course: surgery type, duration of cardiopulmonary bypass (CPB), duration of aortic cross-clamping, types of medications administered; and postoperative course: time to regaining consciousness, duration of mechanical ventilation, transfusion of blood products, administration of the perfusate, development of complications and types of complications. The variables were selected on the basis of perioperative mortality risk scales, mainly on the basis of the euroSCORE. Carotid artery Doppler ultrasound was performed routinely in patients over the age of 70 years and in patients with a history of stroke or TIA. None of the patients had significant (> 70%) occlusions in the carotid or vertebral arteries before the surgery and none of the patients had a history of TIA. None of the patients was found to have impaired consciousness during the physical examination on admission or during evaluation by the anaesthetist during premedication for surgery. Neurological assessment at the postoperative ward was performed daily by the anaesthetist in charge of the ward and documented in the patient notes. If the patient had neurological manifestations, he was consulted and managed by a neurologist from the same hospital. Early mortality was defined as a complication that developed within 30 days post-op. Stroke, confirmed by computed tomography (CT), was defined as a sudden focal or generalised brain dysfunction from vascular causes and persisting for more than 24 h or leading to death. Postoperative encephalopathy was defined as an impairment of consciousness caused by hypoxia and ischaemia and manifested by confusion, agitation, delirium. The surgeries performed were surgeries with the use CPB [conventional coronary artery bypass grafting (CCABG)] valvular and combined surgeries, and surgeries without the use of CPB [off-pump coronary artery bypass (OPCAB)]. We assessed the differences between Group 1 and Group 2 in terms of the above parameters.

Statistical analysis

The results were then analysed statistically: arithmetic means and standard deviations were calculated for quantitative variables and the quantitative and percenage distributions were calculated for qualitative variables. The between-group comparisons of the quantitative variables were carried out using the t-Student test, while the qualitative variables were compared using the χ^2 test for independence. The variables that proved significant in the univariate comparisons were included in the multivariate model. Regression analysis was the final step of the analysis of the risk factors for neurological complications. Based on the analysis of the ROC curve we

Table 1. The clinical characteristics of patients without neurological complications (Group 1) and patients with neurological complications (Group 2). The table provides percentages in a given group and odds ratio (OR) values along with 95% confidence intervals (95% CI) for the occurrence of neurological complications depending on the analysed parameters in Group 2 (n = 36)

	Group 1 (n = 287)	Group 2 (n = 36)	P	OR (95% CI)
Age [years]	64.15 ± 10.33	68.22 ± 8.45	< 0.024	3.255 (1.116–9.492)
Age > 65 years, n (%)	171 (59.6)	22 (61)	NS	–
Women, n (%)	90 (31.4)	12 (33.3)	NS	–
Men, n (%)	197 (68.6)	24 (66.7)	NS	3.385 (1.658–6.909)
EF < 40%, n (%)	60 (20.9)	17 (47.2)	< 0.001	0.295 (0.145–0.603)
EF > 40%, n (%)	227 (79.1)	19 (52.8)	< 0.001	4.667 (2.056–10.593)
euroSCORE, mean score (± SD)	4.31 (2.49)	6.25 (2.87)	< 0.001	0.920 (0.424–1.997)
Hypertension, n (%)	212 (73.9)	26 (72.2)	NS	–
Type 1 diabetes mellitus, n (%)	2 (0.7)	–	NS	0.858 (0.359–2.051)
Type 2 diabetes mellitus, n (%)	63 (22)	7 (19.4)	NS	0.555 (0.234–1.315)
Hyperlipidaemia, n (%)	87 (30.3)	7 (19.4)	NS	2.423 (0.967–6.071)
AF, n (%)	26 (9.1)	7 (19.4)	0.057	–
Obesity, n (%)	15 (5.2)	–	NS	1.629 (0.343–7.749)
Stroke without paresis, n (%)	10 (3.5)	2 (5.6)	NS	6.432 (1.379–29.994)
Stroke with paresis, n (%)	4 (1.4)	3 (8.3)	< 0.033	0.883 (0.109–7.176)
PAD of the lower limbs, n (%)	9 (3.1)	1 (2.8)	NS	1.250 (0.323–7.020)
Varicose veins, n (%)	16 (5.6)	4 (11.1)	NS	–
A history of PTCA, n (%)	17 (5.9)	–	NS	1.282 (0.360–4.567)
IHD, n (%)	19 (6.6)	3 (8.3)	NS	8.382 (1.144–61.442)
Previous on-pump surgery, n (%)	2 (0.7)	2 (5.6)	0.063	

AF — atrial fibrillation; EF — ejection fraction; IHD — ischaemic heart disease; NS — non-significant; PAD — peripheral artery disease; PTCA — percutaneous transluminal coronary angioplasty; SD — standard deviation

calculated the cutoff values for the continuous variables. We calculated odds ratios (OR) with their 95% confidence intervals (CI). P values of less than 0.05 were considered statistically significant. The analyses were performed using SPSS version 12.

RESULTS

Of the 323 patients included in the study, neurological complications developed in 36 of them. Seven (19.5%) patients developed postoperative stroke. Stroke developed within the first 24 h post-op in 3 of them and within the first 72 h post-op in the remaining 4. Six patients were diagnosed with ischaemic stroke (which was associated with right hemisphere damage in 3 patients and with left hemisphere damage in the other 3 patients) and 1 patient was diagnosed with haemorrhagic stroke (right hemisphere). A further 7 (19.5%) patients developed TIA manifested by left-sided pyramidal syndrome (n = 1), left-sided hemiparesis (n = 3), right-sided hemiparesis (n = 1), hemiplegia (n = 1) and aphasia with myoclonic tremor (n = 1). All these patients quickly improved and their signs and symptoms completely resolved within 24 h. Postoperative delirium was observed in 22 (61%) patients and was manifested by: agitation, confusion, hallucinations (mainly visual) and wakefulness disorders. The signs of delirium resolved spontaneously within the next few days of hospitalisation at the postoperative ward. The study group characteristics are provided in Table 1.

The patients in Group 2 were characterised by significantly older age than those in Group 2 (by 4 years), although the percentage of elderly patients was higher in Group 1, a significantly higher risk of death according to the euroSCORE (> 6), a higher incidence of impaired left ventricular contractility (ejection fraction < 40%) and a higher incidence of the history of ischaemic stroke with paresis. Differences bordering on statistical significance were revealed in cases of: coexistence of AF and a history of on-pump heart surgery.

A total of 233 (72%) patients underwent on-pump surgery, while the remaining 90 (28%) patients underwent OPCAB. CCABG was performed in 112 patients. Neurological complications were more common in patients undergoing CCABG than OPCAB (7 *vs* 3 patients; 6.25% *vs* 3.30%). The incidence of neurological complications was the highest in patients undergoing complex coronary and valvular surgeries and undergoing aortic valve surgeries, although in the latter case the difference was only bordering on statistical significance. We found that CPB was an independent risk factor

Table 2. Cardiac surgery types in both study groups and odds ratio (OR) values along with 95% confidence intervals (95% CI) for the occurrence of neurological complications depending on the analysed parameters in Group 2 (n = 36)

	n	Group 1, n (%)	Group 2, n (%)	P	OR (95% CI)
CABG + LVR	12	12 (100)	–	NS	–
LVR + MVR/MVP	3	3 (100)	–	NS	–
CABG + AVR/AVP	13	10 (77)	3 (23)	NS	2.518 (0.660–9.615)
CABG + AVR + MVR/MVP	6	2 (34.4)	4 (66.6)	< 0.002	17.813 (3.138–101.106)
CABG + AVR + MVR + TVR/TVP	1	1(100)	–	NS	–
AVR	20	15 (75)	5 (25)	< 0.058	2.925 (0.995–8.597)
MVR/MVP+ AVR	6	5 (83.3)	1 (17.7)	NS	1.611 (0.183–14.192)
MVR	12	10 (83.3)	2 (17.7)	NS	1.629 (0.343–7.749)
MVR + TVR/TVP	7	5 (71.4)	2 (22.6)	NS	3.318 (0.620–17.765)
CABG + MVR/MVP	11	9 (81.8)	2 (18.2)	NS	1.817 (0.377–8.760)
CABG + MVR/MVP + TVR/TVP	8	6 (75)	2 (25)	NS	2.755 (0.535–14.193)
CABG + TVR/TVP	1	1	–	NS	–
AAA	19	15 (80)	4 (20)	NS	2.267 (0.709–7.246)
VSD	2	–	1 (50)	NS	8.171 (0.500–133.565)

AAA — ascending aortic aneurysm repair; AVP — aortic valvuloplasty; AVR — aortic valve replacement; CABG — coronary artery bypass grafting; MVP — mitral valvuloplasty; MVR — mitral valve replacement; TVP — tricuspid valvuloplasty; TVR — tricuspid valve replacement; VSD — ventricular septal defect closure

Table 3. Cardiopulmonary bypass (CPB) parameters, perfusate supply and tranexamic acid administration in both study groups and odds ratio (OR) values along with 95% confidence intervals (95% CI) for the occurrence of neurological complications depending on the analysed parameters in Group 2 (n = 36)

	Group 1 (n = 287)	Group 2 (n = 36)	P	OR (95% CI)
Duration of CPB [min]	95.98 ± 77.417	161.61 ± 77.886	< 0.001	6.283 (2.902–13.603)
Duration of aortic cross-clamping [min]	56.9 ± 51.103	96.81 ± 56.793	< 0.001	5.653 (2.694–11.864)
Haematocrit [%]	29.52 ± 5.192	26.31 ± 3.56	< 0.001	4.788 (2.220–10.326)
Perfusion pressure < 70 mm Hg	78 (27.2%)	18 (50%)	< 0.005	2.679 (1.326–5.413)
Perfusate	82 (28.6%)	16 (44.4%)	0.042	2.00 (0.988–4.050)
Tranexamic acid	72 (18.5%)	19 (52.8%)	< 0.001	4.934 (2.404–10.128)

for CNS complications. Neurological complications occurred in 98% of patients undergoing on-pump surgery. The numbers and percentages of surgeries using CPB performed in both groups are provided in Table 2.

The highest likelihood of neurological complications was observed in patients undergoing complex coronary and multivalve surgery and undergoing aortic valve surgery.

Table 3 provides information on CPB parameters, haematocrit values and perfusate supply in both groups.

The mean duration of CPB and the duration of aortic cross-clamping were significantly longer in the group with neurological complications. In Group 2, half of the patients experienced decreases in perfusion blood pressure below 70 mm Hg during CPB. It was also observed that haemodilution manifested by a decreased HCT (cutoff value of 28%) was associated with a higher incidence of neurological complications. The decrease in haematocrit (HCT) below 28% occurred in 45.6% and 80.5% of patients in Groups 1 and 2, respectively. Reinfusion of blood from the cardiotomy reservoir was received by a total of 98 patients with Group 2 patients receiving it significantly more commonly than Group 1 patients. Patients from Group 2 were administered tranexamic acid (Exacyl) more often than patients from Group 2.

Table 4 provides data on the time to regain consciousness and the duration of mechanical ventilation in both groups.

The time to regain consciousness and the duration of mechanical ventilation were both significantly longer in Group 2.

Table 5 compares the groups in terms of administration of blood products, propofol and volatile anaesthetics.

We found no statistically significant differences between the groups in terms of the influence of volatile anaesthetics (isoflurane, sevoflurane), the use of sedatives of the propofol

Table 4. Duration of mechanical ventilation and time to regain consciousness in both study groups and odds ratio (OR) values along with 95% confidence intervals (95% CI) for the occurrence of neurological complications depending on the analysed parameters in Group 2 (n = 36)

	Group 1	Group 2	P	OR (95% CI)
Time to regain consciousness [h]	5.15 ± 5.301	43.09 ± 63.261	< 0.011	47.657 (15.463–146.875)
Duration of mechanical ventilation [h]	31.52 ± 167.459	170.64 ± 224.672	< 0.001	55.588 (22.019–140.334)

Table 5. Transfusion of blood products, administration of propofol and volatile anaesthetics for the occurrence of neurological complications

	Group 1	Group 2	P
Blood products	253 (88.2%)	34 (94.4%)	NS
Propofol	109 (38%)	11 (30.6%)	NS
Sevoflurane	249 (86.8%)	32 (88.9%)	NS
Isoflurane	40 (13.9%)	4 (11.1%)	NS

NS — non-significant

type and transfusion of blood products on the development of neurological complications.

Univariate analysis revealed statistical significance for the following preoperative parameters: age above 58.5 years, AF, a history of stroke with paresis, and a euroSCORE of less above 4.5. The following variables associated with the intra- and postoperative periods were statistically significant: coronary and multivalve and valve surgeries, duration of CPB, duration of aortic cross-clamping, maintenance of mean perfusion pressure below 70 mm Hg during CPB, haemodilution, supply of the perfusate, a long time to regain consciousness and a long duration of mechanical ventilation. Table 6 presents the results for the above parameters.

Figure 1 illustrates AUC values for euroSCORE, HCT, duration of CPB and duration of aortic cross-clamping.

The above variables were included in multivariate analysis taking into account their simultaneous effect on the risk of neurological complications. We developed a logistic regression model allowing us to predict the occurrence of neurological complications after heart surgery. The analysis revealed that the following five variables statistically significantly differentiated the group with neurological complications from the group without neurological complications: long duration of mechanical ventilation, a history of stroke with paresis, AF, low HCT values and a long duration of aortic cross-clamping. The likelihood of these complications obtained in the model was 80.6%. The Nagelkerke R^2 coefficient of determination was 0.636, the sensitivity was 74.36%, the specificity was 97.545% and the accuracy was 94.74%. The total mortality

Table 6. Univariate analysis results for pre-, peri- and postoperative parameters

	OR (95% CI)	AUC (95% CI)
Preoperative parameters		
Age > 58.5 years	3.255 (1.116–9.492)	0,608 (0.51–0.70)
Atrial fibrillation	2.423 (0.967– 6.071)	
Stroke with paresis	6.432 (1.379–29.994)	
euroSCORE > 4.5	4.667 (2.056–10.593)	0.700 (0.61–0.78)
Variables associated with the intra- and postoperative period		
CABG + AVR + MVR/MVP	17.813 (3.138–101.106)	
AVR/AVP	2.925 (0.995–8.597)	
Duration of CPB exceeding 142 min	6.283 (2.902–13.603)	0.735 (0.64–0.82)
Duration of aortic cross-clamping exceeding 88 min	5.653 (2.694–11.864)	0.713 (0.62–0.80)
Maintenance of mean perfusion pressure below 70 mm Hg during CPB	2.679 (1.326–5.413)	
HCT < 28%	4.788 (2.220–10.326)	0.691 (0.60–0.77)
Perfusate administration	2.00 (0.988–4.050)	
Time to regain consciousness > 14.5 h	47.657 (15.463–146.875)	0.758 (0.62–0.88)
Duration of mechanical ventilation > 30.5 h	55.588 (22.019–140.334)	0.867 (0.79–0.94)

Abbreviations as in Table 2

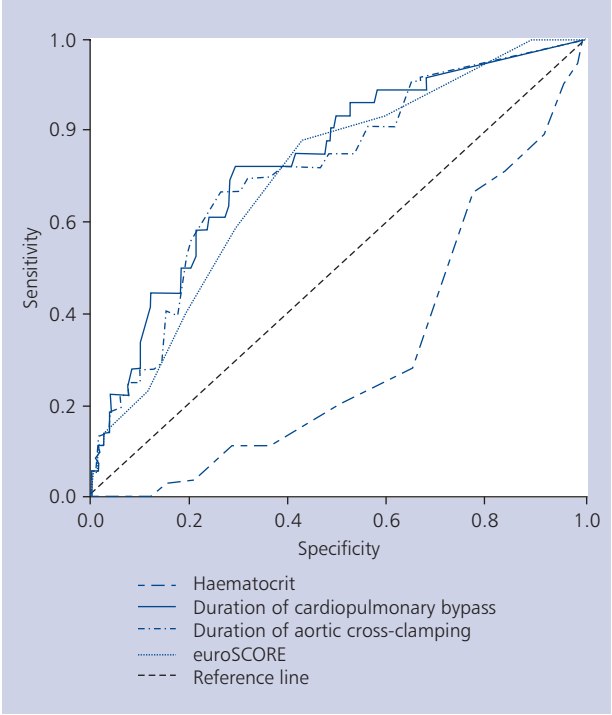

Figure 1. ROC curves with AUC for the euroSCORE, haematocrit, duration of cardiopulmonary bypass and duration of aortic cross-clamping

rate in both groups was 5% (16 patients). Two patients in Group 1 (0.69%) died from acute renal failure being part of postoperative multiorgan failure. A total of 14 patients died in Group 2 (38.9%).

DISCUSSION

More than 60% of perioperative strokes are caused by emboli, 1% by haemorrhage and in the case of 14% of them the cause cannot be established. Emboli in the left hemisphere are more common than those in the right hemisphere [3, 5, 12]. In our study, stroke confirmed by neurological examination and a CT scan developed in 7 (19.5%) patients. Six of these patients developed ischaemic stroke and 1 patient developed haemorrhagic stroke. A more common complication is postoperative encephalopathy, which is manifested by postoperative delirium in the form of impaired consciousness, hallucinations (visual in most cases), increased or reduced psychomotor activity, usually affecting elderly patients. These conditions, according to various authors, affect from 8.4% to 32.0% of the cases [6, 10, 12, 13]. This complication is usually transient but may sometimes precede more serious complications, such as stroke or death [13]. Postoperative delirium was observed in 22 (61%) patients. TIA developed in 7 (19.5%) patients. Many metaanalyses have assessed preoperative risk factors of neurological complications in cardiac surgery. According to their authors, preoperative risk factors of neurological complications include: age below 65 years, the following co-morbidities: AF, hypertension, a history of a cerebrovascular accident, aortic stenosis [2, 4, 6, 8, 14–16]. Our study has shown a much higher risk factors of neurological complications in patients over the age of 68 years, permanent AF, a history of ischaemic stroke with paresis, a history of on-pump cardiac surgery, a high perioperative mortality risk according to the euroSCORE (> 4.5). The better-studied perioperative risk factors of neurological complications include: a long duration of CPB, a long duration of aortic cross-clamping and low HCT values [2, 17]. The contact of the patient's blood with the surface of the heart-lung machine and the toxic effect of pure oxygen are considered to be the main causes of complications in cases of on-pump cardiac surgery. The oxygenation surface, depending on the oxygenator type, ranges from 2.25 m^2 to as much as 4.5 m^2 [8, 15, 18]. It has been demonstrated that the duration of CPB exceeding 60 min and a long duration of aortic cross-clamping are factors promoting complications [2, 4, 15]. In our material, in Group 2, we observed a longer duration of CPB. Where the duration of CPB exceeded 142 min, the incidence of neurological complications was six times higher. It has been shown that the duration of aortic cross-clamping of ≥ 1 h correlated with the development of neurological complications [7]. Our study has confirmed the statistically significant effect of the long duration of aortic cross-clamping on the development of neurological complications. The adverse influence of low haematocrit and excessive haemodilution (HCT < 28%) during CPB is explained by an overlap of two processes. The first one is the insufficient oxygen supply to organs most sensitive to hypoxia and the other one is associated with increased energy expenditure of brain cells under conditions of relative hypoxia [17]. Our study has confirmed that excessive haemodilution during CPB promotes the development of neurological complications.

On-pump surgeries are increasingly performed without using blood products [16]. The perfusate remaining in the oxygenator may be reused on the postoperative ward. Studies have shown that the blood remaining in the cardiotomy reservoir contains proinflammatory cytokines and their resupply may contribute to the development of microemboli and neurological damage [3, 18]. We have shown a statistically significant association between perfusate supply and the development of neurological complications. Antifibrinolytic agents, such as tranexamic acid or aprotinin are used to reduce the risk of postoperative bleeding. While antifibrinolytic agents reduce the risk of bleeding, they also significantly increase the incidence of ischaemic complications [3]. In our material, although tranexamic acid was used significantly more commonly in Group 2 than in Group 1, we have not shown it to increase the risk of neurological complications. Univariate analysis has shown an increased risk of neurological com-

plications in patients who regained consciousness 14 h after being admitted to the postoperative ward. This is consistent with other authors' findings [6–8]. It should, however, be noted that prolonged ventilation may result from stroke. Simultaneous presence of several risk factors increases the likelihood of postoperative complications, including neurological complications. Prolonged ventilation was associated with an increased risk of cerebral complications, particularly in patients with a long duration of aortic cross-clamping and low HCT during the surgery and with a history of stroke with paresis and AF. A considerable limitation of our study was the non-uniformity of the patient population in terms of surgery types, which made it impossible to use some of the statistical methods. Between 2007 and 2008 we did not employ intraoperative brain flow monitoring using cerebral oxymetry, which could have provided us with valuable information. Nevertheless, our study is one of the few studies involving the Polish population that provide a synthetic look at this vital clinical issue, and the knowledge of factors affecting the development of neurological complications may facilitate undertaking preventive measures.

CONCLUSIONS

In patients undergoing heart surgery, the independent risk factors of neurological complications in the first 30 days include: a long duration of ventilation, a history of stroke with paresis, AF, haemodilution manifested by an HCT of < 28% and a long duration of aortic cross-clamping. Neurological complications are associated with high postoperative mortality.

Conflict of interest: *none declared*

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Czynniki ryzyka powikłań neurologicznych w kardiochirurgii

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Streszczenie

Wstęp: Powikłania pooperacyjne są nieodzownie związane z leczeniem kardiochirurgicznym. Najpoważniejszym z nich jest udar mózgu, występujący u ok. 7,5% chorych oraz encefalopatia pooperacyjna obserwowana u 10–30% chorych. Dane z piśmiennictwa wskazują na to, że liczba powikłań stale się zwiększa.

Cel: Celem pracy była analiza czynników ryzyka i rodzaju powikłań neurologicznych u chorych poddawanych operacjom serca.

Metody: Retrospektywnie oceniano 323 kolejnych chorych operowanych w Klinice Kardiochirurgii Uniwersyteckiego Szpitala w Białymstoku pomiędzy lipcem 2007 a czerwcem 2008 r. Grupę I stanowili chorzy bez powikłań neurologicznych (n = 287; 89%), grupę II pacjenci z powikłaniami neurologicznymi (n = 36; 11%). W analizie uwzględniono: stan przedoperacyjny (wiek, płeć, współistniejące choroby), przebieg śródoperacyjny (rodzaj operacji, czas trwania krążenia pozaustrojowego (CPB), czas klemu aortalnego, rodzaj podanych leków, konieczność reinfuzji ze zbiornika kardiotomijnego oraz potrzebę infuzji kwasu traneksamowego) oraz przebieg pooperacyjny (czas powrotu świadomości, czas mechanicznej wentylacji, wystąpienie powikłań i ich rodzajów). Wyniki poddano analizie statystycznej: dla zmiennych mierzalnych wyliczono średnią arytmetyczną i odchylenie standardowe, dla zmiennych jakościowych — ich rozkład ilościowo-procentowy. Do porównania między grupami cech mierzalnych zastosowano test *t*-Studenta, dla cech jakościowych test niezależności χ^2. Zmienne, które okazały się istotne w porównaniach jednoczynnikowych, włączono do modelu wieloczynnikowego. Ostatnim etapem analizy czynników ryzyka powikłań neurologicznych była analiza regresji. Posługując się analizą krzywej ROC, wyznaczono wartości odcięcia dla zmiennych ciągłych. Wyliczono ilorazy szans wraz z 95-procentowym przedziałem ufności. Za poziom istotny statystycznie przyjęto $p < 0,05$.

Wyniki: Wśród 36 chorych z grupy II encefalopatię pooperacyjną obserwowano u 22, u 7 wystąpiły przemijające ogniskowe objawy neurologiczne, udar niedokrwienny wystąpił u 6 chorych (u 3 był związany z uszkodzeniem lewej półkuli mózgu, u 3 prawej półkuli mózgu), u 1 chorego doszło do udaru krwotocznego prawej półkuli mózgu. Wczesna śmiertelność wyniosła 5%, w grupie I zmarły 2 osoby (0,69%), w grupie II — 14 osób (38,9%). Analiza jednoczynnikowa wykazała, że do przedoperacyjnych czynników ryzyka powikłań neurologicznych należą: wiek > 68. rż. (z punktem odcięcia 58,5. rż.), przebyty udar mózgu z niedowładem, migotanie przedsionków (AF) oraz EuroScore > 6 punktów (z punktem odcięcia 4,5 punktów). Do okołooperacyjnych i pooperacyjnych czynników ryzyka należały: rodzaj operacji (złożone operacje wieńcowo-zastawkowe oraz operacje zastawki aortalnej), czas trwania CPB > 142 min, czas zaklemowania aorty > 88 min, wartości średniego ciśnienia perfuzyjnego w czasie CPB < 70 mm Hg, hemodylucja objawiająca się spadkiem hematokrytu (HTC) < 28%, podaż perfuzatu, czas powrotu świadomości > 14,5 h oraz czas wentylacji > 30,5 h. Analiza wieloczynnikowa wykazała wpływ następujących czynników na wzrost ryzyka wystąpienia powikłań neurologicznych: długi czas wentylacji, przebyty udar mózgu z niedowładem, AF, niskie wartości HTC i długi czas zaklemowania aorty. Współczynnik determinacji R^2 Nagelkerke wyniósł 0,636, czułość — 74,36%, swoistość — 97,545%, dokładność — 94,74%.

Wnioski: U chorych po operacjach kardiochirurgicznych do niezależnych czynników ryzyka wystąpienia powikłań neurologicznych w okresie pierwszych 30 dni należą: długi czas wentylacji, przebyty udar mózgu z niedowładem, AF, hemodylucja HTC < 28% i długi czas zaklemowania aorty. Powikłania neurologiczne wiążą się z wysoką śmiertelnością pooperacyjną.

Słowa kluczowe: powikłania neurologiczne, czynniki ryzyka, krążenie pozaustrojowe

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