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正当的 Cardiovascular and Endovascular Surgery of the Clinical Center of Vojvodina in Novi Sad during a five year period (April 2013 - March 2018). Results and Discussion.

Early operative stroke was registered in 12 patients with no significant difference between symptomatic (2.8%) and asymptomatic (1.1%) patients (odds ratio - 2.56, 95% confidence interval 0.8063 to 8.1770 standard deviation 1.596 p = 0.11). Among other risk factors, known to be associated with an increased risk of early stroke after carotid endarterectomy, contralateral carotid occlusion (odds ratio - 3.1154, 95% confidence interval 1.8537 to 526.4871; p = 0.0169) were pointed out as risk factors for early stroke. Most of the perioperative and early postoperative strokes after carotid endarterectomy were due to arterial-arterial thromboembolism, intracerebral hemorrhage and acute carotid occlusion that developed rarely and were associated with severe neurological deficit. Conclusion. Even though our results are in agreement with the literature data, additional measures for surgical quality control would further decrease the incidence of operative stroke.

Key words: Stroke; Carotid Artery Diseases; Endarterectomy, Carotid; Prophylactic Surgical Procedures; Risk Factors; Carotid Stenosis; Intraoperative Complications; Postoperative Complications

Introduction

Carotid endarterectomy is an efficient surgical procedure that prevents primary and secondary ischemic stroke in asymptomatic and symptomatic patients with extracranial carotid artery disease. It has been recognized with the highest class of recommendation and the level of evidence by current guidelines [1]. Stroke after carotid endarterectomy is a major early complication of the procedure. It is an organ-specif-
ic complication that essentially represents the opposite to the primary goal: instead of preventing it, the surgery seems to be causing a stroke. Thus, maintenance of low incidence of perioperative stroke is a condition for successful treatment of carotid artery disease. The acceptable incidence of perioperative stroke is 4% in symptomatic and 3% in asymptomatic patients. This level of risk was defined by multiple randomized controlled trials where the perioperative risk was correlated with the risk of stroke in patients who received only medical treatment without surgery [2]. Having that in mind, every early stroke after carotid endarterectomy has to be considered potentially preventable. It is necessary to analyze and professionally discuss each case. Relevant health facilities performing carotid surgery should conduct a continuous critical observation and statistical follow up of the incidence of perioperative strokes, which should be published in periodical publications and reports [3].

The aim of this research was to analyze incidence, risk factors, potential causes and preventive measures for early stroke after carotid endarterectomy in patients who underwent surgery due to asymptomatic and symptomatic carotid stenosis at the Clinic of Vascular and Endovascular Surgery of the Clinical Center of Vojvodina in Novi Sad.

**Material and Methods**

This observational study included 809 patients who underwent surgery due to extracranial carotid artery stenosis at the Clinic of Vascular and Endovascular Surgery of the Clinical Center of Vojvodina in Novi Sad during a 5-year period (April 2013 - March 2018). During this period, we systematically collected the following data:

- Preoperative data: age, sex, associated diseases and risk factors (hypertension, hyperlipoproteinemia, diabetes, smoking, clinically significant coronary artery disease and peripheral artery disease (PAD)), medications (antiplatelet and antihypertensive drugs, statins), clinical symptoms (asymptomatic and symptomatic carotid disease), degree of stenosis and contralateral carotid artery stenosis were determined by duplex ultrasound and computerized tomography (CT) angiography;
- Operative and early postoperative data: type of anesthesia, surgical technique, operative findings, use of intraluminal shunt protection, operative and early postoperative outcome: major complications in early postoperative period: stroke, myocardial infarction and/or decompensation, and death from any cause; minor complications (cranial nerve injury, wound hematoma, hemodynamic instability, stenocardia, heart rhythm disorders, transient confusion, hyperperfusion syndrome);
- Early operative stroke was defined as a newly recorded neurological deficiency corresponding to the operated carotid artery that lasted more than 24 h and occurred during the period of 30 days after the operation. A total of 12 patients with early postoperative stroke were registered;
- In all patients who presented with early operative stroke, according to the current guidelines, an emergency duplex ultrasound, CT, facultative wound and carotid artery exploration were done, as well as neurological examination. The severity of neurological deficiency was estimated by National Institutes of Health Stroke Scale (NIHSS);
- Results of extracranial carotid artery disease surgery were presented by descriptive statistic values: mean value, frequency and average. Data for postoperative stroke patients were presented as a case series (because the number of patients who had an early postoperative stroke was low), and we used univariate analysis (standard deviation (SD) and odds ratio (OR)) for analyzing risks of operative stroke.

**Results**

The patients who underwent surgery were 54 to 79 years of age, median - 67 years, and 76% of patients were males.

**Risk factors.** Hypertension was found in 85% of patients, diabetes in 37%, hyperlipoproteinemia in 62% and 51% were smokers. Clinically significant coronary artery disease was found in 28% of pa-

**Graph 1.** Incidence of early stroke after carotid endarterectomy in asymptomatic, symptomatic patients and “emergency” carotid endarterectomy

**Grafikon 1.** Učestalost ranog moždanog udara nakon karotidne endarterektomije kod pacijenata koji imaju simptome, pacijenata koji nemaju simptome i urgentno operisanih pacijenata
patients, left ventricular hypertrophy in 22%, significant PAD (class III - VI) in 12%.

**Medical therapy.** Most patients used a single antiplatelet therapy (acetylsalicylic acid or clopidogrel) 58%, dual antiplatelet therapy was used by 3%, 7% used oral anticoagulation therapy and 23% of patients did not use any antiplatelet therapy. Statins were used by 70% of patients and angiotensin-converting-enzyme (ACE) inhibitors were the most common antihypertensive drugs used by 51% of patients, whereas 31% did not use any antihypertensive therapy.

**Operative results.** Of 809 patients who underwent surgery, the majority (447 patients, 63%) were asymptomatic, 248 patients (35%) presented with a symptomatic carotid disease and 13 (2%) were “urgent” cases, operated within the first 48 h after the neurological event. Seven patients were operated in loco-regional anesthesia, in 44% of patients endoluminal protection was used, with direct or patch closure, and in 56% of patients eversion technique was used.

Five asymptomatic patients had a perioperative stroke (1.1%); 7 symptomatic patients also had a perioperative stroke (2.8%) out of which 2 patients underwent “acute” carotid endarterectomy (15% stroke incidence in “acute” carotid endarterectomy group). In total, 1.5% (12 patients) had a periopeative stroke, 4 cases had myocardial infarction (0.7%) and 4 cases had a fatal outcome (0.7%). The difference between symptomatic and asymptomatic patients did not show a statistical significance (OR 2.56; 95% CI 1.8537 to 526.4871, p = 0.0169). The results of operative treatment are shown in Graph 1.

**Types of stroke.** Perioperative stroke which occurred imediatly after the surgery was defined as “intraoperative stroke” and it was registred in 7 patients, while “early postoperative stroke” developed in 5 patients who did not have a neurological deficieny immediately after the surgery, but it developed more than 1 hour later. In case of intraoperative stroke, immediate carotid artery exploration was indicated. In only two cases complete carotid thrombosis and occlusion were detected as well as one case of partial thrombosis and distal intimal flap. These patients were treated by baloon catheter thrombectomy, intimal flap fixation, local removal of the thrombus, local flushing with heparin saline solution, additional systemic heparinization and closure with patch angioplasty or direct suture. The remaining 4 patients underwent carotid artery exploration, but the cause of tromboembolic event was not found. Early postoperative stroke was registered in the rest of 5 patients, 3 cases of ischemic and 2 cases of hemorrhagic (one case of hemorrhagic transformation and one due to cerebrovacular hyperperfusion).

**Risk factors for operative stroke.** Univariate analysis showed two risk factors for operative stroke: high-grade stenosis or occlusion of the contralateral carotid artery (OR 3.1154, 95% CI 1.1620 to 8.3522, p = 0.0239) and absence of previous dual antiplatelet therapy (OR 3.1154, 95% CI 1.8537 to 526.4871, p = 0.0169).

**Outcome of stroke.** In all 12 cases of stroke after carotid endarterectomy, CT was done within 24 h after surgery, and ischemic stroke was found in 9 patients, and hemorrhagic stroke in 3 patients (one intracerebral hemotoma and 2 hemorrhagic transformations of acute ischemic stroke).

The severity of stroke was evaluated by using NIHSS and results are shown in Graph 2. Most of the patients (eight) had a mild to moderate neurological deficiency. In 3 cases the stroke was lethal: in one case a severe stroke was the cause of death, and in two cases mild and moderate stroke was accompanied with acute heart failure and multiple organ failure. Along with the major complications, we analyzed the frequency of minor complications and results are shown in Graph 3.

**Discussion**

Early stroke after carotid endarterectomy is a rare complication and in our series the incidence of 1.1% in asymptomatic and 2.8% in symptomatic patients was far below the reported levels of 4% and 6%, respectively. The risk factors for operative stroke that showed to be significant in our series were contralateral carotid occlusion and absence of dual antiplatelet...
therapy (DAPT), which is in agreement with literature data. Other risk factors suggested in literature, such as age, sex, symptomatic/asymptomatic, PAD, did not show a statistical significance, probably due to low incidence of perioperative strokes [4–6].

In case of intraoperative stroke, the priority is to identify carotid occlusion assuming that these patients would benefit from thrombectomy and restoration of blood flow within 1 h. Early carotid occlusion is caused by dissection of intimal flap or by thrombosis formed at endarterectomized surface of the carotid artery. Clinical findings, including a triad of hemiplegia, hemianopia and higher cortical dysfunction, are likely to be connected with internal carotid artery (ICA) or middle cerebral artery (MCA) mainstream acute occlusion [7]. Ultrasound examination in patients with acute neurological deficiency after surgery is not accurate enough, due to air and hematoma trapped in the wound. In such cases, emergency reoperation is indicated. In our series, less than half of patients had an acute carotid thrombosis as a cause of stroke, indicating that direct ultrasound examination of carotid artery could be done after the wound exploration to avoid unnecessary carotid artery exploration prolonging the procedure.

If not acute carotid thrombosis, the most probable cause of operative stroke is movement of the thrombus during the preparation of the carotid artery, crossclamping, or movement of the thrombus adherent to intraluminal shunt after restoration of flow. In all cases of intraoperative stroke, patients should be admitted to the intensive care unit (ICU) under general anesthesia, and CT should be done as soon as possible [8].

Early postoperative stroke is caused either by the arterial-arterial embolization from the endarterectomized surface of the carotid artery (mostly by thrombus formed from the arterial wall vasa vorum), or intracranial hemorrhage. To evaluate the cause of stroke, CT has to be done as soon as possible. In case of ischemic stroke, reoperation is indicated if there is a clear case of carotid thrombosis evaluated by duplex ultrasound or contrast enhanced CT [9].

Most efficient procedures to decrease the incidence of perioperative stroke are:

- Perioperative detection of arterial emboli by high intensity transient signals (HITS) is useful in order to abort the procedure (carotid bulb preparation and intrararterial shunt insertion) in case of increased HITS. This procedure was not performed in our series [10].
- Completion angioscopy, to exclude adherent thrombus or intimal flap larger than 2 mm, that was also not done in our series [11].
- Routine shunting is not supported by the literature, because shunt insertion may mobilize the thrombus. The only case of intracranial hemorrhage in our series was the result of prolonged brain ischemia and consecutive decrease of cerebrovascular reserve during the eversion carotid endarterectomy without shunting. That suggests that shunting may be used selectively to avoid operative stroke [12, 13].
- Routine DAPT administration at least 5 days prior to surgery, without discontinuation of the therapy. In our series absence of DAPT was a statistically significant predictor of perioperative stroke. At the same time, there were no other hemorrhagic complications in patients that were using DAPT, such as wound hematoma or intracerebral hemorrhage [14].
- Postoperative strict blood pressure control should be done primarily in ICU and continued after admission to the department, at least in the following 48 to 72 hours. Blood pressure should be targeted at 140/80 mmHg to avoid the cerebral hyperperfusion syndrome. Cerebral hyperperfusion syndrome patients have 13 times greater risk for postoperative cerebral hemorrhage. In our series, it was registered in 17% [15].
- Endovascular options for perioperative stroke include emergency carotid artery stenting, thrombus aspiration from occluded MCA, while thrombolysis is rarely indicated. Evaluation of such treatment is expected in the future [16].

Conclusion

Carotid endarterectomy at the Clinic of Vascular and Endovascular Surgery is done with acceptable operating risks for major complications. Even though it is a low risk procedure, measures for surgical quality control would further decrease the incidence of operative stroke.

References


