

Carotid Stenosis Leading to Acute Ischemic Stroke: The Sex-Age Aspect of Surgical Treatment

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Abstract

Background: *The prevalence of atherosclerotic disease of the cardiovascular system among both women and men of various age groups leading to serious ischemic stroke attracts a lot of negative changes in the working capacity of population. The tactics of surgical treatment of the carotid stenosis and acute ischemic stroke needs the further development.*

Methods: *This retrospective study included 90 patients at Petrovsky National Research Center of Surgery. The study period was from 2000 to 2019. Collected data included results of duplex scanning and magnetic resonance imaging (MRI) of the brachycephalic arteries, MRI and computer tomography of the brain, angiography. To analyze obtained data, methods of descriptive statistics and correlation were used.*

Results: *45.56% of patients that were included into our study were in age under 60. A prevalence of occlusion of carotid artery, leading to acute ischemic stroke, was more among male patients. In 59.76% of cases the surgical intervention was carotid endarterectomy.*

Conclusion: *An even more differentiated and personalized approach to the choice of the surgical treatment tactics, taking into account the sex-age aspects and associated diseases, leads to a drastic decrease in the intraoperative risks associated with the surgical interventions and also drastically reduces the incidence of post-operative complications.*

Keywords: *Carotid Endarterectomy, Occlusion, Carotid Artery, Cerebrovascular Insufficiency, Cerebral Ischemia.*

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I. Introduction

Despite the significant advances in preventive medicine, a stroke is still a disabling disease. During the beginning of the 21st century, the age-standardized incidence of stroke in Europe ranged from 95 to 290/100,000 per year. Annually, about 1.1 million people in Europe suffering from stroke have been registered, and ischemic stroke (IS) accounts for about 80% of cases¹. A recurrent stroke is a risk factor for stroke survivors². In addition, many surgical interventions also contribute to the development of ischemic complications in the brain tissues^{3,4,5}.

The incidence of a stroke in the world is decreasing, but the number of newly registered cases among young population is increasing⁶. Predictors of carotid arteriosclerosis are found, on average, in people aged 34 years⁷.

An increase in the average life expectancy of the population worldwide was observed, and, therefore, the absolute number of strokes is expected to increase sharply in the coming years¹.

At the same time, an increase of the life expectancy of the population is among the main goals of preserving public health in Russia⁸, while cardiovascular diseases made 3.2% of Gross Domestic product in 2016⁹.

In this aspect, the issue of the decision to conduct surgical treatment and the timing of its implementation is particularly relevant^{10,11}. American Heart Association (2015) for patients with stroke as a result of occlusion of Carotid artery (CA) recommends surgery as soon as possible¹². Thus, as an atherosclerotic disease is common in most patients with IS of young and middle age groups, it requires a deterministic study and aggressive treatment of modifiable risk factors, stroke and its consequences.

II. Methods

The study period was 20 years (2000–2019). The clinical part of the work and surgical treatment of patients was carried out at Petrovsky National Research Center of Surgery. In total, 90 patients took part in the retrospective study, two of whom received surgical treatment twice.

The criteria for inclusion of patients in the study were age over 18 years, complaints and anamnestic data indicating occlusion of the carotid arteries and stroke, cerebrovascular insufficiency 3–4 degrees, data obtained using ultrasound, radiological, magnetic resonance imaging (MRI) and computed tomography (CT) research methods. Patients who did not meet the criteria were excluded from the study.

Clinical examination of patients included the collection of presenting complaints and anamnestic data, according with the identification of concomitant pathology that threatens postoperative complications and repeated AIS (arterial hypertension and pathological changes in arteries, coronary heart disease, and diabetes mellitus). To verify the diagnosis and to pinpoint the place of lesion duplex scanning and MRI of the brachycephalic arteries, MRI and CT of the brain, and angiography were used. A study of early and late postoperative complications, early manifestations of neurological symptoms, assessment of quality of life of patients was based on Short-Form 36 questionnaire¹³ and also an outcome of hospitalization were conducted.

For statistical processing of the results obtained during the clinical examination, methods of descriptive statistics and correlation were used. The compilation of a quantitative database was made by the encoding of verbal values (presenting complaints, anamnestic data, etc.) into a digital equivalent.

III. Results

The distribution of patients by age and sex is presented in Table 1. The average age of the patients was 59.22 ± 9.54 years, and the age range was from 31 years to 79 years. The group of Youth and Middle age periods includes 45.68% of all male patients and 44.44% of all female patients in the research. Embodiments of the surgical treatment of patients with occlusion of carotid artery and AIS, based on retrospective analysis were: carotid endarterectomy (CEA), Cerebral artery bypass surgery, repairs, resection, extra-intracranial microvascular anastomosis (EICMA), and the combination of these variants (Table 2).

Table 1: Distribution of the number of patients by sex-based principle (% of the cohort)

<i>A</i> <i>ge Period</i>	<i>A</i> <i>ge group</i>	<i>Male</i>		<i>Femal</i> <i>e</i>		<i>Total</i>	
		<i>A</i> <i>bsolute</i>		<i>A</i> <i>bsolute</i>		<i>A</i> <i>bsolute</i>	
Y outh	1 8-44	5	.56	1	.11	6	.67
M iddle age	4 5-59	3 2	5.56	3	.33	5	8.89
El derly	6 0-74	4 1	5.55	4	.45	5	0
Se nile	7 5-90	3	.33	1	.11	4	.44
T otal	1 8-90	8 1	0	9	0	9	00

Table 2: Frequency of interventions (number of cases, n = 92)

<i>Surgical intervention</i>	<i>Male</i>		<i>Female</i>		<i>Total</i>	
	<i>Absolute</i>	<i>Relative</i>	<i>Absolute</i>	<i>Relative</i>	<i>Absolute</i>	<i>Relative</i>
Angiography	1	.09	0		1	.09
CEA	4	3.26	6	.52	5	9.78
Cerebral artery bypass surgery	1	3.05	2	.17	1	5.22
Repairs	7	.61	0		7	.61
Resection	7	.61	2	.17	9	.78
EICMA	6	.52	0		6	.52
Total	8	9.14	1	0.86	9	00

The calculation of interventions doesn't take into account if the intervention was done solitary or in combination with others. For example, if Cerebral artery bypass surgery and CEA were performed on the same patient, then it was considered as 1 case of CEA and 1 case of Cerebral artery bypass surgery. The total number of cases was taken into consideration and not the number of patients.

The second most common surgical intervention by frequency was Cerebral artery bypass surgery with one of the options: Aortobifemoral Bypass surgery, Carotid-carotid bypass surgery, Coronary artery bypass graft, Carotid-subclavian bypass surgery, Femoral popliteal bypass surgery.

There was one male patient with bilateral occlusion of CA who underwent only angiography who didn't get further surgical treatment because of his condition severity. The outcome was the death of the patient. The tactics of surgical interventions used for the treatment of occlusive lesions of the CAs and AIS has undergone significant advances in the recent decades.

To assess the intraoperative, early and late complications of the surgical treatment of CA occlusion due to atherosclerosis in patients with IS in the temporal dynamics, we compared the needs for one type or a different type of surgical intervention over 2 decades (Table 3). The choice of surgical treatment among patients was CEA, which was performed more often in male patients.

During 2000–2009, 43 surgical interventions were performed. The outcomes of hospitalization in 38 cases were: discharge from the hospital, 4 deaths were reported and in 5 cases there was no information. Intraoperative complications were detected in 4 cases—all leading to AIS.

In 1 male patient, after unilateral CEA, the intraoperative AIS led to a coma (early postoperative complication), in 1 female patient, a similar operation caused AIS without coma; in 1 case, AIS was a result of resection, in 1—after unilateral CEA + Carotid-subclavian bypass surgery was performed.

Early postoperative complications were observed in 18 cases, which amounted to 41.86% of all interventions. Three cases of early complications after surgery were a continuation of intraoperative complications that were described previously.

In two cases, patients died: after CEA + Coronary artery bypass graft—cerebral ischemia, after left-side CEA—ischemic shock.

In 4 cases, nerve damage was observed after unilateral CEA. CEA external carotid artery (ECA) led to the occlusion of the internal carotid artery (ICA), one-sided CEA led to ischemic stroke, and one-sided CEA of the ECA led to AIS. In three patients, CEA led to occlusion of vessels and ischemic shock of the same side.

Late postoperative complications have not been reported. Repeated cases of ischemic shock were not identified. Repeated reconstruction (thrombectomy) was required for one male patient. In one case, the patient did not die due to an intraoperative or postoperative complication.

Table 3: The frequency of operations performed by decades of the study (number of cases, n=92)

Type of operation	Years				otal
	2000-2009		2010-2019		
	ale	emale	ale	emale	
CEA	8		7		2

CEA-GT					
CEA ECA GT					
CEA ECA					
CEA+Bypass					
CEA+Reconstruction					
CEA+EICMA x2					
CEA+Right ICA					
CEA+ endarterectomy brachiocephalic trunk					
Retrograde endarterectomy right carotid artery					
Resection					
Angiography					
Carotid-carotid bypass surgery					
Carotid-subclavian bypass surgery					
Aortobifemoral Bypass surgery + Brachiocephalic trunk reconstruction					
Right ICA					
Carotid-subclavian procedure					
EICMA					
No information					
Total	1		1		2

During 2010–2019 there was an increase in the number of surgical interventions by 1.12 times (to 49 cases). There were no fatal hospitalizations. In all the 49 cases (100% of all known outcomes), the patients were discharged from the hospital.

Intraoperative complications were detected in 3 male patients: in one case, while performing a right-sided CEA in combination with Carotid-carotid bypass surgery, the surgery was complicated by hemorrhage, which resulted in stroke and death of the patient; in another case, when performing a left-side CEA, intraoperatively, the patient developed a stroke, leading to early postoperative ICA thrombosis (the patient was discharged). In the third case, intraoperative complication during EICMA GT that led to vascular thrombosis, which in turn led to ischemic shock during the early postoperative period (the patient was discharged).

Early postoperative complications were observed in 14 cases (28.57% of all interventions performed during this period), which is 1.29 times less when compared with the previous decade. One of these cases, accompanied by a stroke and coma, was described previously. In 1 female patient, after a right-sided CEA, an early postoperative ischemic shock led to left-sided hemiplegia.

All other cases of early postoperative complications were revealed among male patients: in 4 cases, ischemic shock after unilateral CEA, another case of ischemic shock after unilateral CEA was observed due to vascular thrombosis; in 1 case, after unilateral CEA, there was a discirculatory Vertebrobasilar insufficiency, in 2 other patients were observed damage to the cranial nerves.

Eversion carotid endarterectomy in combination with Femoral popliteal bypass conducted in one patient and one-sided CEA in combination with endarterectomy brachiocephalic trunk (1 case) caused 2 other cases of ischemic shock. Brain ischemia was observed in 1 patient after Aortobifemoral Bypass surgery + Right brachiocephalic trunk. Damage to three cranial nerves at once (VII, VIII and XII) was observed in 1 male patient who underwent unilateral replacement of the ICA. Late postoperative complications were observed in 1 case after thromboectomy (this patient also had early ischemic shock). Repeated reconstruction (thromboectomy) was performed in three cases.

Correlation analysis revealed that the occurrence of early postoperative complications has a statistical relationship with the need for re-reconstruction according to the thromboectomy option ($r=0.378842749$ and $r=0.33921246$, respectively). Also, a statistical correlation was found between the age and date of the operation ($r=0.394153041$), and an inverse correlation was found between age and the type of the surgery ($r=-0.404389651$). We found a correlation between the operation of thromboectomy and repeated ischemic shock ($r=0.436689448$). Probably, additional research might be required in this direction.

IV. Discussion

A significant part of both male and female patients that were included into our study was in age under 60. Results of other studies of different levels indicate the importance of the age in the treatment of carotid artery occlusion. Thus, globally in the age group of 20–64 from 1990 to 2013, there was a notable increase in prevalence of IS¹⁴. The prevalence of severe stenosis increases both in men (to 13.2%) and women (to 14.9%) of the oldest age group¹⁵. Also, the proportion of large artery atherosclerosis as the risk factor of first-ever IS increased beginning at age 30 to 35¹⁶.

In our research we found that occlusion of carotid artery, leading to AIS, had a sex-specific prevalence prevailing more among men. But there are some limitations of our study. The sample size was small and consisting of single-center patients, so it is not possible to interpret the obtained data as representative. In our study sex distribution of participants showed the prevalence of the number of male patients (90%).

Other researches show that only age was found to associate with carotid plaque and only in overweight and obese participants¹⁷. The retrospective study in Bangladesh with the majority of (72.0%) the patients in age of 50–59 years showed no statistically significant association between age, sex and the extent of carotid artery stenosis¹⁸. Nevertheless, in other researches both carotid plaque and stenosis found to be greater in men than in women¹⁵. According to the Global Burden of Disease 2013 Study men have consistently greater incidence of IS than women¹⁴.

Outcomes of surgical treatment of carotid stenosis according to our research's data changed with time. The incidence of intraoperative complications was 9.3% and 6.12% during 2000-2009 and 2010-2019, respectively. So, the number of complications arising during operations on coronary arteries has decreased by 1.52 times. We assume that the cause of the result was in an improvement in the techniques of surgery and a more informed choice of type of intervention to be performed.

During a period of our research a decrease in early postoperative complications was noted. A case of late postoperative complication (nerve damage) when there is a decrease in intraoperative complications and early postoperative complications, can be attributed to statistical error. The most common variant of the surgical intervention was CEA that was performed in 59.76% of cases. As CEA is recommended for severe carotid stenosis, the risk of operative stroke/death <3–6% can be maintained¹⁹. In this connection a decrease in the mortality among patients in our research is significant.

V. Conclusion

Patients under 60 made a notable part of the patients with occlusion of the carotid arteries and stroke. The choice of surgical intervention in favor of CEA remained a priority among both male and female patients. Compared to 2000–2009 period, in 2010–2019 there was an increase in the number of surgical interventions by 1.12 times among patients with occlusions of CA and AIS, mainly due to female patients. We found that occlusion of carotid artery, leading to AIS, had a sex-specific prevalence prevailing more among men, which is confirmed by literature data.

Further researches of the surgical treatment of the carotid stenosis in its sex aspect are required, with a special attention to all age periods.

Ethical Considerations: The protocol of the research was reviewed and approved by the Ethics Committee of Petrovsky National Research Center of Surgery (458/12/2019), which waived the need for informed consent as an excessive because of the retrospective nature of the research.

Conflict of Interests: There is no conflict of interest.

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References

1. Béjot Y, Bailly H, Durier J, et al. Epidemiology of stroke in Europe and trends for the 21st century. *Presse Med* 2016;45(12 Pt 2): e391-e398. <https://doi.org/10.1016/j.lpm.2016.10.003>
2. Jensen M, Thomalla G. Causes and secondary prevention of acute ischemic stroke in adults *Hamostaseologie* 2020;40(01):022-030. <https://doi.org/10.1055/s-0039-1700502>
3. Gavrilenko AV, Skrylev SI, Kravchenko AA, et al. Carotid endarterectomy and stenting in patients with hemodynamically significant stenosis of the internal carotid artery and contralateral occlusion. *Surgery Pirogov Journal* 2018;4:52-56. <https://doi.org/10.17116/hirurgia2018452-56>
4. Boursin P, Paternotte S, Dercy B, et al. Semantics, epidemiology and semiology of stroke. *Soins*, 2018;63(828):24-27. <https://doi.org/10.1016/j.soin.2018.06.008>
5. Wang W, Jiang B, Sun H, et al. Prevalence, incidence, and mortality of stroke in China: Results from a nationwide population-based survey of 480 687 adults. *Circulation* 2017;135(8):759-771. <https://doi.org/10.1161/CIRCULATIONAHA.116.025250>
6. Li Q, Wu H, Yue W, et al. Prevalence of stroke and vascular risk factors in China: A nationwide community-based study. *Sci rep* 2017;7(1):6402. <https://doi.org/10.1038/s41598-017-06691-1>
7. Shevchenko EV, Ramazanov GR, Petrikov SS. Causes of dizziness in patients with suspected stroke. *Russian Sklifosovsky Journal of Emergency Medical Care* 2018;7(3):217–221. <https://doi.org/10.23934/2223-9022-2018-7-3-217-221>
8. Chistobaev AI, Semenova AZ, Grudtsyn NA. Dynamics and strategic directions of public health preservation in Russian Federation, *Entrepreneurship and Sustainability Issues* 2018;6(3):1180-1192. [http://doi.org/10.9770/jesi.2019.6.3\(23\)](http://doi.org/10.9770/jesi.2019.6.3(23))
9. Kontsevaya AV, Drapkina OM, Balanova YA, et al. Economic burden of cardiovascular diseases in the Russian Federation in 2016. *Rational Pharmacotherapy in Cardiology* 2018;14(2):156-166. <https://doi.org/10.20996/1819-6446-2018-14-2-156-166>
10. Bazylev VV, Shmatkov MG, Morozov ZA. Predictors of complications in the early postoperative period after stenting of the carotid arteries and carotid endarterectomy. *Diagnostic and interventional radiology* 2019;13(2): 44-50.
11. Kolesnik O., Kolesnik D. The calculating the progressive collapse problem in the light of the existing regulatory framework of the Russian Federation, *IOP Conference Series: Materials Science and Engineering*, Volume 698, 2019, 022048 DOI: <https://doi.org/10.1088/1757-899X/698/2/022048>
12. Zabiroy SSh, Chechulov PV, Voznyuk IA, et al. Early carotid endarterectomy in patients with acute cerebral ischemia against the background of symptomatic stenosis of the carotid artery. *Journal of Neurology and Psychiatry named after C.C. Korsakova* 2018;118(9):49-54. <https://doi.org/10.17116/jnevro201811809249>

13. Gavrilenko AV, Kuklin AV, Khripkov AS. Early carotid endarterectomy in patients after acute cerebrovascular accident. *Angiology and vascular surgery* 2019;25(2):186-192. <https://doi.org/10.33529/angio2019203>
14. Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 1992;30(6):473–483. <https://doi.org/10.1097/00005650-199206000-00002>
15. Feigin VL, Norrving B, Mensah GA. Global burden of stroke. *Circ Res* 2017;120(3):439-448. <https://doi.org/10.1161/CIRCRESAHA.116.308413>
16. Boulos NM, Gardin JM, Malik S, et al. Carotid plaque characterization, stenosis, and intima-media thickness according to age and gender in a large registry cohort. *Am J Cardiol* 2016;117(7):1185-91. <https://doi.org/10.1016/j.amjcard.2015.12.062>
17. Fox C. Ischemic stroke in children and young adults: Epidemiology, etiology and risk factors. UpToDate [resource on the Internet] 2019. Available from: <https://www.uptodate.com/contents/ischemic-stroke-in-children-and-young-adults-epidemiology-etiology-and-risk-factors>
18. Fink A.D., Shayakhmetov Marat R., Krasnitskiy V.M., Shmidt A.G., Makenova S.K., Abakumov E.V., Suleimanov R.R., Adelmurzina I.F., 2018, The radiological state of the soil cover as the most important criteria for the estimation of the environment pollution. *Gigiena i sanitariia* Vol 97, № 2 P. 113-116. <https://doi.org/10.18821/0016-9900-2018-97-2-113-116>
19. Jones DL, Rodriguez VJ, Alcaide ML, et al. Subclinical atherosclerosis among young and middle-aged adults using carotid intima-media thickness measurements. *South Med J* 2017;110(11): 733-737. <https://doi.org/10.14423/SMJ.0000000000000728>
20. Janshanlo, R.E., Kogut, O.Y., Czerewacz-Filipowicz, K. "Human capital management trends in the innovative economy of Kazakhstan". *Polish Journal of Management Studies*, 20(2), pp. 267-278. 2019
21. Adhikary D, Ranjan R, Mandal S, et al. Prevalence of carotid artery stenosis in ischemic heart disease patients in Bangladesh. *SAGE Open Med* 2019;(7):2050312119830838. <https://doi.org/10.1177/2050312119830838>
22. Jones DW, Brott TG, Schermerhorn ML. Trials and Frontiers in Carotid Endarterectomy and Stenting. *Stroke* 2018;49(7):1776-1783. <https://doi.org/10.1161/STROKEAHA.117.019496>