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RISK FACTORS FOR MORTALITY AFTER STENTING OF SYMPTOMATIC ATHEROSCLEROTIC STENOSES IN INTRA- AND EXTRACRANIAL ARTERIES: A CROSS-SECTIONAL STUDY

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Abstract

Introduction. Stenosis of intra- and extracranial arteries due to atherosclerosis is one of the most frequent causes of ischemic stroke and mortality worldwide. Stenting of these vessels might be an effective treatment option in symptomatic cases.

Research method. A retrospective study was conducted, including 93 patients with symptomatic atherosclerotic stenoses of intra- and extracranial arteries who underwent stenting. The follow-up period was six years. Stroke, infarction, and death were accepted as primary outcomes. Statistical analysis was carried out using parametric and nonparametric analysis and regression analysis based on the Cox model.

Results. A statistically significant effect of age on mortality rate was revealed. The analysis showed that an increase in blood pressure during the surgery increased the risk of mortality; however, its degree did not have a statistically significant influence on the risk of postoperative stroke. Also, the effect of cholesterol level on mortality was not statistically significant.

Conclusion. Analysis of the risk factors revealed a significant impact of the hypertensive crisis on the mortality of patients, increasing it substantially. Correction and control of blood pressure pre-operatively can reduce the risks of stroke and mortality after stenting over a long period of time.

Key words*: symptomatic stenoses of extracranial and intracranial arteries, endovascular treatment, stenting, risk factors, long-term outcomes of stenting.*

Резюме

ФАКТОРЫ РИСКА СМЕРТНОСТИ ПОСЛЕ СТЕНТИРОВАНИЯ СИМПТОМАТИЧЕСКИХ АТЕРОСКЛЕРОТИЧЕСКИХ СТЕНОЗОВ В ИНТРА- И ЭКСТРАКРАНИАЛЬНЫХ АРТЕРИЯХ: ПОПЕРЕЧНОЕ ИССЛЕДОВАНИЕ

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Введение. Стеноз интра- и экстракраниальных артерий вследствие атеросклероза является одной из наиболее частых причин ишемического инсульта и смертности во всем мире. Стентирование этих сосудов может быть эффективным методом лечения в симптоматических случаях.

Методы исследования. Проведено ретроспективное исследование, включающее 93 пациента с симптоматическими атеросклеротическими стенозами интра- и экстракраниальных артерий, которым было выполнено стентирование. Период наблюдения составил шесть лет. В качестве первичных исходов были приняты инсульт, инфаркт и смерть. Статистический анализ проводился с использованием параметрического и непараметрического анализа, а также регрессионного анализа на основе модели Кокса.

Результаты. Выявлено статистически значимое влияние возраста на смертность. Анализ показал, что повышение артериального давления во время операции увеличивало риск смертности, однако его степень не оказывала статистически значимого влияния на риск развития послеоперационного инсульта. Влияние уровня холестерина на смертность также не было статистически значимым.

Заключение. Анализ факторов риска выявил значительное влияние гипертонического криза на смертность пациентов, существенно ее увеличивая. Коррекция и контроль артериального давления на дооперационном этапе могут снизить риск развития инсульта и смертности после стентирования в течение длительного времени.

Ключевые слова: *симптоматические стенозы экстракраниальных и интракраниальных артерий, эндоваскулярное лечение, стентирование, факторы риска, отдаленные исходы стентирования.*

Түйіндеме

СИМПТОМАТИКАЛЫҚ ИНТРА- ЖӘНЕ ЭКСТРАКРАНИАЛДЫ АРТЕРИЯЛАРДЫҢ АТЕРОСКЛЕРОТИКАЛЫҚ СТЕНОЗЫН СТЕНТТЕУДЕН КЕЙІНГІ ӨЛІМГЕ ӘКЕЛЕТІН РИСК ФАКТОРЛАР: КӨЛДЕНЕҢ ЗЕРТТЕУ

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Кіріспе. Атеросклерозға байланысты интракраниальды және экстракраниальды артериялардың стенозы бүкіл әлемде ишемиялық инсульт пен өлімнің жиі кездесетін себептерінің бірі болып табылады. Бұл тамырларды стенттеу симптоматикалық жағдайларда тиімді емдеу нұсқасы болуы мүмкін.

Зерттеу әдістері. Ретроспективті зерттеу жүргізілді, оның ішінде интракраниальды және экстракраниальды артериялардың симптоматикалық атеросклеротикалық стенозы бар 93 пациент стенттелген. Бақылау мерзімі алты жыл болды. Негізгі нәтижелер инсульт, инфаркт және өлім болды. Статистикалық талдау параметрлік және параметрлік емес талдауды, сонымен қатар Кокс үлгісіне негізделген регрессиялық талдауды қолдану арқылы орындалды.

Нәтижелер. Өлімге жастың статистикалық маңызды әсері анықталды. Талдау көрсеткендей, операция кезінде қан қысымының жоғарылауы өлім қаупін арттырды, бірақ оның дәрежесі операциядан кейінгі инсульт қаупіне статистикалық маңызды әсер етпеді. Холестерин деңгейінің өлімге әсері де статистикалық маңызды емес.

Қорытынды. Тәуекел факторларын талдау гипертониялық криздің пациенттердің өлім-жітіміне айтарлықтай әсерін анықтады, оны айтарлықтай арттырады. Операция алдында қан қысымын түзету және бақылау ұзақ мерзімді стентингтен кейін инсульт пен өлім қаупін азайтуы мүмкін.

Түйінді сөздер: *бас сүйектен тыс және бассүйек ішілік артериялардың симптоматикалық стеноздары, эндоваскулярлық ем, стентинг, қауіп факторлары, стентингтің ұзақ мерзімді нәтижелері.*

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Саршаев М.А., Бердиходжаев М.С., Карибаев К.Р., Турдалиева Б.С., Танбаева Г.З., Маханбетхан Ш.С., Биниязова А.А., Лупежова А.Д., Жумабеков А.К. Факторы риска смертности после стентирования симптоматических атеросклеротических стенозов в интра- и экстракраниальных артериях: поперечное исследование // Наука и Здравоохранение. 2024. Т.26 (5). С. 62-71. *doi 10.34689/SH.2024.26.5.008*

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Introduction

Stroke is a significant public health issue globally. The Global Burden of Disease study reported that between 1990 and 2013, about 26 million people worldwide suffered from a stroke, with 71% of them being of the ischemic type. The number of stroke-related deaths during this period reached 6.5 million, with over half of them attributed to ischemic stroke [10].

Intracranial atherosclerosis (ICAS) is a leading cause of ischemic stroke worldwide, occurring in up to 56% of individuals from different ethnic groups [13]. Studies have shown that ICAS is more prevalent in Asian populations, leading to ischemic stroke in 30-50% of cases, compared to 8-10% in North Americans [16]. Additionally, extracranial carotid artery stenosis is the third most common cause of ischemic stroke globally and the second most common non-traumatic cause of brain damage in adults under 45 [30]. The standard treatment for intra- and extracranial atherosclerotic stenoses includes antiplatelet and lipid-lowering therapy. However, depending on the location and severity of the stenosis, as well as the neurological symptoms, various surgical procedures such as endovascular techniques (carotid angioplasty with stenting, intracranial artery stenting), carotid endarterectomy, and microsurgical extracranial-intracranial arterial bypass (EC-IC bypass) may be considered [16,24,26,30].

Numerous researchers have studied the development of arterial stenoses at different sites under the influence of various risk factors [6,4,8,14,15]. It has been observed that intracranial vessels have a different structure and hemodynamics compared to extracranial arteries. Stenting of extracranial arteries has shown more favorable results than intracranial stenting [17,20,27,28]. However, conflicting data exists regarding mortality and the association of risk factors with serious complications after stenting [2,5,7,18,23,25,28,29]. In this study, we evaluated mortality rate among patients who underwent stenting of intra- and extracranial arteries and the significance of risk factors in the long-term period post-surgery. Also, we subsequently created prognostic models to predict fatal outcomes after surgery depending on the risk factors that patients have.

Materials and methods

A study was conducted on 93 patients with symptomatic atherosclerotic stenoses of intra- and extracranial arteries. The patients underwent endovascular stenting in 2016–2017. The study collected baseline clinical data such as age, sex, acute vascular events, and risk factors like arterial hypertension, diabetes mellitus, coronary heart disease, smoking history, and total cholesterol level at the time of surgery. Preoperative antiplatelet therapy included clopidogrel combined with acetylsalicylic acid for 92 patients, and one patient received ticagrelor with acetylsalicylic acid. Patients were given loading doses of medication before stent placement and recommended to continue the medication postoperatively. Platelet reactivity was measured, and only patients with specific platelet reaction units were selected for stenting. The choice of stent depended on various factors like the location and degree of stenosis, vessel size, and type of atherosclerotic plaque. Patients underwent clinical and neurological examinations post-surgery, and all adverse events related to the procedure were recorded. Neuroimaging follow-up included CT angiography or MR angiography of cerebral vessels at specific intervals.

Outcome assessment

The primary endpoints were stroke, myocardial infarction, fatal outcome, and baseline risk assessment of significant risk factors for different follow-up periods. Survival time (in months) in the qualitative variable was considered from the date of stenting up to the end of the follow-up period, which was November 2022. Reports on primary outcomes (death, stroke, and infarction in the follow-up period) were obtained from outpatient departments.

Statistical analysis was performed in the SPSS-Statistical 26 program. To assess the normal distribution of measured variables, the Shapiro-Wilk test was used. Nonparametric quantitative data were analyzed by the Mann-Whitney U test; parametric data were analyzed with Student's t test. The prognostic model, describing changes in mortality depending on the impact of risk factors, was built by means of Cox regression. The level of statistical significance was determined as $p<0.05$.

Results. General data from perioperative medical records on anamnesis, comorbidities, and stents used can be found in Tables 1 – 5 and figures 3 - 4.

The mean age of patients undergoing stenting (M (SD±)) was 67 years in those with a lethal outcome and 64.38 years without a fatal outcome; the differences were statistically significant ($p = 0.020$) (Table 1). There was no significant difference in blood total cholesterol level in either group: the group with the fatal outcome had a mean total cholesterol level (M (SD±)) of 4.9 mmol/l, while the surviving patients had 4.6 mmol/l as well ($p = 0.058$) (Table 1). The median and interquartile range (IQR) of hypertensive crisis (mm Hg) were -180 (20) and -200 (30), respectively, and the differences were not statistically significant, $p = 0.450$** (Table 1). Following the median and IQR body mass index (BMI), in patients with a fatal outcome of 27.2 and without a fatal outcome of 25.5 ($p = 0.169$), there was no statistically significant difference between the groups (Table 1). The most frequently used stent was Protege; it was implanted in 57 cases (61.3%) (Table 5).

Table 1.

Baseline characteristics of patients before surgery.

Evaluation results	Results	Fatal outcome (1)	Alive (2)	p-value
Age	M (SD±)	67 (±7,2)	64,38 (±6,58)	0,020*
Cholesterol (mmol/L)	M (SD±)	4,9 (±1,4)	4,6 (±1,3)	0,058*
Magnitude of the hypertensive crisis	Me (Q1-Q3)	180 (20)	200 (30)	0,450**
BMI	Me (Q1-Q3)	27,2 (7,42)	25,5 (2,99)	0,169**
Me - median, Q1-Q-3 - interquartile range, M-mean, SD – standard deviation, t Student's test, Mann-Whitney U-test***				

Table 2.

Summary of patients' data.

Outcomes / risk factors	(n)	%
Ischemic stroke > 6 months before stenting	53	56,9
Ischemic stroke < 6 months and > 8days before stenting	39	41,9
Myocardial infarction > 1 month before stenting	18	19,4
Smokers in the past	36	38,7
Current smokers	11	11,8
Intracranial stenting	20	21,5
Extracranial stenting	73	78,5
males	67	72
females	26	28
Degree 1 arterial hypertension	7	7,5
Degree 2 arterial hypertension	8	8,6
Degree 3 arterial hypertension	76	81,7
Diabetes mellitus	34	36,6
Ischemic heart disease	47	50,5
Stroke after stenting	15	16,1
Myocardial infarction after stenting	4	4,3
Mortality	27	29

Table 3. **Stroke rate in patients with intra- and extracranial atherosclerotic stenoses after stenting.**

	Intracranial	Extracranial	Overall
30 days after intervention	None	None	None
90 days after intervention	None	1	1
1 year after intervention	2	2	4
2 years after intervention	None	5	5
3 years after intervention	4	7	11
4 years after intervention	5	8	13
5 years after intervention	7	8	15
Total	7	8	15

Table 4. **Mortality rate in patients with intra- and extracranial atherosclerotic stenoses after stenting.**

	Intracranial	Extracranial	Overall
30 days after intervention	None	None	None
90 days after intervention	None	None	None
1 year after intervention	1	3	4
2 years after intervention	None	4	4
3 years after intervention	2	10	12
4 years after intervention	None	14	14
5 years after intervention	4	18	22
6 years after intervention	7	20	27
Total	7	20	27

Table 5.

Stents used.

№	Stent types	n	%
1	Casper	3	3,2
2	Protege	57	61,3
3	Biotronic	1	1,2
4	Resolute Integrity	7	7,5
5	XIENCE Xpedition	1	1,1
6	Cristallo Ideal	2	2,2
7	Carotid Wallstent	1	1,1
8	Terumo Ultimaster	6	5,5
9	Orsiro	1	1,1
10	Promus PREMIER	2	2,2

As a result, we developed a prognostic model with the Cox regression method. The model describes the changes in mortality depending on the impact of risk factors: age, sex, diabetes mellitus, coronary heart disease, cholesterol level, hypertensive crisis, degree of blood pressure elevation, smoking, localization of atherosclerotic plaques (intracranial and extracranial), and stent use. The selection of predictors by the Wald exclusion method resulted in model 1 given below.

$$hi(t) = h0(t)*\exp(0.020*X1),$$

where hi(t) is the predicted risk of crisis for the i-th patient (in%), h0(t) is the baseline risk of hypertensive crisis development for a certain time period t (in%), and X1 is the extent of hypertensive crisis (mm Hg).

Model 1 was statistically significant (p = 0.043).

The values of the baseline risk of mortality for different time periods are presented in Table 6.

Table 7 and Figure 1 show the change in the risk of a fatal outcome depending on the factor. Furthermore, the analysis revealed a statistically significant increase in the risk of lethal outcome with a 1 mmHg increase in BP during a hypertensive crisis by 1.020 times (p = 0.001).

Using the Cox regression method, we developed a prognostic model describing the changes in mortality depending on the impact of risk factors: age, sex, diabetes mellitus, coronary heart disease, cholesterol level, hypertensive crisis (mmHg), degree of blood pressure increase, smoking, localization of atherosclerotic plaques (intracranial and extracranial), and stent use. The selection of predictors by the Wald exclusion method resulted in the following model:

$$hi(t) = h0(t)*\exp(0.178*X1),$$

where hi(t) is the predicted risk of crisis for the i-th patient (in%), h0(t) is the baseline risk of developing a crisis for a certain time period t (in%), and X1 is the degree of arterial hypertension (1st degree, 2nd degree, 3rd degree).

The statistical significance of model 2 was not substantial (p = 0.103). However, the clinical significance of this increase in risk should be evaluated in the context of the specific population and clinical situation. Finally, Table 6 provides baseline stroke risk values for different time periods, whereas the change in risk of mortality depending on the factor is given in Table 7 and Figure 2.

Table 6.

Baseline risk values for death and stroke for different time periods (max. – 67 months).

Time (months)	Baseline risk value h0(t) for fatal outcome	Baseline risk value h0(t) for ischemic stroke
5	0,000	0,000
29	0,001	0,001
34	0,002	0,002
36	0,002	0,002
40	0,003	0,003
45	0,004	0,004
56	0,004	0,004
58	0,005	0,005
60	0,006	0,006
62	0,006	0,006
64	0,007	0,007
66	0,008	0,008

Table 7.

Changes in the risk of death and stroke after stenting in patients with atherosclerosis compared with the baseline, taking into account the influence of individual factors.

Risk factors	Changes in risk in the presence of a factor		P - value
	HR	95 % CI	
Magnitude of hypertensive crisis (for fatal outcome)	1,020	1,001-1,040	0,02
Blood pressure level (for ischemic stroke)	3,248	0,628-16,788	0,160
67	0,008		0,008

According to the outcomes of the performed statistical analysis, the risk of stroke development increased with the presence of a higher degree of arterial hypertension by 3.248 times, but the result was not statistically significant (p = 0.160). Despite the HR being greater than 1, the result is not statistically significant because of the wide confidence interval and high P value. It is possible that larger studies or consideration of other factors may be needed to assess the association between blood pressure and the risk of stroke more accurately.

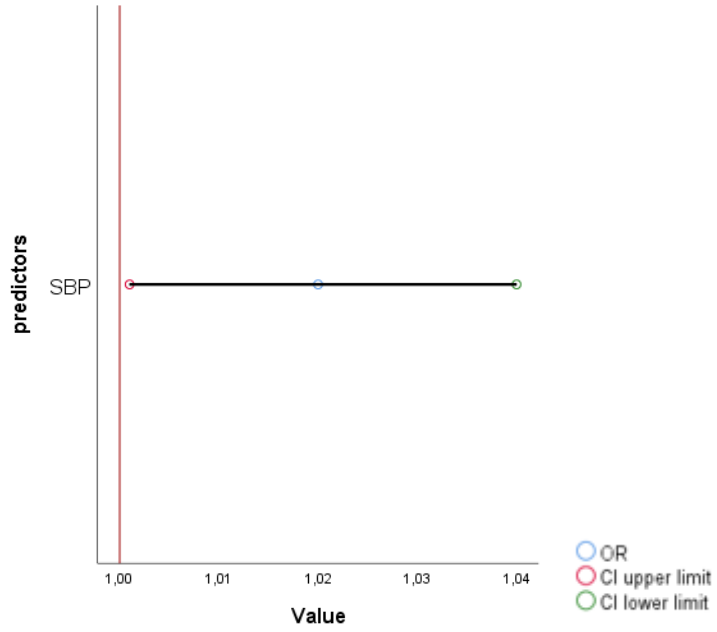

Figure 1. Changes in the risk of death after stenting in patients with atherosclerosis compared with the baseline, taking into account the influence of individual factors.

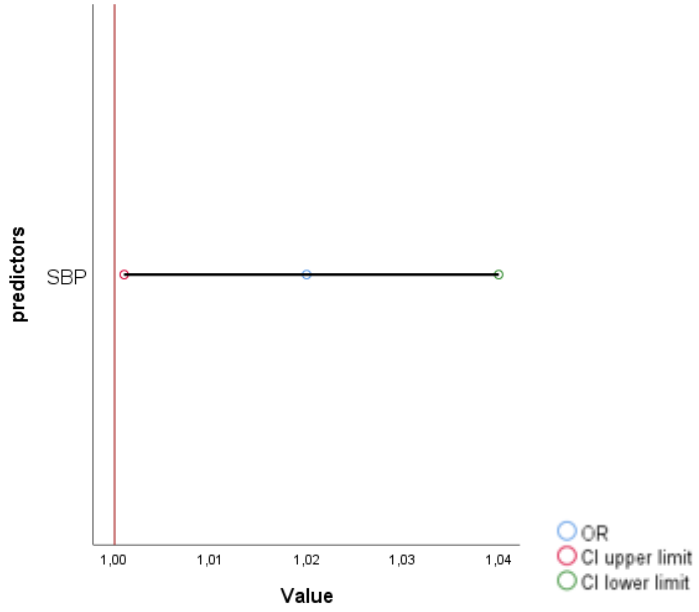

Figure 2. Changes in the risk of stroke after stenting in patients with atherosclerosis compared with the baseline, taking into account the influence of individual factors.

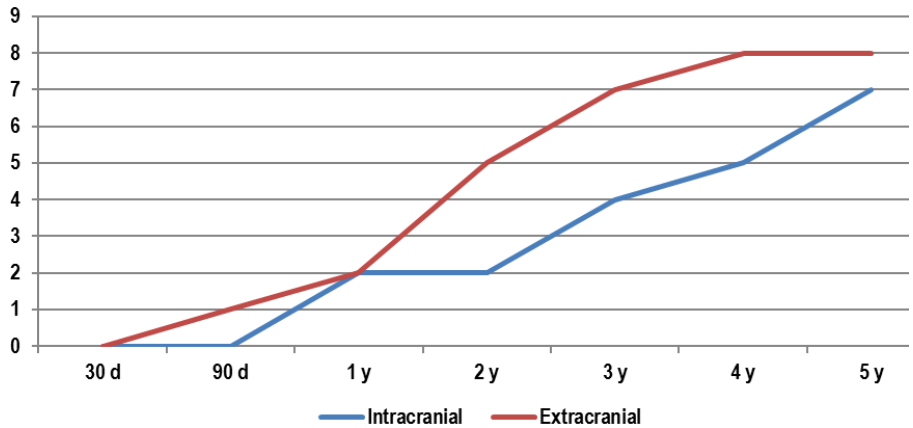

Figure 3. Stroke rate in patients with intra- and extracranial atherosclerotic stenoses after stenting.

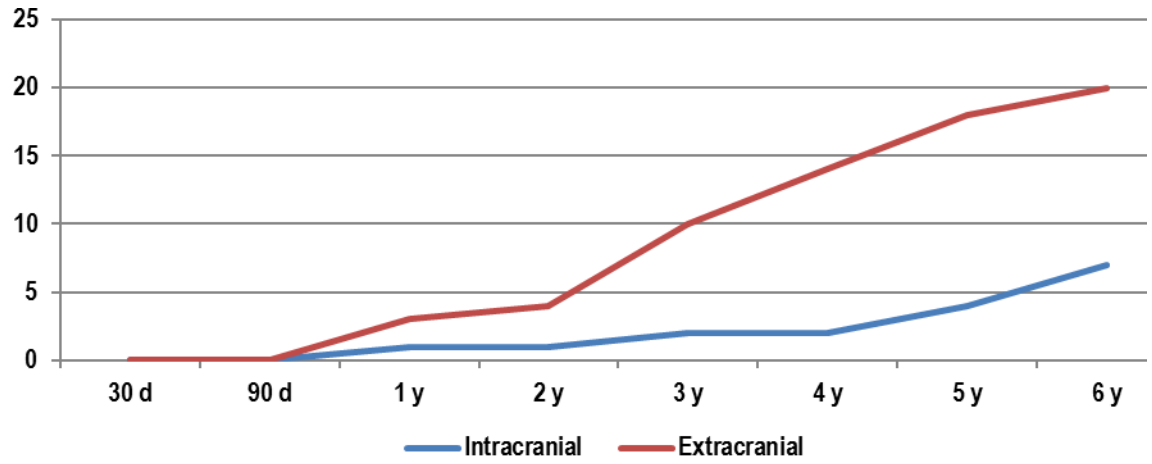

Figure 4. Mortality rate in patients with intra- and extracranial atherosclerotic stenoses after stenting.

Discussion

Many studies have analyzed the rates of perioperative stroke incidence and mortality in the long term, but the results on fatal outcomes were different [1,2,5,7,12,15,18,23,29].

For intracranial stenoses, the guidelines of the American Heart Association and the American Association for Stroke Prevention are currently applied worldwide. The same is true in our country: as the first-line treatment of symptomatic and asymptomatic stenoses of intracranial arteries, double antiplatelet therapy (DAT) with correction of modifiable risk factors is recommended [17, 32].

The SAMMPRIS multicenter RCT, conducted in the United States with a sample of 451 participants, evaluated the risk of recurrent stroke or death in patients with ICAS [5]. The patients were divided into groups according to the type of intervention: the first (224 patients) underwent stenting combined with DAT, and the second (227 patients) had DAT alone. As drug therapy, patients received 325 mg aspirin (ASC) daily for the entire follow-up period and 75 mg clopidogrel daily for 90 days. The risk of stroke or death within 30 days was significantly higher in patients in the first group than in the group receiving DAT alone (14.7% vs. 5.8%; p = 0.002). The SAMMPRIS authors also report that the high mortality and stroke rates in the stenting group were due to perioperative complications such as vessel occlusion by detached plaques. At the 1-year and 3-year follow-ups, a higher incidence of stroke or mortality was reported in the stenting + DAT group than in the control group (19.7% and 12.6% [p = 0.04] in the first year; 23.9% and 14.9% (p = 0.02) in the third year) [5]. However, *Yu W. and Jiang W.* analyzed the results of the SAMMPRIS trial, which studied the incidence rates of recurrent disabling stroke and mortality 30 days after stenting or medical therapy [29]. According to the results of the analysis, the incidence of disabling or fatal strokes was three times higher in the medical therapy group than in the stenting group (6.2% in the medical therapy group versus 2.2% in the stenting group). Thus, in cases where angioplasty and stenting are performed with low rates of periprocedural complications, the long-term benefits of stenting can provide some protection against disabling stroke and death compared to drug therapy alone.

Additionally, the multicenter clinical trial WEAVE evaluated perioperative and postoperative complications at 72 hours with WINGSPAN stenting and DAT. The study included patients with symptomatic intracranial vascular lesions >70%, with baseline mRS ≤3, who had suffered at least 2 strokes and were stented ≥8 days after the last stroke. In contrast to SAMPRISS, the surgeons performing the operations were more experienced (they completed at least 50 operations with the WINGSPAN stent). As a result, only 2.6% of patients developed a stroke or died within 72 hours after surgery. This was followed by the WOVEN trial, in which patients from the WEAVE trial were followed up for 1 year, resulting in a 1-year stroke or death rate of 8.5% [1].

In a study by *Duan I.H. et al.,* including 69 patients over 80 years of age with symptomatic or asymptomatic extracranial internal carotid artery stenosis ≥70%, the three-year survival rate was approximately 90%, whereas the five-year survival rate was 73%; thus, the calculated overall mortality was approximately 5.4% per year. The authors report that stenting in patients in their eighties was safe and effective in the periprocedural period if carefully selected. Long-term follow-up showed a low rate of fatal and nonfatal strokes, and patients survived long enough to benefit from the procedure [7].

In the SAPPHIRE study [28], the authors compared survival and mortality rates in the CAS and CEA patient groups for symptomatic carotid artery stenosis >50% or asymptomatic carotid artery stenosis >80%. The incidence of perioperative mortality, stroke or myocardial infarction within 30 days after surgery, and/or death or ipsilateral stroke at 1 year (12.2% vs. 20.1%, 95% CI 0.7-16.4%) was not significantly different. CAS also performed better than CEA in terms of mortality (6.9% vs. 12.6%), stroke (5.7% vs. 7.3%), and myocardial infarction (2.5% vs. 7.9%). At long-term follow-up, the stroke mortality rate at three years was 21.4% in the group of asymptomatic patients who underwent CAS and 29.2% in patients who underwent CEA [28, 19].

In a systematic review by *Ding X. et al.* on the differences in the degree of influence of risk factors in intra- and extracranial stenosis among Asian populations, smoking and dyslipidemia were recognized as the most significant for the development of atherosclerosis, especially in the extracranial localization of the lesion [6, 11]. This may be because intracranial arteries are more resistant to hypercholesterolemia due to the different protective functions of vascular wall cells. LDL may impair

the vasodilation of extracranial arteries but not intracranial arteries [21].

Miao Z. et al. (2012) compared endovascular and drug treatment of stenotic middle cerebral artery lesions and identified a history of arterial hypertension as a factor in disabling stroke or mortality (P = 0.015). Other risk factors, namely, age, sex, physical characteristics, body mass index, serum lipid levels, blood glucose levels, coronary heart disease, family history, smoking, alcoholism, and neurological deficit, did not influence end-point events [15, 20].

Conclusion

In summary, this study on risk factors on mortality after stenting of intra- and extracranial arteries revealed a significant impact of hypertensive crisis on the mortality of patients, increasing it substantially. Correction and control of BP before surgery can reduce the risks of stroke and mortality over a long period of time. Large randomized trials in this direction are needed in the future to understand the influence of other risk factors on fatal outcomes.

Data availability. *Study data are available from the authors upon request.*

Ethical approval. *The conduct of the study was approved by the local research ethics committee (LEC).*

Informed consent. *Informed consent was obtained from patients during the course of the study.*

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References:

1. *Alexander M.J., Zauner A., Chaloupka J.C., Baxter B., Callison R.C., Gupta R., Song S.S., Yu W.* WEAVE Trial Sites and Interventionalists (2019). WEAVE Trial: Final Results in 152 On-Label Patients. Stroke, 50(4), 889–894. https://doi.org/10.1161/STROKEAHA.118.023996

2. *Barnard Z.R., Alexander M.J.* Update in the treatment of intracranial atherosclerotic disease. Stroke and vascular neurology, 2019. *5*(1), 59–64. https://doi.org/10.1136/svn-2019-000279

3. *Brott T.G., Calvet D., Howard G., Gregso J., Algra A., Becquemin J.P., de Borst G.J., Bulbulia R., Eckstein H.H., Fraedrich G., Greving J.P., Halliday A., Hendrikse J., Jansen O., Voeks J.H., Ringleb P.A., Mas J.L., Brown M. M., Bonati L.H.* Carotid Stenosis Trialists' Collaboration Long-term outcomes of stenting and endarterectomy for symptomatic carotid stenosis: a preplanned pooled analysis of individual patient data. The Lancet. Neurology, 2019. 18(4), 348–356. https://doi.org/10.1016/S1474-4422(19)30028-6

4. *Brott T.G., Howard G., Roubin G.S., Meschia J.F., Mackey A., Brooks W., Moore W.S., Hill M.D., Mantese V.A., Clark W.M., Timaran C.H., Heck D., Leimgruber P.P., Sheffet A.J., Howard V.J., Chaturvedi S., Lal B.K., Voeks J.H., Hobson R.W.,* 2nd, & CREST Investigators. Long-Term Results of Stenting versus Endarterectomy for Carotid-Artery Stenosis. The New England journal of medicine, 2016. *374*(11), 1021–1031. https://doi.org/10.1056/NEJMoa1505215

5. *Chimowitz M.I., Lynn M.J., Derdeyn C.P., Turan T.N., Fiorella D., Lane B.F., Janis L.S., Lutsep H.L., Barnwell S.L., Waters M.F., Hoh B.L., Hourihane J.M., Levy E.I., Alexandrov A.V., Harrigan M.R., Chiu D., Klucznik R.P., Clark J.M., McDougall C.G., Johnson M.D.* SAMMPRIS Trial Investigators Stenting versus aggressive medical therapy for intracranial arterial stenosis. *The New England journal of medicine*, 2011. *365*(11), 993–1003. https://doi.org/10.1056/NEJMoa1105335

6. *Ding X., Li C., Yu K., Gao A., Xiao L., Peng F., Wang J., Chen L., Wu Y.* Different risk factors between intracranial and extracranial atherosclerotic stenosis in Asian population: a systematic review and meta-analysis. The International journal of neuroscience, 2014. 124(11), 834–840. https://doi.org/10.3109/00207454.2013.879580

7. *Duan J.H., Xu S.W., Dai C., Xiao H., Zhong J., Ma F., Mo J.W., Wang S., Zhang X., Lin Z.* Immediate and late outcomes of stenting for severe extracranial internal carotid artery stenosis in octogenarian patients. Brain and behavior, 2017. 8(1), e00873. https://doi.org/10.1002/brb3.873

8. Eberhardt O., Naegele T., Raygrotzki S., Weller M., Ernemann U. Stenting of vertebrobasilar arteries in symptomatic atherosclerotic disease and acute occlusion: case series and review of the literature. Journal of vascular surgery, 2006. *43*(6), 1145–1154. https://doi.org/10.1016/j.jvs.2006.02.027

9. *European Stroke Organisation, Tendera M., Aboyans V., Bartelink M.L., Baumgartner I., Clément D., Collet J.P., Cremonesi A., De Carlo M., Erbel R., Fowkes F. G., Heras M., Kownator S., Minar E., Ostergren J., Poldermans D., Riambau V., Roffi M., Röther J., Sievert H.,* … ESC Committee for Practice Guidelines. ESC Guidelines on the diagnosis and treatment of peripheral artery diseases: Document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries: The Task Force on the Diagnosis and Treatment of Peripheral Artery Diseases of the European Society of Cardiology (ESC). European heart journal, 2011. 32(22), 2851–2906. https://doi.org/10.1093/eurheartj/ehr211

10. *Feigin V.L., Krishnamurthi R.V., Parmar P., Norrving B., Mensah G.A., Bennett D.A., Barker-Collo S., Moran A. E., Sacco R.L., Truelsen T., Davis S., Pandian J.D., Naghavi M., Forouzanfar M.H., Nguyen G., Johnson C.O., Vos T., Meretoja A., Murray C.J., Roth G.A.* GBD 2013 Stroke Panel Experts Group. Update on the Global Burden of Ischemic and Hemorrhagic Stroke in 1990-2013: The GBD 2013 Study. Neuroepidemiology, 2015. 45(3), 161–176. https://doi.org/10.1159/000441085

11. *Furie K.L., Kasner S.E., Adams R.J., Albers G.W., Bush R.L., Fagan S.C., Halperi J.L., Johnston S.C., Katzan I., Kernan W.N., Mitchell P.H., Ovbiagele B., Palesch Y.Y.,*

Sacco R.L., Schwamm L.H., Wassertheil-Smoller S., Turan T.N., Wentworth D. American Heart Association Stroke Council, Council on Cardiovascular Nursing, Council on Clinical Cardiology, and Interdisciplinary Council on Quality of Care and Outcomes Research. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: a guideline for healthcare professionals from the american heart association/american stroke association. Stroke, 2011. 42(1), 227–276. https://doi.org/10.1161/STR.0b013e3181f7d043

12. *Gao P., Wang T., Wang D., Liebeskind D.S., Shi H., Li T., Zhao Z., Cai Y., Wu W., He W., Yu J., Zheng B., Wang H., Wu Y., Dmytriw A.A., Krings T., Derdeyn C.P., Jiao L.* CASSISS Trial Investigators. Effect of Stenting Plus Medical Therapy vs Medical Therapy Alone on Risk of Stroke and Death in Patients with Symptomatic Intracranial Stenosis: The CASSISS Randomized Clinical Trial. JAMA. 2022., 328(6), 534–542. https://doi.org/10.1001/jama.2022.12000

13. *Gorelick P.B., Wong K.S., Bae H.J., Pandey D.K.* Large artery intracranial occlusive disease: a large worldwide burden but a relatively neglected frontier. *Stroke*, 2008. 39(8), 2396–2399. https://doi.org/10.1161/STROKEAHA.107.505776

14. *Halliday A., Harrison M., Hayter E., Kong X., Mansfield A., Marro J., Pan H., Peto R., Potter J., Rahimi K., Rau A., Robertson S., Streifler J., Thomas D.* Asymptomatic Carotid Surgery Trial (ACST) Collaborative Group. 10-year stroke prevention after successful carotid endarterectomy for asymptomatic stenosis (ACST-1): a multicentre randomised trial. Lancet (London, England), 2010. 376(9746), 1074–1084. https://doi.org/10.1016/S0140-6736(10)61197-X

15. *Kang B.M., Yoon S.M., Oh J.S., Oh H.J., Ahn J.M., Yun G.Y.* Long-term outcomes of carotid artery stenting in patients with carotid artery stenosis: A single-center 14-year retrospective analysis. *Journal of cerebrovascular and endovascular neurosurgery*, 2023. 10.7461/jcen.2023.E2022.07.007. Advance online publication. https://doi.org/10.7461/jcen.2023.E2022.07.007

16. *Kim D.J.* Intracranial Stenting; the Current Landscape. Neurointervention, 2021. 16(1), 2–5. https://doi.org/10.5469/neuroint.2021.00087

17. *Kleindorfer D.O., Towfighi A., Chaturvedi S., Cockroft K.M., Gutierrez J., Lombardi-Hill D., Kamel H., Kernan W.N., Kittner S.J., Leira E.C., Lennon O., Meschia J.F., Nguyen T.N., Pollak P.M., Santangeli P., Sharrief A.Z., Smith, S.C., Turan T.N., Williams L.S.* 2021 Guideline for the Prevention of Stroke in Patients With Stroke and Transient Ischemic Attack: A Guideline From the American Heart Association/American Stroke Association. *Stroke*, 2021. 52(7), e364–e467. https://doi.org/10.1161/STR.0000000000000375

18. *Lal B.K., Brott T.G.* The Carotid Revascularization Endarterectomy vs. Stenting Trial completes randomization: lessons learned and anticipated results. Journal of vascular surgery, 2009. *50*(5), 1224–1231. https://doi.org/10.1016/j.jvs.2009.09.003

19. *Markus H.S., Harshfield E.L., Compter A., Kuker W., Kappelle L.J., Clifton A., van der Worp H.B., Rothwell P., Algra A.* Vertebral Stenosis Trialists' Collaboration. Stenting for symptomatic vertebral artery stenosis: a preplanned pooled individual patient data analysis. The Lancet. Neurology, 2019. 18(7), 666–673. https://doi.org/10.1016/S1474-4422(19)30149-8

20. *Miao Z., Jiang L., Wu H., Bao Y., Jiao L., Li S., Wu J., Hua Y., Li Y., Zhu J., Zhu F., Liu X., Ling F.* Randomized controlled trial of symptomatic middle cerebral artery stenosis: endovascular versus medical therapy in a Chinese population. Stroke, 2012. *43*(12), 3284–3290. https://doi.org/10.1161/STROKEAHA.112.662270

21. *Napoli C., Paternò R., Faraci F.M., Taguchi H., Postiglione A., Heistad D.D.* Mildly oxidized low-density lipoprotein impairs responses of carotid but not basilar artery in rabbits. Stroke, 1997. 28(11), 2266–2272. https://doi.org/10.1161/01.str.28.11.2266

22. *Petty G.W., Brown R.D., Whisnant J.P., Sicks J.D., O'Fallon W.M., Wiebers D.O.* Ischemic stroke subtypes: a population-based study of incidence and risk factors. Stroke, 1999. 30(12), 2513–2516. https://doi.org/10.1161/01.str.30.12.2513

23. EC/IC Bypass Study Group. Failure of extracranial-intracranial arterial bypass to reduce the risk of ischemic stroke. Results of an international randomized trial. N Engl J Med. 1985 Nov 7. 313(19):1191-200. doi: 10.1056/NEJM198511073131904. PMID: 2865674.

24. Saia F., Belotti L.M., Guastaroba P., Berardini A., Rossini R., Musumeci G., Tarantini G., Campo G., Guiducci V., Tarantino F., Menozzi A., Varani E., Santarelli A., Tondi S., De Palma R., Rapezzi C., Marzocchi A. Risk of Adverse Cardiac and Bleeding Events Following Cardiac and Noncardiac Surgery in Patients With Coronary Stent: How Important Is the Interplay Between Stent Type and Time From Stenting to Surgery? Circulation. Cardiovascular quality and outcomes, 2016. 9(1), 39–47. https://doi.org/10.1161/CIRCOUTCOMES.115.002155

25. *Sardar P., Chatterjee S., Aronow H.D., Kundu A., Ramchand P., Mukherjee D., Nairooz R., Gray W.A., White, C.J., Jaff M.R., Rosenfield K., Giri J.* Carotid Artery Stenting Versus Endarterectomy for Stroke Prevention: A Meta-Analysis of Clinical Trials. Journal of the American College of Cardiology. 2017, 69(18), 2266–2275. https://doi.org/10.1016/j.jacc.2017.02.053

26. *Wang T., Yang K., Luo J., Gao P., Ma Y., Wang Y., Li L., Liu Y., Feng Y., Wang X., Jiao L.* Outcomes after stenting for symptomatic intracranial arterial stenosis: a systematic review and meta-analysis. Journal of neurology, 2020. 267(3), 581–590. https://doi.org/10.1007/s00415-018-09176-x

27. *Wang T., Yang K., Zhang X., Luo J., Xu R., Wang X., Yang Y., Bai X., Ma Y., Yan Y., Jiao L.* Endovascular Therapy for Symptomatic Intracranial Artery Stenosis: a Systematic Review and Network Meta-analysis. Translational stroke research, 2022. 13(5), 676–685. https://doi.org/10.1007/s12975-022-00996-8

28. *Yadav J.S., Wholey M.H., Kuntz R.E., Fayad P., Katzen B.T., Mishkel G.J., Bajwa T.K., Whitlow P., Strickman N.E., Jaff M.R., Popma J.J., Snead D.B., Cutlip D.E., Firth B.G., Ouriel K.* Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy Investigators (2004). Protected carotid-artery stenting versus endarterectomy in high-risk patients. The New England journal of medicine, 351(15), 1493–1501. https://doi.org/10.1056/NEJMoa040127

29. *Yu W., Jiang W.J.* Stenting for intracranial stenosis: potential future for the prevention of disabling or fatal stroke. Stroke and vascular neurology, 2018. *3*(3), 140–146. https://doi.org/10.1136/svn-2018-000158

30. *Ooi Yinn Cher, and Nestor R Gonzalez.* Management of extracranial carotid artery disease. Cardiology clinics vol. 33,1 (2015): 1-35. doi:10.1016/j.ccl.2014.09.001

31. *Ferguson G.G., Eliasziw M., Barr H.W., Clagett G.P, Barnes R.W, Wallace MC, Taylor D.W., Haynes R.B., Finan J.W., Hachinski V.C., Barnett HJ.* The North American Symptomatic Carotid Endarterectomy Trial : surgical results in 1415 patients. Stroke. 1999 Sep;30(9):1751-8. doi: 10.1161/01.str.30.9.1751. PMID: 10471419.

32. Gonzalez N.R., Jiang H., Lyden P., Song S., Schlick K., Dumitrascu O., Quintero-Consuegra MD, Toscano JF, Liebeskind DS, Restrepo L, Rao N, Hinman J, Alexander MJ, Schievink W, Piantadosi S, Saver JL. Encephaloduroarteriosynangiosis (EDAS) revascularization for symptomatic intracranial atherosclerotic steno-occlusive (ERSIAS) Phase-II objective performance criterion trial. Int J Stroke. 2021 Aug. 16(6):701-709. doi: 10.1177/1747493020967256. Epub 2020 Oct 29. PMID: 33115382.

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