Research Article

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Comparative Results of Emergency Carotid Endarterectomy and Emergency Carotid Angioplasty with Stenting in the Acute Period of Ischemic Stroke. Multicenter Study Results

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AIM OF STUDY Study of hospital results of emergency carotid endarterectomy (CEE) and carotid angioplasty with stenting (CAS) in the acute period of acute cerebrovascular accident (ACVA).

MATERIAL AND METHODS From January 2008 to August 2020, the study included 615 patients with hemodynamically significant stenosis of the internal carotid arteries (ICA), operated on in the acute period of ischemic stroke (within 3 days from the onset of stroke). Depending on the type of revascularization implemented, all patients were divided into 2 groups: group 1 — CAS (n=312); 2nd group — CEE (n=357). Inclusion criteria were as follows: 1. Mild neurological disorders: NIHSS score 3–8; Modified Rankin Scale score 2 of less; Barthel Scale > 61; 2. Indications for CEE / CAS according to the current national recommendations; 3. Ischemic focus in the brain not more than 2.5 cm in diameter. Exclusion criteria: 1. Presence of contraindications to CEE / CAS. Carotid angioplasty with stenting was performed according to the standard technique; in all cases, distal embolism protection systems were used. Carotid endarterectomy was performed according to the classical and eversion techniques. When the retrograde pressure in the ICA was less than 60% of the systemic pressure, a temporary shunt (TS) was installed. In the postoperative period, all patients underwent multislice computed tomography (MSCT) of the brain. In the absence of negative dynamics in the neurological status, MSCT was performed on the 7th day after the operation, if available, it was performed urgently. The checkpoints were the development of such unfavourable cardiovascular events as death, myocardial infarction (MI), stroke / transient is-chemic attack (TIA), "silent" stroke, "silent" hemorrhagic transformations, combined end-point (death + all strokes / TIA + MI). Strokes were silent if diagnosed according to MSCT, without symptoms.

RESULTS In 69% of diabetic patients with anterior myocardial infarction and in 63% of patients with posterolateral MI 12 months after PCI, signs of LV inferiority were revealed in the form of an increase in the indices of end-diastolic and systolic volumes of the LV and low ejection fraction (≤45%). In patients without diabetes, these figures were 18% and 31%, respectively. High concentrations of NT-proBNP on the first day of myocardial infarction after PCI were of the greatest value in the diagnosis and prognosis of LV UR after 12 months.

RESULTS When analyzing hospital complications, significant differences in the frequency of lethal outcome were not obtained (group 1: n=6 (1.92%); group 2: n=8 (2.24%); p=0.98; OR=0.85; 95% CI 0.29–2.49); MI (group 1: n=5 (1.6%); group 2: n=5 (1.4%); p=0.91; OR=1.14; 95% CI 0.32–3.99); ACVA (ischemic type) / TIA (group 1: n=5 (1.6%); group 2: n=6 (1.7%); p=0.82; OR=0.95; 95% CI 0.28–3.15), as well as "silent" ACVA (group 1: n=7 (2.2%); group 2: n=15 (4.2%); p=0.23; OR=0.52; 95% CI 0.21–1.3). However, the vast majority of hemorrhagic transformations (group 1: n=2 (0.64%); group 2: n=13 (3.6%); p=0.018; OR=0.17; 95% CI 0.03–0.76) and all "silent" hemorrhagic transformations (group 1: n=0; group 2: n=26 (7.3%); p=0.001; OR=0.02; 95% CI 0.001–0.33) were observed only in the

CEE group, which was reflected in the maximum values of the combined end point: group 1: n=22 (7.05%); group 2: n=73 (20.4%); p<0.0001; OR=0.29; 95% CI 0.17–0.48). Thus, in the CEE group, every 5th patient had a complication.

CONCLUSION Carotid angioplasty with stenting is the safest method of revascularization for patients in the acute period of ACVA. This is largely due to the reduction in the risk of reperfusion syndrome and the prevention of embolism due to the use of modern protection systems. Carotid endarterectomy can be performed with comparable efficiency only when a temporary shunt is placed in the internal carotid arteries in the absence of unstable atherosclerotic plaque.

Keywords: carotid endarterectomy, eversion carotid endarterectomy, classical carotid endarterectomy, temporary shunt, hemorrhagic transformation, emergency carotid endarterectomy, carotid angioplasty with stenting, stenting of the internal carotid artery, acute period of stroke, circle of Willis

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ACVA - acute cerebrovascular accident
ASP – atherosclerotic plaque
AG – angiogram
BCA – brachiocephalic arteries
BP – blood pressure
Br – brain
CAS – carotid angioplasty with stenting
CCI – chronic cerebral ischemia
CEE – carotid endarterectomy
CI – confidence interval
CILE – chronic ischemia of lower extremities
COPD – chronic obstructive pulmonary disease
CRF – chronic renal failure
DM – diabetes mellitus
EF – ejection fraction
ICA – internal carotid artery
IS – ischemic stroke
LV – left ventricle
MCA – middle cerebral artery
MI – myocardial infarction
MSCT – multislice computed tomography
OR – odds ratio
PCI – percutaneous coronary intervention
PICS – postinfarction cardiosclerosis
PM – pacemaker
TIA – transient ischemic attack
TS – temporary shunt

INTRODUCTION

Today, carotid endarterectomy (CEE) is the first-line operation among the methods of cerebral revascularization (CR) in the presence of hemodynamically significant stenosis of the internal carotid artery (ICA) [1, 2]. However, with the continuous modernization of interventional technologies, carotid angioplasty with stenting (CAS) is being used increasingly as an alternative [3–5]. The debate about which method is better - CEE or CAS - never subsided. [3–7]. In the work of LaiTe Chen et al., which included 17,074 CAS and 110,247 CEE, logistic regression showed that patients undergoing CEE had a lower chance of developing postoperative ventricular arrhythmia (odds ratio (OR) = 0.81, 95% confidence interval (CI): 0.66-0.98), neurological complications (OR = 0.55, 95% CI: 0.51-0.59), death (OR = 0.52, 95% CI: 0.42-0.64) [6]. A systematic review by Stavros K. Kakkos et al. 9 randomized controlled trials were identified involving 1479 patients who underwent CEE and 2230 - CAS. The incidence of acute cerebrovascular accident (ACVI) and death after 30 days was significantly higher for CAS (2.94%) compared with CEE (1.89%): OR = 1.57; 95% CI = 1.01-2.44; p=0,044. In addition, the ACVA level after 30 days was significantly higher for CAS (2.90%) than for CEE (1.82%): OR = 1.63; 95% CI =1.04–2.54; p=0.032 [7]. According to the results of the large CREST study, the incidence of periprocedural stroke and mortality after CAS was also higher than after CEE (6.1% versus 1.3%; p=0.01) [8]. Dakour Aridi H. et al. In a study involving 95,687 patients, it was found that in the 30-day postoperative period, re-hospitalization due to vascular complications was more likely after CAS compared with CEE (5.8% versus 3.8%; p=0.003). Also, patients re-hospitalized after CAS stayed in the hospital longer (5 days versus 4 days; p = 0.001) and had an increased hospital mortality (6.2% versus 2.8%) [3].

Indeed, if the phenomenon of restenosis after CEE is more likely in a period exceeding 6 months as a result of neointimal hyperplasia, then for CAS the loss of the vessel lumen at the hospital and 30-day postoperative stage more often becomes acutely symptomatic and is caused by stent thrombosis, bending, residual stenosis, [9–11]. However, according to the analysis carried out by B.G. Alekyan et al., large randomized controlled trials NASCET, ECST, SAPPHIRE, ACST-1, ACAS, CAVATAS, CREST, SPACE, SPACE-2, ECST-2, CREST-2 have not demonstrated a clear advantage of one revascularization method over another one. At the same time, the authors come to a unanimous opinion that CEE is the operation of choice in the presence of hemodynamically significant stenosis of the ICA, and CAS may be more preferable in the case of a high surgical risk of open reconstruction [12]. However, national guidelines

suggest that CAS should not be used when there is a high risk of complications in asymptomatic and elderly patients (evidence level C), but its use is justified in symptomatic patients with high surgical risk. [1]. There is some dissonance between the current prescriptions and the latest research, possibly due to the fact that the domestic recommendations were adopted in 2013 and took into account the level of interventional technologies that existed at that time. At the same time, even a small step forward by 5 years could have already changed the general conceptual opinion about the place of CAS in modern carotid surgery.

Despite an impressive layer of research devoted to comparing the results of the CEE and CAS, the issue of using these technologies in the conditions of the acutest period of ONMK has not yet been closed. The national guidelines indicate vague timelines for the possible application of CEE. It can be implemented with a minor stroke within 2 weeks, with a full stroke (more than 3 points on the Rankin scale) – after 6–8 weeks [1]. At the same time, taking into account the classification of ACVA periods, within 2 weeks from the onset of neurological symptoms, both the most acute (up to 3 days) and acute (up to 28 days) stages of stroke fit [13]. In which of these time intervals, the CEE would be safer remains unclear. As for the CAS, the recommendations do not provide indications for its use on an emergency basis, but allow the implementation of this technique in symptomatic high-risk patients when CEE is not possible. By all definitions, the term "symptomatic" in this context means a history of stroke or transient ischemic attack (TIA) [1]. However, the national guidelines do not indicate exactly what time interval should elapse between a neurological event and CAS, which creates additional uncertainty in the choice of revascularization strategy for a given cohort of patients. The results of numerous studies, cited above, do not allow us to assert with complete confidence the safety of interventional correction, comparable to CEE, in planned patients as well. Despite this, the performed CAS volumes in Russia for 2019 reached impressive figures – 5081 cases, which begins to create worthy competition for open reconstruction, thereby confirming its effectiveness [14]. Thus, the question of the place of CAS in emergency carotid surgery can be resolved only with consideration of the new postulates of national recommendations. In turn, this requires large-scale research to study this problem.

The aim of this multicenter study was to study the hospital results of emergency CEE and CAS in the most acute period of stroke.

MATERIAL AND METHODS

This cohort comparative retrospective open-label study for the period from January 2008 to August 2020 included 615 patients with hemodynamically significant ICA stenoses who were operated on in the most acute period of ischemic stroke (IS) (within 3 days from the onset of stroke). Depending on the type of revascularization implemented, all patients were divided into 2 groups: group 1 - CAS (n = 312); group 2 - CEE (n = 357). The choice of the timing and method of revascularization was carried out by a multidisciplinary council, including a cardiovascular surgeon, endovascular surgeon, neurosurgeon, cardiologist, neurologist. The risk stratification of postoperative complications and the severity of the comorbid background were assessed using a scale EuroSCORE II. The severity of coronary lesions was assessed using a scale SYNTAX Score. The state of neurological status was determined according to the following scales: NIHSS, modified Rankin scale, Bartel scale and Rivermead mobility index. Inclusion criteria were: 1. Mild neurological disorders: from 3 to 8 points on the NIHSS scale; no more than 2 points on the Rankin modification scale; more than 61 points on the Bartel scale; 2. Indications for EEE / CAS according to the current national recommendations; 3. Ischemic focus in the brain is not more than 2.5 cm in diameter. Exclusion criteria: 1. Presence of contraindications to CEE / CAS.

Carotid angioplasty with stenting was performed according to the standard technique. The following types of stents were used: RX Acculink («Abbot Vascular»), Protégé RX («Medtronik»), Precise Pro RX («Cordis Corporation»), RX Xact («Abbot Vascular»), CGuardTM Embolic Prevention System (EPS) («InspireMD»), Cristallo Ideale («Medtronik»), WALLSTENT™ («Boston Scientific Corporation»). Devices were used to prevent embolism: Filter Wire EZ («Boston Scientific Corporation»), RX Accunet («Abbot Vascular»), Spider FX («Medtronik»), Emboshield NAV («Abbot Vascular»), ANGIOGUARD™ RX («Cordis Corporation»). The compensatory capabilities of cerebral blood flow during CEE at both institutions were assessed as follows. A pharmacological increase in blood pressure (BP) up to 190/100 mm Hg was performed, 5000 IU of heparin was injected intravenously, the arteries were clamped. An invasive measurement of the retrograde pressure in the ICA was performed. At a BP level less than 60% of the systemic BP, a temporary shunt (VS) was used. Also, during the operation, all patients underwent cerebral oximetry using the Invos 5100 C apparatus (Medtronic). With a decrease in oximetry indicators below 30% of the initial value, the VS was installed.

In the postoperative period, all patients underwent MSCT GM. In the absence of negative dynamics in the neurological status – on the 7th day after the operation, in the presence of negative dynamics – urgently.

Control points were understood as the development of such unfavorable cardiovascular events as death, MI, ACVA / TIA, "silent" ACVA, "silent" hemorrhagic transformations, bleeding type 3b and higher on the Bleeding Academic

Research Consortium (BARC) scale, ICA thrombosis, combined end point (death + all ONMK / TIA + IM). Strokes identified according to the control MSCT of GM and without symptoms were considered as "dumb" strokes.

The study was carried out in accordance with Good Clinical Practice and Declaration of Helsinki principles.

The type of distribution was carried out using the Kolmogorov-Smirnov test. The groups were compared using Pearson's chi-square test with Yates and Mann – Whitney corrections. Differences were assessed as significant at $p < 0.05$. Research results processed using a package of applied programs Graph Pad Prism (www.graphpad.com).

The groups were comparable in terms of the overwhelming number of indicators. Most of the patients were of the male sex and corresponded to old age. Every 5th patient had a history of myocardial infarction, about half of the entire sample suffered from stroke / TIA. The EuroSCORE II indicator in the general cohort was 3.45 ± 2.1 points, which corresponded to the average severity of the comorbid background (Table. 1).

Table 1

Clinical and demographic characteristics

Index	Group 1 (CAS)		Group 2 (CEE)		p	OR	95% CI
	n=312	%	n=357	%			
Age, years	63,8±5,9	–	64,6±5,9	–	0,16	–	–
Male	184	58,9	198	55,5	0,4	1,15	0,84–1,57
Angina pectoris I – II FC	137	43,9	126	35,3	0,59	0,91	0,68–1,22
PICS	65	20,8	61	17,1	0,25	1,27	0,86–1,88
DM	44	14,1	34	9,5	0,08	1,56	0,96–2,51
COPD	7	2,24	13	3,6	0,4	0,6	0,23–1,54
PM implantation	5	1,6	8	2,24	0,75	0,71	0,23–2,19
CILE ⩾2 ст.	55	17,6	52	14,6	0,33	1,25	0,82–1,89
Smoking	154	49,3	169	47,3	0,65	1,08	0,8–1,47
Atrial fibrillation	57	18,3	63	17,6	0,91	1,04	0,70–1,54
CRF	20	6,4	22	6,2	0,97	1,04	0,55–1,95
MFA (subclinical) with hemodynamically significant lesion of three pools	61	19,5	78	21,8	0,52	0,86	0,59–1,26
LV EF	59,8±2,3	–	60,7±3,1	–	0,32	–	–
Pulmonary hypertension	1	0,32	2	0,6	0,9	0,57	0,05–6,32
Postinfarction LV aneurysm	2	0,64	5	1,4	0,56	0,45	0,08–2,34
PCI in the past	57	18,3	68	19,04	0,87	0,95	0,64–1,40
CABC in the past	6	1,9	9	2,5	0,79	0,75	0,26–2,15
Real ACVA / TIA repeated	113	36,2	126	35,3	0,86	1,04	0,75–1,42
CILE ⩾2 ст.	312	100	357	100	–	–	–
EuroSCORE II, M±m	3,4±2,5	3,5±1,7	0,51	–	–	–	–

Notes: CAS — carotid angioplasty with stenting; CABC — coronary artery bypass grafting; CEE — carotid endarterectomy; LV — left ventricle; MFA — multifocal atherosclerosis; ACVA — acute cerebrovascular accident; PICS — postinfarction cardiosclerosis; DM — diabetes mellitus; TIA — transient ischemic attack; CILE — chronic ischemia of lower extremities; COPD — chronic obstructive pulmonary disease; CKF — chronic kidney failure; LVEF — left ventricular ejection fraction; EF — ejection fraction; FC — functional class; PCI — percutaneous coronary intervention; PM — pacemaker

RESULTS

When analyzing angiographic parameters, the groups did not differ. Every 5th patient had a contralateral occlusion of the ICA; in one third of cases, an unstable atherosclerotic plaque (ASP) was visualized. Damage to the coronary bed was moderate (Table 2).

Table 2

Angiographic and perioperative characteristics

Index	Group 1 (CAS)		Group 2 (CEE)		p	OR	95% CI
	n=312	%	n=357	%			
Percentage of ICA stenosis	–	77,9±3,6	–	81,2±4,5	0,35	–	–
Contralateral ICA occlusion	58	18,9	65	18,2	0,97	1,02	0,69–1,51
Unstable ASP	94	30,1	109	30,5	0,97	0,98	0,70–1,36
SYNTAX Score, scores	11,5±3,7	–	12,3±3,6	–	0,41	–	–
ICA clamping time, minutes	–	–	26,8±4,1	–	–	–	–
CEE classical	–	–	145	40,6	–	–	–
CEE eversional	–	–	212	59,4	–	–	–
Temporary shunt application	–	–	119	33,3	–	–	–

Notes: ASP — atherosclerotic plaque; ICA — internal carotid artery; CAS — carotid angioplasty with stenting; CEE — carotid endarterectomy

In the open surgery group, the eversion technique was used more often. In this case, the ICA clamping time was within the optimal values.

When analyzing hospital complications, significant differences were not obtained in the frequency of death, the occurrence of MI, stroke / TIA (ischemic type), as well as "silent" stroke. However, the vast majority of hemorrhagic transformations were recorded in the CEE group, which was reflected in the maximum values of the combined endpoint. Thus, in the CEE group, every 5th patient received a complication (Table 3).

Table 3

Hospital complications

Index	Group 1 (CAS)		Group 2 (CEE)		p	OR	95% CI
	n=312	%	n=357	%			
Death	6	1,92	8	2,24	0,98	0,85	0,29–2,49
Myocardial infarction	5	1,6	5	1,4	0,91	1,14	0,32–3,99
ACVA (ischemic type) / TIA	5	1,6	6	1,7	0,82	0,95	0,28–3,15
"Silent" ACVA (ischemic type)	7	2,2	15	4,2	0,23	0,52	0,21–1,30
Hemorrhagic transformation	2	0,64	13	3,6	0,018	0,17	0,03–0,76
"Silent" hemorrhagic transformation	0	0	26	7,3	0,001	0,02	0,001–0,33
ICA thrombosis	1	0,32	0	0	0,94	3,44	0,13–84,89
Bleeding type 3b or higher, BARC	3	0,96	6	1,7	0,63	0,56	0,14–2,29
Combined endpoint (death + ACVA / TIA (all) + MI)	22	7,05	73	20,4	<0,0001	0,29	0,17–0,48

Notes: ICA — internal carotid artery; MI — myocardial infarction; CAS — carotid angioplasty with stenting; CEE — carotid endarterectomy; ACVA — acute cerebrovasacular accident; TIA— transient ischemic attack

ACVA of ischemic and hemorrhagic type in group 2 was characterized by a more severe neurological deficit, which was reflected in negative dynamics on all scales during 7 days of postoperative observation (Table 4).

Table 4

Dynamics of neurological status

	Group 1 (CAS) before surgery	Group 2 (CEE) before surgery	p1-2	Group 1 (CAS) (7th day after surgery)	Group 2 (CEE) (7th day after surgery)	p1-2	p (dynamics)
NIHSS	5,81±0,8	6,72±0,5	0,33	4,83±0,2	7,9±0,3	0,003	p (Gr.1): 0,04 p (Gr.2): 0,0001
Rivermead Mobility Index	10,2±2,0	11,5±2,5	0,91	11,5±2,5	10,1±1,4	0,09	p (Gr.1): 0,74 p (Gr.2
Modified Rankin Scale	1,72±0,4	1,86±0,5	0,45	1,7±0,53	3,07±0,47	0,05	p (Gr.1): 0,64 p (Gr.2): 0,03
Bartel scale	75,3±9,2	74,6±5,4	0,18	83,1±5,2	62,5±8,1	0,01	p (Gr.1): 0,58 p (Gr.2): 0,01

Notes: CAS — carotid angioplasty with stenting; CEE — carotid endarterectomy

Against this background, we present two most indicative cases of stroke development after emergency CEE with an analysis of the reasons for their formation and a negative outcome against the background of the full volume of surgical and conservative treatment in the postoperative period.

Clinical cases

Patient K., 57 years old. He was admitted to the clinic in a planned manner for coronary angiography (CAG) and BCA angiography (AG BCA). It is known that the patient has been suffering from arterial hypertension for several years (max blood pressure 240/100 mm Hg, adapted to blood pressure 130/80 mm Hg), the clinical picture of angina pectoris – for three years. He twice underwent ischemic stroke in the pool of the left middle cerebral artery (MCA); the results of color duplex scanning of ICA revealed 65% stenosis of the left ICA. According to CAG data: occlusion of the circumflex artery and 80% stenosis of the right coronary artery (Fig. 1). According to the results of ICA AG, 70% stenosis of the ICA on the left is determined (Fig. 2).

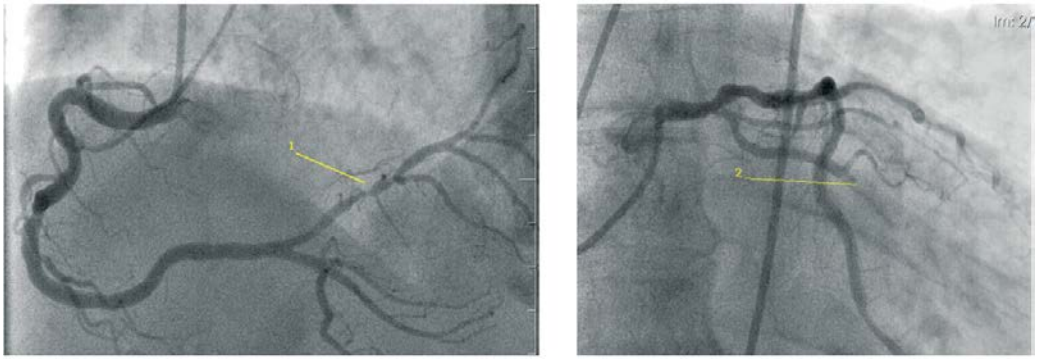

Fig. 1. Coronary angiography: 1 — stenosis of the right coronary artery; 2 — occlusion of the circumflex artery

Fig. 2. The results of brachiocephalic artery angiography: stenosis of the internal carotid artery on the left

On the first day after coronary angiography, the patient has an increase in neurological deficit: the development of sensorimotor aphasia, right-sided hemianopsia, paresis of the 7th pair of cranial nerves on the right according to the central type; while the patient sits down on his own, stands on his feet, walks. Then the patient underwent MSCT of the brain, which revealed: signs of chronic ischemia of its substance, the zone of cystic-gliosis transformation in the left parietal lobe (Fig. 3 - 1), communicating hydrocephalus according to the substitution type.

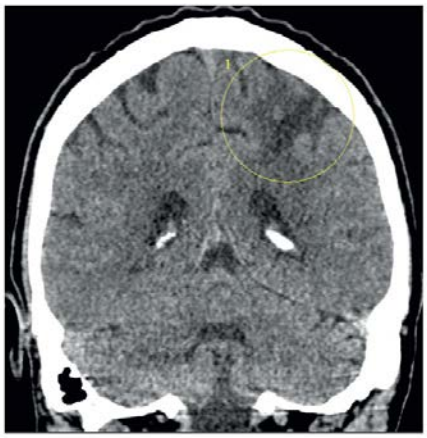

Fig. 3. Results of multislice computed tomography of the brain: 1 — area of cistous and gliotic transformation of the left parietal lobe

Given the stable course of coronary artery disease, the distal nature of coronary artery disease (3rd order small diameter arteries, the presence of collaterals to occlusion) and the relative low risk of cardiovascular events, emergency percutaneous coronary intervention (PCI) is not indicated. Considering the hemodynamically significant symptomatic stenosis of the ICA on the left, the TIA clinic in the left MCA pool, the patient's stable condition and clear consciousness, the patient was transferred to the neurosurgical department for CEE on the left on an emergency basis.

Carotid endarterectomy was performed according to the classical technique with plasty of the reconstruction zone with a xenopericardial patch. Intraoperatively, signs of an unstable atherosclerotic plaque were revealed in the form of areas of calcification and ulceration (Fig.4).

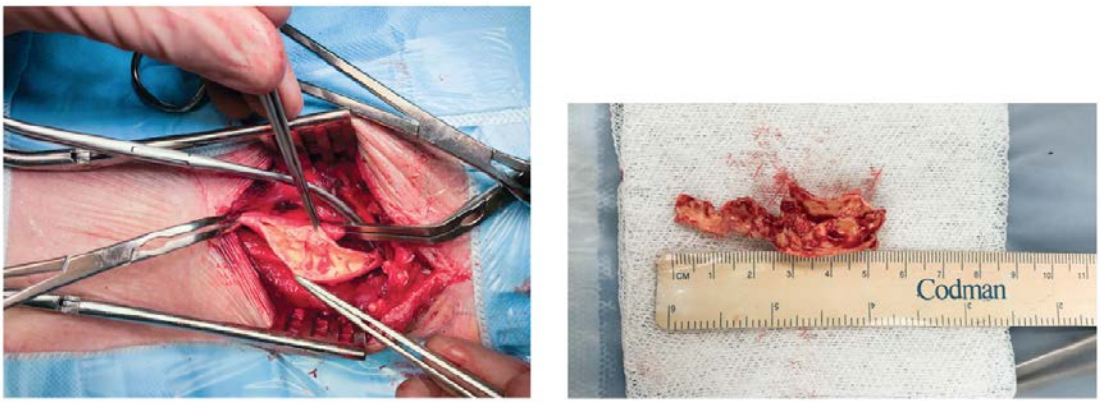

Fig. 4. Intraoperative pictures of stenosis area and atherosclerotic plaque

After the operation, an increase in neurological symptoms was revealed in the form of increased hemiparesis, the development of aphasia and psychomotor agitation. The patient underwent MSCT of the brain, according to the results of which data for stroke were not obtained (Fig. 5).

Fig. 5. Results of multislice computed tomography of the brain in early postoperative hours

Further, a color duplex scan was carried out, according to the results of which it was found that the arteries in the reconstruction zone were patent. To verify the diagnosis of stroke in the early postoperative period, it was decided to conduct MSCT of the brain with perfusion. During the MSCT perfusion study, the zone of hypoperfusion was visualized in the left parietal lobe, the zone of the penumbra from the “forehead-crown” junction to the “crown-back of the head” junction (Fig. 6).

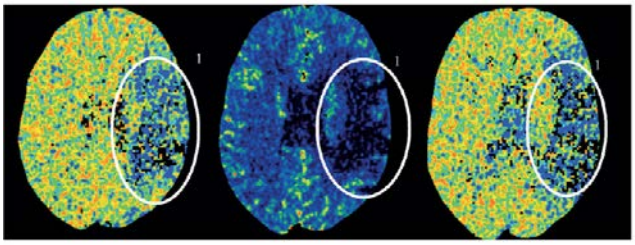

Fig. 6. MSCT-perfusion study: 1 — hypoperfusion area

The patient was transferred to the resuscitation and intensive care unit, medical therapy for IS was started. The next day after CEE, repeated MSCT of the brain was performed, which revealed an extensive ischemic focus in the previously verified zone of hypoperfusion (Fig. 7).

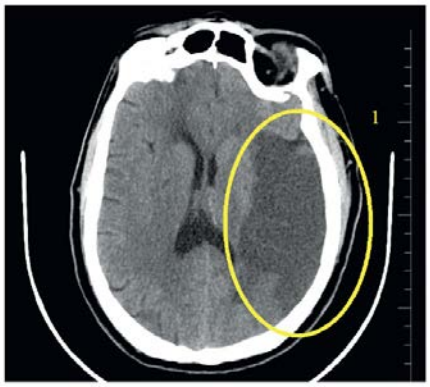

Fig. 7. Multislice computed tomography of the brain on the following day after carotid endarterectomy: 1 — acute cerebrovascular accident of ischemic type in the left parietal-temporal region

Against the background of the therapy started on time, positive dynamics were obtained and on the 8th day after CEE, the neurological deficit returned to the preoperative level, which made it possible to refer the patient for further treatment and rehabilitation to the neurological department.

Thus, this clinical example demonstrates not only a mandatory set of perioperative studies necessary to resolve the issue of choosing the timing of CEE for patients with multifocal atherosclerosis, but also the result of using a diagnostic procedure that is not included in the standards of care for patients with hemodynamically significant BCA stenoses according to data MSCT with perfusion. Detection in the first postoperative hours of areas of hypoperfusion of the brain made it possible to start the therapy of the revealed IS on time and to avoid an unfavorable outcome of the disease.

Patient Z., 54 years old. He was admitted to the institution in a planned manner to perform the CEE on the left. Earlier, according to the MSCT-AG data, the patient had ICA subocclusion on the left (Fig. 8).

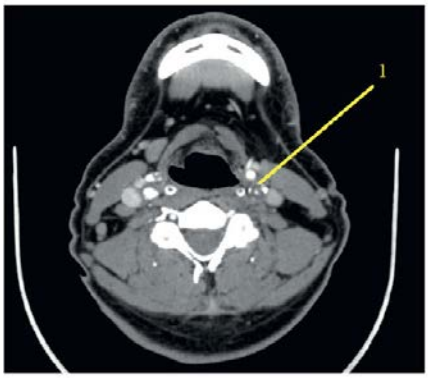

Fig. 8. Multislice computed tomography — angiography of brachiocephalic artery: 1 — subocclusion of internal carotid artery on the left

At the same time, as a result of a mandatory study of the viability of the circle of Willis, a variant structure was visualized: the left posterior communicating artery continues into the posterior cerebral artery and forms a complete posterior trifurcation (Fig. 9 - 2), the right posterior communicating artery is absent (Fig. 9 - 1), the vertebral arteries are asymmetric – the right artery is hypoplastic.

Fig. 9. Angiography of the circle of Willis: 1 — absence of the right posterior communicating artery; 2 — trifurcation area

Three hours before the operation, the patient had a growing neurological deficit: the development of right-sided hemiparesis, psychomotor agitation. After the MSCT of the GM, data on the presence of CVA were not received. A decision was made to perform the classical CEE with plastics of the reconstruction zone with a xenopericardium patch on an emergency basis. Brain protection was carried out by increasing blood pressure during carotid artery clamping. After the completion of general anesthesia, contact with the patient was not established, the level of consciousness was coma II. The patient underwent MSCT of the brain, according to which it was established: signs of acute intracerebral hematoma on the left, a bridge on the left with a breakthrough of blood into the ventricular system, hemotamponade of the IV ventricle. Edema of the substance of the brain. Median dislocation (Fig. 10).

Fig. 10. Multislice computed tomography of the brain in the postoperative period: 1 — acute intracerebral hematoma

In the neurosurgical department an emergency surgical intervention was performed: resection craniotomy in the fronto-parietal-temporal region on the left, removal of an intracerebral hematoma of the left hemisphere, installation of an intracranial pressure sensor. В послеоперационном периоде сохранялось тяжелое состояние, уровень сознания — кома II. On the next day, a control MSCT of the brain was performed, according to which small fragments of residual blood are visualized in the left subcortical nuclei and along the surgical approach; pronounced perifocal edema of the substance of the left hemisphere with the transition to the left cerebral peduncle. Areas of secondary ischemia from the contralateral side: in the thalamus, right cerebral peduncle, internal capsule. The same volume of blood remains in the lateral and 4th ventricles; the minimum amount of blood in the cavity of the 3rd ventricle; moderate in the plumbing. Smoothness of the furrows of the cerebral hemispheres (Fig. 11).

Fig. 11. Multislice computed tomography of the brain on day 2 after the removal of intracerebral hematomas: 1 — residual hematoma, cerebral edema

Against the background of intensive treatment (infusion, nootropic, antibacterial, analgesic, hypothermia), a slow negative dynamics was noted in the form of aggravation of consciousness to coma III, atony, areflexia, and the appearance of unstable hemodynamics. Death occurred on the 9th day after CEE.

Thus, intraoperative hemorrhagic stroke is the most formidable complication of CEE, accompanied by a serious neurological deficit and an unfavorable prognosis. In this clinical example, the cause of the incident was the development of hyperperfusion syndrome against the background of insufficient collateral blood flow due to the abnormal structure of the circle of Willis.

DISCUSSION

According to the data of the European Society of Vascular Surgery (ESVS), it is known that in symptomatic patients, the implementation of carotid interventions is indicated as soon as possible, since the period of maximum risk of recurrent stroke includes the first 7-14 days from the onset of the neurological process [15]. According to ESVS, it is advisable to perform both CEE and CAS, but for the latter the levels of evidence are much lower. Thus, both in our country and abroad, the interventional approach to the correction of ICA stenosis on an emergency basis takes only an alternative position after CEE [15].

In Russia, the results of CEE and CAS in the most acute period of ACVA were studied earlier. However, most often they counted single observations. In addition, the overwhelming majority of studies did not distinguish between the periods after stroke on the most acute (up to 3 days) and acute (up to 28 days), thereby misleading practicing doctors. In the work of A.I. Khripun et al. only 15 patients with CEE and 5 with CAS were included. The operations were performed in the period from 2 to 7 days after the stroke. Neurological deficit in the form of TIA was recorded intraoperatively during the performance of the interventional procedure. At the same time, it remained unclear what period of ACVA was really in question. The authors concluded that revascularization could be effective if the following conditions were combined: neurological deficit of no more than 3 points on the Rankin scale and no more than 11 points on the NIHSS scale, the size of the ischemic focus in the brain ⩽4 см [16]. In a study by D.A. Altman, 32 patients underwent CEE, 20 - CAS. Aagain the same mistake was made. The title of the article mentioned only the acute period of ACVA, and in fact, revascularization was carried out in a period of "from several hours to 2 weeks". In the open surgery group, one stroke was recorded as a result of technical deficiencies that resulted in ICA thrombosis. In the cohort of interventional procedures, one TIA was obtained intraoperatively [17]. In the work of A.I. Zozulya the results of CEE and CAS in acute IS were also studied. However, the interventions were performed in the period from 3 hours to 10 days. However, the overall complication rate reached 24.7%. Conclusions were made about the greater efficiency of the CEE [18]. Despite the overwhelming number of studies combining the most acute and acute period of stroke in a single concept of acute stroke, there are works that correctly delimit the scope of revascularization. So, in the work of A.A. Fokin et al. 86 patients underwent emergency CEE within 6 hours from the onset of the disease. Negative dynamics in neurological status was obtained in 11 patients (12.9%), lethal outcome - in 7 (8.1%) [19]. However, in the overwhelming majority of domestic works are devoted only to isolated successful cases of CEE in the acute period of ACVA, although the centers in which they were implemented perform hundreds of planned CEE and CAS [20, 21].

Against this background, foreign authors demonstrate more specific results of brain revascularization precisely in the most acute period of stroke. Thus, in the study by B.T. Jankowitz et al. 59 CEE and 61 CAS were performed within 48 hours from the onset of neurological deficit. In terms of stroke + death, the groups were comparable: 5.1% (n = 3) and 4.9% (n = 3) [22]. In the study of P. De Rango et al. the same indicator was 3.8% and 6.9% after CEE and CAS, respectively. The overall risk of perioperative stroke was 3.3% (95% CI, 2.1–4.6) after CEE and 4.8% (95% CI, 2.5–7.8) after CAS [23]. In a study by A. Roussopoulou et al. 63 patients underwent emergency CAS, and 248 – emergency CEE. The authors demonstrated that open surgery was associated with a slight increase in the risk of stroke [24].

The results of our work demonstrate a large number of postoperative stroke of a different nature. It should be borne in mind that more than half of them were of a "dumb" nature. Due to the fact that in the postoperative period all patients underwent MSCT AG of the brain, it was possible to identify those patients in whom ACVA proceeded secretly, without any negative dynamics in the neurological status. Indeed, in studies conducted earlier on elective patients, a similar trend has been proven repeatedly. [25–27]. It is difficult to assume whether the picture of the lesion worsened when performing emergency CEE and CAS, but the risk factors leading to such a trend corresponded to the present reality. So, according to R.A. Vinogradov et al., the predictors of the development of "silent" ischemic events in the brain after CEE are old age, the absence of the anterior communicating artery, atrial fibrillation, the use of IS. After CAS - embolic ASP in the ICA and atrial fibrillation [25]. However, the data obtained in our study helped to prove that in all cases when IS was used, no hemorrhagic transformations of the brain were recorded. In the work of P. Perini et al., who studied the routine use of IS among patients in the acute period of stroke, the effectiveness and safety of this method was presented [28]. This approach allows maintaining the hemodynamic blood pressure in the ipsilateral ICA throughout the entire CEE, reducing the risk of reperfusion stroke. Probably, it is the factor of constancy of the hemodynamic flow that reduces the number of hemorrhagic transformations after an emergency CAS, since during this procedure, arterial clamping does not occur [29, 30].

Summarizing the results of our work, it is necessary to emphasize a more negative trend in the neurological status after CEE relative to CAS. This is due not only to the presence of a larger number of postoperative stroke of a different nature, but also to negative dynamics according to various scales (Rankin, NIHSS, etc.) without significant rehabilitation potential. In all cases, we performed revascularization in the presence of an ischemic focus in the brain that did not exceed 2.5 cm in diameter. However, this approach did not become the key to the success of the studied reperfusion interventions. In our opinion, in the overwhelming majority of cases, ACVA after CAS had an embologic nature, and after CEE – hyperperfusion one. In the first case, the frequency of neurological catastrophes was reduced to suboptimal values using systems of protection against distal embolization. Today, this approach is mandatory when performing such interventions. In turn, for CEE in the most acute period, the national recommendations do not imply additional measures to contain the hyperperfusion syndrome [1]. Returning to the fact that no hemorrhagic transformations were recorded during the use of IS in our work, we can conclude that the IS has a protective effect on the homeostasis of cerebral hemodynamics. However, it should be remembered that the installation of the IS itself is an embologic factor in the formation of new ischemic foci of the brain lesions. Thus, we find ourselves in a vicious circle. The use of IS will really reduce the frequency of ACVA only in the presence of a stable ABP in the ICA. In the case of the opposite conditions, reducing the risk of developing hemorrhagic transformation, we will increase the likelihood of the formation of a new focus of ischemic stroke.

CONCLUSION

For patients in the most acute period of acute cerebrovascular accident, the safest method of revascularization is carotid angioplasty with stenting. This is largely due to a decrease in the risk of reperfusion syndrome and prevention of embolism due to the use of modern protection systems. Carotid endarterectomy can be performed with comparable efficiency only with temporary shunt in the absence of unstable atherosclerotic plaque in the internal carotid artery. Thus, emergency open revascularization may be preferable only if there are contraindications for carotid angioplasty with stenting.

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