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EARLY CEREBRAL REVASCULARIZATION FOR THE PREVENTION OF RECURRENT ISCHEMIC STROKE

Mamadaliev Abdurakhmon Mamatkulovich
Specialized Scientific and Practical Center of Neurosurgery and Neurorehabilitation,
Samarkand State Medical University

Abstract. This study aimed to evaluate the safety and efficacy of early surgical revascularization of the brachiocephalic arteries in patients with acute ischemic stroke. Seven patients underwent carotid endarterectomy or stenting within 7 days of symptom onset. Surgical intervention was performed after stabilization of neurological status at a low NIHSS score. Clinical outcomes, complication rates, and neurological improvement were analyzed and compared with international literature. The results suggest that, with strict patient selection (neurological deficit ≤3 on Rankin and lesion size ≤4 cm), early revascularization may be both safe and associated with improved neurological recovery. Current global data support this strategy for both endarterectomy and stenting. However, broader studies are needed to confirm these findings and develop standardized inclusion criteria.
Keywords: ischemic stroke, carotid endarterectomy, stenting, brachiocephalic arteries, early revascularization, neurological deficit

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РАННЯЯ РЕВАСКУЛЯРИЗАЦИЯ ГОЛОВНОГО МОЗГА ДЛЯ ПРОФИЛАКТИКИ ПОВТОРНОГО ИШЕМИЧЕСКОГО ИНСУЛЬТА

Мамадалиев Абдурахмон Маматкулович
Специализированный научно-практический центр нейрохирургии и нейрореабилитации
при Самаркандском государственном медицинском университете

Аннотация. Целью исследования явилось определение безопасности и эффективности ранней хирургической реконструкции брахиоцефальных артерий у пациентов с ишемическим инсультом. В исследование включены 7 пациентов, которым была выполнена каротидная эндартерэктомия или стентирование в течение 7 суток от момента развития инсульта. Хирургическое вмешательство проводилось после достижения неврологического плато при стабильно низких значениях по шкале NIHSS. Проанализированы клинические исходы, частота осложнений, динамика неврологического статуса и сопоставлены данные с результатами мировой литературы. Результаты показали, что при строгом отборе пациентов (по степени неврологического дефицита и объему ишемии) ранняя реваскуляризация может быть безопасной и сопровождается значительным улучшением неврологических показателей. Представлены современные данные из литературы, подтверждающие оправданность подобной тактики, в том числе при стентировании и эндартэрэктомии. Полученные данные требуют подтверждения в крупномасштабных исследованиях.
Ключевые слова: ишемический инсульт, каротидная эндартерэктомия, стентирование, брахиоцефальные артерии, ранняя реваскуляризация, неврологический дефицит

TAKRORIY ISHEMIK INSULTNING OLDINI OLISH UCHUN BOSH MIYANI ERTA REVASCULARIZATSIYA QILISH

Mamadaliev Abdurakhmon Mamatkulovich
Samarqand davlat tibbiyot universiteti huzuridagi
Ixtisoslashtirilgan ilmiy-amaliy neyroxirurgiya va neyroreabilitatsiya markazi

Annotatsiya. Ushbu tadqiqotda o‘tkir ishemik insultga uchragan bemorlarda brakiosefal arteriyalarni erta jarrohlik yo‘li bilan revaskularizatsiya qilishning xavfsizligi va samaradorligi baholandi. Tadqiqotga insult rivojlanganidan keyin 7 kun ichida karotid endarterektomiya yoki stentlash o‘tkazilgan 7 bemor kiritildi. Operatsiyalar nevrologik simptomlar barqarorlashgandan so‘ng, past NIHSS ballari fonida o‘tkazildi. Klinik natijalar, asoratlar chastotasi va nevrologik holatdagi ijobiy dinamikalar tahlil qilindi va xalqaro adabiyotlar bilan taqqoslandi. Tadqiqot natijalari shuni ko‘rsatdiki, nevrologik tanqislik darajasi va infarkt hajmi bo‘yicha qat’iy tanlov asosida erta revaskularizatsiya xavfsiz bo‘lishi va bemorlarning funksional holatini yaxshilashi mumkin. Dunyodagi zamonaviy adabiyotlar bu yondashuvni tasdiqlaydi, ammo keng miqyosdagi qo‘shimcha tadqiqotlar talab etiladi.

Kalit so‘zlar: ishemik insult, karotid endarterektomiya, stentlash, brakiosefal arteriyalar, erta revaskularizatsiya, nevrologik tanqislik

Introduction. The optimal timing for revascularization of the brachiocephalic arteries following an ischemic stroke remains a subject of ongoing debate among clinicians and researchers [1, 2]. Early intervention on the internal carotid artery (ICA) is primarily aimed at preventing recurrent ischemic events, which, according to international studies, occur in 6.4% of patients within 2–3 days, 19.5% within 7 days, and 26.1% within 14 days following the index stroke [3]. Other studies report a 5–21% recurrence rate within the first month, with mortality reaching up to 30% in recurrent stroke cases [4, 5]. B. Rantner et al. [6] emphasize that patients with symptomatic complicated atherosclerotic plaques in the ICA are at the highest risk of recurrent stroke within the first 48 hours. Both international and domestic guidelines recommend performing carotid endarterectomy (CEA) within two weeks in patients with minor, non-disabling stroke (modified Rankin Scale score ≤3) [7–9]. Nevertheless, the principle of “early surgery” is interpreted variably—some advocate for intervention as early as possible, while others recommend surgery only when clinically and logistically feasible [2, 6]. Multiple studies demonstrate that early surgical treatment of symptomatic ICA lesions is effective and safe in preventing recurrent ischemic events in the carotid territory. However, other data show no significant difference in clinical outcomes (stroke recurrence, all-cause mortality, stroke-related mortality) based on the timing of carotid surgery, suggesting that early revascularization may not provide a distinct advantage [10, 11]. The timing of early carotid artery stenting (CAS) remains even more controversial. Studies report a significantly higher risk of perioperative ischemic complications when CAS is performed within the first 48 hours, particularly in cases involving unstable or ulcerated atherosclerotic plaques [2]. Given the heterogeneity of existing evidence and the lack of consensus, we present the clinical experience of the Neurosurgery Clinic of Samarkand State Medical University, where early surgical intervention was performed in patients with symptomatic carotid artery stenosis during the acute phase of ischemic stroke, emphasizing safety protocols, patient selection, and outcome optimization.
Materials and Methods. Between 2022 and 2024, **seven patients** (5 males and 2 females, mean age: **67 ± 9 years**) underwent **early surgical revascularization** of the brachiocephalic arteries at the **Neurosurgical Clinic of Samarkand State Medical University** within the first **7 days** after the onset of an ischemic stroke. The decision for intervention was made via a multidisciplinary **clinical board**, comprising a **vascular surgeon, neurosurgeon, interventional radiologist, neurologist, and anesthesiologist**. The **average timing of revascularization** was **4.6 days** (range: 2–7 days) post-stroke onset. Importantly, **all interventions were performed after neurological stabilization**, defined as achieving a **neurological plateau**—a state in which the patient’s neurological status remained stable for 24–72 hours prior to surgery, as assessed by the **National Institutes of Health Stroke Scale (NIHSS)** [5]. Preoperative NIHSS scores ranged from **0 to 7**, with a **mean score of 3.9 ± 2.7**, indicating minor to moderate stroke severity. All patients had **documented ischemic lesions** ipsilateral to the carotid or subclavian artery stenosis/occlusion,

verified via **computed tomography (CT)** or **magnetic resonance imaging (MRI)**. Lesion sizes ranged from **4 to 32 mm**, with an average diameter of **10 mm**.

Surgical Techniques. Carotid endarterectomy (CEA) was performed in **four patients**, including: **Three eversion CEAs**; **One classical CEA** with synthetic patch angioplasty and temporary intraluminal shunting. Indications for **temporary shunt placement** included **retrograde ICA pressure <40 mmHg** and **absence of pulse waveform**. All CEAs were performed under **endotracheal general anesthesia** with **cervical plexus block** for regional pain control. Choice of technique was tailored based on **anatomic complexity**, **stenosis localization**, and **patient-specific surgical risk**.

Endovascular Interventions. Two patients underwent **ICA stenting**, based on findings of **multivessel coronary artery disease** detected by **preoperative diagnostic coronary angiography**.

One patient with **complete occlusion of the first segment of the left subclavian artery** and associated **subclavian steal syndrome** underwent **stenting of the occluded segment**, as the suspected etiology of stroke.

Outcome Measures. The following **in-hospital outcomes** were monitored:

- Postoperative **hematoma or wound bleeding**;
- **Recurrent ischemic events** (TIA or stroke);
- **Myocardial infarction**;

All-cause in-hospital mortality. Postoperative NIHSS scores and early neurological recovery were recorded for all patients. No intraoperative complications were observed, and all patients were discharged to either home or a rehabilitation facility based on functional status.

Results and Discussion. The clinical outcomes of early revascularization procedures in patients with acute ischemic stroke are summarized in the accompanying table (not shown here). Notably, **no cases of in-hospital mortality or recurrent postoperative ischemic stroke** were recorded in this patient cohort. **Postoperative complications** were observed in **two patients**:

One patient developed a **surgical site hematoma**, which required wound revision and evacuation. Another patient experienced a **transient ischemic attack (TIA)** during **carotid artery stenting** on **post-stroke day 5**. This patient developed **aphasia and right-sided hemiparesis** immediately following **balloon angioplasty** of the stented internal carotid segment. Angiographically, there was **marked contrast stagnation** distal to the **cerebral protection device**, likely due to **atheromatous embolization**. Full neurological recovery occurred promptly after the **removal of the protection filter**, confirming the suspected mechanism.

Although many studies suggest that **the highest risk for ischemic complications following ICA stenting occurs within the first 48 hours** of stroke onset [2], our findings indicate that **clinically significant events can still occur even beyond this window**, as demonstrated by the TIA on day 5. Neurological recovery during the hospital stay was favorable in most cases. The **mean NIHSS score improved from 3.9 ± 2.7 to 2.0 ± 1.7**, reflecting a nearly **50% reduction in neurological deficit** following surgical or endovascular revascularization.

While numerous international studies have focused on outcomes of **carotid interventions within 14 days** of ischemic stroke onset, **evidence on revascularization during the acute (first 7 days) or hyperacute period remains limited** [6, 12, 13]. In a study by **S.A. Papoyan et al.** [18], carotid endarterectomy (CEA) performed during the acute phase of ischemic stroke in 32 patients showed **no mortality or neurological deterioration**, supporting the safety of early intervention. Inclusion criteria included ICA stenosis ≥60% and Rankin score ≤3.

In the **CREST trial**, **J. Meschia et al.** [15] analyzed outcomes of CEA and carotid artery stenting based on timing from the ischemic event. Among 1,180 patients divided into three groups (1–14 days, 15–60 days, and >60 days), there were **no statistically significant differences** in the composite endpoint of **perioperative stroke or death**, suggesting that timing did not significantly influence the safety of carotid revascularization, regardless of the technique used. Further supporting these findings, **L. de Castro-Afonso et al.** [15] reported **similar rates of early (≤30 days)** and **delayed (30 days to 12 months)** adverse events (stroke, intracranial hemorrhage, major cardiovascular outcomes) between early (≤14 days) and late (>14 days) ICA stenting. The authors

emphasized that **early stenting may be safe** if the **ischemic lesion volume does not exceed one-third of the middle cerebral artery (MCA) territory**.
Similarly, **E. Charmoille et al.** [21] compared early (1–14 days, mean 9.3 days) and delayed (>14 days) CEA outcomes in patients with symptomatic carotid stenosis. Their results showed a **30-day stroke or death rate of 1.7%** in the early group versus **3.5%** in the delayed group. The composite endpoint of **stroke + myocardial infarction + death** was **1.7% vs. 5.9%**, respectively, again demonstrating **comparable or better outcomes with early intervention**.
Taken together, the present clinical data from the **Samarkand Neurosurgery Clinic** support the **feasibility and safety** of **early revascularization (within 7 days)** in carefully selected patients following ischemic stroke. These findings are consistent with broader evidence suggesting that **timely carotid revascularization may reduce the risk of recurrent ischemic events without increasing procedural risk**, particularly when performed during the phase of neurological stabilization. A study by **M.S. Mikhailov et al.** [22] presented outcomes of **surgical treatment in 55 patients** who underwent carotid revascularization in the **acute phase of ischemic stroke**. Inclusion criteria included a **modified Rankin Scale score ≤4**, **NIHSS ≤15**, and **ischemic lesion size ≤60 mm**. Interventions were performed between **1 and 18 days** from symptom onset. The **overall mortality rate was 3.6%**, with two deaths due to **multi-organ failure**; **no recurrent strokes were observed** at autopsy. The mean **NIHSS score decreased from 5.58 to 1.83** postoperatively, and **neurological improvement** was observed in **83% of patients**, while **complete functional recovery (Rankin 0)** occurred in **20%** of cases. The authors concluded that **carotid revascularization within 18 days** is generally safe and effective, with **minimal hemorrhagic or reperfusion-related complications**.
In another retrospective analysis, **A. Ivkošić et al.** [17] evaluated **69 patients** undergoing **early carotid surgery (within 20 days)** for **symptomatic ICA stenosis (70–99%)**. All procedures used **endotracheal anesthesia** and **temporary intraluminal shunting**. The **rate of postoperative stroke** was **2.63% (2 patients)**. The authors highlighted that **early revascularization provides greater protection** against recurrent ischemic events compared to delayed CEA, without an increased risk of perioperative complications.
A large meta-analysis by **P. de Rango et al.** [25], incorporating data from **47 studies**, further supports the safety of **early carotid interventions** (CEA or CAS) within **15 days** after stroke onset. The **perioperative stroke rate** was **3.4% for CEA** and **4.8% for CAS**. Combined stroke + death rates were **3.8% (CEA)** and **6.9% (CAS)**. When limited to **procedures performed within 7 days**, the risk was **3.3% (CEA)** and **4.8% (CAS)**. Notably, when CEA was performed **within 48 hours**, the risk of perioperative stroke was **5.3%**, though outcomes varied by clinical status: **8% for ischemic stroke** vs. **2.7% for TIA**, emphasizing that early surgery is safer in patients with **transient ischemic attacks** than in those with established stroke.
In a more recent clinical study, **I. Barbetta et al.** [26] directly compared outcomes in patients undergoing carotid intervention for **TIA versus acute stroke**. The **median timing** of intervention was **48 hours (range 13–117 hours)**. The findings further confirm that **early surgical or endovascular treatment** is feasible and generally safe when performed in appropriately selected patients, especially during the window of **neurological stabilization**.
These findings align with the experience of the **Neurosurgical Clinic of Samarkand**, where early carotid and subclavian revascularization (within 7 days post-stroke) resulted in **no in-hospital mortality or major neurological deterioration**, and produced favorable functional outcomes.
In the study by I. Barbetta et al., 90 patients were stratified into three distinct groups based on clinical presentation:

- Group A: patients with transient ischemic attacks (TIA) (n = 27),
- Group B: patients with minor ischemic stroke (n = 52),
- Group C: patients undergoing emergency carotid endarterectomy (CEA) during evolving stroke (n = 11).

No postoperative strokes were observed in Group A, while the incidence was 5.8% in Group B and significantly higher at 27.3% in Group C. The overall postoperative mortality rate was 4.4%, with deaths attributed to hemorrhagic stroke, acute myocardial infarction, and recurrent ischemic stroke

in two patients. Due to the unfavorable outcomes in patients with active stroke-in-evolution, the authors advise extreme caution when considering emergency CEA in this subgroup.
Between 2001 and 2010, E. Ferrero et al. [29] assessed the outcomes of early CEA (within 48 hours) in 176 patients following TIA or minor stroke. Patients were divided into three groups:

- Group 1 (n = 55): single TIA;
- Group 2 (n = 55): multiple TIAs;
- Group 3 (n = 66): minor stroke (Rankin score 2–4).

The composite 30-day event rate (TIA + stroke + myocardial infarction + death) was 3.9%, and stroke incidence was 1.8%, 0%, and 7.6%, respectively, across the groups, with no statistically significant differences. The authors concluded that CEA performed within 48 hours may be safe in carefully selected patients, particularly when the primary objective is prevention of recurrent stroke.
According to S. Bruls et al. [30], emergency CEA (performed within 48–72 hours) may be appropriate for neurologically unstable patients, albeit with a slightly elevated perioperative stroke and mortality rate compared to elective CEA. In their single-center prospective study, outcomes were assessed in 48 unstable patients undergoing CEA within 24 hours of symptom onset (mean timing: 10.16 ± 7.75 hours). The cohort included:

- 26 patients with progressing neurological deficits (ischemic stroke, increasing NIHSS score),
- 22 patients with three or more TIAs and NIHSS score of 0.

Only one patient (2%) died due to hemorrhagic transformation of a previously undetected infarct. The authors argue that urgent CEA should be considered in unstable patients following rapid diagnostics, including non-contrast brain CT and duplex ultrasound [12].
A more comprehensive study by B. Rantner et al. [6] included 761 patients with symptomatic ICA stenosis:

- 40.1% presented with TIA,
- 2.3% with amaurosis fugax,
- 38.6% with ischemic stroke.

Patients were categorized by timing of CEA:

- 0–2 days,
- 3–7 days,
- 8–14 days,
- >14 days.

The composite endpoint of stroke + mortality was:

- 4.4% (0–2 days),
- 1.8% (3–7 days),
- 4.4% (8–14 days),
- 2.5% (>14 days), with no statistically significant difference between groups ($p = 0.25$).

These findings suggest that CEA can be safely performed within the first week following an ischemic event in neurologically stable patients, but individualized risk assessment is crucial—particularly for patients with stroke-in-evolution. At the Neurosurgical Clinic of Samarkand State Medical University, these international findings reinforce the observed positive outcomes in early revascularization, provided that patients are selected based on neurological stability, imaging findings, and multidisciplinary consensus. The strategy of timely but cautious intervention remains essential to optimize outcomes and avoid perioperative complications.
According to multivariate regression analyses in several published cohorts, the timing of carotid revascularization does not significantly influence perioperative outcomes when proper patient selection and perioperative protocols are maintained. In a study by P. Gajin et al. [13], 58 patients underwent urgent carotid endarterectomy (CEA) within 6 hours of ischemic symptom onset. Of these, 46 had recurrent TIAs and 12 were experiencing stroke-in-evolution. In the TIA group, no recurrent ischemic events were observed, while 3 patients (25%) in the evolving stroke group developed new ischemic lesions confirmed via follow-up brain CT. There were no perioperative

deaths, and the authors concluded that CEA within 6 hours is a safe and viable approach with acceptable complication rates in appropriately selected patients.
However, a large-scale analysis of 27,839 patients from the U.S. National Registry, who underwent ICA revascularization during stroke hospitalization, suggested that the optimal timing for intervention appears to be toward the end of the first week post-admission [22].
An equally important clinical aspect emphasized by several authors is the improvement in neurological status following early surgical revascularization of the brachiocephalic arteries [10, 19, 23]. In a cohort of 100 patients with NIHSS <5, early CEA performed within 0–14 days showed no significant differences in rates of mortality, myocardial infarction, or perioperative stroke when compared with delayed interventions; however, patients in the early intervention group demonstrated greater improvement in neurological function [23].
Consistently, I. Barbetta et al. [26] reported significant NIHSS score improvement in 79% of patients who underwent CEA approximately 48 hours after the ischemic event. Likewise, in the series by M.S. Mikhailov et al. [22], the mean NIHSS score decreased from 5.58 to 1.83 following ICA revascularization within 18 days of stroke onset.
These collective findings from the international literature indicate that no definitive consensus currently exists regarding the optimal timing for carotid or brachiocephalic artery reconstruction during acute ischemic stroke. Nevertheless, most authors agree on the efficacy and relative safety of early intervention, provided the patient is appropriately selected.
Based on the current data and the clinical experience of the Neurosurgical Clinic of Samarkand, early surgical intervention within the first 7 days may be considered safe and effective in carefully selected patients—those with:

- a modified Rankin Scale score ≤3,
- NIHSS score ≤7, and
- ischemic lesion size ≤4 cm.

Moreover, early revascularization may promote improved postoperative neurological recovery, particularly by reducing motor and sensory deficits.
However, it is important to note that uniform inclusion and exclusion criteria are currently lacking. There is no consensus on thresholds for neurological severity or infarct size, which limits the reproducibility and generalizability of current findings. Thus, the promising results observed in our cohort require validation in larger, prospective studies to further refine the patient selection criteria and optimize treatment algorithms.

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