Occlusions of the brachiocephalic trunk are a rare pathology. In a series of ultrasound screenings, the brachiocephalic trunk occlusions were diagnosed in 20 out of 30,000 examined patients [5] and were detected in patients with manifestations of chronic cerebral ischemia in 1.5–2% of cases on average [12]. Atherosclerosis, nonspecific aortoarteritis, fibromuscular dysplasia, and intima dissection are the major risk factors for the development of occlusions [15]. Due to the well-developed collateral compensation of blood circulation in the chronically occluded brachiocephalic trunk, the clinical picture is frequently presented by progressive circulatory encephalopathy and vertebrobasilar insufficiency, as well as by signs of ischemia in the right hand [2, 3, 14, 15]. Ischemic stroke or transient ischemic attack (TIA) in the basin of the right middle cerebral artery (MCA) is revealed rather infrequently [7]. In this regard, the indications for surgical treatment in such cases essentially depend on the proposed surgical and anesthetic risks of surgical intervention. Despite the current progress in cardiovascular surgery, the use of open thoracic reconstructive surgery is still associated with the high incidence of complications and perioperative mortality; it is not considered to be justified in patients with chronic occlusions of the brachiocephalic trunk [2, 4, 15, 17, 20]. As endovascular surgery was developed, angioplasty and the stenting technique became the “Gold standard” of surgical treatment of stenosing pathology of the proximal aortic arch branches; the rate of technical success is more than 91%, and passability in the reconstructed area is more than 77% of cases during 2 years of follow-up [13, 19]. On the other hand, due to the low rate of successful recanalization (40%) and the risk of ischemic complications, the endovascular treatment of occlusions of the proximal aortic arch branches currently requires further study [1]. Hybrid approaches (open reconstructive interventions in the X-ray surgery room, additionally equipped for performing endovascular angioplasty and stenting under the X-ray optical control) have recently started to be used to improve the effectiveness of surgical treatment of chronic occlusions of the proximal aortic arch departments [8, 11]. This paper provides example of using direct and endovascular techniques to treat patients with chronic occlusion of the brachiocephalic trunk.

Case report

Patient S., 69 years old, was treated at the Burdenko Neurosurgical Institute in September 2009. When admitted to hospital, the patient complained of systemic headache, dizziness, unsteady gait, episodes of numbness and short weakness in the left limbs over the past six months with a frequency of 5–6 times per month, weakness and numbness in his right hand. The neurological status included mild pyramidal symptoms as left-sided hemiparesis and hemiataxia (4 points), increased tendon and periosteal reflexes on the left. Mild left-sided smoothness of the nasolabial fold was revealed. The patient demonstrated instability in Romberg’s test. He had low-amplitude nystagmus in extreme positions, vestibular ataxia, and grade 2 encephalopathy. The somatic status was characterized by coronary artery disease (functional class III), effort angina, hypertension stage II. Furthermore, the patient had chronic obstructive pulmonary disease and emphysema.
An objective examination showed that the right hand was pale, cold, no *a. radialis* pulse on the right side was observed. Blood pressure was 70/50 mm Hg on the right, 140/90 mm Hg on the left. Duplex scanning revealed critical stenosis of the right internal carotid artery (ICA) over 85%, combined with occlusion of the brachiocephalic trunk and signs of the common carotid–vertebral steal syndrome (Fig. 1). Hemodynamically significant stenosis of the left subclavian artery in the 1st segment and opening of the left vertebral artery were observed.

Selective angiography was performed after the patient had been admitted to hospital; the initial diagnosis was confirmed. A direct blood flow in the right common carotid artery (CCA) was found; it was provided by collaterals of the deep cervical arteries and retrograde blood flow in the right vertebral artery (see Fig. 1a).

Progressive chronic cerebral ischemia and TIA in the MCA basin were the reason for surgical intervention. In order to prevent possible complications, a decision was made to simultaneously use direct and endovascular techniques. The surgery was conducted by two teams of surgeons in an X-ray operating room and included three main stages. Taking into account the patient’s physical status and the need for neurodynamic monitoring, local regional anesthesia with blockade of branches of the right brachial plexus was selected as an anesthetic method. Multimodal neuromonitoring was additionally conducted; it included transcranial Doppler ultrasound (TCD) examination to detect the blood flow in the M1 segment of MCA on the right side and cerebral oximetry on the surgery side. Positioning of the patient is shown in Fig. 2a.

At the first stage, the open approach to the neurovascular bundle on the right side was performed. A 10-cm-long skin incision was made along the medial edge of the sternocleidomastoid muscle on the right side. *M. platizma* was dissected. The medial edge of the sternocleidomastoid muscle was mobilized; the muscle was assigned laterally with a retractor. The facial vein was sutured and ligated. The internal jugular vein, along with the surrounding fiber, was displaced laterally. The CCA and its

---

**Fig. 1. Occlusion of the brachiocephalic trunk (3) with formation of the syndrome of vertebral–subclavian and carotid–vertebral steal.**

a – compensation scheme of the collateral blood flow in the right CCA (1) and the subclavian artery (2) due to the retrograde flow from the right vertebral artery (4). The arrows indicate direction of blood flow; b, c – angiographic picture of brachiocephalic trunk occlusion.
bifurcation are isolated. Ripple in arteries was weak (c-horizontal type). A dense atherosclerotic plaque in the area of CCA bifurcation, extending for 3.5 cm proximally to the CCA, was determined by palpation. The plaque was then densified diffusely in the external carotid artery (ECA) and ICA for 1.5 cm and 3.5 cm, respectively. The root of the hyoglossal nerve was located 3 cm above the bifurcation. ICA was isolated throughout 4 cm. The carotid body was coagulated and cut off. Traction sutures were placed on the CCA, ICA, ECA, and the superior thyroid arteries. During the test clamping of the CCA, the linear velocity of blood flow in the MCA on the right side was not reduced (80 cm/s); no focal symptoms were determined. It attested to good compensation of circulation in the basin of the occluded ICA and made it possible to prophylactically isolate the ICA from the bloodstream for a long period of time required for recanalization and stenting of the brachiocephalic trunk and following carotid endarterectomy. After the preliminary systemic heparinization (intravenous administration of 2,500 IU of heparin), the vascular clamps were superimposed on ICA, ECA, and the superior thyroid artery. A 7F introducer fixed with a tourniquet was inserted into the proximal lumen of the CCA through a small linear incision of its anterior wall (Fig. 2b).

At the next step, surgical interventions for recanalization and stenting of the brachiocephalic trunk were performed by the team of endovascular neurosurgeons.

After applying vascular clamps on the ICA and ECA, angiography was performed through the introducer; this showed the presence of occlusion of the brachiocephalic trunk from the aortic arch to the level of its discharge of the subclavian artery, while the latter was passable (Fig. 1b). A 4F catheter was inserted at the occlusion level through the introducer under X-ray control. The Co-Bra CîTop 6 vascular recanalization system (Ovalum) was also introduced through it. This device was used to establish a passage through the atheromatous masses to the aortic arch. Next, stepwise dilation was performed on a 014" microconductor with 2.5×20 mm balloon catheter, and then with a 4×20 mm catheter throughout its length. A delivery system was positioned and the peripheral stent OmniLink 8×28 mm (opened at a pressure of 8 atm) on the Roadrunner 035" conductor was implanted at the occlusion level (Fig. 3a). According to control angiography, direct blood flow in the brachiocephalic trunk and right subclavian artery was restored. At this stage, endovascular surgery was completed. The CCA pulse emerged in the wound. The catheters and the introducer were removed; a clip was superimposed on the CCA.

At the third stage, right-sided direct carotid endarterectomy was performed according to the conventional procedure [21]. The linear incision on the CCA was distally extended along the anterolateral wall of the CCA from the point where the CCA introducer had been inserted (for 3.5 cm) with the transition to the anterior wall of the ICA (for 1.5 cm). A dense heterogeneous atherosclerotic plaque was detected; it had elements of decay that blocked up to 75% of the CCA lumen and up to 95% of the ICA orifice (for 1.5 cm distally from the bifurcation). Open endarterectomy from the CCA bifurcation (for 3 cm distally from it), from the ECA ostium (over 1 cm), and from the ICA ostium (over 1.5 cm) was performed. The arterial lumina were washed with normal saline solution. The remaining hanging small pieces of the plaque were removed with a mosquito clamp. A good retrograde flow from the ICA and mainline bloodstream from the CCA were observed. The arteriotomy opening was closed by continuous encircling stitch, using thread 7.0. Blood flow in the right MCA (during compression) was 70–80 cm/s. The clamps were removed from the arteries in the following order: ECA, CCA, ICA. After starting the blood flow, good pulsation of the arteries in the wound was observed. The total time of arterial clamping was 1 hr 48 min, including 15 min for reconstruction in the area of CCA bifurcation. Hemostasis was achieved.
A hemostatic gauze was applied on the region of arterial suture. The wound was closed with layered stitches until the active drainage to the vascular bundle. Local symptoms were not observed during arterial clamping. After the blood flow had been restored, the linear velocity of blood flow in the MCA increased to 110–120 cm/s.

Control intraoperative angiography showed good passability in the reconstruction zone of the right CCA bifurcation (Fig. 3b). In the postoperative period, the patient received antiplatelet therapy (75 mg of clopidogrel and 100 mg of aspirin daily). The patient noted regression of TIA, increased strength in the left extremities and right hand, as well as partial regression of vertigo.

The patient subsequently underwent routine endovascular angioplasty, stenting of the left subclavian artery, and open endarterectomy of the left vertebral artery os-tium. During the 3-year follow-up, the reconstructed areas were passable; the bloodstream in the brachiocephalic arteries was anterograde and of the mainstream type. The patient was neurologically stable. No TIA was observed.

Discussion

The effectiveness of managing such a rare cause of chronic cerebral ischemia as occlusion of the brachiocephalic trunk considerably depends on the correct strategy of surgical interventions. This clinical case report presents the experience of curing a patient with the subcompensated course of cerebral ischemic disease along with advanced atherosclerosis. In these circumstances, surgical treatment was justified only with the minimal risk of surgical complications [16]. Endovascular recanalization followed by angioplasty and stenting of the brachiocephalic trunk was selected as the main reperfusion method. This minimally invasive technique associated with low perioperative risks has recently started to be used to restore blood flow in proximal aortic arch branches [1, 14]. The relatively low frequency of successful attempts of recanalization (40–50%), especially in cases of long chronic occlusions, limits the practical use of this intervention. Choice of the endovascular approach plays a great role in recanalization success: the closer approach to the occlusion, the more efficient intervention [1]. The transcarotid approach is optimal in patients with occlusions of the brachiocephalic trunk; however, it is associated with a high frequency of complications (cerebral embolism, CCA wall dissection, hemorrhage with developing hematoma of the neck). This approach is currently used in endovascular interventions rather rarely [9, 13]. In order to prevent complications of the conventional transcarotid approach in the described case report, open preparation of the neurovascular bundle on the right side followed by controlled retrograde catheterization CCA through a small arteriotomy incision of the distally occluded CCA was performed. This allowed one to achieve the most favorable conditions for endovascular recanalization of the brachiocephalic trunk. Direct carotid endarterectomy on the right side to treat 85% stenosis of the right internal carotid artery and suturing the arteriotomy incision allowed one to neutralize the drawbacks of the conventional transcarotid endovascular approach and to simultaneously execute planned reconstruction of the carotid arteries. This approach is justified in patients with advanced atherosclerosis, especially in the presence of stenotic lesions of the carotid pool and lower limb arteries (Leriche’s syndrome).

Another important problem in surgery of chronic occlusions of the brachiocephalic trunk is preventing ischemic complications (in particular, cerebral embolism), which requires careful preoperative examination of the collateral circulation [13]. According to the ultrasound and angiographic studies, brachiocephalic trunk

Fig. 3. Results of the surgical intervention.

a – condition after recanalization and stenting of the brachiocephalic trunk,
b – control angiography of the ICA after its reconstruction.
occlusion causes various types of collateral compensation of the blood flow in the CCA, subclavian and vertebral arteries [6, 10, 15]. Syndromes of subclavian–carotid and subclavian–vertebral steal with the formation of retrograde blood flow in the carotid and vertebral arteries are most frequently revealed [6]. Under these conditions, the risks of cerebral embolism and hemodynamic ischemic stroke are minimal, as proven by a series of successful endovascular recanalization with stenting of the aortic arch branches through the transfemoral approach [1, 12, 14].

Occlusions of the brachiocephalic trunk are much less frequently accompanied by the anterograde blood flow in the CCA due to carotid–subclavian steal [6]. In this case report, the patient had direct blood flow in the CCA and ICA supplied by the retrograde flow in the right vertebral artery and collaterals from the deep thoracic arteries (Fig. 1a). In such cases, there is an extremely high risk of ischemic complications due to cerebral embolism during recanalization of the brachiocephalic trunk [13]. This fact makes it necessary to ensure distal protection. When the endovascular approach alone is used, this is limited by technical difficulties and the need for using multiple approaches, which is not always feasible [1, 13]. Open access to the neurovascular bundle made it possible to temporarily “turn off” the ICA and ECA from the blood flow by applying vascular clamps on them. This was a simple and effective method for protecting against cerebral embolism. Multimodal intraoperative neuromonitoring of metabolism and cerebral blood flow (TCD ultrasonography and cerebral oximetry) to assess the tolerability of temporary occlusion of the ICA is important in this case [21]. Signs of cerebral blood flow compensation in the basin of the temporarily occluded right ICA in the reported case allowed one to conduct endovascular and direct stages of surgical interventions on the ICA clamped for 1 h 48 min without the development of neurological deficiency. Signs of sub- or decompression of the cerebral blood flow could serve as a basis for using a temporary intraluminal shunt or distal protection against embolism (traps).

Surgical intervention under local regional anesthesia should be paid special attention. This method is absolutely indicated in patients with a history of severe somatic disorders (in particular, those with severe chronic obstructive pulmonary disease). Neurodynamic monitoring and verbal contact with the patient during the surgery allow one to properly interpret the neuromonitoring data in the case of subcompensation of the cerebral blood flow, when neurological deficiency may develop with a delay [18].

Conclusion

Direct and endovascular methods for surgical management of occlusive pathology of the brachiocephalic arteries are not always competing. The joint use of these approaches, with attention paid to the individual features of a patient, allows one to combine the advantages of each method, increase their efficiency, and improve the quality of surgical treatment of chronic occlusions of the brachiocephalic trunk.

REFERENCES


16. Thalhammer Ch., Aschwanden M., Jäger K.A. Occlusion of the brachioce- 
17. Pokrovsky A.V. Pathologies of the Aorta and Its Branches. Moscow: Medi-
sky A.V., Usachev D. Yu. Early intrasurgery diagnosis of cerebral ischemia 
during carotid interventions. Clinical report on reasonable combination of 
regional and general anesthetic techniques. Regional anesthesia and treat-
19. Bel'yaev D.F., Pokrovsky A.V. Comparative study of delayed results of 
open surgeries and endovascular atherosclerotic stenosis of the brachioce-
and surgical methods for treating aorta arch branch occlusions with cerebro-
treatment of patients with occlusive and stenotic lesions of brachiocephalic 