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Case Report
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A Case of One-Stage Treatment for Six Cerebral Aneurysms of One Carotid Basin with Concomitant Occlusion of the Contralateral Internal Carotid Artery

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ABSTRACT We present a clinical case of successful one-stage treatment of a patient with six cerebral aneurysms of one carotid basin with concomitant chronic occlusion of the contralateral internal carotid artery. The role of hemodynamics in the pathogenesis of brain aneurysms, as well as methods and stages of surgical treatment of patients with multiple aneurysms are discussed.

Keywords: multiple aneurysms, occlusion of the internal carotid artery, etiology and pathogenesis of brain aneurysms
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ACA — anterior cerebral artery
ACHA — anterior choroidal artery
ACoA — anterior communicating artery
AVM — arteriovenous malformation
BCA — brachiocephalic arteries
BP — blood pressure
CAG — cerebral angiography
CT — computed tomography
ICA — internal carotid artery
MA — multiple aneurysms
MRI — magnetic resonance imaging
OA — ophthalmic artery
PCoA — posterior communicating artery
PVD — primary vascular department

INTRODUCTION

Patients with multiple aneurysms (MA) account for 7.3 to 35.6% of all patients with cerebral aneurysms. In patients with MA, two aneurysms are most often detected - from 68 to 78% of all cases. Patients with three aneurysms make up 14 to 25%, with four - 2.9 to 7%, with five - 0.75 to 5%. In isolated observations, 6 or more aneurysms are detected [1].

Hemodynamically significant stenoses and occlusions of the internal carotid artery (ICA) occur in 3% of patients with cerebral aneurysms [2, 3]. The main cause of aneurysm formation is considered to be hemodynamic stress, leading to deformation and stretching of the “weak areas” of the vascular wall [4]. This theory is confirmed by described cases of spontaneous regression of aneurysms when ICA stenosis or occlusion is eliminated [5].

According to a meta-analysis conducted in 2020, only 150 cases of ICA stenosis or occlusion in combination with intracranial aneurysms were documented. Of these, multiple aneurysms in the amount of 2 to 4 were diagnosed in 16 patients (10.7%) [6]. In the literature available to us, we have not encountered cases of detection of 6 aneurysms in the presence of an occluded contralateral ICA.

Surgical tactics for the treatment of multiple intact aneurysms are multivariant. One-stage and multi-stage operations using intravascular, microsurgical and combined methods are widely used in practice [7].

The article presents a female patient with 6 aneurysms of the left carotid pool and occlusion of the contralateral ICA in the supraclinoid segment.

Clinical observation

Patient L., 67 years old, fell ill acutely, on 5.12.23; against the background of intractable high blood pressure (BP), a headache appeared, outpatient treatment was ineffective. She was hospitalized in the primary vascular department (PVD) at her place of residence; magnetic resonance imaging (MRI) of the brain did not detect any evidence of subarachnoid hemorrhage.

Cerebral angiography (CAG) revealed multiple aneurysms of the left carotid pool: the orifice of the left ophthalmic artery (OA) (Fig. 1a.b), left posterior communicating artery (PCoA), left anterior choroidal artery (ACHA), A1 segment of the left anterior cerebral artery (ACA), anterior communicating artery (ACoA) (Fig. 1c), and occlusion of the right ICA in the supraclinoid segment (Fig. 1e). Compensation of arterial blood flow in the right carotid pool is achieved by flowing through the ACoA from the hypertrophied left ACA (Fig. 1d). The patient was transferred for surgical treatment to the Research Institute – Ochapovsky Regional Hospital No.1.

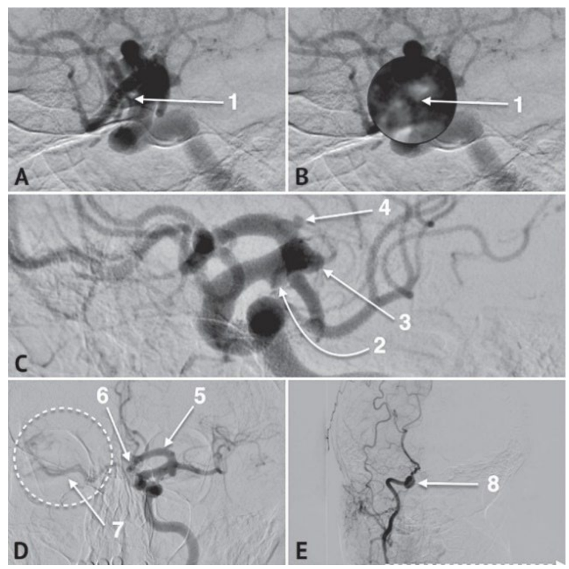

Fig. 1. Cerebral angiography of patient L. before surgery on 08.12.2022: 1 — aneurysm of the left ophthalmic artery (A, B); 2 — aneurysm of the left posterior communicating artery (C); 3 — aneurysm of the left anterior villous artery (C); 4 — aneurysm of the A1 segment of the left anterior cerebral artery (C); 5 — hypertrophied left A1 anterior cerebral artery (D); 6 — aneurysm of the anterior communicating artery (D); 7 — the right carotid basin is filled through the anterior communicating artery (D); 8 — occlusion of the right internal carotid artery in the supraclinoid region (E)

On admission, the patient's condition was satisfactory. Neurological status: complaints of headache and dizziness. Somatic status: no gross deviations from the norm. The patient’s endocrine disorders: hypothyroidism (she underwent surgery for nodular goiter), and type 2 diabetes mellitus in the compensation phase.

Due to the non-optimal shape of the dome for intravascular occlusion and the small size of the existing aneurysms, it was decided to refrain from intravascular treatment. Considering the asymptomatic type of aneurysmal disease, the availability of all existing aneurysms from one surgical approach, a decision was made to perform simultaneous clipping of all existing aneurysms from an open access.

From the left-sided pterional approach, the left ICA was isolated to the level of the bifurcation. Hypertrophy of the left ACA was noteworthy (Fig. 2A).

It was found that the presumed small aneurysm of the left ophthalmic artery orifice was actually a distal aneurysm arising from the OA trunk (Fig. 2B). The aneurysm of the left posterior communicating artery orifice was “blister-like” (Fig. 2C). A medium-sized aneurysm of the left ACHA orifice and a small aneurysm of the A1 segment of the left ACA with a posteriorly directed dome have a typical saccular structure (Fig 2D, E).).

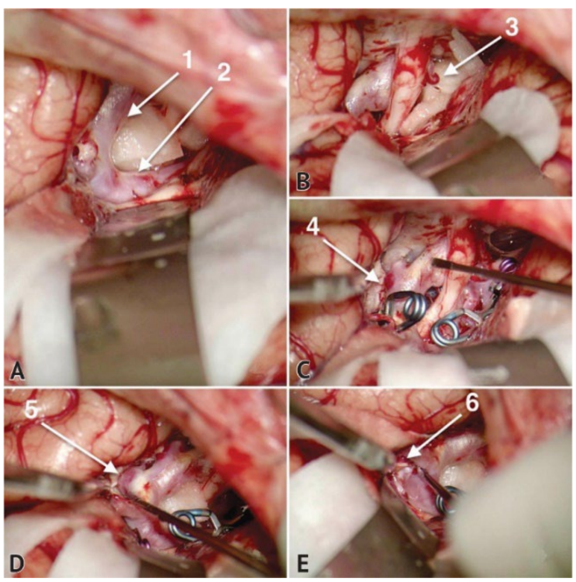

Fig. 2. Intraoperative photo. A — hypertrophied left anterior cerebral artery (2) comparable in diameter to the internal carotid artery (1); B — aneurysm of the left ophthalmic artery (3); C — aneurysm of the left posterior communicating artery (4), clips are visualized on the aneurysms of the anterior villous and anterior communicating arteries; D — aneurysm of the left anterior villous artery (5), a clip is visualized on the aneurysm of the anterior communicating artery; E — aneurysm of the A1 segment of the left anterior cerebral artery (6)

After dissection of the interhemispheric fissure and economical resection of the straight gyrus, the ACoA complex was isolated. A doubling of the ACoA was determined (Fig. 3b), on each of those aneurysms were found: a medium-sized aneurysm with an anterior dome direction and a small aneurysm with an inferior dome direction (Fig. 3a). Thus, 6 aneurysms were clearly verified. To exclude shielding by previously applied clips, the final neck isolation and clipping were performed sequentially from the most distal aneurysms to those located more proximally.

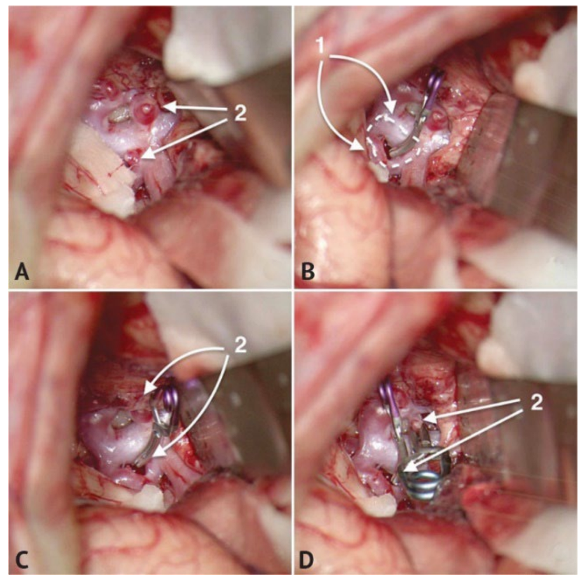

Fig. 3. Intraoperative photo. Step-by-step clipping of first a small aneurysm, then a larger aneurysm: A — aneurysms of the anterior communicating artery: medium-sized one with an anterior dome direction and small one with an inferior dome direction (2), before clipping; B — doubling of the anterior communicating artery (1), clip on a small aneurysm with an inferior dome direction; C — aneurysm with an anterior dome direction before clipping and clipped aneurysm with an inferior dome direction; D — aneurysms are clipped

When isolating the ACoA complex, two aneurysms were found: medium-sized aneurysm with an anterior dome direction and a small aneurysm with an inferior dome direction. Clipping of closely spaced ACoA aneurysms presented technical challenges, which required removing the permanent clip from the initially clipped larger aneurysm and clipping the small aneurysm first, and then re-clipping the larger aneurysm (Fig. 3C,D) in a way that does not interfere with working on the remaining aneurysms (Fig. 3C,D).

Temporary clipping of the ICA for 2 minutes was used only when the blister-like aneurysm of the PCoA was shut down. Upon visual examination after clipping: cerebral vessels were passable, blood flow through the main arteries was not compromised.

The postoperative period went smoothly. No cerebral complications were noted. Asymptomatic postcatheterization thrombosis of the right radial artery, verified in the postoperative period by ultrasound examination data, regressed due to prescribed antiplatelet therapy. Postoperative computed tomography (CT) and angiographic control: the aneurysm cavities were not contrasted, cerebral blood flow was not compromised, no signs of ischemia or hemorrhage were observed in the surgical site (Fig. 4).

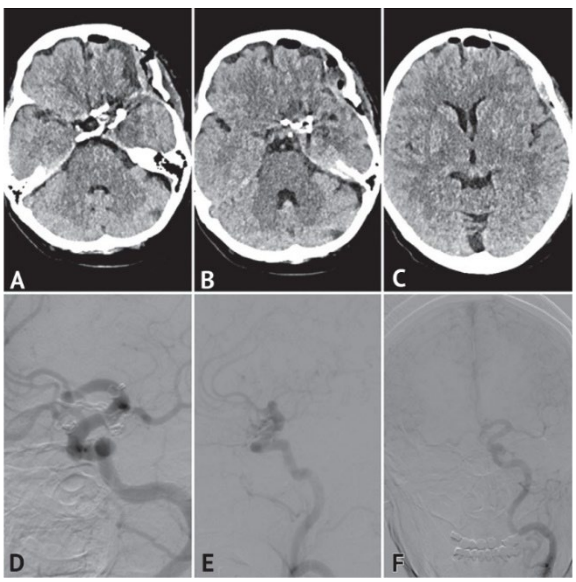

Fig. 4. Postoperative computed tomographic (A–C) and angiographic control (D–F) of patient L. There are no signs of hemorrhage and foci of ischemia in the area of the operation according to computed tomography of the brain. According to cerebral angiography, the cavities of the aneurysms are not contrasted

After 6 months, control angiography confirmed the stability of all the embolized aneurysms with preservation of cerebral blood flow. With no negative dynamics in her neurological and somatic status, the patient returned to her usual way of life.

DISCUSSION

In the development of cerebral aneurysms, researchers distinguish three groups of congenital and acquired factors:

— vascular wall factors (connective tissue diseases, media defects, “sutures” at the branching points of arteries, Rotter branching pads, atherosclerosis, vasculitis and vasculopathy);

— anatomical factors (multivariant structure of the Willis polygon with increased local blood flow in bifurcation zones and places of origin of lateral branches, as well as acute and chronic occlusions of cerebral arteries, leading to modulation of cerebral hemodynamics);

— central hemodynamic factors (acute and chronic increase in blood pressure) [8, 9].

It has now been established that none of the vascular wall factors are decisive in aneurysm development [10]. Mathematical modeling showed that the individual anatomy of cerebral arteries is of great importance in the formation of aneurysms, since minimal changes in the takeoff angles and diameters of the distal branches of the experimental model significantly alter the shape and size of the hemodynamic load zones [12]. It was also established that changes in local cerebral blood flow, for example, when activating natural flows through the anterior and posterior communicating arteries, can modify cerebral hemodynamics and lead to the development of an aneurysm [13].

Thus, the formation of aneurysms occurs in case of a combination of “vascular wall factors” and geometric features of cerebral arteries in humans, with excessive barimetric effects and imbalance of local humoral factors of blood flow autoregulation [11]. This concept is indirectly confirmed by the fact that the development of de Novo aneurysms against the background of stenotic lesions of the brachiocephalic arteries (BCA) is more often observed in patients with hypertension and nicotine dependence [14].

The exact incidence of hemodynamically significant stenosis and occlusion of the ICA in patients with cerebral aneurysms is unknown, but is estimated to be 3% [15]. Aneurysms may form both on the side of occlusion and on the contralateral side. In cases where aneurysms are detected on the side of the ICA occlusion, intravascular treatment may not be feasible, since the delivery of microcoils must be carried out through the PCoA or ACoA, which is not always technically possible. Open surgery is the method of choice in those cases.

When multiple aneurysms are detected on the side opposite to the ICA occlusion, accessible for intravascular treatment, their staged shutdown by a combined method is possible. In the acute period of hemorrhage, the first stage is always to shut down the ruptured aneurysm in the most optimal way.

As for open surgeries on intact multiple aneurysms, it is advisable, in the absence of intraoperative complications, to clip the maximum number of aneurysms during one procedure, although the final choice of treatment strategy is made by the surgeon [16].

In cases where the nature of the atherosclerotic lesion of the BCA allows for revascularizing interventions on the neck, some authors suggest first performing carotid endarterectomy or stenting and dynamically monitoring cerebral aneurysms for 1–2 years, due to the possibility of regression of aneurysms after normalization of cerebral blood flow. Such cases once again highlight the leading role of hemodynamic stress in the formation of aneurysms [17].

A special feature of our observation is that the patient had no clinical indications of previous ischemic stroke in the right carotid pool. According to the CAG data, there were no signs of significant atherosclerotic lesions of the BCA. The ICA was occluded in the supraclinoid segment, distal to the orifices of the PCoA and ACHA, which explains the absence of signs of previous ischemia in the right subcortical region according to CT and MRI data.

Another interesting detail of this observation was the origin of the aneurysm of the ophthalmic segment of the ICA not in the area of the orifice of the OA, but distally, directly from the trunk of the artery, which is casuistry [18]. This arrangement is more typical for the combination of OA aneurysms with arteriovenous malformation (AVM), or Moyamoya disease, when the OA actively participates in arteriovenous discharge or collateral circulation. The cause of the development of such distal aneurysms is considered to be hemodynamic stress, which is supported by cases of regression of “flow aneurysms” after AVM embolization [19].

In cases of intact multiple aneurysms of one vascular pool, we are in favor of clipping all available aneurysms during one surgical procedure, since such key risk factors for an unfavorable outcome as intracranial hypertension and cerebral arterial spasm, which limit surgical aggression in conditions of acute hemorrhage, are absent. Exceptions include cases of complex and giant aneurysms of paraclinoid localization, which require a special approach to treatment, as well as the development of unplanned intraoperative complications, when an extended scope of intervention should be avoided.

The advantages of one-stage treatment include single anesthesia, reduction in the overall duration and cost of multi-stage treatment; reduction in psychological impact on the patient while waiting for subsequent surgeries. This is especially true for open surgery in elderly and senile patients, for whom, on the one hand, every anesthesia is a serious test, and on the other hand, natural involutional changes in the brain facilitate wide dissection of the basal cisterns.

When performing intracranial operations for occlusions of the main arteries of the BCA, prolonged temporary clipping should be avoided, since this can lead to cerebral infarctions "at a distance" - in areas of adjacent blood circulation. It is advisable to preliminarily isolate all aneurysms without clipping them. During final clipping, in order to avoid unintentional traction damage to the arteries of the base of the brain, adhere to the principle of sequential application of clips "from more distal aneurysms to those located proximally".

In our experience, reoperation of remaining unclipped aneurysms via previously used microsurgical corridors is a high-risk surgery, since it is associated with significant technical difficulties due to developing adhesive process in the surgical site, and limitation of freedom of manipulation because of the presence of previously applied clips in the surgical field fused with the surrounding vascular structures. In case of one-stage treatment, such complications do not arise.

CONCLUSION

The lack of recommendations and the small number of clinical observations of the treatment of patients with multiple cerebral aneurysms in combination with stenosis of the internal carotid artery force us to rely on the surgeon's own experience, and the treatment and diagnostic capabilities of a particular medical institution.

The combination of multiple cerebral aneurysms and hemodynamically significant stenosis of the internal carotid artery adds to the knowledge of the hemodynamics and pathogenesis of aneurysmal disease of the brain and possible treatment options.

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