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ENDOVASCULAR TREATMENT OF PATIENTS WITH DISTAL ANEURYSMS OF CEREBELLAR ARTERIES

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Aim. To evaluate short- and long-term angiographic and clinical outcomes of endovascular treatment of patients with distal aneurysms of cerebellar arteries.

Materials and methods. The outcomes of endovascular treatment of 6 patients with distal aneurysms of cerebellar arteries who underwent surgery at the Neurosurgical Division No. 3 of the Polenov Russian Research Institute of Neurosurgery between January 1 of 2017 and March 31 of 2023 were analyzed.

Results. The following endovascular methods were used: occlusion of the aneurysm sac using only detachable coils (n = 2); occlusion using stent-assisted coiling (n = 3); deconstructive intervention with occlusion of the main artery (n = 1). In 1 of 2 cases of coil-only aneurysm occlusion, additional stent-assisted occlusion was performed due to recurrence. Among 6 aneurysms, 1 (16.65 %) aneurysm was radically excluded from the blood flow (class A); 4 (66.7 %) were excluded subtotally (class B); 1 (16.65 %) was excluded partially (class C). Control angiography at least 6 months after showed radical exclusion of the aneurysm from the blood flow (class A) in 5 (83.3 %) patients, subtotal exclusion (class B) in 1 (16.7 %) patient.

Clinical outcome was excellent in 5 (83.3 %) patients (0 points per the modified Rankin scale); in 1 patient after deconstructive surgery, augmentation of neurological symptoms with following partial regression was observed (2 points per the modified Rankin scale). Complications during deconstructive surgery were observed in 1 (16.7 %) patient.

Conclusion. Deconstructive surgery of the distal aneurysms of cerebellar arteries can be associated with high risk of postoperative ischemic complications with development of persisting neurological deficit. Surgical interventions with preservation of the artery lumen (including reconstructive surgeries) should be the method of choice in endovascular treatment of distal aneurysms of cerebellar arteries due to minimal risk of ischemic complications and improved clinical outcomes of surgical treatment.

Keywords: distal aneurysms of cerebellar arteries, endovascular treatment, deconstructive interventions, low-profile stents

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BACKGROUND

Distal aneurysms of the cerebellar arteries are a very rare pathology comprising only 0.6–0.9 % of all cerebral aneurysms, but their incidence is 4.3 times higher than of distal aneurysms of other cerebral arteries [1]. Aneurysms are considered distal if they are located distally from the first segments or 1 cm or more from the cerebellar artery entrance [2, 3].

The most common distal aneurysm of the cerebellar arteries is distal aneurysm of the posterior inferior cerebellar artery (PICA) [4–7]. Distal aneurysms of the anterior inferior cerebellar artery (AICA) and superior cerebellar artery (SCA) are very rare and comprise <0.5 % of all cerebral aneurysms. The literature describes about 100 observations of distal aneurysms of the AICA and less than 50 of SCA [1, 8, 9].

Usually, distal aneurysms of the cerebellar arteries are small saccular aneurysms, but fusiform, giant, and partially thrombosed aneurysms are not uncommon [1, 3].

Supposedly, the most common cause of distal aneurysms is dissection injury of an artery [5, 10, 11]. Distal aneurysms of the cerebellar arteries are very prone to rapture, and their first clinical manifestation is subarachnoid hemorrhage. More than half of raptured aneurysms are <7 mm in size [1, 12].

Traditional method of choice in treatment of distal aneurysms of the cerebellar arteries is microsurgical intervention [13–19]. However, deep location of these aneurysms, closeness of the brainstem and cranial nerves, large number of perforating arteries branching from the cerebellar arteries make microsurgical treatment of the distal aneurysms technically complex and associated with certain risks [17, 20]. According to some studies, complication rate for “open”

treatment of distal aneurysms of the cerebellar arteries is 68 % [21].

Compared to aneurysms in other locations, distal aneurysms are rarely accessible for direct clipping and frequently require revascularization techniques. According to the study by A. Rodríguez-Hernández et al. (2013), only in 40 % of cases distal aneurysms of the cerebellar arteries were accessible for direct clipping; in most cases (47.5 %) deconstructive intervention was performed or microanastamosis was necessary (17.5 % of cases) [1].

In recent years, articles describing endovascular technique as the method of choice for treatment of distal aneurysms of the cerebellar arteries have become more common [6, 22–24].

Modern endovascular methods include aneurysm occlusion with coils including using stent and balloon assistance, trapping of the artery with coils and liquid embolizing materials, and implantation of flow-diverter stents.

One of the most common approaches to treatment of distal aneurysms is deconstructive surgery with occlusion of the aneurysm and part of the parent artery [25–28].

According to some study results, due to collateral anastomoses between the cerebellar arteries, deconstructive interventions in the distal parts of the cerebellar arteries are safe and easy on the patients [25–28]. However, the presence of perforating arteries branching from the cerebellar arteries, absence of accurate methods of collateral blood flow measurement and evaluation of functional significance of the artery carrying the aneurysm do not allow to consistently predict risks of ischemic complications and clinical outcomes of deconstructive surgeries.

Due to development of endovascular techniques, design of new low-profile stents, improved imaging and microinstrument control, new possibilities of endovascular treatment of patients with distal aneurysms became available. The number of articles on endovascular treatment of distal aneurysms using reconstructive techniques and preservation of the carrying artery has been growing [23, 24, 26].

We present a case series of endovascular treatment of distal aneurysms of the cerebellar arteries using reconstructive and deconstructive techniques.

Aim of the study is to evaluate short- and long-term angiographic and clinical outcomes of intravascular treatment of patients with distal aneurysms of cerebellar arteries.

MATERIALS AND METHODS

Short- and long-term outcomes of endovascular treatment of patients with distal aneurysms of cerebellar arteries who underwent surgery at the Neurosurgical Division No. 3 of the Polenov Russian Research Institute of Neurosurgery – branch of the Almazov National Medical Research Center, Ministry of Health of Russia, between January 1 of 2017 and March 31 of 2023 were analyzed. During this period, 9 patients with distal aneurysms of cerebellar arteries underwent surgery which comprised 0.3 % of all cases of cerebral aneurysms (n = 2647) treated in this period. From the analysis 3 patients were excluded because they were operated on using microsurgical technique due to unsuccessful or technically impossible endovascular intervention.

Among 6 patients included in the study, 5 were admitted to the Polenov Russian Research Institute of Neurosurgery for a planned procedure, 1 was admitted as an emergency due to hemorrhage caused by aneurysm rapture.

Spiral computed tomography angiography and cerebral angiography data were used to evaluate the location, shape, size of the aneurysm and its neck, as well as anatomical characteristics of the parent artery.

Selection of endovascular method of surgical intervention was performed based on anatomic, topographic and morphometric characteristics of the aneurysm, parent artery diameter, hemorrhage period. Special attention was paid to the characteristic of the parent artery, its availability for catheterization.

During the planning of stent implantation, all patients underwent compulsory preoperative preparation: determination of the baseline functional platelet activity and prescription of double antiplatelet therapy 7 days prior to the planned surgery (clopidogrel 75 mg/day and acetylsalicylic acid 100 mg once a day) or 1 day prior to surgery (ticagrelor 90 mg 2 times a day and acetylsalicylic acid 100 mg once a day). Before surgery, functional platelet activity was evaluated in all patients using the light transmission aggregometry (LTA) to obtain graphic and digital data showing safe range of residual platelet activity for stent implantation (optimally, above 20 and below 40 %).

Before discharging, functional outcomes of surgical intervention per the modified Rankin scale (mRs) were evaluated.

RESULTS

The characteristics of clinical picture, results of laboratory tests, and treatment of 6 patients with distal aneurysms of cerebellar arteries who underwent endovascular surgery were analyzed.

Clinical and laboratory evaluation

Patients with distal aneurysms of the cerebellar arteries: men – 4, women – 2; age between 44 and 70 years (median 54 years).

In our case series, 1 patient was admitted as an emergency due to hemorrhage caused by aneurysm rapture, the other 5 patients were admitted for planned procedures. Among the 5, 3 had history of aneurysm rapture, in 1 patient aneurysm was diagnosed during examination due to other pathology (no rapture), in 1 patient aneurysm was diagnosed during angiography after hemorrhage of a cerebral aneurysm in another location. All patients were admitted in compensated condition with the mRs score of 0–2.

The primary clinical manifestation of these aneurysms in 66.7 % of patients (n = 4) was subarachnoid hemorrhage without formation of an intracerebral hematoma.

Short summary of the patient data, location and structure of the aneurysms, treatment techniques and outcomes

Case No.	Sex	Age, year	Aneurysm characteristics					Treatment techniques and outcomes					
			Location	Shape	Size*, mm	Neck	Diameter of the artery, mm	Surgery	Compli-cations	Postoperative control		Control after >6 months	
										RROC radicality	mRS outcome, score	RROC radicality class	mRS outcome, score
1	Male	56	PICA (p3)	Saccular	6	Narrow	2.5	Coils + stent	None	B	0	A	0
2	Male	47	PICA (p2)	Fusiform	8.5	No data	1.5	Coils + stent	None	B	0	A	0
3	Female	52	PICA (p5)	Fusiform	9	No data	1.1	Coils	None	C	0	A	0
4**	Male	54	PICA (p3)	Saccular	9.6	Narrow	1.7	Coils	None	B	0	C (recur-rence)	No data
								Coils + stent	None	A	0	A	0
5	Male	44	PICA (p4)	Saccular	4.5	Wide	1.5	Coils	None	B	0	B	0
6	Female	70	SCA (s3)	Saccular	4.6	Wide	0.9	Deconstruc-tion	Yes	A	3	A	2

**The size of the aneurysm was determined as the maximum diameter of aneurysm dome. **The treatment was carried out in 2 stages.*
Note. *PICA – posterior inferior cerebellar artery; SCA – superior cerebellar artery; RROC–Raymond–Roy Occlusion Classification; mRs – modified Rankin scale.*

Anatomic and topographic features and morphometric characteristics of distal aneurysms of cerebellar arteries

Location. All aneurysms of the cerebellar arteries were classified per location in accordance with the J.R. Lister et al. classification [2]. The most common were aneurysms of the PICA, in particular of the tonsilomedullary (p3) segment (p2 – 1, p3 – 2, p4 – 1, p5 – 1, s3 – 1) (see Table).

Sizes and shapes. Evaluation of aneurysm size was performed based on the results of intraoperative cerebral angiography: maximal diameter of the aneurysmal dome, width of its neck, as well as dome to neck ratio (DNR) were measured. At width >4 mm or DNR <2, the neck was considered wide. Per the shape of aneurysmal sac, saccular (with distinct neck) and fusiform (without neck, with long segment of abnormal structure on the artery) aneurysms were identified.

According to the obtained data, distal aneurysms of the cerebellar arteries had saccular structure in 4 (66.7 %) cases, fusiform in 2 (33.3 %) cases. The size varied between 4.5 and 9.6 mm, mean size of all aneurysms was 7 mm, mean size of raptured aneurysms was 8.3 mm. Saccular aneurysms in 50 % of cases (n = 2) had wide necks. Irregular shape with signs of dissection was observed in 66.7 % (n = 4) of patients. One patient had multiple cerebral aneurysms.

Endovascular treatment

All surgical interventions were performed under general anesthesia in an operating room with X-ray equipment using a dual-projection angiograph. The first stage of intravascular intervention was selective cerebral pan-angiography in standard projections. Then 3D rotational angiography was performed to evaluate the size and shape of the aneurysm.

Selection of the tactics of endovascular intervention was based on morphometric characteristics of the aneurysm, its shape, characteristics of the parent artery, and hemorrhage period. The priority of intravascular treatment was aneurysm occlusion with preservation of the parent artery which was achieved in the majority of observations (n = 5). In total, 7 surgical interventions were performed to treat 6 distal aneurysms. Aneurysm occlusion with coils and preservation of the parent artery was performed in 3 patients including in 1 case as the first stage of treatment at the acute period of hemorrhage. Aneurysm occlusion with coils and stent-assistance was also performed in 3 patients: in 2 patients as the primary treatment method, in 1 patient as the 2nd treatment stage in aneurysm recurrence after coil occlusion in the acute period.

In only 1 observation, deconstructive intervention using a non-adhesive composition was performed. This decision was made due to small diameter and tortuosity of the parent artery (SCA) and aneurysm location distally from the typical point of branching of perforating arteries supplying the brainstem.

Evaluation of primary and long-term angiography results

During analysis of angiograms measured at the end of surgical treatment and in the long-term period, radicality of aneurysm exclusion from the blood flow per the Raymond–Roy Occlusion Classification (2006) was performed.

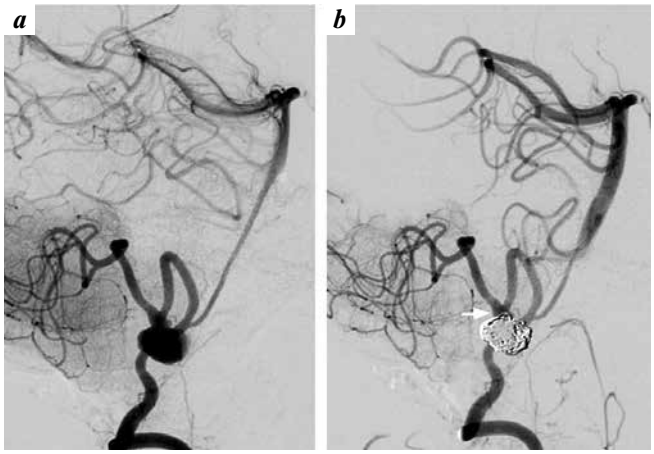

Fig. 1. *Selective left-sided vertebral angiography (lateral projection): a – prior to aneurysm occlusion with coils: contrasting of saccular aneurysm of the tonsilomedullary segment (p3) of the left posterior inferior cerebellar artery is observed; b – subtotal occlusion of the aneurysm with detachable coils is observed (arrow shows residual aneurysm filling)*

Among 6 aneurysms, 1 (16.7 %) was completely obliterated (class A), 4 (66.7 %) subtotally (class B), and 1 (16.7 %) partially (class C).

We considered the results of control angiography exam performed at least 6 months after the surgical treatment long-term results.

In the long-term period, in the majority of cases changes in occlusion radicality were observed. Thus, control angiography showed complete obliteration of the aneurysm in 4 (66.7 %) patients, subtotal in 1 (16.7 %) patient, and partial in 1 (16.7 %) patient. Additionally, increased radicality was detected as subtotal occlusion transformed into total in 2 (50 %) cases, partial into total 1 (16.7 %) case. However, decreased radicality (aneurysm recurrence) from subtotal to partial occlusion was observed in 1 (16.7 %) patient after aneurysm occlusion in acute hemorrhage period. Due to aneurysm recurrence after coil occlusion, in 1 (16.7 %) case repeat surgical treatment was performed: stent-assisted microcoil occlusion with total exclusion of the aneurysm from the blood flow (class A) confirmed during control angiography 6 months after repeat intervention.

Easly and long-term clinical outcomes

Analysis of intra- and postoperative complications, early and long-term outcomes of surgical treatment was performed.

Clinical outcome was excellent in 5 (83.3 %) patients (score 0 per mRS), in 1 patient increased cerebellar deficit was observed due to cerebellar infarction with partial regression at discharge from the hospital (score 2 per mRs).

Surgery-related complications, namely intraoperative rapture during microangiography and ischemia in the cerebellar artery system, were observed in 1 (16.7 %) patient

during deconstructive surgery. There were no other complications in our case series.

Long-term clinical outcomes were also observed in all 6 patients. In none of the cases repeat hemorrhages, increased neurologic deficit were observed.

Clinical case 1. *Male patient, 60 years, was admitted to the Polenov Russian Research Institute of Neurosurgery with a clinical picture of subarachnoid hemorrhage. Selective cerebral angiography showed a saccular aneurysm of the p3 segment of the left PICA of irregular double-chamber shape with diverticular protrusions, size 9.3 × 8.2 mm with neck 3.5 mm (Fig. 1, a).*

Emergency subtotal occlusion of the aneurysm with detachable coils was performed to prevent repeat hemorrhage (Fig. 1, b).

The patient was discharged without focal and meningeal neurologic symptoms. No repeat episodes of hemorrhage were observed, the patient did not undergo planned control examinations.

Six years after primary surgical intervention during control cerebral angiography, increased pre-neck filling of the aneurysm was observed both due to packing of the coil complex and aneurysm growth in the pre-neck area.

At first, 3 treatment options were considered: deconstructive intervention with aneurysm occlusion along with the parent artery, aneurysm embolization with stent assistance, and implantation of low-profile flow-diverter stent.

Deconstructive intervention with aneurysm occlusion in conjunction with the parent artery was associated with high risk of ischemic complications due to aneurysm location on the

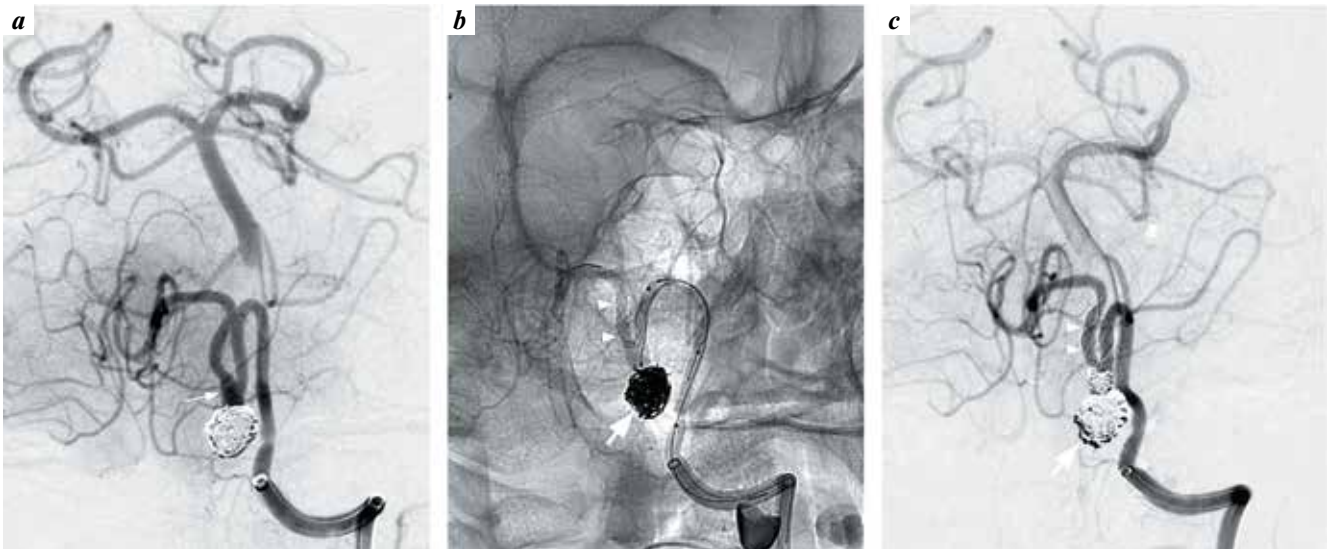

Fig. 2. *Selective left-sided vertebral angiography 6 years after aneurysm occlusion with coils (oblique view): a – prior to stent-assisted aneurysm occlusion: enlargement of the filling part of the aneurysm is observed (arrow); b, c – using the jailing technique (b), total occlusion of the aneurism with LEO Baby assisting stent and detachable coils was performed (c): opening of the assisting LEO Baby stent (b); condition after stent-assisted total aneurysm occlusion (c) (bold arrows show the position of the coil complex, pointing arrows show the position of the stent)*

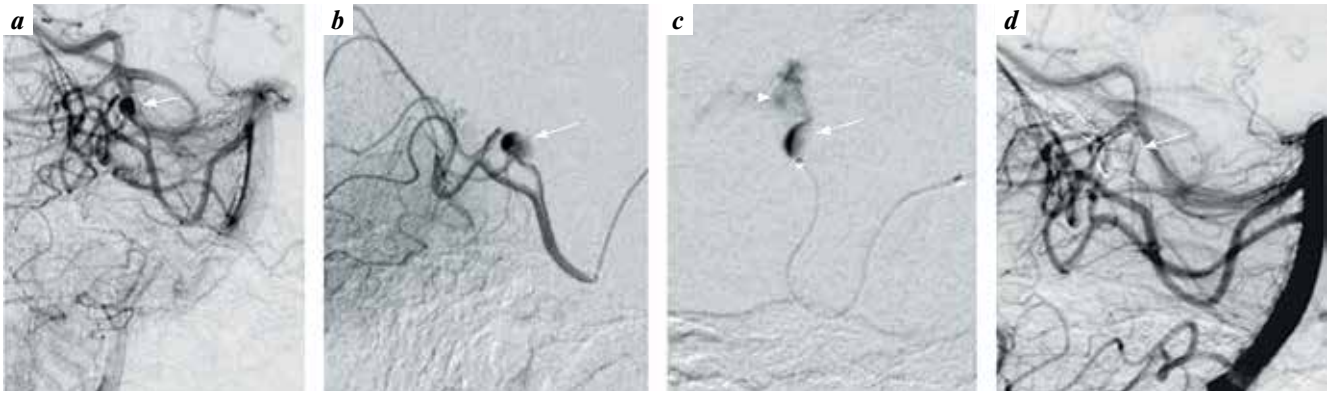

Fig. 3. *Selective left-sided vertebral angiography (lateral projection): a, b – prior to aneurysm occlusion with coils: contrasting of saccular aneurysm of the cerebellomesencephalic (s3) segment of the right superior cerebellar artery is observed during vertebral angiography (a) and microangiography (b) (arrow); c – microangiography shows extravasation of the contrast agent (pointing arrow) – aneurysm rupture (arrow) in the context of microangiography; d – condition after embolization using non-adhesive SQUID 18 agent: total exclusion of the aneurysm with a part of the vessel was performed (arrow)*

tonsillomedullar segment as this could lead to occlusion of the perforating arteries supplying the brainstem.

Implantation of a more rigid low-profile flow-diverter stent also carried high complication risks due to tortuosity of the artery (distal perforation of the parent artery, incomplete opening, over-rotation of stent with subsequent occlusion of the artery).

A decision was made to perform aneurysm occlusion with a low-profile assisting stent. This choice was based on lower manipulation risks during catheterization of tortuous arteries with a small-diameter catheter with internal opening of 0.0165 inches. Using an assisting low-profile stent LEO Baby and detachable coils, total aneurysm occlusion was performed (Fig. 2).

In the postoperative period, no worsening of focal or meningeal neurologic symptoms was observed. The patient was discharged in stable compensated condition on day 2 after surgical intervention. Control angiography 6 months later showed complete exclusion of the aneurysm from the blood flow (class A).

Clinical case 2. *Female patient Ya., 70 years, was admitted to the Polenov Russian Research Institute of Neurosurgery for planned surgical treatment. Spiral computed tomography angiography showed distal aneurysm of the right SCA, selective cerebral angiography showed a saccular aneurysm of the cerebellomesencephalic (s3) segment of the right SCA, size 4.6 × 3 mm with wide neck 2.5 mm, diameter of the parent artery 0.7 mm (Fig. 3, a).*

Considering distal location of the aneurysm – far from the typical point of branching of perforating arteries – and small diameter and tortuosity of the artery, a decision was made to perform deconstructive surgery using liquid embolizing agent (non-adhesive composition). This choice was based on lower manipulation risks of aneurysm catheterization with a tinner catheter.

Intraoperatively during superselective cerebral microangiography, signs of contrast agent extravasation were observed – aneurysm rapture (Fig. 3, b, c). Using the Sonic microcatheter and SQUID 18 non-adhesive composition, the aneurysm was embolized in conjunction with the distal part of the artery (Fig. 3, d).

Postoperative computed tomography of the brain showed hyperdense contents (blood with the contrast agent) in the posterior cranial fossa, right occipital lobe area with full regression at the control examination on day 5 after surgical intervention.

In the early postoperative period, worsening of neurologic symptoms were observed in the form of dysarthria, cerebellar coordination insufficiency. Magnetic resonance imaging of the brain 2 weeks after surgery showed infarction of the right cerebellar hemisphere with primarily cortical localization at subacute stage without signs of brainstem ischemia (Fig. 4). Conservative therapy and rehabilitation treatment led to almost complete regression of the symptoms (score 2 per mRs). The patient was discharged in stable compensated condition under the care of a neurologist at the place of residence.

Control angiography 6 months after surgery showed total exclusion of the aneurysm from the blood flow (class A). Neurologic deficit regressed completely.

DISCUSSION

Classification of the cerebellar arteries segments proposed by J.R. Lister et al. (1982) is the most commonly used [2].

According to this classification, PICA is divided into 5 segments: anterior medullar, lateral medullar, tonsillomedullar, telovelotonsillar, and cortical; AICA into 4 segments: anterior pontine, lateral pontine, flocculopenduncular, and cortical; SCA into 4 segments: anterior pontomesencephalic, lateral pontomesencephalic, cerebellomesencephalic, and cortical.

An alternative classification proposed by C.G. Drake et al. (1996) divides distal aneurysms of the cerebellar arteries into proximal (located within 1 cm from the artery entrance) and distal [3].

These classifications are mostly useful during planning of surgical intervention as they describe the relationship between aneurysms and closely located cranial nerves and the brainstem. allow to select optimal access to the aneurysm, and predict risks of postoperative cranial nerve deficit.

Moreover, evaluation of the presence of perforating arteries is also very important during endovascular surgery planning to predict risks of ischemic complications due to deconstructive interventions.

Currently, deconstructive interventions remain the most common surgeries in treatment of distal aneurysms of cerebellar arteries [24–28].

Perforating arteries supplying the brainstem mainly start at the proximal arterial segments. Therefore, deconstructive interventions on cerebellar artery aneurysms distally from the tonsillomedullar segment of PICA, ponomesencephalic segment of SCA, and 2 cm distally from the AICA entrance are considered safe and rarely cause brainstem stroke [6, 19, 23, 24, 29].

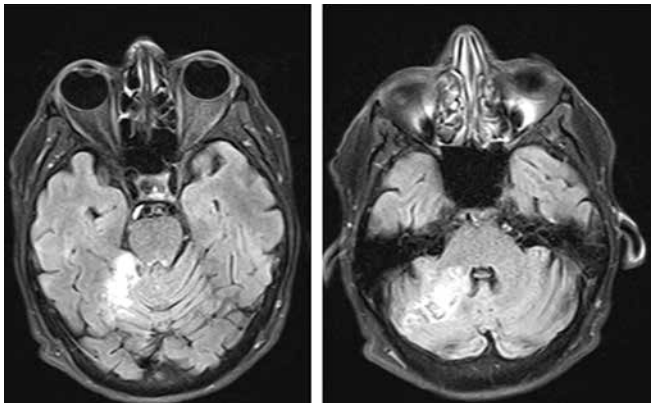

Fig. 4. *Magnetic resonance imaging of the brain on day 12 after surgery (axial projection). Postischemic cystic gliotic changes in predominantly cortical parts of the right cerebellar hemisphere in the system of the right superior cerebellar artery*

In cases of cerebellar ischemia, it is usually small, affects only cortical parts of the cerebellum, and is asymptomatic or manifests through insignificant clinical symptoms as in the described clinical case [6, 25, 30]. However, even sufficiently distal deconstruction carries the risk of retrograde arterial thrombus with brainstem stroke, and acetylsalicylic acid should be prescribed at least for 1 week prior to surgery [31].

While some authors note relative safety of deconstructive interventions in more proximal parts of the arteries justifying it by the absence of perforating arteries in the affected segment and pronounced anastomotic networks on the brainstem surface, such interventions are associated with high risk of ischemic complications and should be performed only in extreme cases [32–35]. Thus, according to J.G. Malcolm et al., deconstructive interventions on aneurysms located on the first 3 PICA segments lead to brainstem stroke in 7.1 % of patients, cerebellar hemisphere stroke in 57 % of patients [36].

There is an increase in the number of studies which consider preservation of the parent artery one of the most important tasks in treatment of distal aneurysms of cerebellar arteries [23, 24, 31].

In distal aneurysms of cerebellar arteries with narrow necks available for catheterization, embolization with detachable coils can be the method of choice [37–39]. In the short term, this treatment method is sufficiently effective, however recurrence rate after these surgeries remains high. According to M. Cellerini et al., in patients after PICA aneurysm embolization using coils favorable outcome y (score 0 per mRs) was observed in 90.9 % of cases, but recurrence rate was 27.3 % [40]. N. Chalouhi et al. also note high recurrency rate (50 % of cases) and the necessity of repeat surgical interventions (37.5 % of cases) after coil occlusion of aneurysm in this location [30].

Our data also confirms high risk of recurrence after isolated coil occlusion (in 1 of 2 patients) and the necessity of dynamic angiographic control in this patient group.

In distal aneurysms of cerebellar arteries with wide neck or fusiform structure, occlusion with detachable coils can be technically impossible or carries high risk of complications. According to our observations, use of stent assistance, new generation low-profile assisting stents in some cases allows to exclude these aneurysms with preservation of the parent artery and reconstruction of the affected segment [23, 24].

According to E.A. Samaniego et al., endovascular occlusion of the PICA trunk using a low-profile assisting stent LVIS Junior (MicroVention) led to excellent clinical outcomes (score 5 per the Glasgow scale) in all 7 patients. In 1 case, the authors observed a vasospasm during manipulation for stent implantation. Short-term angiography follow-up (median 5.1 months) did not show in-stent-stenosis or parent artery occlusions; control angiography 12 months after surgery showed recurrence in 2 patients requiring additional aneurysm occlusion with detachable coils [23].

The literature also describes cases of successful application of low-profile assisting stents in treatment of distal aneurysms of the SCA and AICA using stent assistance technique and implantation of telescopic stents [31, 41, 42].

In our study, 50 % of patients ($n = 3$) underwent reconstructive surgery (stent-assisted embolization) using the LEO Baby low-profile assisting stent (Balt Extrusion, France). Intra- and postoperative complications were absent in our patient group. Control angiography 6 months after surgery showed total exclusion of the aneurysm from the blood flow (class A) in all patients ($n = 3$) without signs of in-stent-stenosis or parent artery occlusion.

Use of low-profile flow-diverter stents is a promising but insufficiently studied treatment method for aneurysms of this locations. R.N. Alokaili and M.E. Ahmed in 2014 were the first to report on successful implantation of the SILK+ (Balt Extrusion) flow-diverter stent for treatment of this pathology [43]. Additionally, D.C. Lauzier et al. described 5 cases of successful treatment of distal PICA aneurysms using the PED Flex flow-diverter stents (Medtronic) [44].

Due to the structure of distal aneurysms of cerebellar arteries, causes of formation, as well as characteristics of parent artery, intraoperative ischemic and hemorrhagic complications are more common in endovascular treatment of such aneurysms than aneurysms of other locations; according to some data, in 10–25 % of cases [5, 6, 30, 33]. Frequency of unsuccessful surgical interventions is also higher in the group of distal aneurysms. Thus, in the study by N. Chalouhi et al., comparison of treatment results of proximal and distal PICA aneurysms, unsuccessful surgical treatment was 4 time more frequent in the group of patients with distal aneurysms than in the group of patients with proximal aneurysms [30].

In our study, surgeries were successful in all cases. In 1 (16.7 %) case, intraoperative rapture of the aneurysm occurred during microangiography which necessitated deconstructive intervention and led to a localized cerebellar stroke.

CONCLUSION

Distal aneurysms of the cerebellar arteries are a very rare pathology, and currently there are no standard approaches to their treatment. Deconstructive surgery of the distal parts of the cerebellar arteries can be associated with high risks of postoperative ischemic complications and development of persistent neurologic deficit. Evaluation of the risk of ischemic complications after these surgeries is empiric and does not have instrumental credibility criteria. In our opinion, outcomes of surgical treatment using these interventions cannot be sufficiently predicted. However, these techniques are still widely used in surgery of distal aneurysms of the vertebrobasilar system including cerebellar artery aneurysms.

Due to the evolution of endovascular techniques in treatment of patients with both proximal and distal aneurysms, in most cases radical occlusion of the aneurysm with preservation of the parent artery can be achieved. Development of low-profile assisting and flow-diverter stents

opened new possibilities in treatment of distal aneurysms of the cerebellar arteries.

In our opinion, surgical interventions preserving artery lumen (including reconstructive surgeries) should be the method of choice in endovascular treatment of distal cerebral aneurysms including located on the cerebellar arteries due to minimization of the risk of ischemic complications and improved clinical outcomes.

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