

Results of the surgical treatment of the distal segment Anterior Cerebral Artery Aneurysms

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Conflict of Interest

The authors declare that they have no conflict of interest.

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A frequency of the spontaneous subarachnoid hemorrhage (SAH) ranges from 5,2 to 19,4 of cases per 100 000 of the population per year. Arterial Aneurysm (AA) rupture more than in 50% of patients becomes the reason of the SAH (J. Frosen, A. Piippo, 2006; E. Laaksamo, R.Tulamo, 2008; I.I. Scorokhoda, O.A. Tsimeyko 2006). The frequency of the AA in the population according to the data of different authors ranges from 0,2 to 9,9% (Aortic coarctation is correlated with bicuspid aortic valve and intracranial aneurysm: a case report and review of the literature – 2006).

Most often SAH occurs in the age from 30 to 60 years. During the first month after AA rupture about 80-88% of patients who are treated conservatively die (A.N.Konovalov, 1990, V.V.Lebedev,1996).

AA of the Anterior Cerebral Artery (ACA) distal segments are rare and account about 1,5-9% of all intracranial AA [1-7]. By other authors data distal segment ACA AA account 69-82% from the general quantity of all distal aneurysms of brain vessels [8]. Distal segment of the ACA by the Stephens and Stilwell (1969) begins from the Anterior Communicating Artery (AComA) and ends above the Splenium of the Corpus Callosum [9, 10, 12, 13].

According to the data of the ISUIA research (International Study of Unruptured Intracranial Aneurysms) range of the AA rupture risk appeared very wide and depended on AA size and location. The risk of AA rupture in Anterior Semicircle of Cerebral Vessels, which includes AA of the ACA distal segments, is from 0 to 40%.

Modern treatment of the cerebral AA is represented by two methods (Yasargil G.M., 1984): microsurgical (MS) and endovascular (EV) operations [5]. By the data of the multicentre randomised comparative study ISAT (International Subarachnoid Aneurysm Trial, 2002) in 2143 patients registered the decreasing of disability and mortality after EV operations in comparison with the MS AA clipping [11]. Because of the

definite conditions of the patients selection, 69% of patients with cerebral AA were excluded from the research, also 9% of patients refused to take part in the research. In result of this issue, ISAT doesn't image the characteristic of the routine flow of the patients with AA and cannot justify indications for one or another method of cerebral AA treatment, even more in cases of AA with rare localisations that include AA of the ACA distal segments.

Assessment of the MS and EV operations results in cases of distal segments ACA AA is necessary for the detection of factors that can influence on the treatment results and proving of the rational indications concerning the method of the surgical operation. That way solution of the actual task of the cerebral AA modern treatment can improve the effectiveness of the distal segment ACA AA exclusion from the bloodstream.

The objective — to research factors that influence on the results of the distal segments ACA AA surgical treatment with the purpose of the effectiveness improving.

Material and methods

The total number of patients with cerebral AA, who were treated and observed in SO "Institute of Neurosurgery named after acad. A.P. Romodanov NAMS of Ukraine ", Kyiv from 1998 to 2015 yy. is 2610 cases. The work is bases on the retrospective analysis of the examination and treatment results for 89 (100%) patients with the distal segments ACA AA.

Inclusion criteria: patients with the distal segment ACA AA, verified by the data of the clinical-instrumental investigation methods and operated by the MS or EV method.

The main amount of patients who were included into the research was formed by patients of the ripe age (30-44 years) – 30,3% (n=27) and of the middle age (45-59) –43,8% (n=39). Average age of the patients: 36,7±11,6 years (from 26 to 76 years), women - 58,43% (n=52), men – 51,57% (n=37).

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Basic amount of patients – 83,1% (n=74) hospitalized in the acute period of the hemorrhage (time after the hemorrhage was not more than 21 day), in the “cold” period (more than 21 day after manifestation) – 11,2% (n=10); 5,6% (n=5) cases with no ruptured distal segments ACA AA: 4,5% (n=4) of these AA were detected as accidental findings and 1,1% (n=1) case of the giant aneurysm with pseudo-tumor course of the disease.

Among the 89 patients who were operated because of distal segment ACA AA, in – 94,4% (n=84) cases the beginning of the disease was represented by the clinic of the spontaneous intracranial hemorrhage. The pre-hemorrhage period in most of patients ran without any symptoms. 16,9% (n=15) patients from these 89 had one rebleeding, 11,2% (n=10) – two re-ruptured hemorrhages and 5,6% (n=5) patients – three haemorrhages. Among 15 patients who one repeatedly haemorrhage in 9% (n=8) cases re-rupture happened during the 21 day from the first hemorrhage. In case of the several repeated hemorrhages the period of the disease we counted since the last episode of the hemorrhage.

After hospitalization detailed neurological and general clinical examination was performed for all patients. Presence of the cerebral, meningeal and neurological focal symptoms was examined. Neurosurgeon, radiologist, neurologist, ophthalmologist, otolaryngologist, therapist and other specialists took part in the clinical examination of the patients. Standard complex of the laboratory researches included blood group test, common blood analysis, biochemical blood analysis, liquor analysis, clinical urine analysis, coagulogram.

Severity of patient's condition before the operation was assessed by the modified Hunt-Hess scale: 0 degree – 5,6% (5 from 89 patients), I-st degree – 11,2% (10 from 89), II-nd degree – 34,8% (31 from 89), III-d degree – 28,2% (25 from 89), IV-th degree

– 13,5% (12 from 89), V-th degree – 6,7% (6 cases).

State of consciousness of all patients was assessed by the Glasgow Coma Scale before the surgical measures: 55,1% (49 patients) were in the clear consciousness (15 points by GCS). Impairment of the consciousness: in 28,1% (25 patients) – 13-14 points by GCS, in 10,1% (9 patients) – 9-12 points, and 8 and less points – in 6,7% (6 cases). Impairment of the consciousness from the moment of the hospitalization to the moment of the operation became more obvious in 4 patients, in 3 patients it was associated with the repeated hemorrhage, in 1 patient was detected the increasing of the angiospasm. In other patients intensity of the consciousness impairment stayed on the same level or progressed in the course of the treatment.

Results.

Surgical treatment of the patients with the distal segments of ACA AA was performed by the two methods. 80,9% (n=72) patients with 79 cerebral AA were operated by MS method, 19,1% (n=17) patients with 17 AA – by EV approach.

In 89 patients who were included in work was diagnosed 96 (100%) distal segments ACA AA.

The main group was formed by the saccular AA – 98% (n=94), fusiform aneurysms – 2% (n=2). In the main there were AA with small and medium sizes – 92,7% (n=89). Most often – in 78,1% (n=75) cases, AA were located in the segment A3 that is the typical place for AA location of this group.

93 AA were excluded by the reconstructive technique, 2 of them – by the wrapping. In 3 cases AA were excluded together with the parent artery by the deconstructive technique. Proximal occlusion of the parent artery by the clips performed in two cases (as complication of the clipping), by EV method (balloon occlusion) – just in 1 case (Table 1).

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Table 1
Methods of AA treatment

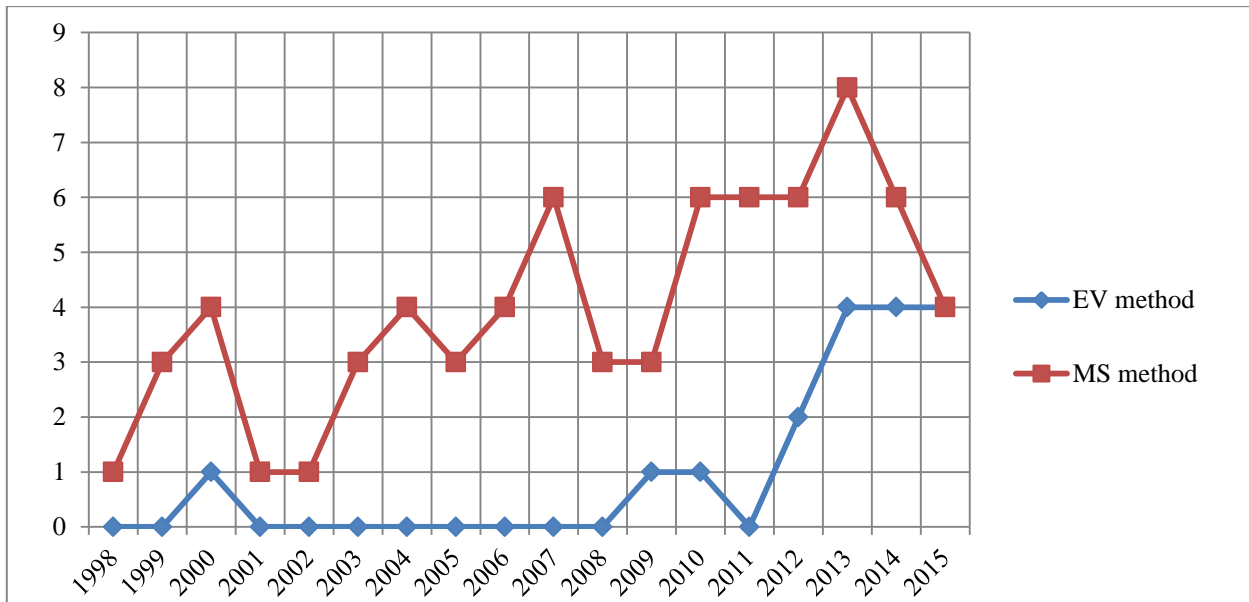
Treatment Method	Quantity of AA (n=96)
Clipping	78,1%(n=75)
Wrapping	2,1%(n=2)
Embolization	16,7%(n=16)
<i>Proximal occlusion*</i>	
Surgical	2,1%(n=2)
Endovascular	1,0%(n=1)

* proximal occlusion by the clips – as complication

By the analysis of the anatomical characteristics of AA, which were operated by two methods, it was detected that AA sizes operated by EV were smaller than in the group of MS method. Sizes of AA neck in the group of MS – $2,78 \pm 0,81$ mm, in EV group – $2,7 \pm 0,76$ mm. These index – was one of the factors for treatment method choosing. In cases with AA wide neck, advantages were

provided to MS method, although with the protection techniques appearing (stent- and balloon-assisting) range of the distal segments ACA AA for EV treatment was significantly expanded.

Quantity of AA operated by EV method increased during the last years. This trend corresponds to the data of the world literature (see Pic 1).



Pic 1. Division of the patients by the treatment method in the different years.

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Both methods are effective for distal segments ACA AA exclusion. Choosing of one or another method performs individually for each patient on the base of the clinical condition (presence of the complicated hemorrhage, brain swelling, dislocational syndrome, angiospasm) and the x-ray

anatomical AA characteristic, taking into account the advantages and disadvantages of the methods in each definite case.

Results of the surgical treatment depending on the severity of the patient's condition by the modified Hunt-Hess scale presented in Table 2.

Table 2.

Results of the surgical treatment depending on the severity of the patient's condition by the modified Hunt-Hess scale

Results	Severity of the patient's condition (Hunt-Hess)												Quantity of the patients	
	0		I		II		III		IV		V			
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Good recovery	4	80	10	100	25	80,6	10	25	—	—	—	—	49	55,1
Moderate disability	1	20	—	—	4	12,9	8	32	2	16,7	1	16,7	16	17,6
Severe disability	—	—	—	—	1	3,2	3	12	4	33,3	3	50	11	12,3
Vegetative state	—	—	—	—	—	—	1	4	2	16,7	—	—	3	3,3
Death	—	—	—	—	1	3,2	3	12	4	33,3	2	33,3	10	11,2
Total	5	100	10	100	31	100	25	100	12	100	6	100	89	100

Results of AA treatment depending on the severity of patient's condition by GCS presented in Table 3.

Table 3.

Results of AA treatment depending on the severity of patient's condition by GCS

Results	Glasgow Coma Scale (points)								Quantity of the patients	
	15		14–13		12–9		≤8			
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Good recovery	43	87,8	6	24	—	—	—	—	49	55,1
Moderate disability	6	12,2	7	52	2	22,2	1	16,7	16	17,9
Severe disability	—	—	6	24	3	33,3	2	33,3	11	12,3
Vegetative state	—	—	2	8	1	11,1	—	—	3	3,3
Death	—	—	4	16	3	33,3	3	50	10	11,2
Total	49	100	25	100	9	100	6	100	89	100

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Results of the surgical treatment of the patients were analysed depending on the term of the operation after the hemorrhage (Table 4).

Table 4.

Results of the surgical treatment depending on the term of operation after the hemorrhage

Results	Term of the hemorrhage				Unruptured AA		Quantity of the patients	
	1–21 day		>21 day					
	abs.	%	abs.	%	abs.	%	abs.	%
Good recovery	38	51,4	7	70	4	80	49	55
Moderate disability	13	17,6	2	20	1	20	16	17,9
Severe disability	10	13,5	1	10	—	—	11	12,3
Vegetative state	3	4	—	—	—	—	3	3,3
Death	10	13,5	—	—	—	—	10	11,2
Total	74	100	10	100	5	100	89	100

Dependence of the results of the surgical treatment from the clinical and anatomical form of the hemorrhage was detected and statistically accurate ($p < 0,01$) (Table 5).

Table 5.

Results of the surgical treatment depending on the clinico-anatomical form of the hemorrhage

Results	Clinico-anatomical form of the hemorrhage								Quantity of the patients	
	SAH		SAH+ICH*		SAH+ICH+IVH**		SAH+ IVH			
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Good recovery	19	70,4	11	45,8	—	—	2	33,3	32	47,1
Moderate disability	5	18,5	4	16,6	—	—	4	66,7	13	19,1
Severe disability	1	3,7	3	12,5	6	54,5	—	—	10	14,7
Vegetative state	1	3,7	1	4,2	1	9,1	—	—	3	4,4
Death	1	3,7	5	20,8	4	36,4	—	—	10	14,7
Total	27	100	24	100	11	17,5	6	100	68	100

*ICH - Intracerebral hematoma

**IVH - Intraventricular hemorrhage

The results of the surgical treatment on the moment of the discharge were assessed by the Glasgow Outcome Scale (GOS), good results – 55,1% (n=49) patients, moderate disability – 12,3% (n=11), severe disability – 12,3% (n=11), vegetative state – 3,3% (n=3), death – 11,2% (n=10) (Table 6).

Table 6.

Clinical and neurological results of the treatment by the GOS

Results	Absolute number	%
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Good	49	55,1%
Moderate disability	16	17,6%
Severe disability	11	12,3%
Vegetative state	3	3,3%
Death	10	11,2%
Total	89	100%

Most of the patients – 72,9% (n=65) on the moment of the discharge didn't have disability symptoms or had mild disability, total amount of negative results were detected in – 26,8% (n=24) patients (see Table 7 and 8).

Table 7.

Clinical and neurological results of the treatment by GOS in patients, operated by MS method

Results	Absolute number	%
Good	37	51,4%
Moderate disability	13	18,1%
Severe disability	10	13,9%
Vegetative state	2	2,7%
Death	10	13,9%
Total	72	100%

Table 8.

Clinical and neurological results of the treatment by GOS in patients, operated by EV method

Results	Absolute number	%
Good	11	64,7%
Moderate disability	4	23,5%
Severe disability	1	5,9%
Vegetative state	1	5,9%
Death	0	0%
Total	17	100%

Discussion

We studied factors that influence on the results of the surgical treatment in patients with distal segments ACA AA. There was analysed The dependence of treatment results: severity of the patient's condition by GOS and modified scale Hunt-Hess, terms of the operation performing since the moment of AA rupture, clinical and anatomical form of the hemorrhage.

Severity of the patient's condition before the operation (Hunt-Hess scale) influences on the results of the surgical treatment. In the patients with 0-I degree of severity in all cases after surgical treatment good recovery was detected. With the

deterioration of the severity in patient's condition (III or more degree) the quantity of bad functional results and lethal cases increased. Statistical accurate connection was detected between the severity of the patient's condition by Hunt-Hess scale and results of the treatment (p<0,01).

Statistical accurate connection was detected between the results of the surgical treatment and level of the patients consciousness by GCS before the operation (p<0,01). Lethal cases were not detected among the patients who were in the clear consciousness before the operation, quantity of the patients who had the symptoms of the moderate disability — just 12% (6 from 49).

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Deterioration of the surgical treatment results was detected in patients with impairment of the consciousness. Lethality in patients who had 14-13 points by the GCS was 16% (4 from 5), and increased to the 33,3% (3 from 9) in case of the impairment of the consciousness by spoor type, among the patients in coma, lethality was detected in 50% (3 from 6 cases).

Thus, impaired consciousness is a risk factor for adverse outcomes of the surgical treatment of Anterior Cerebral Artery distal segments aneurysms. The branches of the Anterior Cerebral Artery distal parts blood supply the internal surface of the frontal and parietal lobes, on the external surface - the upper and partially middle frontal gyrus, as well as the upper part of the central gyrus. On the lower brain surface Anterior Cerebral Artery branches blood supply the straight gyrus, olfactory tract, olfactory triangle, ocular gyrus, and the main part of the corpus callosum, which are the structures of the central nervous system and are responsible for its integration functions. The state of consciousness reflects the normal functioning level of the reticular formation, midbrain, thalamus, and their bilateral relationships with all parts of the cerebral cortex.

Aneurysmal subarachnoid hemorrhage in distal segments of Anterior Cerebral Artery diffusely damages the cerebral cortex, causes artery vasospasm and leads to the development of secondary ischemic damage of the above brain structures, which manifest by consciousness different severity degree violations. Coma - as a violation of the integration function of all central nervous system and functional connections between its parts. It causes the systemic dysregulation, which in particular becomes one of the reason of water-salt metabolism and thermoregulation disorders. This assumption was confirmed by the analysis of pathomorphological studies protocols, where it was established that the main death reasons were progressive edema of the brain diencephalic parts on the background of

cerebral circulation lesion caused by decompensated cerebral vasospasm and disruption of compensation from the severe concomitant somatic pathology.

Consequently the impairment of the consciousness is the risk factor of the unfavourable treatment result in patients with the distal segments ACA AA.

Among the patients who were operated in the acute period of the hemorrhage (1-21 day) mortality was 17,5% (10 from 74) and at the same time the quantity of bad results after the surgical treatment was increased - 17,6% (13/74). Results of the treatment of patients who were operated in the term later than 21 day after AA rupture were much better: no any lethal cases, good recovery was detected in 70% (7 from 10 patients). In the group of patients with no AA rupture - we didn't have any lethality and good recovery after treatment we observed in 100% (5 from 5 cases). The difference of the results of surgical treatment between groups of patients who were operated in the different terms after the hemorrhage was connected with more severe state of the patients before the operation in the acute period of the hemorrhage.

The surgical intervention necessity in the acute period of aneurysm rupture was conditioned by urgent or vital indications, which were associated with an anatomical form of hemorrhage and its effect on the brain, it's dislocation and blood breakthrough into the ventricular system. By our opinion, the main reasons for the surgical unsatisfactory results of Anterior Cerebral Artery distal aneurysm are: secondary cerebral ischemia due to the vasospasm and the complex clinical-anatomical form of hemorrhage, which led to a rapid development of brain edema and dislocation. Above mentioned pathological processes, as a rule, were accompanied by intracranial hypertension with brain twnsion or prolapse into the trepanation hole during the operation. This significantly complicated the aneurysm clipping and increased the traumatic brain injury during access to the aneurysm.

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However, despite the foregoing, statistical accuracy was not detected by the analysis of the influence of the operation performing term (from the moment of AA rupture) on the results of the treatment ($p>0,05$).

Results of the surgical treatment in patients with the complicated clinical and anatomical forms of the haemorrhage were worse in comparison with the patients who had only SAH.

Anterior Cerebral Artery distal aneurysm hemorrhage usually localized in the interhemispheric region, and the topical place of intracerebral hematoma formation become the medial parts of the frontal or parietal lobe and the corpus callosum. During the aneurysm rupture, in addition to the headache, nausea and loss of consciousness, were appeared other symptoms specific to this aneurysm localization: akinetic mutism, behavioral changes and cognitive impairments, disorientation, delirium, memory dysfunction, Korsakov's syndrome. Sometimes we observed lower paraparesis in combination with impairment of pelvic organs. These symptoms were associated with damage to the waist gyrus and other structures of the limbic system. Focal neurological symptoms were caused by the intracerebral hematoma and mass effect formation, or ischemic brain damage. The rupture of Anterior Cerebral Artery distal segment aneurysms resulted in hemorrhage into the interhemispheric crack in more than half of the cases and was characterized by worse consequences than the rupture of aneurysms of other localizations.

After operation 11,2% (10 from 89) of patients died. On the base of the pathomorphological researches protocol analysis was detected that the main reason of the lethal cases were: increasing brain swelling especially in the diencephalic part, cerebrovascular circulation dysfunction on the top of the decompensated cerebral angiospasm and presence in patients of the severe somatic concomitant pathology.

Conclusions

1. Aneurysms of the distal segments of the ACA were registered in 3,4% (89 patients) among the 2610 cases with cerebral AA during the period since 1998 to 2015.

2. Typical clinical symptoms of AA verification were: clinic of AA rupture 94,4% ($n=84$). In 39,3% ($n=35$) cases SAH coexist with the intracerebral hematoma, in 19,1% ($n=17$) cases – with the intraventricular hemorrhage.

3. 16,9% ($n=15$) patients with the distal segments ACA AA had the multiple AA, 5,6% ($n=5$) patients from them had multiple AA located in the distal segments of ACA.

4. Dependence of the results of the surgical treatment from the severity of the patient's condition before the operation was detected: noted the functional negative results and lethal cases quantity increasing beginning from the III degree by Hunt–Hess scale.

5. Statistical accurate connection was detected between the severity of the patient's condition by GCS and the results of the treatment ($p<0,01$). Among the patients who were in the clear consciousness before the operation, lethal cases were not detected and quantity of the patients who had symptoms of the moderate disability was – 12,2%. Deterioration of the treatment results was detected in patients with reduced consciousness level. Lethality in the patients who had 13-14 points by GCS was – 16% and increased to the – 33,3% in case of the impairment of the consciousness by the sopor type, patients who was in coma initially – died in the 50% of cases.

6. Lethality after the operation increased from 10% in patients of the average age to 23,5% in patients of the old age. Quantity of the cases of the severe disability increased from 17,6% in comparison with 10% in patients of the ripe and middle age.

7. Dependence of the results of the surgical treatment of the distal segment ACA AA from the term of the operation after the hemorrhage was detected. Among the patients who were operated in the acute period of the

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hemorrhage (1-21 day) lethality was 17,5% and at the same time increased quantity of bad results of the surgical treatment (19,3%). Operation results in patients who were operated in the period more than 21 day after AA rupture didn't have lethal outcomes had good results in 64,7% cases. In patients with no AA rupture lethality was (0%) and good results were detected in 100% cases.

Acknowledgements

The authors wish to acknowledge SO "Institute of Neurosurgery named after acad. A.P. Romodanov NAMS of Ukraine " and SI "Scientific-practical Center of Endovascular Neuroradiology NAMS of Ukraine", Kyiv for help in collecting, reviewing and analyzing the clinical data related to this manuscript.

The objective — to research factors that influence on the results of the distal segments Anterior Cerebral Artery Aneurysms (ACA AA) surgical treatment with the purpose of the effectiveness improving.

Materials and methods.

Retrospective analysis of the examination and treatment results of 89 (100%) patients with the distal segments ACA AA from 2610 observations of cerebral AA who were hospitalized in SO "Institute of Neurosurgery named after acad. A.P. Romodanov NAMS of Ukraine" from 1998 to 2015 is submitted.

Patients of the ripe age (30-44 years) – 27(30,3%) and of the middle age (45-59 years) –43,8% (n=39). Average age of the patients: $36,7 \pm 11,6$ years (from 26 to 76 years), women - 52 (58,43%), men – 37 (51,57%). Basic amount of patients– 74 (83,1%) hospitalized in the acute period of the hemorrhage, in the “cold” period (more that 21 day after manifestation) – 10 (11,2%). In 4 (4,5%) from 5 (5,6%) patients distal segments ACA AA were detected as accidental findings and 1 (1,1%) case - is the giant AA with pseudo-tumor course of the disease. In 89 patients, who were included in the research 96 (100%) distal segments ACA AA were diagnosed. By the method of the direct

surgery 72 (80,9%) of patients with 79 AA were operated, by the method of the endovascular surgery - 17(19,1%) of patients with 17 AA.

Results. Typical clinical symptom of distal segment ACA AA was aneurysm rupture 94,4% (n=84). In 39,3% (n=35) cases SAH coexist with the intracerebral hematoma, in 19,1% (n=17) cases – with the intraventricular hemorrhage. Dependence of the results of the surgical treatment from the severity of the patient's condition before the operation was detected: noted the functional negative results and lethal cases quantity increasing beginning from the III degree by Hunt–Hess scale. Statistical accurate connection was detected between the severity of the patient's condition by Glasgow Coma Scale and the results of the treatment ($p < 0,01$). Deterioration of the surgical treatment results was detected in patients with reduced consciousness level.

The results of the surgical treatment on the moment of the discharge were assessed by the Glasgow Outcome Scale: good results – 55,1% (n=49) patients, moderate disability – 17,6% (n=16), severe disability – 12,3% (n=11), vegetative state – 3,3% (n=3), death – 11,2% (n=10). In patients who were operated in the acute period of the hemorrhage (1-21 day) mortality was (17,5%) and at the same time increased quantity of bad results of the surgical treatment (19,3%). Operation results in patients who were operated in the period more than 21 day after AA rupture didn't have lethal outcomes, quantity of good results - 64,7% cases. In patients with no AA rupture lethality was (0%) and good results were detected in 100% cases.

Conclusions. Dependence of the results of the surgical treatment from the severity of the patient's condition by the Glasgow Coma Scale and modified Hunt–Hess scale, terms of the operation performing after the aneurysm rupture, clinico-anatomical form of the hemorrhage was detected.

Direct and endovascular surgery is effective method for distal segments ACA AA

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treatment. Choosing of one or another method has to be performed individually on the base of the clinical condition of the patient (presence of the complicated hemorrhage, brain swelling, dislocational syndrome, angiospasm), x-ray anatomical AA

characteristic with taking into account the advantages and disadvantages of the methods in each definite case.

Key words: surgical treatment, arterial aneurysm, brain.

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