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Late results and health-related quality of life in patients after endovascular treatment for multiple intracranial aneurysms

Oleinik A.A.[1], Ivanova N.E.[1], Goroshchenko S.A.[1], Oleinik E.A.[1], Ivanov A.Yu.[2]

[1] *Polenov Neurosurgical Institute, Almazov National Medical Research Centre*
12, Mayakovsky Str., Saint Petersburg, 191014, Russian Federation

[2] *Saint-Petersburg State Pediatric Medical University*
2, Litovskaya Str., Saint-Petersburg, 194100, Russian Federation

ABSTRACT

Aim. To assess the results of endovascular treatment in patients with multiple intracranial aneurysms (MIA) in the late postoperative period according to health-related quality of life (HRQoL) concept.

Materials and methods. 172 cases of patients having undergone endovascular MIA repair were examined. The evaluation of patient health-related quality of life was carried out using the SF-36 (The Short Form (*36*) Health Survey), the ICF (the International Classification of Functioning), and the modified Rankin Scale (mRS).

Results. The complication of subarachnoid hemorrhage (*SAH*) appears in approximately 1,2% of cases in the late postoperative period. When assessing the health-related quality of life according to the SF-36 domains in patients with Subarachnoid hemorrhage (SAH), the QoL showed a decrease in "Social Functioning" ($p = 0.03$). In patients with pseudotumor cerebri (PTC) a decrease was seen in "Role-Physical Functioning" (RP) ($p = 0.004$), while "General Health" (GH) ($p = 0.049$), "Social Functioning" (SF) ($p = 0.005$) and "Mental Health" (MH) ($p = 0.009$) subscales also saw decreases.

Having more than two inpatient surgical procedures is also associated with the health-related quality of life of patients ($p < 0.05$). Assessment of activity with ICF showed the *intensity* of irregularities on the d4501 domain – "walking short distance" – depended on the existing SAH ($p < 0.05$). Procedural complications affected the *patient's* daily *activities* on the domains d4501 – "walking long distance" ($p = 0.03$), and d640 – "doing household chores" ($p = 0.01$).

Conclusion. The assessment with ICF allows the specification of patient activity and participation in public life. The SF-36 scale provides additional information on the patients' subjective perception of their condition. Considering the quality of life in the late postoperative period is not completely restored in all patients, ongoing rehabilitation measures, diagnostic cerebral angiographies and improvements in the surgery techniques are required.

Key words: cerebral aneurysms, multiple aneurysms, postoperative period, long-term results, endovascular treatment, quality of life.

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✉ *Oleinik Anna A.,* e-mail: doctor.an.an@mail.ru.

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Отдаленные результаты и качество жизни у пациентов с множественными церебральными аневризмами после эндоваскулярного лечения

Олейник А.А.[1], Иванова Н.Е.[1], Горощенко С.А.[1], Олейник Е.А.[1], Иванов А.Ю.[2]

[1] Российский научно-исследовательский нейрохирургический институт (РНХИ) им. проф. А.Л. Поленова, Национальный медицинский исследовательский центр (НМИЦ) им. В.А. Алмазова
Россия, 191014, г. Санкт-Петербург, ул. Маяковского, 12

[2] Санкт-Петербургский государственный педиатрический медицинский университет (СПбГПМУ)
Россия, 194100, г. Санкт-Петербург, ул. Литовская, 2

РЕЗЮМЕ

Цель. Оценить результаты лечения больных после эндоваскулярных вмешательств по поводу множественных церебральных аневризм (МнА) в отдаленном послеоперационном периоде с учетом качества жизни пациентов.

Материалы и методы. Проанализированы данные 172 наблюдений с МнА, оперированных эндоваскулярно. Исследование качества жизни производилось с использованием общего опросника The Short Form-36 (SF-36), Международной классификации функционирования (МКФ), шкалы Рэнкина.

Результаты. В отдаленном послеоперационном периоде субарахноидальное кровоизлияние (САК) отмечено в 1,2% случаев. При оценке по шкале SF-36 у больных, перенесших в анамнезе САК, качество жизни снижалось по субшкале «Социальное функционирование» ($p = 0,03$), у больных с псевдотуморозным типом течения – по субшкалам «Ролевое функционирование, обусловленное физическим состоянием» (RP) ($p = 0,004$), «Общее состояние здоровья» (GH) ($p = 0,049$), «Социальное функционирование» (SF) ($p = 0,005$), «Психическое здоровье» (MH) ($p = 0,009$). Число оперативных вмешательств >2 также ассоциировано с качеством жизни пациентов ($p < 0,05$). При оценке активности по МКФ выраженность нарушений по домену d4501 – ходьба на близкие расстояния – зависела от перенесенного САК ($p < 0,05$). Осложнения эндоваскулярного лечения оказывали влияние на активность пациентов по доменам d4501 – ходьба на дальние расстояния ($p = 0,03$), d640 – выполнение работы по дому ($p = 0,01$).

Заключение. Уточнить, каковы активность и участие в общественной жизни пациента, позволяет проведение оценки по МКФ. Дополнительную информацию о субъективном восприятии пациента своего состояния позволяет получить шкала SF-36. Учитывая, что качество жизни в отдаленном послеоперационном периоде не у всех пациентов восстанавливается полностью, возникает необходимость в дальнейшем проведении реабилитационных мероприятий, контрольных церебральных ангиографий, а также в усовершенствовании методов хирургического лечения.

Ключевые слова: артериальные аневризмы, множественные церебральные аневризмы, отдаленные результаты, эндоваскулярное лечение, качество жизни, результаты эндоваскулярного лечения.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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INTRODUCTION

On average, cerebral arterial aneurysms (CAA) in a healthy adult population occur in approximately 3.2% of cases [1]. Multiple cerebral aneurysms (MCA) of blood vessels of the brain among CAA occur according to various sources of literature in 2–44.9% of cases [2–3]. The average prevalence of CAA is 20.1% [4]. CAA is the most common cause of subarachnoid hemorrhage (SAH) [5]. Almost 30% of monitored patients with MCA have SAH [6]. Case mortality rate from repeated CAA rupture is as high as 68–70% [7–8]. The choice of tactical decisions in surgical treatment in patients with MCA is personalized. It considers the size, shape and localization of CAA, the course of the disease, and the daily functioning of a patient. Treatment of MCA, as a rule, requires combined methods applied in several stages [9–10]. According to various sources, decrease in quality of life (QoL) occurs in one third of MCA survivors 1 year after SAH [11–13]. There are studies comparing QoL of patients according to the type of surgery (microsurgical and endovascular management) [14] that do not identify any differences. They, moreover, compare preoperative and postoperative QoL [15]. At the same time, the available literature is not yet sufficient to draw conclusions for the problem of QoL studying and clinical manifestations in patients after endovascular treatment of MIA.

Having several AAs and the need for repeated surgical interventions and angiographic control determine the relevance of the QoL examination in such patients [16]. The objective of the work is to evaluate the results of endovascular surgical treatment of patients with MIA in the late postoperative period, regarding the dynamics of neurological disorders and QoL.

MATERIALS AND METHODS

The information from 172 cases of MIA patients after endovascular repair was examined. These patients received endovascular therapy at the Department of Surgery for Brain and Spinal Cord Vascular Pathology at Polenov Neurosurgical Institute between 2012 and 2018. A comprehensive follow-up examination of patients, operational outcomes, and QoL after endovascular treatment in the long-term postoperative period was carried out.

The cases included adults aged 26–77, the median age (the sample mean +/- a margin of error ($M \pm m$), sample size $n = 172$)) was about 54.19 ± 0.83 years. 81.4% of patients were women (140/172), 18.6% were men (32/172). The male to female gender ratio was 1:4.4. A total of 172 patients were diagnosed with 441 MIA. Patients with 2 AAs accounted for 62.2% (107/172), 25.6% had 3 AAs (44/172), 7.5% had 4 (13/172), 3.5% had 5 (6/172), 0.6% had 6 (1/172), and 0.6% had 7 (1/172).

The size of the identified AA was of the following types: miliary (up to 3mm) (22.7%, 100/441), regular size (4–15 mm) (71.7%, 316/441), large (16–25 mm) (2.0% ,9/441), and giant (>25mm) (3.6%, 16/441). 50% of patients (86/172) had one or more SAHs in their history, 5.8% (10/172) of patients had AAs with prognosis of pseudotumor cerebri. All patients underwent 1 to 5 endovascular surgeries.

In general, 172 patients underwent 354 endovascular aneurysm repairs. One-stage operations were performed in 30.8% of patients (53/172). In 15.1% (8/53) of cases, AAs were totally excluded from the bloodstream within the one stage. In 41.5% of patients (22/53), AAs were shut down; however, there were miliary AA and/or aneurysmal expansion of the visceral patches, requiring intensive monitoring. 37.7% of patients (20/53) underwent the first step of surgical management from the planned multistage treatment. 5.7% of patients (3/53) are under the follow-up monitoring. 69.2% (119/172) of patients were treated with multistage surgery: all AAs were excluded from the bloodstream in 55.5% (66/119) of the patients, 44.5% (53/119) of the patients underwent two or more surgical procedures, however, reoperation is planned on other AAs (patients are at the stage of elective surgery for AA exclusion from the bloodstream). The evaluation of surgical treatment occurred over the following 6- to 24-month period. The follow-up was specified during repeated hospitalizations for control angiography or coronary intervention, outpatient visits and clarifying correspondence. Patients were asked to fill out a questionnaire designed for this purpose. The data of a standard diagnostic neurosurgical complex was also evaluated: examination by a neurologist, neuro-ophthalmologist and a therapist, MRI + MR angiography of the brain, CT scan of the brain, selective cerebral angiography, EEG. The research of QoL in the late postoperative period was carried out using the general SF-36 (The Short Form-36 Health Status Survey) questionnaire and ICF (International Classification of Functioning). The functional status of patients before and after surgery was evaluated using the modified Rankin scale (J. Rankin, 1957). Data were analyzed using Statistica software integrated for Windows; frequency indicators of the qualitative indi-

cators were compared using non-parametric statistical criteria (Pearson's chi-squared test (χ^2), Fisher's exact test). Comparison of frequency indicators was carried out using nonparametric statistics (Mann – Whitney *U*-test, Analysis of variance (ANOVA)). The assessment of the studied dynamics parameters after the received treatment was carried out using the Wilcoxon signed-rank test. The criterion for the level of statistical significance of differences was $p < 0.05$.

RESULTS

Procedural complications of endovascular treatment occurred in 3.4% (12/354) of patients. Coronary complications: in 9 of 12 cases, intraoperative rupture of AA in 3 of 12 cases. According to the follow-up data, in the late postoperative period, SAH was verified in 1.2% (2/172) of patents – rupture of unoperated AA; ischemic complications (with regard to self-discontinuation of antiplatelet therapy) in 1.2% (2/172) of patients, and stent migration in 0.6% (1/172) of cases. According to the control cerebral angiogram performed in the late postoperative period (between 6 months and 2 years after the surgery), the development of de novo AA or the unoperated AA growth occurred in 8.7% (15/172) of cases, AA recurrence or recanalization was found in 19.2% (33/172) of cases – 9.3% of operations performed (33/354). In 5.2% (9/172) of cases, control cerebral angiogram was not performed (it was refused by the patients).

There were the following focal neurologic complications in the late postoperative period: cranial nerve dysfunction – 6.9% (12/172), motor disorders – 5.2% (9/172), impaired sensitivity – 2.3% (4/172), impaired coordination – 2.9% (5/172), speech disorders – 2.3% (4/172), visual disturbances – 3.5% (6/172), cognitive impairment – 10.5% (18/172), symptomatic epilepsy – 6.4% (11/172). Focal neurological signs resulted from the experienced SAH, the pseudotumor cerebri, and intraoperative complications. Assessed dynamics of activities of daily living according to the modified Rankin scale before surgery and in the late postoperative period is presented in Fig. 1.

In the late postoperative period, the functional status of patients according to the Rankin scale was worsened in those who had past *SAH* ($p = 0.04$) and complications of surgical interventions ($p = 0.001$).

QoL scored on SF-36 subscales in the late postoperative period is presented in Table 1.

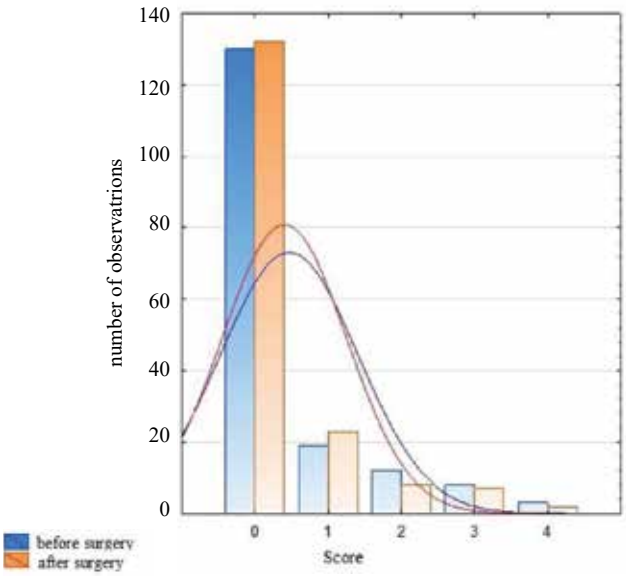

Fig. 1. Dynamics of daily activity assessment on the Rankin scale before surgery and in the late postoperative period

Table 1

Quality of life on SF-36 subscales in the late postoperative period

Subscales	*M* ± *SD*	*Min–Max*	Median, 25 and 75% quartiles (*Me (LQ;UQ)*)
PH (Physical Health)	44.91 ± 10.16	20.26–0.96	44.81 (38.64–55.05)
MH (Mental Health)	49.78 ± 9.76	20.54–61.53	51.74 (44.82–57.35)
PF (Physical Functioning)	75.15 ± 25.86	0–100	80 (67.5–95)
RP (Role-Physical)	66.72 ± 32.56	0–100	75 (50–100)
BP (Bodily Pain)	66.2 ± 26.17	0–100	62 (41–100)
GH (General Health)	61.78 ± 19.13	12–95	67 (45–77)
VT (Vitality)	60.93 ± 14.88	10–80	60 (60–70)
SF (Social Functioning)	77.33 ± 26.77	0–100	75 (75–100)
RE (Role-Emotional)	74.42 ± 29.8	0–100	66.67 (66.67–100)
MH (Mental Health)	73.07 ± 18.13	0–100	76 (66–86)

In the analysis of the QoL of different age groups, a decrease in QoL on the subscales "Physical functioning" (PF) ($p = 0.005$), and "General health" (GH) ($p < 0.045$) was found in elderly patients and patients with dementia compared to the other patients. Gender and number of AA have little impact on the QoL of patients in the late postoperative period ($p > 0.05$). A decrease in QoL of patients with the existing *SAH* on the "Social functioning" (SF) subscale ($p = 0.03$) was found. An analysis of QoL on subscales SF-36 was carried out regarding the manifestations of AA in the late preoperative period (SAH, pseudotumor cerebri, showing no symptoms AA). It has been found that the indicators were worse according to the subscale "Role-physical functioning" (RP) ($p = 0.004$), "General health" (GH) ($p = 0.049$), "Social functioning" (SF) ($p = 0.005$), and "Mental health" (MH) ($p = 0.009$) in the group of patients with pseudotumor cerebri. The presence of cephalgic disorder lowered the QoL according to the subscales "Bodily Pain" (BP) ($p = 0.004$) and "Mental health" (MH) ($p = 0.04$). Speech disturbances existing in the late postoperative period significantly reduced QOL in the subscale "Role-Physical Functioning" (RP) ($p = 0.001$), "General health" (GH) and "Mental health" (MH) ($p = 0.04$). Visual disturbances reduced QoL on the subscales "General Health" (GH) and "Mental Health" (MH) ($p = 0.03$). The presence of a disorder of the cranial nerve function decreased the indicators "Role-Physical Functioning" (RP) ($p < 0.05$), "General health" (GH), "Vitality" (VT) and "Mental health" (MH) ($p = 0.005$). The presence of motor impairment reduced the indicators "Physical Functioning" (PF), "Role-Physical Functioning" (RP) ($p = 0.0001$), "General health" (GH) ($p = 0.01$), "Role-Emotional" (RE) and "Mental health" (MH) ($p < 0.05$); in addition, the indicator "Physical component of health" was also reduced ($p = 0.001$). Sleep impairment reduced QoL on the subscales "Physical functioning" (PF) and "Role-Physical Functioning" ($p = 0.01$). It has been found that the number of stages of surgical interventions is also associated with QoL of patients. In the monitored group with 2 or more surgical interventions compared with the group with 1 surgical intervention, a reduced QoL was found according to the "Role-Physical Functioning" (RP), "Social functioning" (SF), "Role-Emotional" (RE), "Mental health" (MH) ($p = 0.04$) subscales and "Psychological Component of Health" ($p = 0.001$). The existence of complications related to the surgical treatment worsened the quality of life of patients in "Vitality" (VT) and "Psychological Component of Health" ($p < 0.05$).

The assessment of the impairments in patients in the late postoperative period according to the ICF classification was conducted using the domains of activity and participation (d4500 – walking short distance, d4501 – walking long distance, d4600 – moving around within the home, d4602 – moving around outside the home and other buildings, d5101 – washing oneself, d5400 – dressing, d630 – preparing meals, d640 – doing housework). Evaluation on the ICF components of activity and participation is presented in Fig. 2 (implementation) and Fig. 3 (capacity). Patients' adaptation to the activity impairments in the late postoperative period is visible in the difference between "implementation" and "capacity" indicators.

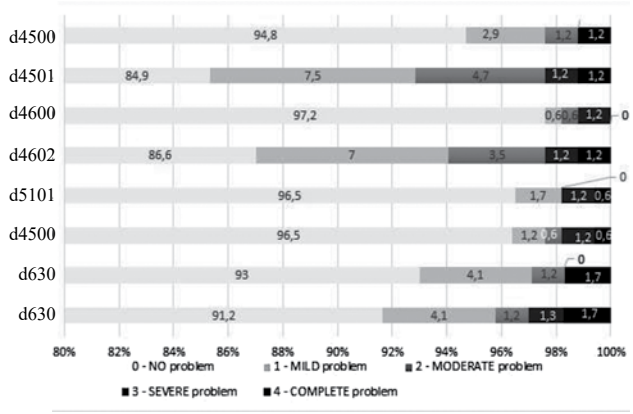

Fig. 2. Evaluation of activity and participation based on the ICF in the late postoperative period (performance)

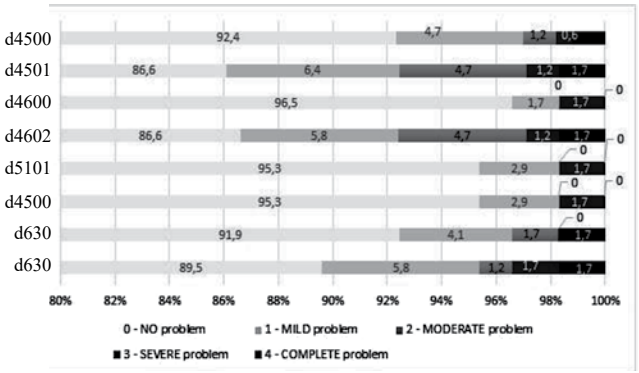

Fig. 3. Evaluation of activity and participation based on the ICF in the late postoperative period (capacity)

These indicators allow evaluating the patient's skills in the use of equipment and involvement of other people in helping the patient. The evidence of existing impairment on the d4501 domain – walking short distance, depended on the existing SAH ($p < 0.05$). Endovascular treatment complications affected the activity of patients on domains d4501 – long-distan-

ces walking ($p = 0.03$), and d640 – doing housework ($p = 0.01$).

DISCUSSION

QoL is an important indicator which allows more complete characterization of patients' functional and psychological status after suffering SAH and complications of surgical MIA repair. The research specifies the factors that cause negative subjective perception of patients after MIA endovascular treatment. The experienced SAH had an impact only on the "Social functioning" (SF) subscale, due to the long time interval after *SAH* and successful rehabilitation measures. Similar data were derived on the effect of complications of surgical interventions on the psychological component of health [17]. Unlike other studies [16–17], we did not identify an impact of the number of aneurysms on QoL. However, it was identified that QoL is associated with the number of surgical interventions performed on MIA. This indicates that the necessity of repeated surgical interventions, associated with AA recurrence or recanalization, affects QoL. Neurologic impairment worsened QoL, as in other studies [18]. In addition, we have found that the use of traditional scales for QoL assessments does not always allow understanding of how the patient functions in real life. Using ICF assessment allows the obtainment of information on the patient's activity and their participation in public life, as well as a depiction of the connection between function and structural impairments in the body. Additional information on the patients' subjective perceptions of their condition can be obtained within the SF-36 questionnaire. All these data allow forming the most complete picture of QoL of patients in the late postoperative period.

CONCLUSION

Good results of endovascular treatment for multiple aneurysms have been achieved. QoL in patients with MA depends on the past SAH, the number of surgical interventions, complications of endovascular treatment, and having a pseudotumor cerebri.

At the same time, there is a need for further rehabilitation measures, as well as for the improvement of surgical treatment methods, and for follow-up *c*erebral angiogram. Given that QoL is a comprehensive assessment of the rehabilitation measures effectiveness in patients with MA, the assessment of this indicator before and after surgery, and in the late postoperative period, is a necessary criterion for patients' functional status assessment. It is necessary to conduct a structured screening of cognitive complaints, neurologic impairment, emotional problems and clarification of personal factors. Identification of these problems is necessary for adapting rehabilitation programs to the individual needs of patients.

REFERENCES

1. Vlak M.H., Algra A., Brandenburg R., Rinkel G.J. Prevalence of unruptured intracranial aneurysms, with emphasis on sex, age, comorbidity, country, and time period: a systematic review and meta-analysis. *The Lancet Neurology.* 2011; 10: 626–636. DOI: 10.1016/S1474-4422(11)70109-0.
2. Wilson F.M., Jaspan T., Holland I.M. Multiple cerebral aneurysms – a reappraisal. *Neuroradiology.* 1989; 31: 232–236. DOI: 10.1007/BF00344349.
3. Juvela S. Risk factors for multiple intracranial aneurysms. *Stroke.* 2000; 31 (2): 392–397. DOI: 10.1161/01.STR.31.2.392.
4. Jabbarli R., Dinger T.F., Darkwah Oppong M., Pierscianek D., Dammann P., Wrede K.H. et al. Risk factors for and clinical consequences of multiple intracranial aneurysms. *Stroke.* 2018; 49 (4): 848–855. DOI: 10.1161/STROKEAHA.117.020342.
5. Muehlschlegel S. Subarachnoid hemorrhage. *CONTINUUM Lifelong Learning in Neurology.* 2018; 24 (6): 1623–1657. DOI: 10.1212/CON.0000000000000679.
6. Macdonald R.L., Schweizer T.A. Spontaneous subarachnoid haemorrhage. *Lancet.* 2017; 389 (10069): 655–666. DOI: 10.1016/S0140- 6736(16)30668-7.
7. Brain aneurysm surgery; edited by V.V. Krylov. In three volumes. Volume I. Moscow, 2011 (in Russ.).
8. Fung C., Mavrakis E., Filis,A., Fischer I., Suresh M., Tortora A., Cornelius J.F., Bostelmann R., Gralla J., Beck J., Raabe A., Khan M.O., Steiger H.J., Petridis A.K. Anatomical evaluation of intracranial aneurysm rupture risk in patients with multiple aneurysms. *Neurosurgical Review*. 2019; 42 (2): 539–547. DOI: 10.1007/s10143-018-0998-1.
9. Hejreddin A.S., Jeliava Sh.Sh., Jakovlev S.B., Filatov Ju.M., Kaftanov A.N., Belousova O.B., Sazonov I.A., Arustamjan S.R., Mikeladze K.G., Buharin E.Ju., Dorohov P.S. Tactics of surgical treatment in patients with unruptured asymptomatic cerebral aneurysms. *Problems of Neurosurgery named after N.N. Burdenko.* 2016; 80 (5): 32–43 (in Russ.). DOI: 10.17116/nei- ro201680532-43.
10. Orning J.L., Shakur S.F., Alaraj A., Behbahani M., Charbel F.T., Aletich V.A., Amin-Hanjani S. Accuracy in identifying the source of subarachnoid hemorrhage in the setting of multiple intracranial aneurysms. *Neurosurgery.* 2018; 83: 62–68. DOI: 10.1093/neuros/nyx339.
11. Andersen C.R., Fitzgerald E., Delaney A., Finfer S. A systematic review of outcome measures employed in aneurysmal subarachnoid hemorrhage (aSAH) clinical research. *Neurocritical Care.* 2019; 30 (3): 534–541. DOI: 10.1007/s12028-018-0566-0.
12. Proust F., Bracard S., Lejeune J.-P., Thines L., Leclerc X., Penchet G., Bergé J., Morandi X., Gauvrit J.-Y., Mourier K., Ricolfi F., Lonjon M., Sedat J., Bataille B., Droineau J., Civit T., Magro E., Pelissou-Guyotat I., Cebula H., Lallouche K., David P., Emery E., Courthéoux P., Vignes J.-R., Béni-

chou J., Aghakani N., Roche P.-H., Gay E., Bessou P., Guabrillargues J., Irthum, B. For the FASHE investigators a randomized controlled study assessing outcome, cognition, autonomy and quality of life in over 70-year-old patients after aneurysmal subarachnoid hemorrhage. *Neurochirurgie*. 2018; 64 (6): 395–400. DOI: 10.1016/j.neuchi.2018.08.004.
13. Taufique Z., May T., Meyers E. et al. Predictors of poor quality of life 1 year after subarachnoid hemorrhage. *Neurosurgery.* 2016; 78 (2): 256–264. DOI: 10.1227/NEU.0000000000001042.
14. Brilstra E.H., Rinkel G.J.E., van Der Graaf Y., Sluzewski M., Groen R.J., Lo R.T.H., Tulleken C.A.F. Quality of life after treatment of unruptured intracranial aneurysms by neurosurgical clipping or by embolisation with coils: A prospective, observational study. *Cerebrovascular Diseases*. 2004; 17 (1): 44–52. DOI: 10.1159/000073897.
15. Yamashiro S., Nishi T., Koga K. et al. Improvement of quality of life in patients surgically treated for asymptomatic unruptured intracranial aneurysms. *J. Neurol. Neurosurg. Psychiatry.* 2007; 78 (5): 497–500. DOI: 10.1136/jnnp.2006.098871.
16. Dammann P., Wittek P., Darkwah Oppong M., Hütter B.-O., Jabbarli R., Wrede K., Wanke I., Mönninghoff C., Kaier K., Frank B., Müller O., Kleinschnitz C., Forsting M., Sure U. Relative health-related quality of life after treatment of unruptured intracranial aneurysms: long-term outcomes and influencing factors. *Therapeutic Advances in Neurological Disorders.* 2019; 12: 1–12. DOI: 10.1177/1756286419833492.
17. Pala A., Pawlikowski A., Brand C., Schmitz B., Wirtz C.R., König R., Kapapa T. Quality of life after treatment of unruptured intracranial aneurysms. *World Neurosurgery.* 2019. 121: e54–59. DOI: 10.1016/j.wneu.2018.09.010.
18. Passier P.E.C.A., Visser-Meily J.M.A., Rinkel G.J.E., Lindeman E., Post M.W.M. Determinants of health-related quality of life after aneurysmal subarachnoid hemorrhage: A systematic review. *Quality of Life Research*. 2013. 22 (5): 1027–1043. DOI: 10.1007/s11136-012-0236-1.

Authors contribution

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Authors information

Oleinik Anna A., Neurologist, Polenov Neurosurgical Institute, Almazov National Medical Research Centre, Saint-Petersburg, Russian Federation. ORCID 0000-0002-0848-5706.

Ivanova Natalia E., Dr. Sci. (Med.), Professor, Head of the Science Department, Polenov Neurosurgical Institute, Almazov National Medical Research Centre, Saint-Petersburg, Russian Federation. ORCID 0000-0003-2790-0191.

Goroshchenko Sergei A., Cand. Sci. (Med.), Neurosurgeon, Polenov Neurosurgical Institute, Almazov National Medical Research Centre, Saint-Petersburg, Russian Federation. ORCID 0000-0001-7297-3213.

Oleinik Ekaterina A., Neurologist, Polenov Neurosurgical Institute, Almazov National Medical Research Centre, Saint-Petersburg, Russian Federation. ORCID 0000-0001-7559-1499.

Ivanov Alexey Yu., Dr. Sci. (Med.), Professor, Department of Cardiovascular Surgery, Saint-Petersburg State Pediatric Medical University, Saint-Petersburg, Russian Federation. ORCID 0000-0001-5777-2886.

(✉) **Oleinik Anna A.,** e-mail: doctor.an.an@mail.ru.

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