Research Article
https://doi.org/10.23934/2223-9022-2021-10-2-276-284

Results of Surgical Treatment of Patients with Cerebral Aneurysms in the Acute Period of Hemorrhage Transported Over a Considerable Distance

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RELEVANCE To provide emergency specialized neurosurgical care to patients living in rural areas, medical evacuation to a neurosurgical hospital is required. Despite the fact that medical evacuation is a necessary stage of medical care, there are not enough studies on the impact of transportation of patients with a ruptured cerebral aneurysm over long distances. There is little information about the time intervals for transportation, the timing of the start of treatment and the outcomes of the disease in patients who are at a considerable distance from the neurosurgical hospital.

AIM OF THE STUDY To analyze the impact on the extensive results of surgical treatment of patients with cerebral aneurysm rupture.

MATERIAL AND METHODS A retrospective analysis of the results of surgical treatment of 145 patients with cerebral aneurysm rupture in the acute period of hemorrhage, hospitalized in the Regional Cascular Center of the State Budgetary Institution of the Sakha Republic (Yakutia) "Republican Hospital No. 2 — Center for Emergency Medical Aid" in the period from 01.01.2017 to 31.12.2018. Patients were divided into two groups: Group I — patients from remote areas of the Republic of Sakha (Yakutia) who underwent medical evacuation by the Disaster Medicine Service of the Sakha Republic (Yakutia); Group II — hospitalized from the territory of the city of Yakutsk and its nearest suburbs.

RESULTS 145 patients were hospitalized at the Regional Vascular Center in Yakutsk. Sanaviation (Sanitary Aviation) delivered 91 patients from the districts of the republic to the regional vascular center (62.8% of the total number of patients) (Group I), 54 patients (37.2%) were hospitalized from the territory of the urban district of Yakutsk (Group II). The distance of transportation by ambulance aircraft in Group I ranged from 45 to 1330 kilometers. Deterioration from admission to the local medical organization to admission to the regional vascular center was noted in 8 patients (8.8%), improvement in the condition in 25 (27.5%) patients, there were no dynamics of changes in the state of 58 (63.7%) patients. The total number of deaths in two groups of patients was 11 (12.1%) patients. Postoperative mortality had no statistically significant differences between the two study groups: in Group I — 7.7% (7 patients), in Group II — 7.4% (4 observations) (p=1,000).

CONCLUSIONS With an established system of medical evacuation, transportation over a considerable distance does not worsen the course of the disease and the results of surgical treatment of patients with cerebral aneurysm ruptures in the acute period of hemorrhage.

Keywords: aneurysmal subarachnoid hemorrhage, regional vascular center, primary vascular department, disaster medicine, sanitary aviation, medical evacuation, patient transportation

For citation Vorobyov EA, Dashyan VG, Savvina NV, Makievskij MY, Chugunova SA, Yakhontov IS, et. al. Results of Surgical Treatment of Patients With Cerebral Aneurysms in the Acute Period of Hemorrhage Transported Over a Considerable Distance. *Russian Sklifosovsky Journal of Emergency Medical Care*. 2021;10(2):276–284. https://doi.org/10.23934/2223-9022-2021-10-2-276-284 (in Russ.)

Conflict of interest Authors declare lack of the conflicts of interests

Acknowledgments, sponsorship The authors express their gratitude to the Deputy Chief Physician for Clinical Expert Work of the SBI RH2-EMC of Sakha Republic (Yakutia), N.S. Petrova for administrative support in the study.
The study had no sponsorship

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AOH – acute occlusive hydrocephalus
aSAH – aneurysmatic subarachnoid hemorrhage
CA – cerebral aneurysm
CRH – central regional hospital
CT – computed tomography
DH – district hospital
EMC – emergency medical services
EVD – external ventricular drainage
GCS – Glasgow Coma Scale
ICH – intracerebral hemorrhage
IVH – intraventricular hemorrhage
LMO – local medical organization
ME – medical evacuation
MO – medical organization
PMS – paramedic and midwifery station
PVC – primary vascular compartment
RCDM – regional center for disaster medicine
RICU – resuscitation and intensive care unit
RS (Y) – The Republic of Sakha (Yakutia)
RVC – regional vascular center
SDH – subdural hematoma
X-ray CT – X-ray computed tomography

INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) is one of the most severe forms of acute cerebrovascular accident with a high mortality and disability rate [1]. The most significant factors predisposing to an unfavorable outcome in aSAH are the severity of primary hemorrhage, angiospasm, and repeated rupture of the cerebral aneurysm (CA) [2]. Repeated rupture of CA is the cause of death in 60% of cases, and cerebral ischemia due to angiospasm - in 15–20% [3, 4]. To prevent a repeated rupture of the CA, it is necessary to manage it as early as possible by microsurgical or endovascular methods [5]. This requires early hospitalization of patients with SAH in specialized neurosurgical departments.

At the onset of the disease, most patients with aSAH are admitted to hospitals where no neurosurgical care is available. These patients require medical evacuation (ME) to a neurosurgical hospital to provide highly qualified medical care, including surgical treatment [6, 7]. European guidelines for the treatment of patients with aSAH suggest early transfer to a neurosurgical hospital if logistical and technical capabilities

are available [8]. In regions remote from large neurosurgical centers, ME of patients with CA rupture is a necessary stage of treatment, and without it, intervention in the early period of hemorrhage is impossible. There are not enough studies on the effect of transportation over long distances and the type of ME on the course of the disease in patients with CA rupture. There is little information about the time intervals for transportation and the timing of treatment initiation for patients who, at the time of the onset of the disease, are at a considerable distance from the neurosurgical hospital, as well as about the effect of the transportation scheme on the outcome of the disease.

The aim of our study was to analyze the effect of long distance transportation on the results of surgical treatment of patients with CA rupture.

MATERIAL AND METHODS

A retrospective analysis of the results of surgical treatment of 145 patients with CA rupture admitted to the Regional Vascular Center (RVC) and transferred for surgical treatment to the neurosurgical department of the State Budgetary Institution "Republican Hospital No. 2 - Center for Emergency Medical Aid" (Yakutsk) from Jan 1, 2017 to Dec 31, 2018. Criteria for inclusion in the study group: patients with aSAH in the acute period of hemorrhage who underwent surgical treatment (clipping or coiling in the acute period of the disease). Exclusion criteria: patients with SAH of nonaneurysmal etiology; patients with aSAH who underwent surgical treatment in the period of the disease more than 21 days from the moment of CA rupture).

The study analyzed the following parameters: gender; age; the timing of surgical treatment from the moment of the disease; place of residence (city, village), method of transportation (air medical service (helicopter or plane), ground transport); neurological status according to the *NIHSS (National Institutes of Health Stroke Scale)*, the level of consciousness according to the *Glasgow Coma Scale* (GCS), the severity of the condition according to the *Hunt-Hess* scale, the assessment of the nature of hemorrhage according to the *Fisher* scale, the presence of intraventricular hemorrhage (IVH), acute occlusive hydrocephalus (AOH) based on X-ray computed tomography (X-rat CT) data upon admission to the primary vascular department (PVD), RVC and before surgery; surgical method (clipping or coiling); outcomes of surgical treatment (death; assessment of neurological status according to the *NIHSS* scales, functional outcome according to the *modified Rankin Scale (mRS)* upon discharge from the hospital.

The examined patients were divided into two groups: Group I - patients from the regions of the Republic of Sakha (Yakutia) (Republic of Sakha (Yakutia)), (Republic, rural residents) who underwent ME from the site of the disease from the local medical organization (LMO) to the RVC of Yakutsk by the service of the disaster medicine in the Republic of Sakha (Yakutia) (by helicopter, airplane), ground transport; Group II - hospitalized via EMS, self-referral and transfer from medical organizations (MO) of Yakutsk and its nearest suburbs (the territory of the urban district of Yakutsk, urban residents). To verify the SAH in rural hospitals, a lumbar puncture or computed tomography (CT) of the brain (in the conditions of the primary vascular department) was performed; upon confirmation of the SAH diagnosis and after telemedicine consultation communication with a neurosurgeon and a neurologist, the patients were transported to the RVC by air medical service accompanied by resuscitator. Patients living in Yakutsk were hospitalized in the RVC via EMS self-referral or transfer from the Yakutsk municipal district.

The Disaster Medicine Service (Regional Center for Disaster Medicine - RCDM, sanitary aviation) delivered patients with aSAH from remote regions of the republic to the RVC. At the same time, for distance of up to 80 km and satisfactory roads, ground transport was used (in the absence of roads, a helicopter was used, including at short distances); for a transportation distance of up to 300 km, a helicopter was used for the ME, and an airplane was used for a distance of more than 300 km.

At the RVC, all patients (100%) underwent CT on a *Somatom Sensation* 64-slice tomograph (*Siemens*, Germany) and cerebral subtraction angiography on an *Innova* 3100 *IQ* seriograph (*General Electric*, USA).

All patients were treated according to the guidelines for the clinical management of patients with subarachnoid hemorrhage due to rupture of cerebral aneurysms [9].

Statistical analysis of the data obtained was carried out using the *Statistica* 13 software package (*StatSoft*, USA) and *Microsoft Excel*, 2016 (*Microsoft*, USA). The normality of the distribution of quantitative traits was determined using the Kolmogorov test. Quantitative traits were described by medians, 25% and 75% quartiles (Me [Q1; Q3]). For parameters that do not follow the laws of normal distribution, the nonparametric Mann – Whitney method was used. To compare the frequencies of qualitative signs, the Pearson χ^2 test and the 2-sided Fisher's exact test were used, and the odds ratio *(OR)* and 95% confidence interval *(CI)* for statistically significant differences were also calculated.

RESULTS

Of the 145 patients included in the study, there were 55 men (38%) and 90 women (62%). Air medical service delivered 91 patients (62.8% of the total), including 34 men and 57 women (group I) from the districts of the republic to the RVC. From the territory of the urban district of Yakutsk, 54 (37.2%) patients (21 men and 33 women) were hospitalized (group II). The average age of patients was 51.1 ± 11.2 years, while the age of men was statistically significantly less than that of women (47.8 ± 9.6 versus 53.1 ± 11.7 years) (p = 0.003). The age of patients between groups I and II had no statistically significant differences: 53 [44.0; 58.0] years versus 52 [42.0; 58.0] years, respectively (p = 0.584).

The distance of transportation by air medical service from LMO to RVC in group I was from 45 to 1330 kilometers. At the same time, the transportation scheme was complicated (ME between three or more MOs) in 49 patients (53.8%), simple (ME between two MOs) - in 42 (46.2%) patients.

All patients underwent surgical treatment: clipping in 103 cases (71%), coiling in 42 cases (29%), including group I - 68 (74.7%) and 23 (25.3%), respectively; in group II - 35 (64.8%) and 19 (35.2%), respectively (p = 0.203; χ^2 = 1.618; df = 1).

The period from the moment of CA rupture to the beginning of surgical treatment in patients of group I was statistically significantly longer in comparison with that in patients of group II: 3.0 [2.0; 6.0] versus 2.0 [1.0; 5.0] days, respectively (p = 0.002).

The intensity of hemorrhage according to non-contrast CT scan during hospitalization at the RVC did not have statistically significant differences between the two groups.

The level of consciousness according to the GCS at the onset of the disease in group I during hospitalization in the LMO and before transportation by air ambulance was the same - score 15.

Repeated CA ruptures before hospitalization in the RVC in group I were in 24 patients (26.3%), in group II - in 6 (11.1%). At the same time, in group I, a repeated rupture was observed according to the CT data (the appearance of negative dynamics compared to the primary CT performed in the PVD) without a significant deterioration in the condition - in 10 patients (41.6%); only according to a typical clinical picture - in 12 patients (50%). For these patients, CT was not performed at the LMO due to the lack of a tomograph at the MO. In 2 patients (8.3%), there was a combination of negative dynamics according to the X-ray CT in LMO with a typical clinical picture of repeated CA rupture. In group II, a repeated rupture was diagnosed on the basis of a typical clinical picture (Fig. 1).

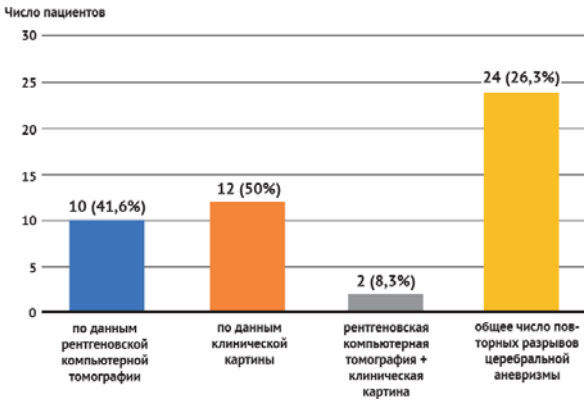

Fig. 1. Repeated ruptures of the central aneurysm before hospitalization in the regional vascular center in group I (rural residents), n=24

Deterioration in the interval from admission to the LMO to admission to the RVC (level of consciousness according to GCS and / or worsening of the condition according to the *Hunt-Hess* scale) was noted in 8 patients (8.8%), improvement in the condition was noted in 25 (27.5%), there were no dynamics of changes in the state in 58 (63.7%). At the same time, in 7 patients (7.7%), deterioration occurred during transportation by air to the RVC (Fig. 2).

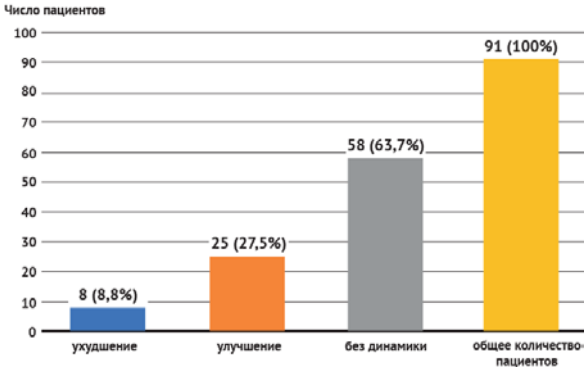

Fig. 2. The dynamics of the state of patients from admission to a local medical organization to hospitalization in the regional vascular center in group I (rural residents), n=91

During hospitalization in the RVC, the severity of the condition of patients in group II was higher than in patients in group I (the severity according to the *Hunt-Hess* scale of 1–2 degrees was in 63 patients (69.2%) in group I and in 28 (51.9 %) - in group II ; severity of 3-5th degree in 28 patients (30.8%) in group I and in 26 (48.1%) - in group II ($p = 0.036$; $\chi^2 = 4.379$; $df = 1$; $OR = 2.089$; 95% CI : 1.043–4.187) The level of wakefulness according to the GCS was equal in both groups: 15.0 [14.0; 15.0] in group I, 15.0 [13.0 ; 15.0] in group II ($p = 0.020$) The severity of neurological symptoms during hospitalization in the RVC according to the *NIHSS* scale was also higher in group II and amounted to 1.5 [0.0; 9.0] points versus 0.0 [0.0; 2.0] in group I ($p = 0.042$) (table).

Table

Clinical characteristics of patients with ruptured aneurysm

Parameters	I group (rural residents), *n* = 91	II group (city residents), *n* = 54	*R*
Average age, years Me [Q1; Q2]	53 [44.0; 58.0]	52 [42.0; 58.0]	0.584
Female, *n* (%)	57 (62.6)	33 (61.1)	0.855 $\chi^2 = 0.034$; $df = 1$
Assessment by GCS upon admission to the RVC; Me [Q1; Q3]	15.0 [14.0; 15.0]	15 [13.0; 15.0]	0.020
Severity according to the *Hunt – Hess* scale upon admission to the RVC			
1st-2nd degree	63 (69.2)	28 (51.9)	0.036 $\chi^2 = 4.379$; $df = 1$ $OR = 2.089$; 95% CI : 1.043-4.187
3-5th degree	28 (30.8)	26 (48.1)	
NIHSS score upon admission to the RVC, Me [Q1; Q3]	0 [0; 2.0]	1.5 [0; 9.0]	0.042
Number of days before surgery, Me [Q1; Q3]	3.0 [2.0; 6.0]	2.0 [1.0; 5.0]	0.002
Repeated rupture of aneurysm before surgery, *n* (%)	3 (3.3)	2 (3.7)	1,000
Clinically significant vasospasm before surgery, *n* (%)	10 (11)	8 (14.8)	0.604
Hunt-Hess score before surgery			
1st-2nd degree	64 (70.3)	26 (48.1)	0.008 $\chi^2 = 7.082$; $df = 1$ $OR = 2.553$; 95% CI : 1.270-5.130
3-5th degree	27 (29.7)	28 (51.8)	
Glasgow score before surgery, Me [Q1; Q3]	15.0 [14.0; 15.0]	14.5 [12.0; 15.0]	0.007
NIHSS score before surgery, Me [Q1; Q3]	2.0 [0; 2.0]	1.0 [0; 12.0]	0.046
Clipping aneurysm, *n* (%)	68 (74.7)	35 (64.8)	0.203 $\chi^2 = 1.618$; $df = 1$
Aneurysm embolization, *n* (%)	23 (25.3)	19 (35.2)	
Intraoperative complications, *n* (%)	23 (25.3)	19 (35.2)	0.203 $\chi^2 = 1.618$; $df = 1$
Number of ICU bed-days after surgery, Me [Q1; Q3]	3.0 [2.0; 6.0]	4.0 [3.0; 9.0]	0.020

The number of bed-days in the hospital, Me [Q1; Q3]	23.0 [20.0; 29.0]	24.5 [19; 32]	0.317
Fatal outcome, *n* (%)	7 (7.7)	4 (7.4)	1,000
Favorable outcome (score 0-2, *mRS* scale), *n* (%)	66 (72.5)	37 (68.5)	0.607 $\chi^2 = 0.265$; *df* = 1
Unfavorable outcome (score 3-5, *mRS* scale), *n* (%)	18 (19.8)	13 (24.1)	0.542 $\chi^2 = 0.372$; *df* = 1

Notes: RICU - resuscitation and intensive care unit; RVC - Regional Vascular Center; GCS - Glasgow Coma Scale

There were no statistically significant differences between the surveyed groups in the frequency of detection:

1. Intracerebral hematoma (ICH): in group I - 21 (23.1%) patients, in group II - 15 (27.8%) patients (p = 0.526; χ^2 = 0.401, *df* = 1).

2. Vasospasm according to transcranial Doppler sonography: in group I - 41 patients (45.1%), in group II - 18 (33.3%) patients (p = 0.165, χ^2 = 1.929, *df* = 1).

3. Ischemia due to angiospasm: in group I - 3 patients (3.3%), in group II - 0 (p = 0.294).

4. AOH before surgery was detected in 3 patients (3.3%) in group I and in 5 patients (9.3%) in group II (p = 0.128, χ^2 = 2.311, *df* = 1).

The incidence of IVH in group I (rural residents) was statistically significantly higher than in group II: 58 patients (63.7%) and 24 patients (44.4%), respectively (p = 0.023; χ^2 = 5.133, *df* = 1).

Deterioration of the state according to clinical and neurological data from the moment of hospitalization at the RVC to the operation on the *Hunt – Hess* scale was diagnosed in 12 patients (14.3%) in group I and in 10 patients (18.5%) in group II (p = 0.387; χ^2 = 0.749, *df* = 1) and was associated with repeated CA rupture (in group I - 3 cases (3.3%); in group II - 2 cases (3.7%) (p = 1,000)) and an increase in vasospasm (in group I 10 cases (11%); in group II - 8 cases (14.8%) (p = 0.499; χ^2 = 0.456, *df* = 1)).

Before surgery, the level of consciousness according to the GCS was 15.0 in group I [14.0; 15.0], and 14.5 [12.0; 15.0] (p = 0.007) in group II. Other parameters for assessing the condition of patients are presented in Table.

The removal of the ICH was performed in 9 patients (9.9%) in group I and in 7 patients (12.9%) in group II. The removal of subdural hematomas was performed in 2 patients (2.2%) of group I and in 3 patients (5.6%) of group II. External ventricular drainage (EVD) was installed in 3 patients (3.3%) in group I and in 5 patients (9.3%) in group II.

Intraoperative complications after open surgery developed in 23 patients (25.3%) in group I and in 19 patients (35.2%) in group II, the difference between the groups was statistically insignificant (p = 0.203; χ^2 = 1.618, *df* = 1). Thus, intraoperative aneurysm rupture was observed in 17 patients (18.7%) in group I and in 14 patients (25.9%) in group II (p = 0.304; χ^2 = 1.058, *df* = 1); occlusion of the carrying vessel occurred only in 3 patients (3.3%) of group I (p = 0.294). Repeated clipping of the aneurysm as a second operation was performed in 2 patients (2.2%) of only group I (p = 0.529).

After embolization of the aneurysm, repeated ruptures of aneurysms were not observed in group I, in group II, recurrent bleeding developed in 1 patient (1.8%) (p = 0.372); coil migration after embolization was observed in 2 patients (2.2%) in group I (p = 0.529).

The total duration of inpatient treatment was: 23 in group I [20; 29] bed-days, in group II - 24.5 [19; 32] bed-days (p = 0.317). The number of bed-days in the intensive care unit (ICU) in the postoperative period in group I was statistically significantly less than in group II: 3.0 [2.0; 6.0] versus 4.0 [3.0; 9.0], respectively (p = 0.020).

The total number of deaths in the two groups of patients was 11 (7.6%). Postoperative mortality did not have statistically significant differences between the two study groups: in group I - 7.7% (7 patients), in group II - 7.4% (4 observations) (p = 1,000).

The functional outcome of the disease at the end of the acute period of hemorrhage did not have statistically significant differences between the study groups: a favorable outcome (score 0-2, *mRS* scale) in group I was observed in 66 patients (72.5%), in group II - in 37 patients (68.5%) (p = 0.607; χ^2 = 0.265; *df* = 1). An unfavorable outcome (score 3-5, *mRS* scale) in group I was observed in 18 patients (19.8%), in group II - in 13 (24.1%) (p = 0.542; χ^2 = 0.372; *df* = 1).

DISCUSSION

For patients living in rural areas, the possibility of providing neurosurgical care is limited, and, as a rule, rural residents with acute neurosurgical pathology are initially hospitalized in hospitals without a neurosurgical service [10]. Despite the isolated publications that surgical treatment of CA ruptures in local hospitals is possible, in most cases, CA rupture is a disease that requires high-tech methods of diagnosis and treatment in specialized centers [11, 12]. There are a number of studies that have shown that in hospitals where there is a sufficient concentration of patients with ruptured aneurysm (more than 30 year) [13–18]. Taking this into account, medical transportation of patients with suspected CA rupture to a specialized neurosurgical hospital is a necessary measure. In this case, it is required to know how much transportation, especially long and multistage transportation, can affect the course of the disease.

In our study, the majority of patients (62.8%) were rural residents and were delivered by air medical service from remote areas of the republic. The high frequency of the use of air ambulance is associated with the climatic and geographical characteristics of the terrain: a vast, inaccessible territory with the presence of many small rural settlements remote from each other with a low population density, a significant remoteness of the ME zone (the northern regions of the republic are at a flight distance of over 1000 km by air transport) from Yakutsk, by road the distance is more than 2.5 thousand kilometers) from the only neurosurgical hospital providing emergency medical care to patients with CA ruptures.

One of the variables influencing the timing of surgical treatment was the method of patient transportation. The terms of surgical intervention from the moment of CA rupture were longer in patients delivered by air medical service (3.0 [2.0; 6.0] days versus 2.0 [1.0; 5.0] days) ($p = 0.002$). Similar results were obtained by *J. Weyhenmeyer et al*., who showed that patients hospitalized by ground transport, receive surgical treatment from the moment of illness is faster. In their study, patients delivered by ground transport received treatment after 37.1 ± 40.1 hours, and by air transport - 41.3 ± 63.3 hours after CA rupture [6]. This circumstance is due to the fact that air transport is used to evacuate patients over longer distances: according to *A. Soetrberg et al*., air transport is mainly used at a medical evacuation distance of more than 100 km [18]. Also, the transportation of patients with aSAH by air takes more time compared to ground evacuation, since it is technically and organizationally complex [19]. Hard-to-reach regions with a low population density, as a rule, have a harsh climate, and the weather factor often determines the possibility of air communication.

In our study, a longer period of time from the onset of the disease to surgical treatment in the group of patients hospitalized by air medical service, in addition to the considerable distances, can also be explained by the fact that the patients of this group were initially hospitalized in the LMO (paramedic and midwifery station (PMS), district hospitals (DH), central regional hospitals (CRH) or primary vascular departments), where, after the diagnosis of SAH, telemedicine consultation with a neurosurgeon and a neurologist was carried out, further treatment and diagnostic tactics were determined.

In rural residents transported by air medical sevice, from admission to the medical center to admission to the RVC, there were no dynamics of changes in the state in 58 patients (63.7%), improvement in the condition was noted in 25 patients (27.5%), deterioration in the condition of patients during the transportation of the air ambulance. aviation from LMO to RVC was found in 8.8% of patients. The results of our study differ from the study carried out by *A. Sorteberg et al*., according to which 79.3% of patients had no negative dynamics during transportation of patients with SAH in Norway [18].

The diagnosis of a repeated CA rupture before arrival at the RVC in rural residents delivered by air medical service was made on the basis of a combination of negative clinical and tomographic pictures. In our study, the frequency of CA repeated ruptures reached 26.3%, which is higher than the data published by *H. Ohkuma et al* - 13.6% and *A. Sorteberg et al* - 15.7% [20, 18]. However, there was no significant deterioration in the condition in patients who underwent repeated rupture compared with other patients. On the contrary, it was found that at the stage of hospitalization in the RCC, the severity of the condition according to *Hunt – Hess*, the level of wakefulness and neurological deficit were more pronounced in the group of urban patients. Thus, the number of patients with severe symptoms (3–5 degrees according to *Hunt – Hess*) was statistically significantly higher among patients hospitalized from the city, compared with their number hospitalized by air ,edical service: $p = 0.036$; $\chi^2 = 4.379$; $df = 1$; $OR = 2.089$; 95% CI : 1.043-4.187). The same ratio of the severity of the patient's condition was observed before surgery ($p = 0.008$; $\chi^2 = 7.082$; $df = 1$; $OR = 2.553$; 95% CI : 1.270–5.130). This can only be explained by the onset of some improvement in the process of transporting patients.

The incidence of intraoperative complications did not differ between the two study groups ($p = 0.203$). The length of hospital stay did not have statistically significant differences between the groups of

urban and rural residents hospitalized by air ambulances - 24.5 [19.0; 32.0] and 23.0 [20.0; 29.0] days, respectively (p = 0.317). But the stay in the ICU after the operation was statistically significantly higher among patients hospitalized from the city, in comparison with patients delivered by air ambulance from afar: 4.0 [3.0; 9.0] versus 3.0 [2.0; 6.0] (p = 0.020) bed-days. Our data differ from the results of *AR Catalano et al*., Which showed that patients transferred from other hospitals stayed longer in the ICU (8 versus 5 bed-days) and in the hospital (11 versus 13 bed-days) compared to patients delivered directly to the neurosurgical hospital [21]. But their study included patients with intracranial hemorrhages of various origins (aneurysmal, hypertensive, etc.), and all patients were transported by ground transport.

The low postoperative mortality and good functional outcomes in patients in our study correspond to the results of treatment of ruptured CA neurosurgical hospitals with a high concentration of patients with aSAH [22-24].

The number of deaths (in group I - 7 (7.7%), in group II - 4 (7.4%)) did not have statistically significant differences between the two groups (p = 1,000).

In a study by *J. Weyhenmeyer et al.* mortality was higher in patients delivered by air compared to its level in patients delivered by land (19.3% versus 13.9%) [6].

According to *A. Soterberg et al* ., On the contrary, in patients with aSAC transferred from other hospitals using ground and air transport, the mortality rate was equally lower compared to that in patients who were directly hospitalized (18.7 versus 36.8%) (p <0.0001) [18].

Our postoperative mortality rates are comparable to those of *Y. Wengui et al.* who analyzed the work of the Comprehensive Vascular Center in Los Angeles, USA. From 2012 to 2014, they treated 112 patients with CA ruptures. All patients were operated on within 24 hours from the moment of illness (endovascular method - 50.8%, microsurgical method - 44.1%). A good outcome (*mRS* 0-3) was observed in 50% of patients, an unfavorable (*mRS* 4-5) - in 33.9%, postoperative mortality was 16% [25].

CONCLUSION

When transported by air medical service over a considerable distance, deterioration occurred only in 8.8% of patients with aSAH. The severity of the clinical manifestations of hemorrhage before surgical treatment is less pronounced in rural residents hospitalized by air ambulances, in comparison with the data of patients hospitalized from the city.

The ratio of the frequency of using microsurgical and endovascular methods for excluding aneurysm was 74.7% and 25.3% in the group of patients hospitalized by air ambulance, and 64.8% and 35.2% in the group of patients hospitalized from the city (p = 0.203). The frequency of intraoperative complications did not have statistically significant differences between the examined groups.

The overall postoperative mortality rate was 7.6%; in patients hospitalized by air medical service, it did not have statistically significant differences with mortality among city residents and was comparable to the indicators of large neurosurgical centers in the country. The functional outcome of the disease among surviving patients did not have statistically significant differences between groups.

Thus, with an established system of medical evacuation, transportation over a considerable distance does not worsen the course of the disease and the results of surgical treatment of patients with ruptured cerebral aneurysms in the acute period of hemorrhage.

Postoperative mortality among patients with ruptured cerebral aneurysms in the acute period of hemorrhage in cases of medical evacuation at a considerable distance using air medical service was 7.7%, and among patients hospitalized within the city district, it was quite comparable by conventional methods - 7.4%. The number of favorable outcomes in these groups of patients also did not differ significantly - 72.5% and 68.5%, respectively.

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Received on 05.10.2020

Review completed on 12.03.2021

Accepted on 30.03.2021