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## ORGANIZATION OF MEDICAL EVACUATION OF PATIENTS WITH SEVERE COVID-19 AND THE RESULTS OF THEIR TREATMENT IN THE INTENSIVE CARE RESUSCITATION UNIT

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In order to study the timeliness of medical evacuation of the patients with severe novel coronavirus from the districts of the Sakha Republic (Yakutia), a retrospective analysis of data from the Republic's Center for Disaster Medicine (RCDM) for 2019-2022 was carried out. To compare the treatment results of patients living in the city of Yakutsk and patients evacuated from the districts of the republic ("city", "district"), we conducted a prospective observational case-control study of 600 patients with severe COVID-19 in the specialized anesthesiology, resuscitation and intensive care unit (ARICU) of the Sakha Republic Clinical Hospital in 2020-2022. Lethal outcome ( $n=397$ ) was chosen as the studied criterion. It was found that the study groups had statistically significant differences in age ( $p=0.002$ ), body mass index (BMI) ( $p=0.001$ ), saturation (SaO<sub>2</sub>) of mixed blood upon admission to the ARICU ( $p=0.003$ ), oxygenation index ( $p=0.011$ ), and the severity of the condition according to the SOFA (Sequential Organ Failure Assessment) score. The patients evacuated from the districts were characterized by younger age, higher body mass index, and greater damage to lung tissue. City residents were more prone to experience brain failure, acute kidney injury, and the development of multiple organ dysfunction. The mortality rate for the district patients with severe COVID-associated community-acquired pneumonia was 65.8%; for urban patients it made 66.3%, with no statistically significant differences established ( $p=0.906$ ). Thus, the arrangement of medical evacuation for COVID-19 patients to a specialized institution during the pandemic ensured the availability and timeliness of specialized care provided to them.

**Keywords.** Novel coronavirus, community-acquired pneumonia, city, district, lethal outcome.

**Introduction.** The timeliness of specialized and high-tech medical care plays a decisive role in the outcome of a disease. Medical evacuation makes a major

contribution to the availability of medical care in high-level medical institutions in emergency situations. Emergency medical evacuation requires quick and correct solving of organizational and clinical issues. It is necessary to justify the evacuation of a patient, determine indications and contraindications for transportation, select the optimal type of ambulance transport, as well as to form and equip an evacuation medical team, taking into account characteristics of the pathology and severity of the patient's condition.

Medical evacuation has become particularly relevant in the context of the spread of the novel coronavirus (nCoV) COVID-19, characterized by the massive scale of the disease, the need to comply with infection safety measures and provide respiratory support during the transportation of patients. In regions with large territories and underdeveloped transport infrastructure, including the Sakha Republic (Yakutia), the main burden of transporting COVID-19 patients to specialized departments fell on the air ambulance service.

With the beginning of the spread of nCoV COVID-19 in the Sakha Republic (Yakutia), a comprehensive action plan was adopted to provide medical care to patients with a severe course of the disease [1].

To provide inpatient care to COVID-19 patients, a three-level system of medical

care was deployed in the republic: Level 1 medical care was provided in central district hospitals on beds allocated for patients with mild forms of COVID-19; Level 2 medical care was provided by medical organizations equipped with a PCR laboratory and equipment for radiation diagnostics (X-ray computed tomography (CT)); Level 3 was carried out at the Sakha Republic Clinical Hospital, where specialized departments for patients with COVID-19 were formed, including the Anesthesiology, Resuscitation and Intensive Care Unit (ARICU) with 36 beds [4].

To provide qualified medical care to residents of the entire republic, sanitary flights of the Republic's Center for Disaster Medicine (RCDM) carried out both inter-district transfer and transportation to medical institutions in Yakutsk.

When arranging the evacuation of COVID-19 patients, the RCDM introduced a set of measures to increase the epidemiological safety: additional briefings for flight and technical personnel; purchase of personal protective equipment and isolation boxes for transporting patients; increased supply of medical oxygen; and additional contracts with organizations providing post-flight disinfection of the aircraft. A significantly increased burden of evacuating patients from the districts of the republic required additional resources. Thus, to perform sanitary flights to COVID-19 patients, 100

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million rubles were allocated by order of the Head of the Sakha Republic (Yakutia) of November 13, 2020, No. 433-RG from the reserve fund of the Russian Federation within the framework of the subprogram "Equalization of financial capabilities of the budgets of constituent entities of the Russian Federation and local budgets" under the state program of the Russian Federation "Development of federal relations and creating conditions for effective and responsible management of regional and municipal finances". In addition, the Republic's Medical Center "Reserve" provided medical protective suits, respirators, protective screens, pump sprayers, isolation boxes, and anti-epidemic kits. Additional medical and paramedic teams were formed to evacuate COVID-19 patients. The airlines providing medical flights added aircraft (a MI-8 helicopter and an An-26 aircraft) equipped with isolation boxes. The routing of COVID-19 patients from certain districts was promptly revised to optimize the workload of the central air ambulance station, taking into account the availability of beds in infectious diseases hospitals in Yakutsk.

Obviously, the outcome of the patient's treatment is one of the main criteria for the proper arrangement and adequacy of medical and evacuation measures. Therefore, along with studying the features of arranging medical evacuation for COVID-19, it is necessary to analyze the final treatment results of the patients evacuated to a specialized department to assess the continuity and effectiveness of the measures taken. This established the aim of the study.

**Aim of the study:** to analyze the features of arranging medical evacuation of patients with severe COVID-19 and the results of their treatment at the specialized unit of anesthesiology, resuscitation and intensive care in the Sakha Republic (Yakutia)

**Materials and methods.** To achieve this aim, a retrospective analysis of the main performance indicators of the Re-

public's Center for Disaster Medicine (RCDM) of the Ministry of Health of the Sakha Republic (Yakutia) was carried out. The volume and structure of completed air ambulance missions during the spread of the nCoV COVID-19 were studied by air ambulance mission logs and patient evacuation records for 2019-2022.

To compare the treatment results of the patients evacuated by air ambulance, a prospective observational case-control study was performed on 600 patients with COVID-19 complicated by community-acquired pneumonia (281 men (46.8%) and 319 women (53.2%)), treated at the ARICU, Sakha Republic Clinical Hospital, in the period 2020-2022. The patients were divided into groups: those admitted by referral from clinics or transferred by ambulance medical teams in Yakutsk (city patients, n=451) and those transported by the RCDM from the central district hospitals (CDH) of the republic (district patients, n=149).

Lethal outcome (n=397) was chosen as the studied criterion.

The inpatient study was carried out in accordance with the ethical standards of the Declaration of Helsinki of the World Medical Association "Ethical principles for medical research involving human subjects" as amended in 2008, and the "The rules of clinical practice in the Russian Federation", approved by order

of the Ministry of Health of the Russian Federation of June 19, 2003, No. 266, and approved by the local Committee on Biomedical Ethics, Institute of Medicine, Ammosov North-Eastern Federal University. Before participating in the study, the patients were informed about the aims and methods of the study and gave their consent.

Inclusion criteria for the study: age over 18 years, inpatient treatment in the ARICU, diagnoses U07.1 "COVID-19, virus identified" and U07.2 "presumed COVID-19, virus not identified"; patients with severe community-acquired COVID-19-associated pneumonia with pulmonary lesions according to CT results at 50-75% (CT-3) and 75-100% (CT-4), patient's informed consent to participate in the study.

Exclusion criteria: age under 18 years, patient's refusal to participate in the study.

When statistically processing the RCDM data, the analytical, expert assessment and mathematical analysis methods were used. A statistical analysis of the ARICU data was performed using IBM SPSS Statistics version 26.0. The indicators were checked for normal distribution using the Kolmogorov-Smirnov test with Lilliefors correction (for n>50) and the Shapiro-Wilk test (for n<50), with p-value>0.05 as normal distribution. All measured quantitative indicators had a distribution different from normal, and

Table 1

The distribution of evacuated patients by some disease entities in 2019-2022 (abs. number)

Disease	2019	2020	2021	2022
Acute coronary syndrome	378	443	462	532
Acute cerebrovascular accident	355	385	389	502
Injuries	416	396	497	606
Pregnancy, childbirth and postnatal period	362	356	338	364
COVID-19		503	1511	398

Table 2

Number of air ambulance missions and evacuated COVID-19 patients by groups of districts

Groups of districts	2020		2021		2022	
	Missions	Patients	Missions	Patients	Missions	Patients
Arctic	81	141	230	459	97	134
Northern	22	25	51	117	38	65
South-Western	63	98	144	232	30	35
Zarechnaya	82	121	165	246	65	87
Vilyui	73	91	198	437	52	75
Central	15	27	16	20	2	2
TOTAL	336	503	804	1511	284	398

Table 3

## A comparative characteristic of the COVID-19 patients in the study groups

Indicator	City patients, n=451		District patients, n=149		p-value
	Me [IRQ]	Min;Max	Me [IRQ]	Min;Max	p
Age, years	68 [60; 76]	18-94	63 [57; 70]	20-100	0.002
BMI, kg/m <sup>2</sup>	29.3 [25.8;33.0]	14.69-52.1	31.2 [27.9;36.2]	20.0-57.46	0.001
SaO <sub>2</sub> of mixed blood upon admission to ARICU, %	84 [78;89]	40-99	80 [76;88]	52-94	0.003
Oxygenation index, mm Hg	267 [169;333]	58-450	218 [140;333]	70-430	0.011
APACHE II, score	16 [14;18]	5-44	17 [14;18]	8-49	0.972
SOFA, score	6 [5;8]	1-23	6 [4;8]	2-18	0.05
Duration of treatment at ARICU, bed-day	6 [3;10.5]	0-56	7 [4;11]	1-40	0.112

then nonparametric statistical methods were used. For descriptive statistics of quantitative data, medians (Me) and interquartile range (IQR) were calculated; for categorical data, absolute numbers with percentages were calculated. A comparative nonparametric analysis of quantitative data was carried out using the Mann-Whitney U test. A comparative analysis of nominal binary data was performed by constructing a four-field table with calculation of Fisher's exact test or Pearson's  $\chi^2$  test depending on the expected minimum number, with calculation of the odds ratio at 95% confidence interval.

**Results and discussion.** An analysis of completed air ambulance missions showed that in the period 2019-2022 the main reasons for the medical evacuation of patients were acute coronary syndrome (ACS), acute cerebrovascular accident (ACVA), severe injuries, pregnancy and childbirth, with the growing trend. Since March 2020, patients with nCoV COVID-19 contributed to the changes in the structure of air ambulance mission; their maximum number was observed in 2021 at 1,511 patients, which exceeded the number of patients with the above diagnoses more than 3-fold (Table 1).

Table 2 presents the distribution of air ambulance missions by groups of regions of the republic.

The largest number of patients were evacuated from the Arctic group of regions: 141 patients in 2020, 459 in 2021, 134 in 2022; it was followed by the Zarechnaya (across the Lena River from Yakutsk) group of districts: 121 patients in 2020, 246 in 2021, 87 in 2022; and the Vilyui group: 91 patients in 2020, 437 in 2021, 75 in 2022 (Table 2).

While being in central district hospitals before evacuation, all patients with severe COVID-19 were consulted by

Table 4

## Comorbidities in the COVID-19 patients in the study groups (abs. number; specific weight)

Indicator	City patients, n=451	District patients, n=149	p-value
Chronic cardiovascular diseases, including AH	422 (93.6) 407 (90.2)	140 (94.0) 139 (93.3)	0.865 0.260
Chronic kidney disease	218 (48.3)	64 (43.0)	0.254
Chronic lung diseases, including bronchial asthma	194 (43.0) 29 (6.4)	149 (35.6) 5 (3.7)	0.109 1.159
Diabetes mellitus, type 2	169 (37.5)	57 (38.3)	0.864
CNS chronic diseases	166 (36.9)	30 (20.1)	<0.001
Chronic liver diseases	28 (8.3)	11 (9.6)	0.666
Oncological diseases	35 (7.8)	9 (6.0)	0.485
Rheumatic diseases	6 (1.3)	6 (4.0)	0.082

Table 5

## Clinical and laboratory characteristic of the patients (abs. number; specific weight)

Indicator	City patients, n=451	District patients, n=149	p-value
Total lung damage (CT 4)	253 (56.1)	101 (67.8)	0.012
Vasopressor support	77 (17.1)	18 (12.1)	0.145
Acute brain failure	144 (31.9)	33 (22.1)	0.023
Acute coronary syndrome	17 (5.1)	2 (1.8)	0.129
Noninvasive ALV on day 1	308 (68.4)	106 (71.1)	0.537
Invasive ALV on day 1	8.9% (40)	7.4% (11)	0.586
Acute kidney injury	210 (46.6)	36 (24.2)	<0.001
Acute liver failure	100 (22.2)	37 (24.8)	0.511
Multiple organ dysfunction syndrome (MODS)	316 (70.1)	85 (57.0)	0.003
Deaths	299 (66.3)	98 (65.8)	0.906

doctors of the Regional Center for Telemedicine Consultations, established on the basis of the Sakha Republic Clinical Hospital under orders of the Ministry of Health of the Sakha Republic (Yakutia) No. 01-07/437 of 09 April 2020 "On remote advisory centers of anesthesiology and resuscitation for the diagnosis and treatment of infectious diseases caused by coronavirus strain COVID-19 and pneumonia" [2] and No. 213 of 18 April 2020 "On the organization of telemedicine consultations on COVID-19" [3].

Along with studying the features of arranging medical evacuation for COVID-19, in accordance with the aim of the research and in order to study the effectiveness of the air ambulance missions completed, we performed a comparative analysis of the treatment results of the most severe category of the patients evacuated by air ambulance, whose course of illness was complicated by community-acquired pneumonia.

The data analysis showed that the study groups demonstrated statistically significant differences in age ( $p=0.002$ ), body mass index (BMI) ( $p=0.001$ ), saturation (SaO<sub>2</sub>) of mixed blood upon admission to the ARICU ( $p=0.003$ ), oxygenation index ( $p=0.011$ ) and severity of the condition according to the SOFA (Sequential Organ Failure Assessment) scale. There were no significant differences in the APACHE II (Acute Physiology Age Chronic Health Evaluation) severity scale and duration of treatment in the ARICU (Table 3).

Generally, the groups did not differ in comorbidities, among which arterial hypertension/hypertensive disease (AH/HD), chronic kidney disease and chronic lung diseases prevailed (Table 4).

The exceptions were diseases of the central nervous system (CNS) like post-stroke encephalopathy, dementia, Alzheimer's disease, Parkinson's disease, epilepsy, post-traumatic encephalopathy, which were more common in the city

patients. This factor is also responsible for the more frequent presence of acute brain failure in this group of the patients ( $p=0.023$ ). In addition, acute kidney injury ( $p=0.001$ ) and multiple organ dysfunction syndrome were more often observed in the city patients. At the same time, the patients evacuated from the central district hospitals more often demonstrated total lung damage (more than 75% of the lung tissue) according to computed tomography of the chest organs, which indicated the severity of their condition, the presence of severe respiratory failure and the justification for their admission to the specialized intensive care unit (Table 5).

All patients in the study groups received basic therapy in the ARICU in accordance with the Temporary Guidelines for the Prevention, Diagnosis and Treatment of the novel coronavirus (COVID-19) that were current during the period of their treatment. There were no deaths observed during transportation of the patients from the central district hospitals. The mortality rate of patients with severe COVID-associated community-acquired pneumonia evacuated from central district hospitals to the ARICU of the Sakha Republic Clinical Hospital was 65.8%; for city patients - 66.3%, with no statistically significant differences established ( $p=0.906$ ).

**Conclusion.** Air ambulance service in the Sakha Republic (Yakutia) is critical for ensuring the availability, timeliness and completeness of emergency medical care. The results of our study indicate that during the COVID-19 pandemic, the total number of air ambulance calls increased by an average of 32.3% compared to 2019; in 2021, medical evacuation of patients with severe COVID-19 to a specialized department in the city of Yakutsk ranked first in the structure of air ambulance missions. The analysis of the treatment results of patients transported by air ambulance to the specialized department in Yakutsk showed the validity

and timeliness of their evacuation. During the transportation of the patients from the districts of the republic, no deaths were recorded; the results of their treatment in a specialized ARICU for patients with nCoV COVID-19 did not differ from the treatment outcomes of the patients from Yakutsk, who had access to comprehensive medical care.

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