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Анализ внутрибольничной летальности у пациентов с новой коронавирусной инфекцией (COVID-19) Клинического центра Сеченовского университета

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АННОТАЦИЯ

Актуальность. Эпидемия новой коронавирусной инфекции (COVID-19) потребовала осуществить в сжатые сроки перестройку работы всей системы здравоохранения Российской Федерации. При этом летальность пациентов является важнейшим результативным показателем, отражающим успешность организационных мероприятий по совершенствованию деятельности медицинских организаций. Исходная готовность инфраструктуры позволила оперативно на базе Клинического центра Сеченовского университета развернуть стационар для оказания медицинской помощи пациентам с COVID-19.

Цель. Провести анализ внутрибольничной летальности пациентов с COVID-19 Клинического центра Сеченовского университета.

Материалы и методы. Был проведен анализ базы данных COVID-19 (n = 19 230) Клинического центра Сеченовского университета за 2020–2022 г.

Результаты. Общая госпитальная летальность в стационарах Клинического центра Сеченовского университета при COVID-19 составила 8,5%, что находится на более низком уровне при сравнении с данными зарубежных исследований (Италия, Испания, Великобритания, США, Иран). Основные предикторы летальности: исходные — мужской пол, возраст (преимущественно > 75 лет); наличие у пациентов злокачественных новообразований, болезней нервной системы, болезней системы кровообращения, болезней эндокринной системы; возникающие в процессе стационарного лечения — искусственная вентиляция легких, перенесенные хирургические вмешательства.

Заключение. Опыт работы Клинического центра Сеченовского университета говорит о возможности быстрого решения организационных задач, стоящих перед системой здравоохранения в период пандемии COVID-19, с результатами, характеризующимися низкой летальностью госпитализированных больных.

Ключевые слова: новая коронавирусная инфекция; COVID-19; пандемия; оказание медицинской помощи; внутрибольничная летальность; клиническая больница

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Analysis of In-Hospital Mortality of Patients with New Coronavirus Infection (COVID-19) of Clinical Centre of Sechenov University

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ABSTRACT

INTRODUCTION: The epidemic of a new coronavirus infection (COVID-19) required a restructure of the entire healthcare system of the Russian Federation within a limited period of time. Here, the mortality of patients is the most important effective parameter that reflects successfulness of organization measures for improvement of the activity of medical institutions. The initial preparedness of the infrastructure permitted to rapidly deploy a hospital on the base of the Clinical Centre of Sechenov University for providing medical assistance to patients with COVID-19.

AIM: To analyze the in-hospital mortality of patients with COVID-19 at the Clinical Center of Sechenov University.

MATERIALS AND METHODS: The COVID-19 database (n = 19 230) of the Clinical Centre of Sechenov University for 2020–2022 was analyzed.

RESULTS: The overall in-hospital mortality in COVID-19 hospitals of the Clinical Centre of Sechenov University was 8.5%, which is the lower level compared to the data of foreign studies (Italy, Spain, Great Britain, USA, Iran). The main predictors of mortality are: basic — male gender, age (mainly > 75 years); existence of malignant neoplasms, diseases of the nervous system, diseases of the cardiovascular system, diseases of the endocrine system in patients; diseases occurring in the course of hospital treatment — artificial lung ventilation, past surgical interventions.

CONCLUSION: The working experience of the Clinical Center of Sechenov University shows a possibility for quick salvation of organizational tasks facing the healthcare system in the period of COVID-19 pandemic, with the results characterized by low lethality of hospitalized patients.

Keywords: *new coronavirus infection; COVID-19; pandemic; providing medical care; in-hospital mortality; clinical hospital*

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LIST OF ABBREVIATIONS

APV — artificial pulmonary ventilation

CI — confidence interval

COVID-19 — COronaVirus Disease 2019

OR — odds ratio

UCH — university clinical hospitals

INTRODUCTION

The pandemic of a new coronavirus infection (COronaVirus Disease 2019, COVID-19) placed extraordinary organizational tasks before the healthcare system. The resources of infectious services available in the epidemiologically favorable period, appear to be insufficient in the emergency situation associated with spread of highly contagious infection. Maintaining the proper quality of medical care in such conditions not only requires the re-profiling of some medical institutions, but also forces medical workers to acquire new competencies [1, 2].

The COVID-19 pandemic dictated the need to restructure the work of the entire healthcare system of the Russian Federation in the shortest possible time. The growth of morbidity with COVID-19 in Moscow required taking decisions directed at both preventing a rapid spread of the disease, and providing the sick with high-quality and available medical care [3]. Already at the beginning of the pandemic it became clear that the resources of infectious diseases services of the city were insufficient and therefore it was decided to re-profile a part of medical institutions [4].

The steady spread of COVID-19 and the need to solve numerous epidemic management tasks determined the relevance of a detailed and comprehensive analysis of the results of the activities of medical organizations during the pandemic. Special attention should be paid to the study of cases of COVID-19 with a fatal outcome, since the mortality of patients is the most important effective parameter reflecting the success of organizational measures to improve the activities of medical organizations in a pandemic [5, 6].

The **aim** of this study to analysis of the in-hospital mortality of patients with a new coronavirus infection of the Clinical Center of Sechenov University.

MATERIALS AND METHODS

In April 2020, on the basis of the Clinical Center of Sechenov University, a hospital was deployed to provide medical care to patients with COVID-19. A significant argument in favor of attracting Sechenov University

hospital beds to provide inpatient medical care to patients with COVID-19 was a sufficiently high degree of initial readiness of the infrastructure:

- in the buildings of four university clinical hospitals (UCHs) involved in providing medical care to patients with COVID-19, inpatient pulmonology units (a total of 170 beds of 'Pulmonology' profile), intensive care units were initially present; UCH No.1 was equipped with apparatus for extracorporeal membrane oxygenation;

- more than 70% of wards of all UCHs were equipped with toilet facilities and shower rooms during the capital repair of 2010–2020, which permitted to provide isolation of the patients;

- all the buildings of the UCH involved in providing medical care to patients with COVID-19, were equipped with CT scanners; in three of them they were in close proximity to the reception departments, in one — in direct access from the reception room, which permitted to organize this study in the shortest possible time, immediately upon admission [1].

In addition, UCH No. 4 was initially working in the routing system of emergency medical care of Moscow Healthcare Department, and in this regard, its work was organized in the regime of readiness for round-the-clock reception of patients [1].

The study presents the results of the analysis of the database of patients with COVID-19 of the Clinical Center of Sechenov University for 2020–2022. The protocol of the study was approved by the Local Ethics Committee of Sechenov University (Protocol No. 22–25 of December 08, 2022).

Statistical processing of the obtained data was performed using the IBM SPSS program version 26.0 (USA). Descriptive statistics of the study results was presented for qualitative parameters by absolute values and relative frequencies calculated per 100 people. Arithmetic mean (M) and mean square deviations (σ), as well as the median and quartiles (first and third) were used to describe the age.

The statistical significance of the differences for quantitative variables was verified using parametric Student's *t*-test for independent samples. The statistical significance of differences in qualitative characteristics in

the intergroup comparisons was assessed using Pearson χ^2 test. A statistically significant probability level for rejecting null hypotheses was considered at $p < 0.05$. To model the mortality factors of hospitalized patients in a new coronavirus infection COVID-19, the multiple logistic regression analysis was used. The sensitivity and specificity of the model were evaluated using ROC analysis.

RESULTS

An in-depth analysis of the structure of patients of the Clinical Center of Sechenov University who underwent treatment for COVID-19 in 2020–2022, and of peculiarities of inhospital mortality, was conducted. The total database of patients of deployed covid hospitals of four UCHs was analyzed (UCH No. 1–4).

In total, 19,230 patients underwent treatment in specialized hospitals of the Clinical Center from April 2020 to March 2022 (of them: 8985 (46.6%) — in 2020, 8540 (44.4%) — in 2021, 1705 (8.9%) — in 2022). To note, 4202 (21.8%) patients were transferred from other inhospital medical organizations of Moscow.

The structure of patients by gender: 8944 (46.5%) men and 10,286 (53.5%) women. The social structure of patients was dominated by pensioners — 9115 (47.4%). There were 4077 (21.2%) non-working people among the patients, 5981 (31.1%) were employed. The smallest number was represented by students — 58 (0.3%) people. Among the patients, 90.8% were urban residents and 6.3% were rural residents.

The mean age of patients was 62.3 ± 15.8 years, according to the median — 63.0 (52.0; 74.0) years. The largest share of hospitalized patients was in the elderly group (60–74 years) — 35.4%. The middle age group (45–59 years) made 25.9% of patients, 22.4% were of senile age (75–90 years), and 14.8% of patients were of the young age (18–44 years). The least number of hospitalized patients were in the group of centenarians (≥ 90 years) — 1.5%.

Eighteen thousand and fifty (93.9%) patients had a complicated course of COVID-19. Surgical operations were performed in 299 (1.6%) patients.

More than half of the patients — 10,083 (52.4%) had some concomitant diseases the most common being diseases of the circulatory system — 7,316 (38.0%) cases, followed by diseases of the respiratory system — 1,968 (10.2%), and diseases of circulatory system — 1,809 (9.4%). Malignant neoplasms were present in 268 (1.4%) patients.

During the analyzed period, 1,636 patients with COVID-19 died in the Clinical Center of Sechenov University. The total inhospital mortality was 8.5%.

Among the mortal cases, 819 (50.1%) occurred in female patients and 817 (49.9%) among male ones. Here, mortality rate among men (9.1%) was higher than among women (8.0%; $p = 0.004$). The mean age of deceased was 74.7 ± 11.7 years, by the median — 76.0 (67.0; 73.0) years.

The mortality level increased in each subsequent age group (Figure 1), the highest mortality rate was noted in the group of patients ≥ 90 years — 35.2%. The differences in mortality rate between all the age groups were statistically significant, $p < 0.001$.

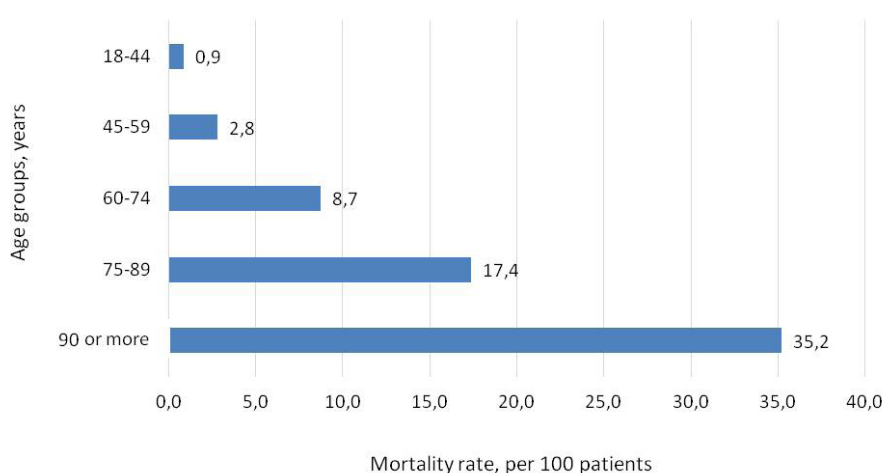


Fig. 1. Mortality rate of patients with a new coronavirus infection (COVID-19) depending on age at the Clinical Center of Sechenov University in 2020–2022, $p < 0.001$.

Among certain social groups of patients, the highest mortality was observed among pensioners — 13.7%, with statistically significant difference from that in all other groups ($p < 0.001$). Among non-working patients, the mortality rate was 4.4%, among working patients — 3.4%, among students — 3.2%.

The highest mortality rate was recorded among patients who required artificial pulmonary ventilation (APV) — 84.5%. For comparison, among patients without use of APV, the mortality rate was 3.5% ($p < 0.001$).

Of attention is statistically significant increase in mortality rate among unvaccinated inpatients, 16.8% versus 6.9% among vaccinated ones ($p < 0.001$).

The likelihood of a fatal outcome was significantly increased by a factor of surgery. In patients who underwent surgery, the mortality rate in the postoperative period was 68.2% (204 out of 299 patients).

Among the concomitant pathology, a higher level of mortality rate was noted in the presence of malignant neoplasms — 25.2% ($p < 0.001$), in diseases of the nervous system — 25.5% ($p < 0.001$), diseases of circulatory system — 17.9% ($p < 0.001$), diseases of endocrine system — 14.8% ($p < 0.001$), diseases of urogenital system — 13.1% ($p = 0.015$).

To determine the main factors of mortality in patients with COVID-19, the frequency of occurrence and the average level of individual signs among recovered and deceased patients were compared.

The analysis of differences by age groups shows that in the group of the deceased, patients of the age group 75–89 years were most common. There were 45.1% of such patients versus 20.0% in the group of recovered patients ($p < 0.001$). Also, patients > 90 years of age were more common in the group of deceased (8.4% vs. 1.4%). In the group of recovered patients, younger age groups of 18–44 years (15.9% vs. 1.6%) and 45–59 years (27.4% vs. 8.6%) predominated. The frequency of patients aged 60–74 years had no statistically significant differences. The mean age of patients in the group of deceased was 74.7 ± 11.7 years versus 61.1 ± 15.7 years in the group of recovered patients ($p < 0.001$).

The gender differences between the groups of deceased and recovered patients consist in a statistically significant predominance of male patients in the group of patients with a fatal outcome — 49.9% versus 46.2% ($p = 0.002$).

In assessment of differences by body mass index at admission to the hospital, statistically significant differences were noted in terms of some increase in this parameter in the group of deceased patients 29.9 ± 6.7 vs. 29.3 ± 5.7 ($p = 0.046$).

A number of signs that influence the course of the disease, have significant differences that characterize the group of patients with fatal outcome. Thus, in the group of patients who underwent surgical intervention,

there were 12.5% of deaths versus 0.5% in the group of recovered patients ($p < 0.001$).

With this, the duration of hospital stay of recovered and deceased patients had no statistical significant differences with the median of 13 days in both groups ($p = 0.186$).

Concomitant diseases occurred in 90.1% of cases with mortal outcomes, which was 1.85 times more often than in the group of recovered patients — 48.6% ($p < 0.001$).

Considering the proportion of concomitant diseases, it is possible to distinguish the main classes of diseases with statistically significant predominance in the group of deceased patients. These were diseases of the circulatory system — 78.1% vs. 34.3% ($p < 0.001$), diseases of the endocrine system — 16.0% vs. 8.8% ($p < 0.001$), malignant neoplasms — 4.1% vs. 1.2% ($p < 0.001$), diseases of the nervous system — 0.9% vs. 0.2% ($p < 0.001$), diseases of urogenital system — 1.9% vs. 1.3% ($p = 0.030$).

To model the factors of mortality of patients hospitalized with COVID-19, the multiple logistic regression analysis was used (Table 1). As the possible predictors, there were considered the patient's gender, age, body mass index, presence of complications, need for APV, social status, presence of a concomitant pathology. As a response variable, a binary variable was used including 2 categories: 0 — no fatal outcome at the time of discharge from hospital, 1 — fatal outcome that occurred during in-hospital treatment of the patient.

The most significant prognostic factor of mortality was staying on a ventilator regime — the odds ratio (OR) 145.509 [95% confidence interval (CI) 116.439–181.837]. Next in importance are malignant neoplasms — OR 3.604 [2.446–5.311], diseases of nervous system — OR 3.553 [1.580–7.988], diseases of circulatory system — OR 2.882 [2.378–3.350], surgeries — OR 2.329 [1.464–3.705]. The statistically significant predictors modeling the probability for fatal outcome in COVID-19, also include male gender — OR 1.624 [1.385–1.905], presence of diseases of the endocrine system — OR 1.595 [1.281–1.985], age — OR 1.086 [1.078–1.094].

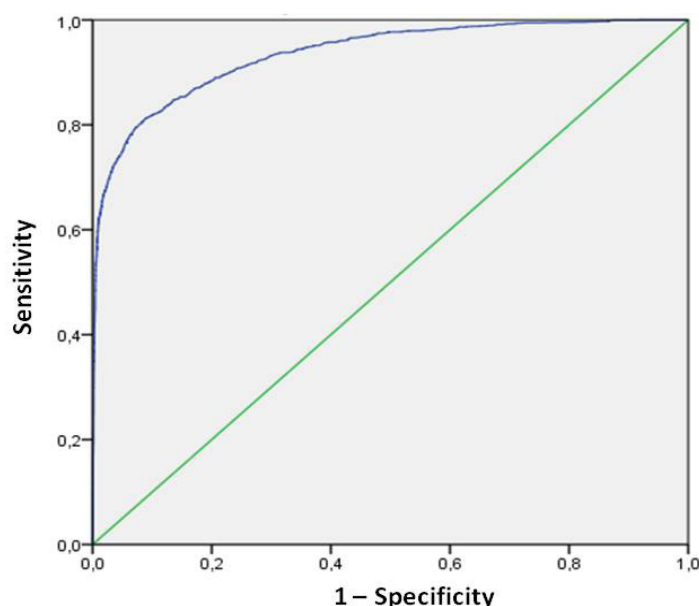
The determination coefficient (R^2) for this model was 0.597, which shows a statistically significant explanation of variance of the response variable by 59.9% by these predictors. With this, the model has 99.1% specificity for predicting the absence of mortality. The sensitivity of the model for correct prediction of the fatal outcome was 59.6%. The total percentage of correct predictions reached 96.0%.

By the results of construction of ROC-curve, AUC parameter was 0.935 ± 0.004 (95% CI 0.928–0.925; $p < 0.001$), which corresponds to a very good quality of prognostic model (Figure 2).

Table 1. Assessment of Predictors of Death from New Coronavirus Infection (COVID-19) at Clinical Center of Sechenov University in 2020–2022

Predictors	Regression Coefficient, b	Standard Error	Wald Statistics, χ^2	p	OR	95% CI for OR
Age	0.083	0.004	505.718	< 0.001	1.086	1.078–1.094
Gender	0.485	0.081	35.555	< 0.001	1.624	1.385–1.905
Artificial Pulmonary Ventilation	4.980	0.114	1 918.181	< 0.001	145.509	116.439–181.837
Surgery	0.845	0.237	12.733	< 0.001	2.329	1.464–3.705
Malignancy	1.282	0.198	42.034	< 0.001	3.604	2.446–5.310
Diseases of endocrine system	0.467	0.112	17.418	< 0.001	1.595	1.281–1.985
Diseases of nervous system	1.268	0.413	9.404	0.002	3.553	1.580–7.988
Diseases of circulatory system	1.038	0.087	140.612	< 0.001	2.822	2.378–3.350

Notes: CI — confidence interval, OR — odds ratio

**Fig. 2.** ROC-curve of the fatal outcome predictor model of patients with COVID-19 at the Clinical Center of Sechenov University in 2020–2022.

DISCUSSION

The study conducted on the basis of the results of the analysis of the activity of covid hospitals of the Clinical Center of Sechenov University, permitted to identify the following factors as predictors modeling fatal outcomes in patients with COVID-19:

- **initial** — male gender, age (mainly, ≥ 75 years); the presence of malignant diseases, diseases of the nervous system, diseases of the circulatory system, diseases of endocrine system in patients;
- **occurring during inhospital treatment** — need in APV, surgical interventions.

The data obtained agree with the results of studies devoted to the analysis of predictors of mortality in COVID-19 [7–13], which emphasizes the importance of the *age factor and existence of concomitant diseases*.

A significant advantage of rendering medical care to patients with COVID-19 in the conditions of a multidisciplinary university clinic of the given model was the possibility of operational re-profiling of departments according to unified logistic schemes.

An important aspect of the activity of a multidisciplinary clinic in the condition of a pandemic was organization of treatment of comorbid patients,

including those transferred from other federal medical organizations.

The following key management decisions that permitted to effectively organize the process of providing medical care to patients with COVID-19 in a multidisciplinary university clinic can be considered:

1. centralization of quality management, including that in the key profiles — pulmonology, anesthesiology and intensive care;

2. centralization of the management of the sanitary and epidemiological regime and protection of personnel;

3. use of unified schemes and local clinical protocols adopted by consensus of all clinics (32 local clinical protocols were adopted);

4. operational data analysis and decision-making in video conferencing format.

The working experience of the Clinical Center of Sechenov University in the conditions of the COVID-19 pandemic has shown that the centralized taking organizational decisions and quality management is equally important in providing favorable treatment outcomes, as the supply of the organization with medical drugs and medical instruments. Along with solving applied problems of providing medical care to patients with COVID-19, university clinics can and should be a platform for conducting clinical trials. In the Clinical Center of Sechenov University, 20 multicenter clinical trials were conducted in 2020–2022, including the study of two vaccines, which was of utmost importance for the fight against the pandemic at the national level.

CONCLUSION

The total inhospital mortality in the hospitals of the Clinical Center of Sechenov University in conditions

of the new coronavirus infection (COVID-19) that made 8.5%, was at a lower level in comparison with the data of foreign studies reflecting mortality rates in hospitals of other countries (Italy, Spain, Great Britain, USA, Iran) which ranged from 10.2% to 28% [3, 14].

Thus, rendering medical care to patients with a new coronavirus infection (COVID-19) in conditions of a multidisciplinary university clinic can be characterized as one of the possible models of effective deployment of medical care systems in new conditions.

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