

Received: 01 August 2022 / Accepted: 16 September 2022 / Published online: 31 October 2022

DOI 10.34689/SH.2022.24.5.001

UDC 616-079.1-24-002-056.52:578.834.1

THE RELATIONSHIP BETWEEN INCREASED WEIGHT AND THE RADIOLOGICAL DEGREE OF LUNG DAMAGE IN COVID-19 PNEUMONIA

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Abstract

Introduction. The SARS-CoV-2 virus has caused a pandemic that has swept the whole world, since the end of 2019. Obese people around the world are at high risk of severe complications from Covid-19 due to the increased risk of chronic diseases caused by obesity.

The aim: to study the relationship between body weight (BMI) and outcomes of Covid-19 pneumonia depending on the radiological stage of lung damage.

Methods. 303 case histories of patients were retrospectively studied who received inpatient treatment in the infectious diseases department of the Semey Emergency Medical Service Hospital for Covid-19 at the peak of incidence from June 15, 2020 to July 15, 2020. A statistical analysis was carried out in the relationship between clinical and radiological indicators.

Results. There were 68 people with an increased BMI from the 290 patients with positive PCR test and who received inpatient treatment, women are 21.6%, men are 25.2%. The average age in the general group was 59.5±15.2. The end point as an unfavorable complication was a fatal outcome (FO). A positive correlation was determined between the degree of pulmonary lesion on CT-3 and CT-4 and FO ($\varphi=0.009$). The severity of Covid-19 pneumonia was based on an assessment of the degree of lung damage according to Chest X-ray and Chest CT. Patients with FO had a percentage of pulmonary lesion greater than 50%. It was found that the prevalence of the pathological process in the lungs is influenced by several unfavorable factors, including BMI.

Conclusions. Increased body weight did not affect mortality from pneumonia, and one of the predictors of the severity of pneumonia and death was the degree of pathological changes in the lungs, which is diagnosed by X-ray methods.

Keywords: Covid-19 pneumonia, BMI, CT of lung, Chest X-ray.

Резюме

ВЗАИМОСВЯЗИ МЕЖДУ ПОВЫШЕННЫМ ВЕСОМ И РЕНТГЕНОЛОГИЧЕСКОЙ СТЕПЕНЬЮ ПОРАЖЕНИЯ ЛЕГКИХ ПРИ COVID-19 ПНЕВМОНИИ

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Введение. С конца 2019 года вирус SARS-CoV-2 стал причиной пандемии, охвативший весь мир. Люди с ожирением, во всем мире, подвергаются высокому риску тяжелых осложнений Covid-19 в силу повышенного риска хронических заболеваний, вызываемых ожирением.

Цель: изучить связь между массой тела (ИМТ) и исходами Covid-19 пневмонии в зависимости от рентгенологической стадии повреждения легких.

Методы. Были ретроспективно изучены 303 истории болезни пациентов, получавших стационарное лечение в инфекционном отделении Больницы скорой медицинской службы г. Семей, по поводу Covid-19 в пик заболеваемости с 15.06.2020 по 15.07.2020г. Проведен статистический анализ связей клинических и рентгенологических показателей.

Результаты. Из 290 пациентов с положительным ПЦР тестом и получивших стационарное лечение, с повышенным ИМТ было 68 человек, женщин – 21,6%, мужчин – 25,2%. Средний возраст в общей группе составил $59,5 \pm 15,2$. Конечной точкой – неблагоприятным осложнением явился летальный исход (ЛИ). Определялась положительная корреляция между степенью легочного поражения на КТ-3 и КТ-4 и ЛИ ($\varphi=0,009$). Тяжесть течения Covid-19 пневмонии основывалась на оценке степени поражения легких по данным рентгенограммы и КТ грудной клетки. Пациенты с ЛИ имели процент легочного поражения больше 50%. Было обнаружено, что на распространенность патологического процесса в легких влияют несколько неблагоприятных факторов, и в том числе ИМТ.

Выводы. Повышенная масса тела не влияла на смертность от пневмонии, а одним из предикторов тяжести пневмонии и летального исхода являлась степень патологических изменений в легких, которая диагностируется рентгенологическими методами.

Ключевые слова: Covid-19 пневмония, ИМТ, КТ легких, рентген органов грудной клетки.

Түйіндеме

ЖОҒАРЫ САЛМАҚ ПЕН COVID-19 ПНЕВМОНИЯСЫМЕН ӨКПЕНІҢ ЗАҚЫМДАНУЫНЫҢ РЕНТГЕНОЛОГИЯЛЫҚ ДӘРЕЖЕСІ АРАСЫНДАҒЫ БАЙЛАНЫС

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Кіріспе. 2019 жылдың аяғынан бастап SARS-CoV-2 вирусы бүкіл әлемді дүр сілкіндірген пандемияға себеп болды. Бүкіл әлем бойынша семіздікке шалдыққан адамдар артық салмақтан туындаған созылмалы аурулардың қаупінің жоғарылауына байланысты Covid-19 вирусының ауыр асқынуларының жоғары қаупіне ие болды.

Мақсаты: өкпенің зақымдануының рентгенологиялық сатысына байланысты дене салмағы индексі (ДСИ) мен Covid-19 пневмониясының нәтижелері арасындағы байланысты зерттеу.

Әдістері. 15.06.2020 жылдан бастап 15.07.2020 жылға дейін Covid-19 ауруының шарықтау кезінде Семей қаласының Жедел медициналық қызмет ауруханасының инфекциялық бөлімінде стационарлық ем қабылдаған пациенттердің 303 ауру тарихы ретроспективті түрде зерттелді. Клиникалық және рентгенологиялық көрсеткіштердің байланыстарына статистикалық талдау жүргізілді.

Нәтижелері. Оң ПТР тесті бар және стационарлық ем алған 290 науқастың ішінен 68 адамда жоғары ДСИ көрсеткіші байқалған, әйелдер - 21,6%, ерлер - 25,2%. Жалпы топтағы орташа жас $59,5 \pm 15,2$ құрады. Соңғы нүктесі - қолайсыз асқыну өліммен аяқталуы (ӨА). КТ-3 және КТ-4 және ӨА-да ($\varphi=0,009$) өкпе зақымдану дәрежесі арасындағы оң корреляция анықталды. Covid-19 пневмониясының ауырлығы кеуде қуысының рентгенографиясы мен КТ-ға сәйкес өкпенің зақымдану дәрежесін бағалауға негізделген. ӨА болған науқастарда өкпе зақымдануының пайызы 50% - дан асқан. Өкпедегі патологиялық процестің таралуына бірнеше қолайсыз факторлар әсер ететіні анықталды, соның ішінде - ДСИ.

Қорытынды. Дене салмағының жоғарылауы пневмониядан болатын өлімге әсер етпеген, бірақ пневмония мен өлімнің ауырлығын болжайтын факторлардың бірі рентгенологиялық әдістермен диагноз қойылған өкпедегі патологиялық өзгерістердің дәрежесі болды.

Түйін сөздер: Covid-19 пневмония, ДСИ, өкпенің КТ-сы, кеуде қуысының рентгені.

Bibliographic citation:

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Мадиева М.Р., Мансурова Ж.А., Каскабаева А.Ш., Курманғалиева А.Н., Куанышева А.Г., Дүйсенбекұлы Е., Раисов Д.Т. Взаимосвязи между повышенным весом и рентгенологической степенью поражения легких при Covid-19 пневмонии // *Наука и Здравоохранение*. 2022. 5 (Т.24). С. 6-11. doi 10.34689/SH.2022.24.5.001

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Introduction

Pneumonia is one of the most common infectious diseases, which affects the respiratory parts of the lungs with obligatory interalveolar exudation and infiltration of the parenchyma in response to the invasion of microorganisms [11]. It is known that pneumonia is a clinical and radiological definition.

The end of 2019 was the beginning of a worldwide pandemic caused by SARS-CoV-2, a new coronavirus infection that originated in Wuhan, China. This infection resulted in the infection of a huge number of patients. On March 13, 2020, patients with Covid-19 were first identified in Kazakhstan, after which the infection quickly spread throughout the country. Since the beginning of the pandemic until today, the Covid-19 virus has been present in the world in the form of modified strains. After mass vaccination of the world's population in 2021, the disease has receded, but new cases of the epidemic are now known.

The prevalence of obesity has increased dramatically over the past two decades [4]. The diagnosis of obesity is often based on body mass index (BMI), which is calculated as weight in kilograms divided by height in meters squared (kg/m^2). The ideal BMI is between 18.5 and 24.9. Overweight is defined as a BMI of 25 to 29.9, and in the obesity classification, BMI is 30.0 or more [6]. Older age and comorbidities have been reported as risk factors for death, while current global experience seems to indicate increasingly severe cases among younger age groups [7]. In the first cases analyzed for risk factors for severe disease, the prevalence of diabetes was 20% and that of hypertension was 30%. In this regard, further study of this disease, its complications, and risk factors is necessary. People with obesity are at high risk for severe complications of Covid-19 worldwide due to the increased risk of chronic diseases caused by obesity [8, 16]. According to Kazakhstani researchers, decompensated diabetes mellitus accompanied some of the deaths of patients with Covid-19 [1]. A search of the literature showed inconsistent results with regard to the causes of mortality in Covid-19. At the same time, we found clear results on the severity of the course of Covid-19 pneumonia in patients with increased BMI [12].

Aim: to examine the correlation between BMI and outcomes of Covid-19 pneumonia depending on the radiological stage of pulmonary injury.

Following the objective of our study, we conducted a retrospective analysis of archival data on patients who were hospitalized during the "first wave" of morbidity in the city of Semey.

Methods. We retrospectively studied case histories of patients who received inpatient treatment in the infectious disease department of the Semey Emergency Medical Service Hospital with a diagnosis of Covid-19 during the peak of morbidity from June 15, 2020 to July 15, 2020. Such data as sex, age, anthropometric data, results of lung X-ray examinations and disease outcomes were taken from the case histories. The total number of case histories was 303, including 290 patients with a positive PCR test, 13 patients had a negative PCR test, so they were excluded from the study. BMI was calculated for all patients. An increased BMI was considered to be $\geq 30 \text{ kg}/\text{m}^2$. According to the protocol of diagnostics and treatment of Covid-19 infection in Kazakhstan [2], the degree of lung saturation (SpO_2) was determined as: mild - ($\text{SpO}_2 0$) $\geq 95\%$, moderate - ($\text{SpO}_2 1$) = 94-92% and severe - ($\text{SpO}_2 2$) $\leq 92\%$ and a maximum of 28 days. The end point, an unfavorable complication, was a fatal outcome (FO). The degree of pulmonary parenchyma damage according to CT data, was defined as: CT-1 (< 25% volume), CT-2 (25-50%), CT-3 (50-75%), and CT-4 (>75%). The study design was approved by the local ethical committee of the "Semey Medical University" NCJSC (protocol № 2 from 20.10.2020).

The collected data were analyzed using SPSS.20. The relationship between BMI and the degree of pulmonary parenchyma damage on radiological data (computed tomography and plain radiography) was studied.

Inclusion criteria. The study included patients the status of Covid-19 and the CT of lung were known.

Exclusion criteria. Patients with PCR-negative status on CoVID-19 and pregnant women were excluded from the study.

Results.

Of the 290 patients who received inpatient treatment, there were 68 patients with elevated BMI, of whom 21.6% were women and 25.2% were men. The average age in was 59.5 ± 15.2 . General clinical characteristics of the patients according to their gender are presented in Table 1.

Following the aim of our study, we divided patients according to outcomes: who survived and with fatal outcome (FO). Thus, 258 patients were discharged with improvement, and recovery and 32 with FO. Female patients - 167, of them 20 (12%) were fatal cases, 147 patients were discharged with recovery. Male patients - 123, including 12(10%) fatal cases, and 111 were discharged with recovery.

Table 1.

General clinical characteristics of patients by gender.

| Variable | Total (n=290; 100%) | Men (n=123; 41.8%) | Women (n=167; 58.2%) | p |
|------------------------------|------------------------|-----------------------|-------------------------|---------------------|
| Age, years | 60±15.3 20-98 | 62±13.2 25-84 | 58±16.4 20-98 | 0.017* |
| PCR+, n(%) | 178(60.5) | 73(59.3) | 105(61.4) | 0.722 ^a |
| BMI ≥ 30 kg/m ² | 68(23.1) | 31(25.2) | 37(21.6) | 0.474 ^a |
| Pregnancy, n(%) | 22(7.5) | 0 | 22(12.9) | <0.001 ^c |
| SP, mm Hg. | 126(10) 80-200 | 130(10) 80-170 | 120(20) 80-200 | 0.073** |
| DP, mm Hg. | 79(0) 40-110 | 80(10) 40-110 | 80(10) 60-110 | 0.057** |
| HR, beats per 1 minute | 86(13) 50-150 | 88(15) 50-150 | 85(12) 67-150 | 0.061** |
| BR per 1 minute | 22(4) 16-35 | 22(4) 16-32 | 21(5) 16-35 | 0.256** |
| Temperature, C ⁰ | 37.3(0.8) 36-39.5 | 37.3(0.8) 36-39.2 | 37.4(0.8) 36-39.5 | 0.333** |
| SpO ₂ 0, n(%) | 109(37.1) | 39(31.7) | 70(40.9) | 0.106 ^a |
| SpO ₂ 1, n(%) | 46(15.6) | 21(17.1) | 25(14.6) | 0.568 ^a |
| SpO ₂ 2, n(%) | 139(47.3) | 63(51.2) | 76(44.4) | 0.251 ^a |
| Radiographic findings | | | | |
| CT 0 | 42(14.3) | 16(13) | 26(15.2) | 0.595 ^a |
| CT 1 | 62(21.1) | 19(15.4) | 43(25.1) | 0.044 ^a |
| CT 2 | 85(28.9) | 38(30.9) | 47(27.5) | 0.525 ^a |
| CT 3 | 82(27.9) | 42(34.1) | 40(23.4) | 0.043 ^a |
| CT 4 | 23(7.8) | 8(6.5) | 15(8.8) | 0.621 ^c |

* Student's t-test; ** Mann-Whitney parametric criterion, a - χ^2 Pearson criterion; b – Fisher's criterion; c – continuity correction; BMI - body mass index; CT - computed tomography; SP and DP - systolic and diastolic arterial pressure; HR - heart rate; PCR - polymerase chain reaction; BR – breathing rate; SpO₂ – lung oxygen saturation.

Table 2.

General clinical characteristics of patients according to fatal outcome.

| Variable | Patients without fatal outcomes (n=258; 89%) | Patients with fatal outcomes (n=32; 11%) | p |
|------------------------------|---|---|--------------------|
| Age, years | 59±15.2 20-93 | 59±15.2 20-93 | 0.238* |
| PCR+, n(%) | 111(90.2) | 12(9.8) | 0.551 ^a |
| BMI ≥ 30 kg/m ² | 27.5(6.2) 19.5-132.7 | 27.2(6.7) 19.9-46.1 | 0.557** |
| Pregnancy, n(%) | 76(29.5) | 9(28.1) | 0.999 ^c |
| SP, mm Hg. | 126±15 80-200 | 119±15.5 90-140 | 0.079* |
| DP, mm Hg. | 80(0) (40-110) | 80(10) (60-90) | 0.089** |
| HR, beats per 1 minute | 88.2±12.4 50-150 | 96.6±19.8 80-150 | 0.123** |
| BR, per 1 minute | 21(4) 16-35 | 24(4) 18-30 | 0.015** |
| Temperature, C ⁰ | 37.3(0.8) 36-39.5 | 37.1(0.9) 36.4-39.0 | 0.489** |
| SpO ₂ 0, n(%) | 107(38.4) | 2(13.3) | 0.093 ^c |
| SpO ₂ 1, n(%) | 45(16.1) | 1(6.7) | 0.287 ^b |
| SpO ₂ 2, n(%) | 127(45.5) | 12(80) | 0.019 ^c |
| Radiographic findings | | | |
| CT0, n(%) | 42(15.1) | 0 | 0.093 ^b |
| CT1, n(%) | 61(21.9) | 1(6.7) | 0.137 ^b |
| CT2, n(%) | 83(29.7) | 2(13.3) | 0.140 ^b |
| CT3, n(%) | 75(26.9) | 7(46.7) | 0.009 ^b |
| CT4, n(%) | 18(6.5) | 5(33.3) | 0.003 ^b |

a – χ^2 Pearson criterion; b – Fisher's criterion; c – continuity correction, ** non-parametric criterion, *parametric criterion. BMI - body mass index; CT - computed tomography; SP and DP - systolic and diastolic arterial pressure; HR - heart rate; PCR - polymerase chain reaction; BR – breathing rate; SpO₂ – lung oxygen saturation.

Analysis of outcomes showed a weak statistical correlation between sex and FO ($\chi^2 = 0.37, p = 0.539$), i.e., mortality was independent of gender. There was a positive correlation between the degree of pulmonary parenchyma damage on CT-3 and CT-4 and FO ($\varphi = 0.009$ and 0.003).

Analysis of correlation between FO and age showed "zero" significance, which implies that mortality from pneumonia was possible in all age groups. Elevated BMI in patients had no effect on mortality, showed no correlation and statistical significance. In this regard, we determined the average BMI values in the group of patients without and with fatal outcome (Table 3).

Table 3.

Average BMI in groups with and without FO.

| Outcome | Average BMI, kg/m ² | 95% CI BMI | p |
|------------|--------------------------------|------------|------|
| without FO | 28.8 | 27.7-29.8 | 0.52 |
| with FO | 27.9 | 25.9-29.8 | 0.94 |

According to the table, the average BMI value in both groups with different outcomes did not exceed 30 kg/m² and was statistically insignificant.

In the adjusted analysis, the severity of patients with Covid-19 pneumonias was based on the assessment of the degree of pulmonary parenchyma damage according to Chest X-ray and CT of lung. Since elevated BMI had no effect on FO, we performed correlation analysis of the connection between BMI (average values) and radiological signs of pneumonia (Table 4). We found the greatest correlation between changes on Chest X-ray, but this was statistically insignificant. Correlation between CT of lung and BMI was weak, but had statistical significance.

Table 4.

Correlation between radiological signs of Covid-19 pneumonia and BMI.

| Patients with radiological signs (n=247) | BMI kg/m ² (n=247) | p |
|--|-------------------------------|-------|
| Computed tomography of lungs | 0,121 | 0,04 |
| Chest X-ray | 0,051 | 0,386 |

Discussion.

Pneumonia is the most common infectious disease, but there is uncertainty about the correlation between obesity and the risk of pneumonia or pneumonia-related mortality. For example, Baik et al.[5] suggested that obesity is directly related to the development of community-acquired pneumonia (CAP). However, Phung et al. [13] did not find that obesity was significantly associated with the risk of pneumonia. Takata et al. [15] indicated that the risk of mortality did not differ between obese and normal-weight patients with pneumonia. Other studies have reported that obese patients with pneumonia had lower mortality compared to patients with normal weight [11].

According to the 2020-2022 studies, obesity has a significant impact on clinical outcomes in patients with Covid-19, high rates of ICU (intensive care unit) hospitalization and mortality. Many studies suggest that obesity/overweight is a risk factor for worse prognosis and high mortality [10,14].

One indicator of the quality of medical care is favorable outcome or recovery. In the present study, we found no

effect of BMI on mortality outcomes from Covid-19 pneumonia (Table 3). Of the total sample (289 individuals), the mortality rate was 11%, including 6 patients with a BMI ≥ 30 kg/m², i.e., mortality rates from Covid-19 pneumonia were independent of the patient's increased weight ($p = 0.94$).

It is known that among the elderly, regardless of their BMI, blood pressure and blood lipid concentrations, there is a decline in immune function, leading to increased susceptibility to infection and causing more severe complications compared to younger people, which reflects deterioration of both acquired and innate immune function [8]. Patients with normal and elevated BMI who were admitted to the Semey infectious diseases hospital were of all age groups (60 ± 15.3), with no significant differences by gender, i.e., older age was not the cause of mortality.

Computed tomography and Chest X-ray is one of the most effective diagnostic methods for rapid Covid-19 pneumonia. Chest X-ray were performed on all patients as part of triage and for hospitalization. Routine Chest X-ray alone cannot be used for Covid-19 triage because mild or early disease may not be reflected radiologically, and radiographic findings may lag behind the clinical signs [9]. Regardless of the Chest X-ray findings, a CT of lungs was recommended in all patients. Assessment of the degree of pulmonary injury on CT was based on the international recommendations of the Radiological Society, according to which the percentage of pathological changes in the lungs is considered as <5%, 25%, 50%, >75%, which corresponds to CT-1, CT-2, CT-3, and CT-4 [3]. In our study among patients with FO, the percentage of pulmonary injury corresponded to CT-3 and CT-4. According to some studies, CT differ in ICU patients, non-ICU patients, and recovered patients, which means that CT scan results can be used as an indicator to assess the severity of Covid-19-induced pneumonia [8].

The results of our study allowed us to draw the following conclusions: increased body weight had no effect on pneumonia mortality, and one of the predictors of pneumonia severity and fatal outcome was the degree of pulmonary parenchyma damage which is diagnosed by radiological methods.

Study limitations.

The limitations of our retrospective study were the following: single-center, short time period, and small sample size for analysis.

Authors' Contributions: All authors were equally involved in the research and writing of this article.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: There is no financial support and sponsorship.

Publication Information: The results of this study have not been previously published in other journals and are not pending review by other publishers.

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