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Relationship between body mass index and disease severity in COVID-19 patients admitted from April to September 2020 at Imam Khomeini Hospital Complex, Tehran, Iran

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Abstract

Introduction: The outbreak of COVID-19 was reported first in China. A COVID-19 infection can lead to severe infection, sustained inflammation, fibrosis, increased intensive care unit admissions, and mortality rates.

Objectives: This study evaluates the relationship between body mass index (BMI) and disease severity in COVID-19 patients admitted from April to September 2020 at Imam Khomeini Hospital Center.

Patients and Methods: Our study included a cross-sectional analysis of patients. We included 120 hospitalized adults (aged over 18 years) from April to September 2020. COVID-19 patients were defined as those with moderate to severe common symptoms (fever or chills, fatigue, and cough) as well as SARS-CoV-2 infection confirmed by reverse transcription polymerase chain reaction (RT-PCR). The BMI measurement was conducted based on the first BMI value listed following admission.

Results: In patients without underlying disease (51 patients), BMI significantly correlates with lymphocyte count and patients taking remdesivir. In patients with underlying disease (69 patients), BMI significantly correlates with age, temperature, hemoptysis, intensive care unit admission, and taking remdesivir. In all patients (120 patients), BMI significantly correlates with age, intensive care unit admission, and taking remdesivir. Additionally, the correlation of hemoptysis with BMI is greater than dry cough and productive cough.

Conclusion: This study highlights the higher risk of intensive care unit admission and taking remdesivir due to severe COVID-19 in obese patients. Clinical practitioners should pay more attention to obese patients and treat them more aggressively and promptly. Therefore, lifestyle modification seems to be effective. Further studies are required to illustrate better whether obesity is a significant independent risk factor for COVID-19.

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Introduction

A COVID-19 outbreak caused by SARS-CoV-2 was declared a global pandemic by the World Health Organization (WHO) on March 11, 2020. Since its first appearance in Wuhan, China, in December 2019, it has rapidly spread throughout China and many other countries (1). This virus exhibits high morbidity and mortality with fatal complications, including acute renal failure, shock, and acute cardiac arrest (2,3). People with underlying health conditions, the elderly, and the obese are more likely to get infections and suffer serious outcomes (4).

Generally, obesity contributes significantly to the pathogenesis of many diseases by stimulating inflammation in adipose tissue (5). It is crucial to understand the impact of obesity on the infection track to prevent morbidity and mortality from many diseases (6,7). Considering that obesity increases a patient's susceptibility to infection, it is important to consider it as a striking risk factor for COVID-19 outcomes (8). Several studies have shown that obesity is a significant risk factor for using mechanical ventilation, hospital admissions, and death from H1N1 influenza (9). It has been determined that obesity, with a body mass index of 30 or higher, increases the risk of severe illness from COVID-19 (10). Compared with other

Key point

The current study highlighted the increased risk of disease severity in COVID-19 patients. As COVID-19 spreads worldwide, clinical practitioners should pay more attention to obese patients and treat them more aggressively and promptly. Hence, lifestyle modification seems to be good.

patients, obese patients have a higher mortality rate from COVID-19 disease (11).

Objectives

Several studies have reported that excess adiposity leads to an increase in inflammatory cells and an increase in airway hyperresponsiveness. Patients with adult respiratory distress syndrome need to breathe harder to maintain their oxygen levels. In obese individuals, this physiological response is complicated. As a result, obesity may be associated with higher morbidity in COVID-19 infections (12).

In the present study, the aim of this study is evaluation of the relationship between BMI and disease severity in COVID-19 patients admitted from April to September 2020 at Imam Khomeini hospital center.

Patients and Methods

Study design

Our study included a cross-sectional analysis of COVID-19 patients hospitalized at Imam Khomeini hospital. A major designated center for COVID-19 patients was located at this hospital during the pandemic. We included 120 hospitalized adults (aged greater than 18 years) from April to September 2020. COVID-19 patients were defined as those with moderate to severe common symptoms (fever or chills, fatigue, and cough) as well as SARS-CoV-2 infection confirmed by RT-PCR.

In this study, all patients with common COVID-19 symptoms with a positive throat swab COVID-19 test were included. We used a convenience sampling method. The study excluded patients who had previous neurological disorders, such as dementia, Alzheimer's disease, and patients with loss or alteration of consciousness during admission.

A total of 120 patients were evaluated while 51 cases of them did not have an underlying disease and the remaining 69 had an underlying disease. The body mass index (BMI) was assessed following admission. Patients without listed weights or heights were not considered, since BMI was not defined. Patients discharged directly from the emergency department (ED) and pregnant women were excluded. We extracted demographic information and BMI scores for all cases. According to their BMI, patients were classified into five subgroups: A) BMI between 18-25 kg/m^2; B) BMI between 26-30 kg/m^2; C) BMI between 31-35 kg/m^2; D) BMI between 36-40 kg/m^2; E) BMI above 40 kg/m^2. Written informed consent was obtained from all patients before the study began.

Demographic characteristics (age, gender), history of comorbid diseases (asthma, cardiovascular disease, hypertension, chronic kidney disease, diabetes mellitus, cerebrovascular disease, cancer), Borg scale, dry cough, respiratory rate, pulse rate, C-reactive protein and erythrocyte sedimentation rate, intubation, days of hospitalization, blood pressure and laboratory findings, drug use, intra-hospital mortality, and month mortality were gathered for all patients using hospital's records. Data clarification was performed by phone call or consultation with relevant physicians if there was missing data.

Statistical analysis

Data analysis was performed in SPSS version 21 (SPSS Inc., Chicago, IL, USA). $P \leq 0.05$ was considered statistically significant. A mean and standard deviation were conducted to express the quantitative data, while numbers and percentages were used to express qualitative data. The normality assumption was checked using the Kolmogorov-Simonov test, and the associations between the disease and qualitative data were evaluated by chi-square. The correlation between quantitative and qualitative variables was analyzed using Pearson's and chi-square's correlations, respectively and comparison between data was conducted by ANOVA analysis.

Results

A total of 120 COVID-19 patients were enrolled, of which 46.6% were males and 53.4% were females. Our study showed a significant correlation of BMI with age ($P=0.023$), intensive care unit admission ($P=0.043$), and taking remdesivir ($P=0.003$) in 120 patients. No significant correlation was detected with the Borg score for dyspnea, gender, hemoptysis, productive and dry cough, admission saturation of oxygen, temperature, respiratory rate, pulse rate, blood pressure, first lab tests for anemia, leukopenia (lymphopenia), thrombocytopenia, first erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), intubation, days of hospitalization, intra-hospital mortality, month mortality, taking dexamethasone, methylprednisolone during hospitalization and extension of lung involvement in five subgroups of BMI.

Table 1 shows the correlation between quantitative variables with BMI in patients. In cases without underlying disease (51 patients), BMI is significantly correlated with lymphocyte count (direct relationship, $P=0.012$). In patients with underlying disease (69 patients), BMI is significantly correlated with age (inverse relationship, $P=0.009$) and temperature (direct relationship, $P=0.043$). In all patients (120 patients), BMI is significantly correlated with age (inverse relationship, $P=0.023$). It means that in older patients BMI is lower.

Table 2 shows the correlation of BMI with qualitative variables in patients. In patients without underlying disease (51 patients) BMI is significantly correlated with taking remdesivir (direct relationship, $P=0.044$). In patients with underlying disease (69 patients), BMI is significantly correlated with hemoptysis (direct relationship, $P=0.002$), ICU (intensive care unit) admission (direct relationship, $P=0.045$), and taking remdesivir (direct relationship, $P=0.002$). In all patients (120 patients), BMI is significantly correlated with ICU admission (direct relationship, $P=0.043$) and taking remdesivir (direct relationship,

Table 1. Correlation between quantitative variables with BMI in patients

BMI (kg/m^2)	Without the underlying disease (51 patients)		With underlying disease (69 patients)		All patients (120 patients)	
	Pearson' correlation	*P* value	Pearson' correlation	*P* value	Pearson' correlation	*P* value
Age (year)	-0.060	0.672	-0.312	0.009*	-0.207	0.023*
Borg score for dyspnea	-0.049	0.728	-0.157	0.170	-0.117	0.201
Temperature (ºC)	-0.017	0.905	0.244	0.043*	0.117	0.200
O_2 saturation (%)	-0.013	0.926	-0.148	0.225	-0.095	0.298
Systolic blood pressure (mm Hg)	0.113	0.426	0.031	0.801	-0.047	0.607
Diastolic blood pressure (mm Hg)	0.208	0.139	0.224	0.065	0.034	0.714
Pulse rate (pulse/min)	0.112	0.428	0.002	0.984	0.051	0.577
Respiratory rate (breath/min)	0.206	0.142	0.047	0.701	0.103	0.259
WBC (/µL)	0.027	0.847	-0.052	0.669	-0.039	0.673
PMN (%)	-0.012	0.932	0.044	0.719	0.027	0.768
Lymphocyte (%)	0.346	0.012*	-0.018	0.886	-0.008	0.927
Hemoglobin (g/dL)	-0.067	0.637	-0.051	0.680	-0.056	0.544
Platelets counts (×10^9 /L)	0.066	0.643	-0.087	0.477	-0.032	0.730
CRP (mg/L)	-0.020	0.890	-0.077	0.532	-0.052	0.571
ESR (mm/h)	0.137	0.333	-0.014	0.906	0.054	0.559
Days of hospitalization	0.067	0.637	0.140	0.253	0.104	0.255

Abbreviations: BMI, Body mass index; BP, Blood pressure; RR, Respiratory rate; WBC, White blood cell; Hb, Hemoglobin; CRP, C-reactive protein; ESR, Erythrocyte sedimentation rate
*P value < 0.05.

Table 2. Correlation between qualitative variables with BMI in patients

BMI (kg/m^2)	Without the underlying disease (51 patients)		With underlying disease (69 patients)		All patients (120 patients)	
	Value[a]	*P* value	Value[a]	*P* value	Value[a]	*P* value
Gender	2.561	0.634	2.583	0.630	3.250	**0.517**
Productive cough	2.630	0.621	7.224	0.125	2.143	0.709
Dry cough	1.626	0.804	2.500	0.645	1.650	0.800
Hemoptysis	1.242	0.871	16.489	0.002*	9.332	0.053
ICU admission	0.333	0.846	6.198	0.045*	5.538	0.043*
Intubation	5.869	0.209	1.783	0.776	3.160	0.531
Intrahospital mortality	4.120	0.390	1.783	0.776	3.334	0.504
1 month mortality	2.414	0.299	3.066	0.216	3.021	0.221
Taking remdesivir	9.793	0.044*	16.489	0.002*	16.369	0.003*
Taking dexamethasone	1.716	0.788	2.165	0.705	1.841	0.765
Taking methylprednisolone	3.599	0.463	7.773	0.100	9.141	0.058
GGO ≤50%	2.718	0.606	4.498	0.343	5.541	0.236
GGO >50%	2.718	0.606	5.195	0.268	5.945	0.203

Abbreviations: BMI, Body mass index; ICU, Intensive care unit; GGO, Ground-glass opacification.
*P value < 0.05. [a] Value represents the correlation between qualitative variables with the BMI of both groups.

$P = 0.003$). It means that a higher BMI is associated with more ICU admission and taking remdesivir.

Table 3 shows the correlation of hemoptysis with BMI is more than dry cough and productive cough.

Discussion

In the present cross-sectional study, in patients without underlying disease (51 patients), BMI was significantly correlated with lymphocyte count and taking remdesivir. In patients with underlying disease (69 patients), BMI is significantly correlated with age, temperature, hemoptysis, ICU admission, and taking remdesivir. In all patients (120 patients), BMI is significantly correlated with age, ICU admission, and taking remdesivir. Furthermore, the correlation of hemoptysis with BMI is more than dry cough and productive cough.

Some studies have shown that BMI correlates with COVID-19 outcomes. This can be seen by the tendency for moderate and severely obese patients to have COVID-19 symptoms for longer periods of time (11,13). According to the study by Kalligeros et al (14) an ICU admission was associated with severe obesity (BMI >35 kg/m^2), while the use of invasive mechanical ventilation was independently associated with a history of heart disease and obesity.

Table 3. ANOVA analysis of the comparison between dry cough, productive cough and hemoptysis with BMI

BMI	Dry cough	Productive cough	hemoptysis
P value	0.038	0.036	0.002

The results of an American study showed that patients younger than 60 years with a BMI between 30 kg/m and 35 kg/m^2, as well as those over 35 kg/m^2, were 1.8 and 3.6 times more likely to be admitted to an ICU, respectively, than those with a BMI <30 kg/m^2 (15). The NHS intensive care national audit and research center reported that, in the UK, 38% of patients admitted to intensive care are obese (16,17).

A meta-analysis found that BMI is a significant determinant of COVID-19 infection and severity at all ages, especially in elderly people. There should be a risk factor for COVID-19 patients with a higher BMI. The risk of being critically ill for elderly male patients with a high BMI is also greater (13,18). Another study showed that people with obesity have a greater risk of severe COVID-19 infections with an increasing BMI (19). In another meta-analysis, obesity was linked both to influenza and COVID-19 risk and severity. The risk of severe outcomes and admission to the intensive care unit of COVID-19 patients with obesity is higher when compared with influenza patients with obesity, but not the risk of mortality. The risk of COVID-19 infection and its development should be decreased by promoting more weight control and physical regulation strategies (20-22).

There was a study in China that demonstrated obese patients were more likely to develop severe COVID-19 infection than normal-weight patients, since increasing hospitalization and deteriorating clinical outcomes were the possible consequences (23).

Multiple factors influence the severity of COVID-19 (24), and obesity might be one of them. Obesity may exacerbate the symptoms of COVID-19 by affecting inflammation, immune responses, and other pathways (25). Age, diabetes, hypertension, and cardiovascular diseases can also interact with obesity to influence the development of COVID-19 (14,20). As a result, discussing more influencing factors for severe COVID-19 would be very valuable.

According to the study by Kalligeros et al (14), obesity affects the mechanics and physiology of the lungs, increases ACE2 expression, increases viral titers and diversity, and prolongs viral shed, which can lead to accelerated growth of COVID-19 and a predisposition to respiratory failure.

Several parameters may play a role in obesity causing severe COVID-19 outcomes, although no exact mechanism has been identified. The first difference between obese and non-obese patients is a changed respiratory physiology, which includes abnormalities such as hypoxemia, ventilation, or perfusion (26). Furthermore, obesity has been shown to impair immune system response and surveillance (27). Additionally, there is evidence that levels of angiotensin-converting enzyme 2 expression in adipose tissue, which has a high affinity for SARS-CoV-2, could play an important role (28).

Conclusion

In this study, obese patients had an increased risk of ICU admission and taking remdesivir due to severe COVID-19. As COVID-19 continues to spread around the world, clinical practitioners should pay more attention to obese patients and treat them more aggressively and promptly, therefore lifestyle modification seems to be appropriate. Further studies are required though to better illustrate whether obesity is a significant independent risk factor for COVID-19.

Limitations of the study

This study has several limitations. First, this study has a self-selection bias, which leads to nonprobability sampling and therefore a lack of generalizability. Second, the transmission/ infection was not definitively proven, although it may have occurred due to exposure to infected patients and the development of infection based on timing and patterns of exposure. Third, this is a retrospective study that permits a preliminary conclusion regarding the clinical course and outcomes of critically ill patients with COVID-19. Hence, further studies are needed.

Authors' contribution

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Funding acquisition: Farzaneh Kianifar, Samaneh Parsa, Mohammad Eslami.
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Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical issues

The research adhered to the principles of the Declaration of Helsinki. The Ethics Committee of Tehran University of Medical Sciences approved this study (Ethical code#IR.TUMS.VCR.REC.1399.11). Additionally, written informed consent was obtained from all participants prior to any intervention. Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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