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The Impact of Body Mass Index on Intensive Care Unit Outcomes of Critically ill Patients

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ABSTRACT

Aim: Conflicting results have been reported regarding the potential impact of obesity on intensive care unit (ICU) outcome. In some studies, lower mortality was reported in obese and morbid obese patients. This situation was defined as "obesity survival paradox". Due to these conflicting results, we aimed to evaluate the effects of body mass index (BMI) on ICU outcomes of critically ill patients.

Methods: This is a retrospective cohort study of adult patients hospitalized in a tertiary ICU of university hospital between January 2015 and December 2019. Patients were categorized into four groups according to their BMIs. Demographic data, admission diagnoses, comorbidities, APACHE II scores, invasive and noninvasive mechanical ventilation (IMV and NIV) use, frequency of sepsis, SOFA scores, length of ICU and hospital stay and ICU outcome (mortality or discharge) were compared. SPSS Statistics for Windows v.23.0.was used for data analysis.

Results: A total of 410 patients were included. According to BMIs, 42% were normal, 32% overweight, 20% obese and 6% morbid obese. The APACHE II score was significantly higher in the normal BMI group ($p = 0.049$). Sepsis was detected in 113 (28%) cases. Although the rate of sepsis was higher in normal BMI group (32%), no statistical difference was found between the groups ($p=0.427$). Ninety-three (23%) patients died of them 27% were normal, 24% were overweight, 15% were obese and 12% were morbid obese ($p=0.05$). While no difference was observed between the groups in terms of IMV use; the frequency and duration of NIV use was higher in obese and morbid obese patient groups ($p<0.05$).

Conclusion: This study revealed that the APACHE II score and the mortality were significantly lower; and NIV use was significantly higher among patients with BMI >25. In order to better clarify the effects of BMI on ICU outcomes, prospective studies with larger patient populations should be performed.

Key words: BMI, obesity, sepsis, ICU outcomes

Introduction

Obesity is being accepted as one of the biggest health problems of the developed countries and has been the subject of many scientific studies (1). It is an important risk factor for many diseases as coronary artery diseases (CAD), hypertension (HT), cerebrovascular diseases (CVD), diabetes (DM) and some malignancies (2). Besides, it may lead to serious respiratory problems, such as obesity hypoventilation syndrome and obstructive sleep apnea (3). It is evaluated and classified according to body mass index (BMI) which is an important and frequently used anthropometric measurement that shows the nutritional status and especially the fat content of individuals (1).

Previous studies have reported that obesity causes an increase in the duration of intensive care unit (ICU) stay, the use of mechanical ventilation, hospital infection rates and the use of hospital resources (4,5). However, recent studies have given conflicting results as although obesity was associated with increased morbidity in critically ill patients, it did not affect mortality (5,6). Even, lower mortality was found in obese and morbid obese patients with acute respiratory distress syndrome (7). This situation was first defined as "obesity survival paradox" in 1999, since an increase in survival with increasing BMI has been identified in patients undergoing hemodialysis (8). Unfortunately, not so much studies have supported this finding due to problems such as subgroup differences and inability of the study population to represent the general population.

In our daily practice, we observe better ICU outcomes among obese critically ill patients and with this study, we aimed to evaluate and document the effect of BMI on ICU outcomes of critically ill patients.

Methods

Approval was obtained from the ethics committee of a university hospital (ethics committee approval number and date:308/April 27, 2020). This is a retrospective cohort study of adult patients hospitalized in the tertiary intensive care unit of university hospital between January 2015 and December 2019. Patients' age, gender, diagnosis at admission, comorbidities, acute physiology and chronic health evaluation (APACHE) II score, SOFA (Severity of Organ Failure Assessment) score, BMI, sepsis both at admission and during the ICU follow-up, need for mechanical ventilation, length of ICU stay and discharge status were recorded.

Definitions

Obesity was evaluated with an anthropometric tool i.e., BMI as body weight /height^2 (kg/m^2). For the calculation, the height and weight of the patients at the time of admission to the hospital were taken as a basis. The measured values were categorized according to the World Health Organization criteria as; "BMI< 20 kg/m^2: Underweight"; "BMI: 20-25 kg/m^2: Normal", "BMI: 25-30 kg/m^2: Overweight", "BMI: 30-40 kg/m^2: Obese", "BMI> 40 kg/m^2: Morbid obese" (9).

Sepsis was defined according to the guideline which was published in 2021. Sepsis described as a life-threatening organ dysfunction that develops due to the patient's irregular immune response to infection (10). Organ dysfunction was evaluated by considering a score above 2 according to the Sequential Organ Failure Assessment (SOFA) score. (11).

Statistics

The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk Test). Descriptive statistics were presented as mean and standard deviation, median (quartiles), frequency distribution, and percentage. The comparisons of BMI groups were evaluated either with one-way analysis of variance (ANOVA) or the Kruskal-Wallis variance analysis whether the normality assumption and variance homogeneity of independent groups were satisfied. The pairwise comparisons were conducted by LSD or Dunn-Bonferroni test with respect to ANOVA or Kruskal-Wallis variance analysis. The association among categorical variables was examined with the Pearson chi-square test. The grade of statistical emphasis was set at a p-value≤0.05. All reported p-values are 2-sided. Data were analyzed using SPSS Statistics for Windows v.23.0.

Results

A total of 410 patients were included in the study. Fifty-four percent of them were male. When categorized according to BMI, 42% were normal, 32% were overweight, 20% were obese, 6% were morbid obese. Being overweight, obese and morbid obese were significantly higher in women than in men (p<0.001). Distribution of general demographic and ICU characteristics at admission according to BMI classification was summarized in Table 1.

Table 1. Distribution of general demographic and ICU characteristics at admission according to body mass index classification

	Normal n (%) 170 (42)	Overweight n (%) 132 (32)	Obese n (%) 83 (20)	Morbid obese n (%) 25 (6)	p value
Gender/ Female	**60 (35)**	**51 (39)**	**57 (70)**	**22 (85)**	***<0.001**
Age, years (mean ± sd)	69.75 ± 16.15	70.14 ± 15.79	74.2 ± 11.54	66.8 ± 9.75	0.068
APACHE II (mean ± sd)	**20.61 ± 7.76**	**19.57 ± 7.79**	**18.53 ± 6.76**	**16.83 ± 6.33**	***0.049**
SOFA Median [min-max]	3[0-16]	3[0-13]	3[0-15]	3[1-19]	0.135
Admission Diagnoses					
Respiratory failure	**44 (26)**	**48 (37)**	**32 (39)**	**12 (46)**	**0.036**
Pneumonia	**56 (33)**	**28 (22)**	**7 (9)**	**2 (8)**	**0.001**
COPD exacerbation	22 (13)	16 (12)	16 (20)	3 (12)	0.435
Sepsis	10 (6)	8 (6)	6 (7)	0 (0)	0.581
Heart failure	9 (5)	9 (7)	9 (11)	4 (15)	0.168
Asthma exacerbation	**2 (1)**	**1 (1)**	**4 (5)**	**2 (8)**	**0.037**
Any malignancy	**8 (5)**	**1 (1)**	**0 (0)**	**0 (0)**	**0.037**
Pulmonary thromboembolism	8 (5)	10 (8)	6 (7)	2 (8)	0.697
Interstitial lung disease	8 (5)	2 (2)	1 (1)	0 (0)	0.204
ARDS	1 (1)	1 (1)	0 (0)	0 (0)	0.856
Others (trauma, postop.)	3 (2)	4 (3)	0 (0)	0 (0)	0.343
Comorbidities					
DM	**30 (18)**	**33 (25)**	**34 (41)**	**10 (40)**	***<0.001**
CAD	**58 (34)**	**61 (46)**	**52 (63)**	**16 (64)**	***<0.001**
HT	**86 (51)**	**79 (60)**	**69 (83)**	**20 (80)**	***<0.001**

*According to p values there is a statistically significant difference, Because of multiple diagnosis and comorbidities, total percentages are >100%.
Abbreviations: **APACHE II:** Acute Physiology and Chronic Health Evaluation, **SOFA:** Sequential Organ Failure Assessment Score; **DM:** Diabetes Mellitus, **CAD:** Coronary Artery Disease, **HT:** Hypertension, **COPD:** Chronic Obstructive Pulmonary disease, **ARDS:** Acute Respiratory Distress Syndrome

The APACHE II score was significantly higher in the normal BMI group than in the other groups (p = 0.049). On the other hand, DM, CAD, and HT were significantly higher in the BMIs > 25 group (p<0.001). When the ICU admission diagnoses of the patients were evaluated, type 1 and type 2 respiratory failure, asthma exacerbation were more common in patients with BMI > 25. On the other hand, pneumonia and any admission due to malignancy were more common in normal group (p< 0.005).

Sepsis was detected in 113 (28%) cases; 32% of the normal group, 26% the overweight, 24% the obese and 20% of the morbid obese group were diagnosed as sepsis at admission and during their ICU stay. Although the rate of sepsis was more common in patients with normal BMI, no statistical difference was found between the groups (p=0,427) (Table 2). Ninety-three (23%) patients died of them 27% were normal, 24% were overweight, 15% were obese and 12% were morbid obese (p=0.05). 128 (31%) patients received invasive mechanical ventilation (IMV) and 187 (46%) patients received noninvasive mechanical ventilation (NIV). NIV use was higher in obese and morbid obese patient groups (p = 0.017). While IMV duration was not different between the groups, NIV duration was longer in obese and morbidly obese patients (Table 2). There was no significant difference between the length of ICU stay among the groups.

Discussion

Herein this study a total of 410 ICU patients were grouped according to their BMIs and evaluated for their ICU outcomes. Female patients were more frequent in obese and morbid obese groups. Similar to our result, in a study by Shuhe Lia et al., in which 5563 people were included, the rate of overweight in female gender was determined as 41.1% and the rate of obese ones as 48.8% (2). On the other hand, in another retrospective study conducted by Yasser Sakr et al. including 3902 patients, being overweight and obese was found to be predominant in the male gender (p<0.05) (12). The predominance of obesity and morbid obesity in different genders in studies may be attributed to the differences in dietary habits and genetic factors among the populations.

In our study, comorbidities such as DM, HT, and CAD were found significantly higher in patients with BMI >25 (p<0.001). This was not surprising since they were the most common obesity-related comorbidities. Similarly, Yasser Sakr et al revealed that the prevalence of cardiac diseases and DM was found to be clearly associated with an increased BMI category. (12).

In our study, the APACHE II score was higher in the normal BMI group. As well as, pneumonia and complications due to underlying malignancy more common in the normal BMI group. On the other hand, respiratory failure and asthma exacerbation were more common in BMIs > 25 group. We couldn't find any statistical difference between the groups in terms of the IMV requirement and duration, and the length of ICU stay. NIV was used more frequently among obese and morbid obese patients and the length of NIV use was longer, as well. Mortality which was the most important ICU outcome parameter, was higher among normal weight patients when compared with the obese and morbid obese ones. These results made us to think that in our study group obese and morbid obese patients were accepted most commonly due to hypoxic hypercapnic respiratory failure and they responded to NIV better. On the other hand, our normal weight patients were composed of more severe patients with malignancies or severe pneumonia which were refractory to NIV and required IMV. And finally higher APACHE II score in normal weight patients indicates more severe illness.

In our study, the SOFA score, the other frequently used ICU score, was evaluated. SOFA scores were similar between the groups when categorized according to BMI. We thought this non-diference could be explained by the similar rate of sepsis between the groups. This result was compatible with Yasser Sakr et al.'s study (12). In contrast, in the study of Schuhe Lila et al. observed higher SOFA scores in obese patients (7.1 ± 4.0 vs. 6.6 ± 3.7, P<0.001) (2).

As stated above, IMV requirement was not different between groups, whereas NIV requirement was significantly higher in obese and morbidly obese patients (p=0.017). In the retrospective analysis by Yasser Sakr et al. the need for mechanical ventilation at ICU admission was higher in morbidly obese patients when compared to normal weigth patients (63.7 vs 47.3%, p= 0.001) (12). But, they did not categorize the need for mechanical ventilation as invasive and non-invasive. In another study Sarvin

Table 2. ICU follow-up characteristics and outcome compared according to BMI classification

	Normal n (%) 170 (42)	**Overweight n (%) 132 (32)**	**Obese n (%) 83 (20)**	**Morbidly obese n (%) 25 (6)**	**p value**
Sepsis, n (%)	54 (32)	34 (26)	20 (24)	5 (20)	0.427
NIV, n (%)	**73 (43)**	**51 (39)**	**47 (57)**	**16 (64)**	***0,017**
IMV, n (%)	62 (37)	40 (30)	20 (24)	6 (24)	0,187
Length of IMV/day (median [min-max])	0 [0-65]	0 [0-46]	0 [0-60]	0 [0-10]	0,579
Length of NIV/day (median [min-max])	**0 [0-28]**	**0 [0-16]**	**3 [0-27]**	**2.5 [0-22]**	***0.004**
ICU length of stay/day (median [min-max]	8 [1-75]	7 [1-91]	9 [1-120]	7 [2-22]	0.699
ICU outcome, n(%)					
Exitus	**47 (27)**	**31 (24)**	**12 (15)**	**3 (12)**	***0.05**

*According to p values there is a statistically significant difference.
NIV: Non-invasive ventilation, **IMV:** invasive ventilation, **ICU:** intensive care unit

Sanaie et al. reported that extubation failure and reintubation rates were significantly higher in overweight, obese and morbidly obese patients than in those with normal weight (p <0.001) (13). We did not analyze the extubation failure and reintubation rates in our study, this is a limitation of our study. But since the need for IMV among the whole ICU stay did not differ between normal and obese patients; it will not be wrong to assume that the extubation failure and reintubation rates might not also differ.

Several studies have shown a strong relationship between obesity and increased length of ICU and hospital stay (14-16). This increased length of stay related to extended mechanical ventilation requirement and increased risk of infection (14, 16–20). In Sarvin Sanaie et al.'s study which inclueded 502 patients, revealed that overweight, obese and morbidly obese patients had longer length of ICU stay (13). However, in our study, there was no statistically significance between the increased BMI and length of ICU and hospital stay (p>0.05).

In our study mortality was found to be significantly lower in patients with BMI >25. Similarly, in the study of Shuhe Lia et al., the overweight and obese patients had significantly better survival than those with normal weight (OR 0.85, 95% CI 0.72–1.00, P<0.05; OR 0.73, 95% CI 0.62–0.86, P<0.001) (2). Likewise, in a retrospective cohort study of 55038 adults hospitalized for sepsis, those with a normal BMI were found to have higher mortality than those with a higher BMI (21). This situation was first defined as "obesity survival paradox" in 1999, since an increase in survival with increasing BMI has been identified (8). Whether this "obesity survival paradox phenomenon" exists has been unclear. The exact underlying mechanism of this paradox has not been described yet, besides there is debate about whether this is a real phenomenon or just a consequence of selection bias. For our ICU population we thought that since the patients with BMI > 25 more commonly presented with hypercapnic respiratory failure and responded well to NIV, they had experienced lower complications of ICU stay.

Limitations

The first limitation of our study is the low number of our patients. The second one is that this was a retrospective study, so we couldn't find the exact height and weight values of some patients from the records and these patients were not included in the study. Finally, it was a single center study. But this study presented a quite well sample of general ICU population with different BMIs.

Conclusions

This study revealed that when the ICU outcomes were evaluated according to BMIs, no difference was identified in terms of need for IMV, development of sepsis, SOFA scores, length of ICU and hospital stay. But the APACHE II score and the mortality were significantly lower; and NIV use was significantly higher among patients with BMI >25. In order to better clarify the effects of BMI on ICU outcomes, prospective studies with larger patient populations should be performed.

AUTHOR CONTRIBUTIONS:

Concept: MA, ZC; **Design:** MA, ZC; **Data Collection and/or Processing:** ZC, BO; **Analysis and/or Interpretation**: MA, BO; **Writing Manuscript**: MA, ZC, BO.

Ethics Committee Approval: Çalışmamız Gazi Üniversitesi Tıp Fakültesi Etik Kurulu tarafından onaylanmıştır.etik kurul onay numarası ve tarih:308/27 Nisan 2020

Informed Consent: Informed consent form was not taken because our study was retrospective.

Peer-review: Externally peer-reviewed.

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