Original Article

Lower body mass index is associated with hospital mortality in critically ill Japanese patients

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Background and Objectives: A recent observational study conducted in European intensive care units (ICU) showed that body mass index (BMI) is associated with mortality. We hypothesized that a lower BMI amongst critically ill Japanese patients was associated with increased hospital mortality, similar to findings noted among critically ill European patients. Therefore, we retrospectively investigated the relationship between BMI and patient outcomes in an ICU. **Methods and Study Design:** We included consecutive patients who were admitted to our ICU between January 2012 and December 2013. Patients were divided into 3 groups based on their BMI at ICU admission. The underweight ("lower") group (group L) included patients with a BMI below 18.5 kg/m^2, the normal weight group (group N) included patients with a BMI between 18.5 and 24.9 kg/m^2, and the overweight/obese ("higher") group (group H) included patients with a BMI above 25.0 kg/m^2. Patient data were retrospectively obtained from electronic patient records. **Results:** A total of 1,616 patients were admitted to our ICU. Of these patients, 346 patients were ineligible, and therefore, 1,270 were included in the analysis. There were 169 patients in group L, 779 patients in group N and 322 patients in group H. Overall, the mortality rate was 8.1% and the median hospital stay was 21 days. The mortality rate in group L was significantly higher than that in both group N and group H (13.6% vs 7.8% vs 5.9%, *p*=0.01). **Conclusions:** Our retrospective study suggests that lower body mass index may be associated with increased hospital mortality in critically ill Japanese patients.

Key Words: body mass index, outcome, mortality, intensive care unit, Japanese

INTRODUCTION

It is generally considered that body mass index (BMI) is related to prognosis.[1] A normal BMI of 22.5-25 kg/m^2 is associated with the lowest mortality risk and the mortality increases when the BMI is either lower or higher than these values.[1] On the other hand, there are also previous reports on the association between BMI and prognosis in patients treated in the intensive care unit (ICU).[2,3] A study performed in the Netherlands reported a J-shaped model, indicating that mortality was the highest in patients with a low BMI and lower in the patients with mild obesity.[2] However, many of these previous studies were performed in Europe and the US, and it is considered that there are ethnic differences in prognosis.[4] Furthermore, there are also differences in the body type between Western and Asian populations. In fact, the influence of low BMI was remarkable as compared with the influence of high BMI in a study on BMI and prognosis performed in an Asian general population.[5] Consequently, it remains unclear whether BMI is indeed associated with prognosis and whether the data obtained from Europe and the US can be used for Asian patients hospitalized in the ICU. Our hypothesis was that low BMI might be especially associated with poor prognosis in Japanese patients in the ICU, similar to for the general population in Asia. To verify this hypothesis, we performed a single-institution retrospective study.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of Kochi Medical School, and the need to obtain informed consent was waived because this study was a retrospective analysis. In our hospital, every patient was able to declare refusing use of data from the present to the future in writing. Therefore, patients who refused the use of their record were excluded from the study.

Consecutive patients hospitalized in our ICU between January 2012 and December 2013 were included in the study. Of these patients, those <20 years of age, those who refused the use of their record at hospitalization and those whose BMI on admission to the ICU was unknown were excluded from the study. The remaining patients were classified into three groups according to their BMI: Group L (BMI <18.5 kg/m^2), Group N (BMI 18.5-25 kg/m^2) and Group H (BMI >25 kg/m^2).

Data regarding the Acute Physiology and Chronic Health Evaluation (APACHE) II score, sequential organ failure assessment (SOFA) score, reason for admission to

the ICU, duration of ICU stay, hospitalization period (days), and prognosis were retrospectively accumulated from the electronic patient records. The primary endpoint was the prognosis at discharge, and the secondary endpoint was the length of hospitalization.

Data are expressed as the mean ± standard deviation. Associations between the outcome and baseline variables were examined by univariate analysis. For the analysis of continuous variables, a t test was used, and a chi-square test was used to analyse categorical variables. Variables were considered potentially associated with outcome when $p<0.05$; these variables were further evaluated using a multivariate logistic regression model. When the linearity assumptions considered were violated, continuous variables were divided into tertiles and analysed as discrete variables. For all analyses, a two-sided p value <0.05 was considered statistically significant. Statistical analysis was performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA).

RESULTS

A total of 1,616 patients were admitted to our ICU. Of these patients, 1,270 were analyzed and 346 patients were excluded from the study. There were 169 patients in group L; 779, in group N; and 322, in group H. Women represented 39% of the retained study population. The median age was 71 years, and the median BMI was 22.5 kg/m^2 (Figure 1). Of the sample, 82.2% were surgical patients. Overall, the mortality rate was 8.1% and the median hospital stay was 21 days. The age in group H was significantly younger than that in both group N and group L (69±17 vs 70±13 vs 66±13, $p<0.001$) (Table 1). The proportion of women in group L was higher than that in both group N and group H (50% vs 37% vs 40%, $p<0.008$). The APACHE II score in group H was significantly lower than that in both group L and group N (21.7±5.7 vs 20.7±5.8 vs 19.8±5.9, $p<0.003$). The mortality rate in group L was significantly higher than that in both group N and group H (13.6% vs 7.8% vs 5.9%, $p=0.01$). The length of hospital stay was not significantly different between groups ($p=0.30$).

The body mass index, gender, age and the APACHE II score were selected as candidate variables ($p<0.05$). The APACHE II score was associated with undesirable outcome (odds ratio=1.20, 95% confidence interval=1.17-

1.24, $p<0.001$) (Table 2). Low BMI was also associated with undesirable outcome (odds ratio=1.84, 95% confidence interval=1.02-3.25, $p=0.04$).

DISCUSSION

The results of this study suggested that low BMI might increase the in-hospital mortality rate as compared with standard BMI in Japanese ICU patients. On the other hand, there was no difference in the prognosis between the high BMI and standard BMI groups. The median BMI was 22.5 kg/m^2; this value greatly differs from that of the studies from Europe and the US (26-27 kg/m^2),[2,3] indicating that the previous results from ICU patients from Western countries cannot simply be adapted to Asian patients.

In not only the general population but also ICU and surgical patients, the association between BMI and prognosis has recently received attention. In surgical patients, a preoperative low BMI is related to a poor prognosis.[6] Conversely, in obese patients, the risks of complications such as surgical site infection and deep vein thrombosis may increase.[7,8] In studies on ICU patients, the findings are conflicting; the prognosis of obese patients is poor, unchanged, or favorable depending on the study.[2,3] In our study, we found that the prognosis was poor in patients with low BMI, while it did not change in obese patients as compared to normal-weight patients. For the general population in Asia, it has been reported that the influence of prognosis was greater in patients with low compared to high BMI.[5] In addition, in the Japanese general population, both under- and overweight are important determinants of premature death.[9] The phenomenon of obese patients with higher BMI having a good prognosis is referred to as the obesity paradox. However, recently, it was reported that obesity did not affect the prognosis after adjusting for nutritional status on admission to ICU.[3] The obesity paradox has been also denied in the general population.[10] Thus, our results can be considered as appropriate.

Our study revealed that the BMI of Japanese ICU patients greatly differed from the data of European and the US populations. However, the difference in physique between the Europeans and Japanese might affect our results. For instance, BMI is influenced by height. Although the average height was less than 160 cm in our study, it was almost 170 cm in a recent European study.[11] When the BMI was 18.5 and 25, the difference in height caused a difference in weight of about 6 kg and 8 kg, respectively. Therefore, it might also be necessary to consider physique-related measures, such as height and not only BMI, to sufficiently compare nutritional studies that include Asian, European, and US populations.

This study has several limitations because it was a retrospective single center study. Therefore, the number of cases was small. In addition, the patients were classified into three groups according to BMI. However, in some previous studies, further division into different groups was performed. Consequently, the exact BMI range associated with the best prognosis remains unclear. The number of cases could be increased if the study period is extended, as in the other studies. However, the therapy may greatly differ between the subjects in the long-term fol-
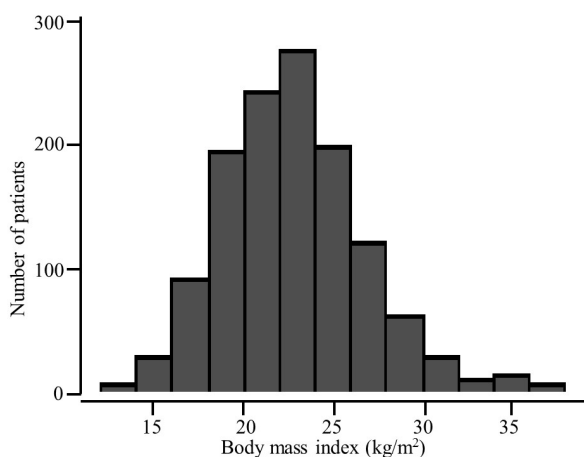

Figure 1. Distribution of body mass index in this study population

Table 1. Patient background and outcome

	Group L (N=169)	Group N (N=779)	Group H (N=322)	p value
Age (yr)	69±17	70±13	66±13	<0.001
Gender (% of women)	50	37	40	0.008
Height (cm)	157±10	158±9	159±9	0.33
Weight (kg)	42±6	55±8	71±11	<0.001
Body mass index (kg/m^2)	16.9±1.4	21.9±1.8	28.2±3.1	<0.001
Admission type (% of surgery)	77	82	85	0.10
APACHE II score	21.7±5.7	20.7±5.8	19.8±5.9	0.003
SOFA score	5.0±3.7	4.9±3.8	4.8±3.9	0.82
Hospital mortality (%)	13.6	7.8	5.9	0.01
Length of hospital stay (days, median)	20	24	21	0.30

Data are expressed as the mean ± standard deviation.

Table 2. Multivariate logistic regression analysis for outcome

	Reference	Adjusted odds ratio	95% confidence interval	p value
Gender	Women	1.24	0.78-2.01	0.36
Age	-	1.02	0.99-1.03	0.07
APACHE II	-	1.20	1.17-1.24	<0.001
Group L	Group N	1.84	1.02-3.25	0.04
Group L	Group H	2.12	1.02-4.40	0.04
Group H	Group N	0.81	0.43-1.46	0.50

APACHE II: Acute Physiology and Chronic Health Evaluation II.

low-up, and, therefore, the period of our study was as short as two years. Finally, several factors other than BMI might influence outcome. However, in the multivariate analysis, low BMI was found to be independently associated with a poor prognosis. To confirm these results, a large-scale observational, prospective multicenter or multilateral study is warranted in the future.

In conclusion, low BMI might increase the in-hospital mortality rate as compared with normal BMI in Japanese ICU patients. Since there is a difference in body type between ICU patients in Western countries and Asia, a future multilateral or multicenter study in Asia is expected to confirm these results.

AUTHOR DISCLOSURES

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日本危重症患者低体质指数与住院死亡率相关

背景与目的：最近在欧洲重症监护病房（ICU）进行的一项观察性研究表明，体质指数（BMI）与死亡率有关。我们假设日本危重症患者低 BMI 与住院死亡率增加相关，与在欧洲危重患者中的发现相似。因此，我们在一个 ICU 回顾性调查 BMI 和患者的预后之间的关系。**方法与研究设计**：我们连续纳入 2012 年 1 月到 2013 年 12 月之间的 ICU 患者。根据患者进入 ICU 时的 BMI，将患者分为 3 组。低体重组（L 组）包括 BMI 低于 18.5 kg/m^2 的患者，正常体重组（N 组）包括 BMI 介于 18.5-24.9 kg/m^2 之间的患者，超重/肥胖组（H 组）包括 BMI 大于 25.0 kg/m^2 的患者。回顾性从电子病历中获得患者的资料。**结果**：共有 1,616 名住我院 ICU 的患者。在这些患者中，346 名不合格，因此，纳入分析的有 1,270 名。L 组有 169 名患者，N 组有 779 名患者，H 组有 322 名患者。患者总的死亡率为 8.1%，平均住院时间为 21 天。L 组的死亡率显著高于 N 组和 H 组（13.6%比 7.8%和 5.9%，*p*=0.01）。**结论**：我们的回顾性研究表明，日本危重患者低体质指数可能与住院死亡率增加有关。

关键词：体质指数、结局、死亡率、重症监护病房、日本