

ORIGINAL ARTICLE

Does obesity impact the outcome of severely burned patients?

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Abstract

Although obesity appears to be an important predictor of mortality and morbidity, little data about the impact of body mass index (BMI) on the outcome of severely burned patients are available. Patients admitted to the General Hospital Vienna between 1994 and 2014, who underwent surgery because of burn injuries, were enrolled in this study. BMI was used to divide patients into five groups: BMI 18.5 to 24.9, 25 to 29.9, 30 to 34.9, 35 to 39.9, and > 40. The groups were compared in terms of difference of mortality and morbidity. Of 460 patients, 34.3% (n = 158) died. Mortality rates were the lowest in patients with obesity class III and the highest in patients with BMI 35 to 39.9 (BMI 18.5-24.9: 30.5%, BMI 25-29.9: 31.5%, BMI 30-34.9: 41.3%, BMI 35-39.9: 55.5%, BMI > 40: 30%; *P* = .031). BMI was not found to be an independent risk factor when corrected with age, percent total body surface area burned, full-thickness burns, and inhalation injury. No significant differences in length of stay, inhalation trauma, pneumonia, wound infection, sepsis, and invasive ventilation were observed. BMI as an independent risk factor for severely burned patients could not be confirmed via multivariate analysis.

KEYWORDS

BMI, burn, morbidity, mortality, obesity

1 | INTRODUCTION

Over the past decades, the prevalence of obesity has constantly increased, now affecting nearly 11% of adult men and 15% of adult women worldwide. Consequently, medical staff will be increasingly faced with obese patients.¹ Recognising and responding to their special needs will play an important role in the clinical outcome of those patients.

Being a main risk factor for health, obesity is often associated with comorbidities such as diabetes mellitus, arterial hypertension, hyperlipidaemia, stroke, and coronary heart disease, as well as some types of cancers.² While obesity is generally considered a risk factor for mortality and morbidity among trauma patients, there is growing evidence for a so-called “obesity paradox.” Initially described in relation to cardiovascular and chronic kidney disease, it asserts that overweight patients are

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predicted to have a better outcome than patients with a normal body mass index (BMI) once ill.^{3,4} Multiple studies have also provided evidence for this paradox among surgical patients.⁵⁻⁷ One reason for the better outcome that is often discussed is the higher caloric reserves of obese patients during the catabolic status, which is often caused by severe illness.⁸

While age, burn severity, and presence of inhalation injury are commonly considered main risk factors for mortality in burned patients, the role of obesity is still controversially discussed. In current literature, very less data regarding the impact of BMI on severely burned patients are available. Furthermore, present data disclose controversial results.⁹⁻¹²

Therefore, this study aims to investigate the prognostic impact of BMI on mortality. Secondary study points include its association with the presence of wound infections, sepsis, and pneumonia, as well as inhalation injury and length of mechanical ventilation in severely burned patients.

2 | MATERIALS AND METHODS

2.1 | Study subjects and variables

All adult patients admitted to the Burn Intensive Care Unit (BICU) between June 1994 and December 2014, who underwent at least one surgical treatment for a thermal injury, were enrolled in this study. Exclusion criteria were BICU admission >72 hours after burn injury or primary care in foreign countries and BMI under 18.5, as well as chemical injuries and frostbites. Furthermore, patients were excluded if important variables of interest were not recorded, such as BMI. Between June 1994 and December 2014, 886 patients were hospitalised and treated surgically at the BICU of Vienna. Of those, 460 met inclusion criteria to be enrolled in our study.

The BMI is the most common tool to classify the nutritional status in adults. It is defined as a person's weight in kilograms divided by the square of the person's height in metres (kg/m^2). According to WHO definitions, the BMI was used to divide the study population into following five groups: group 1 with 18.5 to 24.9 (normal weight), group 2 with 25 to 29.9 (pre-obesity), group 3 with 30 to 34.9 (obesity class I), group 4 with 35 to 39.9 (obesity class II), and group 5 with more than 40 (obesity class III).¹³

The primary endpoint was in-hospital mortality. Secondary endpoints were presence of wound infection, sepsis, and pneumonia, as well as inhalation injury and length of mechanical ventilation. The following data were registered in a computerised database for each

Key Messages

- a 20-year retrospective study including 460 patients was conducted to analyse the impact of obesity on mortality and morbidity of severely burned patients
- the body mass index could not be confirmed as an independent risk factor for severely burned patients
- likewise, length of stay and complication rates were not associated with obesity

patient: age, gender, height, weight at admission, BMI, percent total body surface area (%TBSA) burned, depth of burn, abbreviated burn severity index (ABSI), length of stay, mortality, wound infection, pneumonia, sepsis, inhalation injury, need for mechanical ventilation, and length of mechanical ventilation. The %TBSA was calculated by adding percentages of partial- and full-thickness burns using the rule of nine. The ABSI score was used to predict the risk of mortality for each patient. It was calculated according to Tobiasen et al.¹⁴ Wound infection was defined by at least one positive wound swap. Pneumonia was defined according to current guidelines: in addition to a new pulmonary infiltrate, two of following three criteria needed to be fulfilled: leucocytosis ($>10000/\mu\text{L}$) or leukopenia ($<4000/\mu\text{L}$), high temperature ($>38.3^\circ\text{C}$), and/or purulent sputum.¹⁵ Sepsis was defined according to the AWMF guidelines 2010.¹⁶ The diagnosis of an inhalation injury was always confirmed by bronchoscopy.

2.2 | Ethical considerations

This study was approved by the institutional review board of the Medical University of Vienna and the Vienna General Hospital (protocol registration number 1165/2016).

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

2.3 | Statistical methods

Normally distributed data are presented as mean \pm SD; otherwise, they are presented as median and interquartile

TABLE 1 Demographic data

	All patients	BMI 18.5-24.9	BMI 25-29.9	BMI 30-34.9	BMI 35-39.9	BMI > 40	<i>P</i> value
Number	460	187 (40.7)	162 (35.2)	63 (13.7)	38 (8.3)	10 (2.2)	
Age, mean (SD)	51.1 (18.9)	49.4 (21.3)	50.8 (16.9)	52.5 (17.6)	57.6 (15.8)	51.6 (17.4)	.170
Gender (male)	294 (63.9)	118 (63.1)	107 (66.0)	43 (68.3)	19 (50)	7 (70)	.375
%TBSA, mean (SD)	31.1 (22.6)	29.9 (23.1)	29.5 (20.9)	37.4 (23.1)	34.1 (24.8)	29.5 (26.4)	.05
Full thickness, n (%)	351 (76.6)	142 (76.3)	117 (72.7)	52 (82.5)	34 (89.5)	6 (60)	.141
ABSI score, mean (SD)	7.8 (2.8)	7.6 (2.8)	7.5 (2.6)	8.6 (2.8)	8.9 (2.9)	7.4 (3.4)	.010

Abbreviations: ABSI, abbreviated burn severity index; BMI, body mass index; TBSA, total body surface area.

range. Distribution of data was tested using the Kolmogorov-Smirnov test or the Shapiro-Wilk test. Variables were analysed using contingency tables and Pearson's χ^2 test or Fisher's exact test, as appropriate. To compare normally distributed data, Student's *t* test was applied, and for non-parametric data, the Mann-Whitney *U* test was used. M-analysis of variance was performed to compare multiple groups.

Univariate logistic regression was conducted to identify independent predictors of death. Multivariate logistic regression analyses with the depending variable mortality were developed to adjust for potentially confounding factors. Odds ratios (ORs) are given with the corresponding 95% confidence intervals (95% CI).

All analyses were conducted with IBM SPSS Statistics 22.0 for Windows (New York, New York). Statistical testing was two-sided, and significance was set at $P < .05$.

3 | RESULTS

3.1 | Patient characteristics

Between July 1994 and December 2014, 460 patients fulfilling the inclusion criteria were treated at the BICU of the General Hospital of Vienna. The patients were divided into five groups according to their BMI; 40.7% ($n = 187$) had a normal BMI. Pre-obesity was seen in 35.2% of all patients ($n = 162$). Almost one quarter of all patients (24.2%) were overweight. Sixty-three patients (13.7%) suffered from obesity class I, 38 (8.3%) from obesity class II, and 10 (2.2%) from obesity class III. The average BMI did not change significantly between 1994 and 2014. The mean age of all patients was 51.6 years, and patients were predominately male (63.9%). All patients had at least deep partial-thickness burns, and 76.6% sustained full-thickness burns. The mean %TBSA burned was 31.1%. The average ABSI score was 7.8, predicting an overall mortality of less than 30%. There was a significant difference in the ABSI score when compared between the five study groups ($P = .010$). While patients with

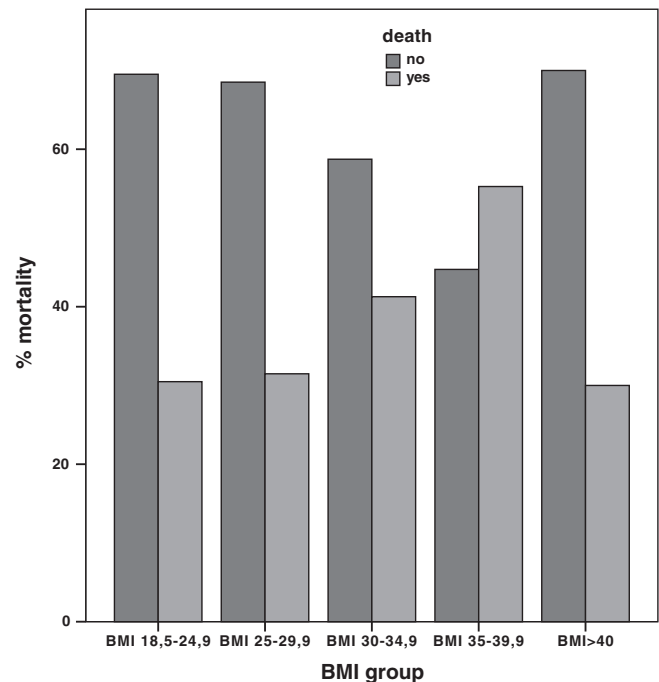


FIGURE 1 Mortality for each BMI group. BMI, body mass index

BMI > 40 displayed the lowest ABSI scores (7.4), patients with BMI 35 to 39.9 had the highest rates (8.9) (Table 1).

Of 460 patients, 158 (34.3%) died during hospitalisation; 30.5% of patients in the normal weight range died. As BMI increased, the mortality rates also increased, reaching the peak in patients with obesity class II (overweight: 31.5%, obesity class I: 41.5%, obesity class II: 55.3%). Notably, patients with obesity III did not follow this trend, displaying a mortality rate of 30%. Thus, the differences between all groups were significant ($P = .031$) (Figure 1).

In univariate logistic regression, BMI (OR 1.039, 95% CI 1.003-1.073, $P = .032$), age (OR 1.036, 95% CI 1.025-1.048, $P = .001$), %TBSA burned (OR 1.065, 95% CI 1.052-1.078, $P = .001$), full-thickness burn (OR 19.798, 95% CI 7.133-54.948, $P = .001$), and inhalation injury

(OR 8.376, 95% CI 5.310-13.214, $P = .001$) were found to be separately associated with mortality (Table 2).

In multivariate analysis, however, the association between BMI and mortality was not confirmed (OR 1.015, 95% CI 0.961-1.073, $P = .587$), whereas all other variables were shown to have a significant impact on mortality (Table 3).

No significant differences in the presence of pneumonia, wound infection, and sepsis were found. Inhalation injury was present in 30.3% ($n = 135$) of all patients, with prevalence ranging from 20.0% in

patients with BMI > 40% to 40.5% in patients with obesity class II. However, differences did not reach statistical significance. Furthermore, no differences were observed in the need for mechanical ventilation and the length of mechanical ventilation. Of all patients, 58% had an indication for intubation and consecutive invasive ventilation. The average invasive ventilation duration was 23 days, with the shortest durations observed among patients with obesity class III (19.2 days) (Table 4).

4 | DISCUSSION

Because of the increasing prevalence of obesity worldwide, overweight patients are becoming into the focus of research. As about 8% of all deaths in Europe can be attributed to excess body weight, improvements in management and treatment of these patients are needed.¹⁷

Obesity is a well-established risk factor for poor outcomes among adult patients. The connection between obesity and chronic diseases such as arterial hypertension or diabetes mellitus is well known. Many studies proved the negative impact of obesity on mortality and morbidity in critically ill patients after surgery, as well as trauma patients.^{18,19}

Our study focuses on the impact of BMI on mortality and morbidity after burn injuries. Several independent risk factors are known to affect the survival of severely burned patients. Among them, the most important are age, gender, %TBSA burned, and depth of burn, as well as inhalation injury.²⁰ The ABSI score combines them to predict the risk of mortality.¹⁴ The impact of BMI on the outcome of severely burned patients is not clear yet.

In our study, we found that higher BMI was associated with higher mortality. Only patients in the highest obesity class, with BMI over 40, did not follow this trend.

TABLE 2 Univariate logistic regression analysis identifying variables that influence burn mortality

	OR	95% CI	P value
Age	1.036	1.025-1.048	<.001
%TBSA	1.065	1.052-1.078	<.001
Inhalation injury	8.376	5.310-13.214	<.001
Full-thickness burn	19.798	7.133-54.948	<.001
BMI	1.039	1.003-1.073	.032

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; TBSA, total body surface area.

TABLE 3 Multivariate logistic regression analysis to predict mortality

	OR	95% CI	P value
Age	1.070	1.049-1.092	<.001
%TBSA	1.077	1.049-1.092	<.001
Inhalation injury	3.621	1.974-6.643	<.001
Full-thickness burn	5.377	1.620-17.847	.006
BMI	1.015	0.961-1.073	.587

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; TBSA, total body surface area.

TABLE 4 Primary and secondary endpoints

	All patients	BMI 18.5-24.9	BMI 25-29.9	BMI 30-34.9	BMI 35-39.9	BMI > 40	P value
Mortality, n (%)	158 (34.2)	57 (30.5)	51 (31.5)	26 (41.3)	21 (55.3)	3 (30)	.031
Length of stay, days (SD)	24.9 (27.4)	25.2 (26.4)	22.9 (23.8)	27.4 (34.6)	29.5 (34.8)	18.7 (13.8)	.555
Wound infection, n (%)	184 (42.5)	71 (39.9)	64 (41.3)	26 (43.3)	18 (54.5)	5 (50.0)	.594
Sepsis, n (%)	133 (30.2)	52 (28.7)	42 (27.3)	22 (36.1)	13 (37.1)	4 (40.0)	.547
Pneumonia, n (%)	137 (31.0)	50 (27.9)	52 (33.5)	23 (37.1)	12 (32.4)	0 (0.0)	.170
Inhalation injury, n (%)	135 (30.3)	51 (28.2)	45 (28.8)	22 (35.5)	15 (40.5)	2 (20.0)	.452
Mechanical ventilation, n (%)	261 (58.0)	102 (55.1)	86 (55.1)	43 (69.4)	24 (64.9)	6 (60.0)	.271
Length of mechanical ventilation, days (SD)	12.7 (24.2)	11.3 (20.8)	11.4 (21.2)	17.1 (32.8)	18.2 (33.8)	12.7 (24.2)	.283

Abbreviation: BMI, body mass index.

Lower mortality rates in this group could possibly be explained with statistical bias because of the small sample size. However, obesity was not a predictor for mortality after controlling for age, %TBSA burned, inhalation injury, and full-thickness burn.

This is in line with previously published studies in which overweight patients did not die significantly more often after burn injuries.⁹ However, in the study conducted by Jeschke et al, only a comparison between patients with BMI < 30 and BMI > 30 was made with around 270 patients. Furthermore, comparisons with this study encounter difficulties as paediatric patients were also included. Another recently published study, which analysed more than 14 600 patients using the Nationwide Inpatient Sample, found a negative relationship between obesity and mortality. Notably, only 3.3% of this study population was obese, which does not authentically reflect the reported nationwide prevalence of 34.9% during the observed period. This might be because of a lack of data and could lead to misclassification bias.¹¹

In contrast, several studies showed a prognostic disadvantage for severely burned obese patients compared with normal-weight patients.^{10,12} Liodaki et al. were able to demonstrate an increased mortality in patients with BMI > 35 in comparison with patients having a BMI < 35. Similarly, this study was again limited by a small sample size of obese patients ($n = 11$).¹² Ghanem et al. reported BMI > 35 as a critical point at which obese patients experience a higher mortality compared with normal-weight patients.¹⁰ In addition, an extensive meta-analysis of more than 2.8 million patients demonstrated that patients with obesity class II or III have an increased all-cause mortality compared with normal patients and mildly obese patients.²¹

Furthermore, previously published studies described obesity to be associated with an increased morbidity. Not only did rates of infection tend to be higher than in normal-weight patients, but length of stay and number of surgical treatments were also increased.^{10,11} However, we could not confirm this association in our study population. In our study, no differences were observed in the prevalence of pneumonia, wound infection, and sepsis. Likewise, length of stay at BICU, incidence of inhalation injury, and length of mechanical ventilation were not significantly different between the groups. In addition, in a study of paediatric burn population, Kraft et al. could not detect significant differences in the incidence of sepsis, multiple organ failure, or mortality.²²

From a pathophysiological view, poor glycaemic control and the pro-inflammatory state that is associated with obesity might act as a driver for increased mortality among obese patients. The excessive release of adipocytokines and adipokines from fat cells favours a

pro-inflammatory milieu resulting in a chronic systemic inflammatory state.²³ Furthermore, insulin resistance is negatively influenced by non-sterified fatty acids. As a result, glucose haemostasis is disturbed, resulting in poor glycaemic control.²⁴ Therefore, early and good glycaemic control is essential in burn patients as it has been shown to be associated with reduced mortality.²⁵

Earlier studies described the high prevalence of pulmonary embolism as a further possible reason for high mortality rates among obese patients. A study, published in 1992, noted a prevalence of 57% of obese patients experiencing pulmonary embolisms.²⁶ However, the incidence of pulmonary embolism is decreasing with the common use of prophylactic anticoagulants. Hence, Liodaki et al. could not find any significant differences in pulmonary embolism rates among obese and non-obese patients.¹² Therefore, pulmonary embolism is a possible explanation for the high mortality rates among obese patients but can be neglected in practice.

Patients with severe obesity are known to be at risk of developing several diseases and frequently have multiple coexisting and related health disorders. Ghanem et al. showed that 80% of severely obese patients had comorbidities.¹⁰ In addition, overweight patients are at higher risk of developing complications following surgery.²⁷ Based on our data, it was not possible to reproduce exactly how many patients had developed serious complications after surgery leading to death. Ghanem et al., however, found severe complications in 92% of obese patients. In that study, 42% of patients developed complications involving more than one organ, leading to multiple organ failure and death.¹⁰

Overweight burn patients are a major challenge for the burn team. General nursing care generally consumes more time than for normal-weight patients, where more staff is needed.¹⁰ Liodaki et al stated that they needed one more person in the morning shift in order to help with the dressing's change, mobilisation, and bathing of obese patients. Moreover, an additional physiotherapist was needed as obese patients required more and longer physiotherapy and breathing therapy.¹² In addition, special equipment is needed in the operation room. The lack of appropriate equipment and inadequate immobilisation could also lead to a poorer outcome of severely obese patients.²⁸

The main limitation of this study is the relatively small number of severely obese patients included. Even after analysing patients' data over a period of 20 years, only 10 patients with BMI over 40 could be included. Therefore, the validity of results for severely obese patients may be restricted.

Another important limitation represents the BMI itself. The BMI is simple, easily calculable, and a good

tool to screen for obesity. Hence, it is the most commonly accepted method for obesity classification. Nevertheless, BMI also has limitations as it does not consider other factors such as fat distribution, genetics, metabolic state, and fitness level. Further scores or tools are needed, including these factors, to estimate the patients' individual metabolomics risk.

One further limitation is the assessment of %TBSA burned in severely obese patients. It is commonly known that the rule of nine is not appropriate to evaluate the burn size in obese patients. For obese patients, different methods to estimate the %TBSA burned are required, for example, the rule of eight.²⁹ Hence, a misclassification bias in severely burned patients cannot be excluded.

Future randomised controlled trials are required to evaluate the influence of obesity in severely burned patients. A special interest should be set on big sample size, especially in obese and severely obese patients. Therefore, multicentric studies should be considered. Until better scoring tools are available, the BMI, as the most commonly used tool to assess obesity, should be used to classify patients. As various studies set the cut-off point for obesity differently, we recommend sticking to the WHO's definition of obesity (BMI > 30), as well as their subdivisions.

5 | CONCLUSION

BMI as an independent risk factor for severely burned patients could not be confirmed in multivariate analysis. Likewise, length of stay and complication rates did not differ between obese and normal-weight patients.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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