AUSTRALASIAN JOURNAL OF Plastic Surgery

Pollock M, Paul E, Lo CH. The obesity paradox in patients with major burn injuries: a single tertiary burn centre review. *Australas J Plast Surg*. 2024;7(2):90090. https://10.34239/ajops.90090

ORIGINAL ARTICLE BURNS

# The obesity paradox in patients with major burn injuries: a single tertiary burn centre review

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Keywords: overweight, body mass index, obesity paradox, burns

Submitted: June 28, 2023 AEST Revised: September 29, 2023 AEST Accepted: November 13, 2023 AEST

DOI: 10.34239/ajops.90090

**Australasian Journal of Plastic Surgery**

**Vol 7, Issue 2, 2024**

## Abstract

**Introduction:** The obesity paradox is a phenomenon described in medical literature where overweight and obese patients have improved survival and better health outcomes. The obesity paradox is of curiosity to many clinicians as the general consensus in medicine has been that a higher body mass index results in poorer health outcomes in both medical and surgical conditions. The aim of this study is to determine whether the obesity paradox exists in our patients with major burn injuries. To our knowledge, this has not been previously investigated in the Australian major burn population.

**Methods:** This is a retrospective study involving patients with major burn injuries >20 per cent total body surface area admitted to the Victorian Adult Burns Service (Melbourne, Australia) from 1 January 2016 to 31 December 2020 (five-year period). Information collected included patient demographics, weight and height, and nature of burn injuries. Primary outcome of interest was inpatient mortality, and secondary outcomes included hospital length of stay, intensive care unit length of stay, duration of ventilation support required and presence of bacteraemia.

**Results:** A total of 1704 patients were admitted, of whom 165 patients met inclusion criteria for analysis. The vast majority of 31 patients (18.8%) who died during admission were palliated. The obesity paradox did not exist in this study population. Furthermore, although not statistically significant, higher levels of body mass index showed increased risk of mortality. There was no significant association between body mass index and hospital length of stay ($p = 0.16$), intensive care unit length of stay ($p = 0.72$), duration of ventilation support ($p = 0.62$) nor bacteraemia ($p = 0.68$).

**Conclusion:** The emerging evidence regarding the obesity paradox in the burn surgery literature is inconsistent. We contend that differences in burn management, including palliation of patients with major burn injuries, contribute to these findings.

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## Introduction

The obesity paradox is a phenomenon described in medical literature where overweight and obese patients have improved survival and better health outcomes.[1] This phenomenon was first described by Fleischmann and colleagues,[1] who found that in patients undergoing haemodialysis, a body mass index (BMI) > 27.5 kg/m$^2$ was associated with improved survival compared to patients with a BMI of 20 kg/m$^2$. Similarly, in a large cohort of 12,534 patients with stages III–IV chronic kidney disease, Babayev and colleagues[2] found that patients with a BMI of 30–34.9 kg/m$^2$ had better survival rates when compared to patients with BMI < 30 kg/m$^2$. Constanzo and colleagues found that the mortality risk was lower in overweight patients (BMI 25–29.9 kg/m$^2$) when compared to those with normal BMI in patients with type 2 diabetes mellitus, and Horwich and colleagues demonstrated similar findings in patients with heart failure.[3,4]

The obesity paradox is of curiosity to many clinicians as the general consensus in medicine has been that a higher BMI results in poorer health outcomes in both medical and surgical conditions, and there is compelling evidence to support this consensus. The research supporting the obesity paradox gives rise to the possibility there may actually be some protective association between having a higher BMI and mortality rates, which is counterintuitive to clinicians.

The aim of this study is to determine whether the obesity paradox exists in patients with major burn injuries. To our knowledge, this has not been previously investigated or published in the Australian major burn population.

## Methods

This is a retrospective study involving all patients with major burn injuries ≥ 20 per cent total body surface area (TBSA) admitted to the Victorian Adult Burns Service (VABS) at the Alfred Hospital (Melbourne, Australia) between 1 January 2016 and 31 December 2020 (five-year period). The VABS provides a statewide adult burns service, admitting approximately 450 patients per year and performing more than 600 operations annually. Only adult patients over 18 years of age were included in this study. This study was approved by the Alfred Hospital Ethics Committee (project number 502/21, approved 29 September 2021).

Patient demographics including age, date of admission, sex, extent (% TBSA) and depth of burn injuries were collected from medical records. In addition, the presence or absence of inhalational injury was noted, defined as respiratory conditions due to smoke inhalation (International Classification of Diseases-9-CM 508.2). This was diagnosed on admission by bronchoscopic findings via flexible nasoendoscopy or bronchoscopy. Patient height (m) and weight (kg) were ascertained, and patients without height or weight documented were excluded from the study. Patient height and weight were usually documented in the first 24 hours of nursing admission as part of the Malnutrition Universal Screening Tool (MUST). The BMI was calculated manually from the height and weight recorded (BMI = weight ÷ height squared). It was categorised according to the World Health Organisation (WHO) classification: underweight (BMI < 18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), obese class I (BMI 30.0–34.9), obese class II (BMI 35–39.9) and obese class III (BMI > 40).[5]

The primary outcome of interest was inpatient mortality. Data regarding secondary outcomes were also collected, including hospital length of stay (LOS), intensive care unit (ICU) LOS, duration of ventilation support required and the presence of bacteraemia. Bacteraemia was defined as at least one positive blood culture, with the causative organism identified.

Statistical analyses were performed using the SAS software version 9.4 (SAS Institute, Cary, North Carolina, USA). Continuous variables were assessed for normality and summarised using mean (standard deviation) or median (interquartile range) according to data type and distribution. Categorical variables were expressed as counts and percentages. The association between BMI categories (normal, pre-obese, classes I, II and III obesity) and inpatient mortality was assessed using logistic regression with results reported as odds ratios (OR) and 95 per cent confidence intervals (95% CI). To account for the confounding effects of age (years) and extent of burn injury (% TBSA), the analyses were further adjusted by these covariates. Duration of ventilation hours, ICU and hospital LOS were compared across BMI categories using Kruskal Wallis test, whereas bacteraemia was compared by Fisher's exact test. All calculated $p$-values were two-tailed and a $p < 0.05$ was chosen to indicate statistical significance.

## Results

A total of 1704 patients were admitted to the VABS during the five-year study period. From that patient cohort, 165 patients met inclusion criteria for further analysis (exclusions included 1530 patients with burn injury < 20 per cent TBSA and nine

patients with inadequate documentation). The mean age was 42.9 years and mean extent of burn injury was 39.2 per cent TBSA (**Table 1**).

**Table 2** provides a summary of primary and secondary outcomes according to BMI category.

From the 31 patients who died during their admission, 15 (48.4%) were palliated within the first 48 hours of admission, presumably due to comorbidities and/or the extent of their burn injury. Five patients (16%) were palliated due to overwhelming sepsis, when ongoing treatment was deemed futile by the treating team. Three patients (9.7%) were palliated due to extensive comorbidities, and six patients (19.4%) were palliated due to multi-organ failure. Two patients (6.5%) were palliated after suffering hypoxic brain injury following presumed cardiac arrest.

On multivariable analysis, age was an independent predictor of mortality, with an OR of 1.14 (95% CI 1.07–1.21, $p < 0.0001$) (**Table 3**). Similarly, for every per cent TBSA burn, the odds of death increased, with an adjusted OR of 1.12 (95% CI 1.07–1.17, $p < 0.0001$). The presence of inhalation injury increased mortality risk, although this difference was not statistically significant (OR 2.45, 95% CI 0.68–8.84, $p = 0.17$). Morbid obesity greatly increased the risk of mortality with an adjusted OR of 5.75 (95% CI 0.73–45.48, $p = 0.098$), and while this was not statistically significant, an increasing trend can be seen in the OR (**Table 3**). There was no significant association between BMI and hospital LOS ($p = 0.16$), ICU LOS ($p = 0.72$), duration of ventilation support ($p = 0.62$) nor bacteraemia ($p = 0.68$).

**Table 1. Summary of patient demographics, BMI and burn injury sustained by patient cohort in study**

| Characteristic | Number (%) | Mean ± SD |
|---|---|---|
| **Total number of patients** | 165 (100) | |
| **Age (years)** | | 42.9 (± 16.8) |
| **Sex** | | |
| Male | 125 (75) | |
| Female | 40 (25) | |
| **Extent of burn injury (% TBSA)** | | 39.2 (± 19.0) |
| **Patients in each burn category** | | |
| 20–39% TBSA | 103 (62.4) | |
| > 40% TBSA | 62 (37.6) | |
| **Patients with inhalation injury** | 47 (28.5) | |
| **Patients in each BMI category** | | |
| Underweight (BMI < 18.5) | 3 (1.8)† | |
| Normal (BMI 18.5–24.9) | 52 (31.5)† | |
| Pre-obese (BMI 25.0–29.9) | 63 (38.2) | |
| Obesity class I (BMI 30.0–34.9) | 28 (17) | |
| Obesity class II (BMI 35.0–39.9) | 13 (7.9)‡ | |
| Obesity class III (BMI ≥ 40) | 6 (3.6)‡ | |

*SD = standard deviation. † Underweight and normal categories were combined for statistical analyses. ‡ Obesity classes II and III were combined for statistical analyses*

## Discussion

An analysis of 519 adult patients admitted to an American Burn Association Verified Burn Center concluded that the obesity paradox exists in burn care.[6] In the burns population, it seems plausible that obese patients can compensate better for the initial catabolism after burn injury.[7] However, the emerging evidence regarding the obesity paradox in the burn surgery literature is inconsistent and contradictory.[8] This phenomenon did not exist in our population of patients with major burn injuries involving ≥ 20 per cent TBSA. Furthermore, although not statistically significant, increasing BMI greatly increased mortality rate (**Table 3**). Our findings are supported by several publications including Liodaki and colleagues, who identified that obese patients with BMI > 35 had a mortality rate five times higher than non-obese

**Table 2. Summary of primary outcome (inpatient mortality) and secondary outcomes by BMI category (total patients = 165)**

| Outcome | Underweight/ normal | Pre-obese | Obesity class I | Obesity classes II and III | All patients |
|---|---|---|---|---|---|
| **Inpatient mortality: n (%)** | 7 (22.6) | 10 (32.2) | 8 (25.8) | 6 (19.4) | 31 (18.8) |
| **Median hospital LOS: days (IQR)** | 34 (16–63) | 25 (12–63) | 22 (13–55) | 19 (6–37) | 27 (14–61) |
| **Median ICU LOS: hours (IQR)** | 146 (10–613) | 71 (11–360) | 37 (2–332) | 89 (4–210) | 94 (10–353) |
| **Median duration of ventilation: hours (IQR)** | 43 (0–326) | 42 (0–200) | 36 (0–137) | 3 (0–133) | 41 (0–184) |
| **Patients with bacteraemia: n (%)** | 12 (46.2) | 8 (30.8) | 4 (15.4) | 2 (7.7) | 26/106 (24.5) |

*IQR = interquartile range*

**Table 3. Logistic regression analyses of inpatient mortality**

| Risk factor | OR | 95% CI | *p*-value |
|---|---|---|---|
| Age | 1.14 | 1.07–1.21 | < 0.0001 |
| Extent of burn injury (% TBSA) | 1.12 | 1.07–1.17 | < 0.0001 |
| Inhalation injury | 2.45 | 0.68–8.84 | 0.170 |
| Underweight/normal BMI | – | – | – |
| Pre-obese BMI | 1.16 | 0.25–5.33 | 0.848 |
| Obesity class I BMI | 1.77 | 0.25–12.33 | 0.546 |
| Obesity classes II and III BMI | 5.75 | 0.73–45.48 | 0.098 |

patients.[9–13] In a meta-analysis involving burn patients, mortality was significantly higher among obese patients with burn injuries.[11] In another retrospective review involving the Japanese population, being overweight (BMI > 25) increased mortality in all age groups, but the findings were not statistically significant.[12] To further add to the debate, a retrospective cohort analysis using the United States National Trauma Data Bank found that overweight (BMI 25–29.9) and obese class I (BMI 30–34.9) patients had the lowest mortality, however BMI extremes (underweight and morbid obesity) were associated with the highest likelihood of death.[14] In another retrospective analysis of 490 patients with severe burns, a significant association between high BMI and decreased in-hospital mortality in the 18–64 age group was identified, but not in the older group ≥ 65 years of age.[8]

The reasons for the inconsistent findings regarding the obesity paradox in burn patients are not entirely clear.[8] We contend that differences in practice regarding palliation of patients with major burn injuries may account for these findings. Palliative care is active care provided for individuals with little or no prospect for cure or survival. The goal of palliative care is optimisation of quality of life. In the major burn setting, palliation may be appropriate early during presentation due to comorbidities and/or severity of burn injury, or later during admission due to deterioration, failure to respond to treatment, and/or development of significant complications. In the current series, almost half (48.4%) of the deceased cohort were palliated within the first 48 hours of admission. This is higher than another prospective multicentre study involving patients with > 20 per cent TBSA burn injuries (15% overall mortality rate), with 0–7 per cent of patients from different BMI categories being palliated.[15] In our burn centre, a departmental protocol regarding palliation was implemented in 2023, however guidelines did not exist during the study period. In an online survey of burn care clinicians in Australia and New Zealand, approximately two-thirds of respondents indicated a high probability of death or a poor predicted quality of life influenced their decision-making.[16] There was no discussion regarding role of BMI in decision-making. It is entirely plausible that patients with significant malnutrition or morbid obesity are more frequent candidates for palliation in some burn centres, due to associated comorbidities or quality of life issues, but not others.[15] In another online survey, decision-making regarding end-of-life care was described as complex, layered, multifactorial and tailored.[17]

Analyses of our data revealed no association between BMI and hospital LOS, ICU LOS, duration of ventilation support nor bacteraemia. This is consistent with several publications.[11,15,18] However, obesity is a low-grade chronic inflammatory disease with multisystemic physiological alterations, including cardiovascular, respiratory, gastrointestinal, haematological and metabolic changes.[19] Adipose tissue is not an inert repository of fat cells, but an active immune modulator populated with macrophages and other immune cells including T, natural killer and mast cells that enhance inflammation within adipose tissue and exert systemic effects by entering the circulation.[19] Obese patients have poor perfusion of adipose tissues, impaired phagocytosis of bacteria from neutrophils, and decreased ability to combat infection.[9,19] They have significantly higher comorbidities, and are often reported to have higher wound infection rates, increased hospital LOS, longer and more intensive medical support and more operations.[9,10,14,20] Obese patients may also present logistical problems including difficulty with fitting into standard beds, patient transportation, positioning for surgery, wound care, physiotherapy and mobilisation.[20]

Most studies measured obesity using the WHO BMI classification.[5,6,12,14] BMI is a standardised tool that is simple, inexpensive and non-invasive.[21] However, BMI does not differentiate between lean body mass and fat.[22] BMI alone does not provide information on the amount, type and location of adiposity.[23] Ideally, to improve accuracy, anthropometric measures could be used to estimate and differentiate the body composition of a patient. An obesity scale including waist circumference along with age, race and gender may better evaluate a patient's metabolic risk.

This retrospective study has limitations. Patients with incomplete data sets (missing height and/or weight) were excluded as BMI could not be calculated (n = 9, 5.2%). However, this was a common theme among other studies. Weight documented may not always reflect dry weight because fluid resuscitation as part of early first aid may have begun at the pre-hospital setting. Major fluid resuscitation may lead to measurements reflecting wet weight and potentially impact patient BMI categorisation.

Our study excluded patients with < 20 per cent TBSA burn injury, reducing our patient population to only patients with severe burn injuries (n = 165), whereas other studies did not.[6] To analyse this smaller patient cohort, underweight patients (n = 3) were grouped with patients with normal BMI (n = 52), and obese class II (n = 13) and obese class III patients (n = 6) were grouped together. We deemed it necessary to exclude patients with < 20 per cent TBSA burn injuries as lesser burn injuries do not have a significant catabolic response nor mortality risk and are not clinically relevant in explaining why an obesity paradox may exist. A larger multicentre study may overcome these limitations, either prospectively or by using a centralised registry such as the Burns Registry of Australia and New Zealand.

The inpatient mortality observed in the current study was 13 per cent in patients with normal BMI and 26 per cent in those with class I obesity. To have an 80 per cent power to demonstrate this difference in mortality at the 5 per cent level of significance, a sample size of 226 will be required. We were able to adjust for confounders including age and extent of burn injury, however other potential confounders such as comorbidities were not adjusted for (for example, cardiovascular disease, diabetes mellitus) due to difficulty quantifying severity of disease and adjusting for this in the data set.

## Conclusion

The obesity paradox did not exist in our population of patients with major burn injuries involving ≥ 20 per cent TBSA. Although not statistically significant, higher levels of BMI showed increased risk of mortality. The evidence regarding the obesity paradox in burn surgery literature is inconsistent and reasons for this are unclear. We contend that differences in burn management, including palliation of patients with major burn injuries, contribute to the varying results in the published literature.

## Patient consent

Patients/guardians have given informed consent to the publication of images and/or data.

## Conflict of interest

The authors have no conflicts of interest to disclose.

## Funding declaration

The authors received no financial support for the research, authorship, and/or publication of this article.

## Ethics approval

This study was approved by the Alfred Hospital Ethics Committee (project number 502/21, approved 29 September 2021).

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