# Nutritional therapy among adult patients with severe burns: A retrospective observational study

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**Running title:** Nutritional therapy of patients with severe burns

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## ABSTRACT

**Background and Objectives:** To examine the effects of nutritional therapy in adult patients with severe burns. **Methods and Study Design:** Sixty adult patients with severe burns were enrolled. Data on nutritional intake through enteral nutrition (EN) or parenteral nutrition (PN) on days 7, 14, 21, and 28 post-injury were collected. Patients were divided into target and non-target groups according to whether their energy or protein intake reached the target. Patient age, length of ventilation, and total bilirubin (TBIL), albumin (ALB), prealbumin (pALB), and C-reactive protein (CRP) concentrations were recorded. **Results:** The percentage of protein targets with protein delivery was lower than that of energy target with energy delivery. The ratio of PN protein to total protein was lower than that of PN energy to total energy on days 7, 14, 21, and 28 ($p<0.001$, $p<0.001$, $p=0.001$, and $p=0.003$, respectively). Compared to the non-target group on day 21, the target group was younger, had lower TBIL on day 7, higher ALB and pALB on day 21, and lower CRP on day 14 ($p=0.025$, $p=0.021$, $p=0.028$, $p=0.029$, and $p=0.049$, respectively). Multivariate logistic regression analysis showed that older age and longer ventilation were independent risk factors in patients who did not meet the nutritional target on day 21 ($p=0.026$ and $p=0.043$, respectively). **Conclusions:** The protein intake of adult patients with severe burns was low. Compared to the non-target group, the target group had better laboratory test results. Older age and longer ventilation were independent risk factors for patients not meeting the nutritional target.


**Key Words: burns, nutrition, energy, protein, risk factors**



## INTRODUCTION

Burns are common yet devastating traumatic injuries worldwide, causing long hospitalization and rehabilitation periods, high disability rates, impaired quality of life, and heavy socioeconomic burdens for patients with burns, their families, and the country. The incidence and mortality rates of burns have steadily declined over the last several decades.[1,2] However, facility rates have been stable. Approximately 10% of outpatients and emergency patients with burns require hospitalization.[3] Most patients have mild to moderate burns, with a small number of patients having a total burn surface area (TBSA) >30%.[4] Multidisciplinary approaches are required for patients with severe burn, including fluid resuscitation, surgical procedures, scab removal, dressing changes, infection control, vital signs maintenance, metabolic support, and nursing. Nutrition therapy is a key component of the whole treatment process.

Persistent hypermetabolism is the most obvious metabolic feature in patients with severe burns, and significant changes in energy and material metabolism occur after burns.[5] In terms of energy metabolism, a brief metabolic inhibition period occurs immediately post-injury, usually lasting for 2–3 d. Subsequently, energy consumption increases significantly, reaching its peak 2–3 weeks post-injury. and the metabolic rate decreases slightly, but remains above normal levels for a long time. In terms of material metabolism, a strong stress response after burns leads to a significant increase in catabolism and relatively insufficient anabolism. During this time, the metabolism of proteins, fats, and carbohydrates undergoes significant changes.[6]

High metabolism after burns is extremely complex, and the current understanding of body and wound metabolism is not sufficiently deep. Determining energy and protein supply has not yet been standardized globally. This study aimed to assess the nutritional intake of adult patients with severe burns, impact of nutritional intake on laboratory test results, and factors influencing nutritional intake.

## MATERIALS AND METHODS

### *Participants and ethics*

Patients admitted to the Wuhan Third Hospital between September 2019 and May 2022 were included in this retrospective observational study. Severe burns refer to burns with a TBSA ≥ 30%, third-degree burn surface area ⩾ 10%, shock, severe inhalation injury, or a combined injury. The inclusion criteria were as follows: (1) TBSA ≥30%; (2) hospital admission within 24 h of injury; (3) an age between 18 and 69 years; (4) thermal burns. The exclusion criteria were as follows: (1) severe kidney, liver, heart, or hematopoietic disease before injury; (2) severe cardiovascular or digestive disease before injury; (3) diabetes mellitus, hyperthyroidism, or other metabolic diseases before injury; (4) pregnancy or lactation; and (5) electrical or chemical burns.

This study only used patients' medical records, had no adverse effects on their clinical outcomes, and did not disclose patients' privacy; hence, it was in accordance with the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of the Wuhan Third Hospital (KY2019-017). Informed consent was obtained from all patients through their legal representatives, and patient anonymity was preserved.

***Data collection***

Patient sex, age, height, weight, BMI, burn type, TBSA, enteral nutrition (EN) initiation time, operations within 28 d post-injury, ventilator use, ICU stay, and mortality were recorded.

Nutrition intake included diet, oral nutritional supplements (ONS), tube feeding and parenteral nutrition (PN), and in this study, EN included diet, ONS, and tube feeding. Nutritional data, including the intake of energy, protein, fat, and carbohydrate; energy and protein adequacy; non-protein calorie nitrogen ratio; and energy and protein intake in EN or PN, were recorded on days 7, 14, 21, and 28 post-injury. Dietary nutrition was calculated according to *Food Composition Tables*. Nutritional data for EN preparations, food for special medical purposes (FSMP), pre-packaged food, and PN preparations were calculated according to their instructions. In this hospital, the nutritional data of adult patients with severe burns were routinely recorded. Once the patients received nutritional therapy, trained nurses recorded the relevant data in the nursing medical records. Trained clinical dietitians then calculated the patients' nutritional intake.

The energy requirement of patients with severe burn was calculated according to the Peng formula as follows: kcal/d = (1094.2477 + 7.3670 × TBSA (%) + 22.3935 × post-burn day (PBD) - 0.0766 × $TBSA^2$ - 1.3496 × $PBD^2$ + 0.4568 × TBSA × PBD) × body surface area (BSA, $m^2$). The protein goal was 1.5 g/kg on day 7 post-injury and 2.0 g/kg on days 14, 21, and 28. Patients whose nutrition reached the energy or protein target were considered the target group, while those whose nutrition reached neither the energy nor protein targets were considered the non-target group.

During the implementation of the study, we recorded laboratory testing indicators on days 7, 14, 21, and 28 post-injury, including total bilirubin (TBIL), albumin (ALB), prealbumin (pALB), and C-reactive protein (CRP), which are conventionally measured in the Department of Clinical Laboratory.

***Statistical analysis***

IBM SPSS Statistics version 26.0 (International Business Machines Corp., Armonk, New York, United States) was used for the statistical analysis. Continuous variables were assessed for normal distribution using the Kolmogorov–Smirnov test. Normally distributed continuous variables were reported as mean ± standard deviation (SD) and analyzed using Student's t-test. Non-normally distributed continuous variables were described as medians (Q1, Q3) and analyzed using the Mann–Whitney U test. Categorical variables are presented as numbers and percentages and were analyzed using the chi-square test. Multivariate logistic regression was used to analyze the risk factors for not meeting the energy or protein targets on day 21 post-injury. All statistical tests were two-tailed. The level of significance was set at $p < 0.05$.

## RESULTS

### *Patient characteristics*

Table 1 shows patient characteristics. This study included 60 patients (45 men and 15 women) with severe burns. The median overall age was 49.5 years (33.3, 56.8), and the median overall TBSA was 75.0% (63.5%, 86.0%). Nutritional data were recorded only when the patients were in the critically ill state; therefore, there were 60, 51, 40, and 32 patients with nutritional data on days 7, 14, 21, and 28 post-injury, respectively. No patients died within 28 d after the injury, and four patients died at the end. On day 21 after severe burns, hypermetabolism peaked and anabolism was gradually enhanced. Therefore, the data of the target and non-target groups on day 21 were analyzed. There were no statistically significant differences in BMI, burn type, TBSA, EN initiation time, operations within 28 d, length of ventilation, ICU stay, or mortality between the target and non-target groups on day 21 post-injury.

### *Total nutrition intake*

Table 2 shows the total nutrition intake on days 7, 14, 21, and 28 post-injury, including EN and PN. Patients had the most amount of energy, fat and carbohydrate intakes on day 21. The percentages of protein target with protein delivery were lower than those of energy target with energy delivery. Non-protein calorie nitrogen ratio was the lowest on day 28, which was 153(106, 210):1.

### *EN and PN intake*

The PN energy was higher than the EN energy on day 7 post-injury ($t = 3.284$, $p = 0.001$). The PN energy was lower than the EN energy on day 21 post-injury ($t = 2.503$, $p = 0.015$). The PN protein was lower than the EN protein on days 7, 14, 21, and 28 post-injury ($z = 3.035$, $p = 0.002$; $z = 4.199$, $p < 0.001$; $z = 5.316$, $p < 0.001$; $z = 3.516$, $p < 0.001$). The ratio of PN protein to total protein was lower than that of PN energy to total energy on days 7, 14, 21, and 28 post-injury ($t = 4.576$, $p < 0.001$; $z = 4.294$, $p < 0.001$; $t = 3.449$, $p = 0.001$; $z = 2.995$, $p = 0.003$) (Table 3).

***Laboratory test results***

Compared to the non-target group on day 21 post-injury, the target group had lower TBIL concentrations on day 7 post-injury, higher ALB and pALB concentrations on day 21, and lower CRP concentrations on day 14 post-injury ($t$=2.339, $p$=0.025; $z$=2.303, $p$=0.021; $t$=2.283, $p$=0.028; $t$=2.269, $p$=0.029; $t$=2.052, p=0.049). (Table 4).

***Risk factors for not meeting energy or protein targets***

Multivariate logistic regression analysis of age, length of ventilation, TBSA, and CRP concentration on day 14 post-injury showed that older age and longer ventilation were risk factors for not meeting energy or protein targets on day 21 post-injury ($p$=0.026 and $p$=0.043, respectively) (Table 5).

## DISCUSSION

In the early stages after severe burns, patients may experience hemodynamic instability and may not tolerate nutrients.[7] The primary task is to maintain a stable internal environment, trophic nutrition should be used,[8] and energy and protein targets should not be pursued blindly. At weeks 1–4 post-injury, the patient's tolerance to nutrients gradually improves; therefore, this study focused on nutritional therapy on days 7, 14, 21, and 28 post-injury. The energy consumption and demand of patients with severe burns has skyrocketed,[9] and effective nutritional therapy is crucial for their treatment.[10] The most accurate method for calculating the energy demand of patients with burns is indirect calorimetry, which measures the patient's resting energy expenditure through oxygen consumption and carbon dioxide production using the metabolic cart. However, the equipment is expensive, it is difficult to measure patients with head and face burns, and this measurement may interfere with the patients. Therefore, this type of equipment is not widely used. Hence, various predictive equations have emerged, including the Curreri, Harris-Benedict, and Toronto formulas.[11,12] The Peng formula has three parameters: TBSA, PBD, and BSA, and has notably higher accuracy and reliability than other formulas.[13] Therefore, in this study, we used the Peng formula to determine the energy requirements of patients with severe burns.

In addition to energy, timely and sufficient protein supply can accelerate burn wound healing, reduce organ damage, enhance immune function, and maintain lean mass.[14] Proteins play crucial roles in the proliferation, migration, and differentiation of epidermal cells, fibroblasts, and immune cells, as well as in angiogenesis and collagen synthesis. According to the European Society of Clinical Nutrition and Metabolism (ESPEN), American Society of

Parenteral and Enteral Nutrition (ASPEN), and Chinese guidelines[15,16] the protein goal on day 7 post-injury was set as 1.5 g/kg and 2.0 g/kg on days 14, 21, and 28.[17] A recent multicenter study demonstrated that only 35.3% of burn injured patients met 80% of goal energy within 48-72 h from admission, and only 35.6% of the recorded patient-days received 1.5-2.0g/kg/d or higher proteins, leaving the majority of patient-days with an inappropriate low protein administration.[18] Similarly, table 2 shows that the proportion of energy provided by proteins was low, and the non-protein calorie nitrogen ratio did not reach 100:1–150:1 in all the different periods post-injury. The main reason for this was that clinical healthcare professionals focused more on wound surgery, dressing changes, medical treatment, and so on and could not pay more attention to nutritional therapy, especially protein supply. The protein content of the protein component formula FSMP was relatively high, reaching up to 88%, making it a good choice for protein supplementation in patients with severe burns. Some patients in this study consumed medical food. Further research is needed to establish the protein requirements of patients with burns.[19]

Patients with severe burns have a high metabolic state for a long time,[20] and some patients have impaired gastrointestinal function, making it difficult to meet their nutritional needs solely through EN.[21] Therefore, supplemental PN is particularly important.[22] The patients should follow the nutritional therapy principle “if the gut works, use it; and if necessary, combine EN and PN”. In this study, protein intake from PN was lower than that from EN, and the ratio of PN protein to total protein was lower than that of PN energy to total energy on days 7, 14, 21, and 28 post-injury. The main reason for this was that when EN was used, the complete nutritional formula was more likely to be selected, which was more reasonable. However, when PN was administered, doctors preferred a personalized formula for multichambered bag preparation. Some physicians are not proficient in nutritional therapy. When prescribed, they may choose amino acid injections of lower concentrations, such as 3%–5%, instead of higher concentrations, such as 8.5%–11.4%. The PN formula could be more rationalized through intelligent systems and training of doctors and multidisciplinary teams,[23] such as consulting doctors from the Department of Clinical Nutrition for Nutritional Therapy Prescriptions.[24]

This study showed that, compared to patients in the non-target group on day 21 post-injury, patients in the target group were younger and had better laboratory test results. Higher TBIL concentrations can affect gastrointestinal function, which may lead to lower nutritional intake. Hypoalbuminaemia has proved to be an indicator of morbidity and mortality risk. The causes of hypoalbuminaemia include protein energy malnutrition, inflammation, crystalloid dilution, external losses, and liver dysfunction.[25] Serum prealbumin is considered to be a sensitive predictor of clinical outcomes and a quality marker for nutrition support.[26] If patients with burns receive sufficient energy, protein, and other nutrient substrates, the liver may synthesize more ALB and pALB and patients may have stronger anti-infection abilities and immunity. Therefore, patients in the target group had higher ALB and pALB concentrations and lower CRP concentrations, which may have helped in wound healing.[27]

Multivariate logistic regression analysis showed that older age and longer ventilator use were independent risk factors in patients who did not meet the nutritional target on day 21 post-injury. As patients grow older, their chewing, taste, smell, and gastrointestinal functions decrease, and their ability to ingest, digest, and absorb food weakens. Therefore, older patients may not meet their nutritional targets. Patients on mechanical ventilation for a long period may have a severely impaired respiratory function and weakened gastrointestinal function; they may have reduced tolerance to carbohydrates, fats, and amino acids from EN and PN.[28] Therefore, they do not contain sufficient energy or proteins.

The limitations of this study were its small sample size, its retrospective nature, and the fact that it was not a prospective randomized controlled trial. Multivariate logistic regression was used to make use of as much of the available data as possible; however, the small number of participants in this study limited the ability to add more factors as variables. Further large-scale and well-designed randomized controlled trials should be conducted before nutritional therapy recommendations can be made for adult patients with severe burns. However, a strength of this study is that “real life” data was reported, observing actual nutrition practices among adult patients with severe burns.



### *Conclusions*

The protein intake of adult patients with severe burns was low. Compared to the non-target group, the target group had better laboratory test results. Older age and longer ventilation were independent risk factors for patients not meeting the nutritional target.

## CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflicts of interest.

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**Table 1.** Patient characteristics

| | Total (n=60) | Target group on day 21 (n=19) | Non-target group on day 21 (n=21) | Statistical value | *p* value |
|---|---|---|---|---|---|
| Age (y) | 49.5 (33.3, 56.8) | 43.0 (32.0,52.0) | 51.0(43.5,61.0) | *z =2.237* | 0.025 |
| Sex [n(%)] | | | | $x^2$=0.301 | 0.583 |
| Men | 45 (75.0%) | 13 (68.4%) | 17(81.0%) | | |
| Women | 15 (25.0%) | 6 (31.6% | 4(19.0%) | | |
| Height (cm) | 167.0±6.6 | 164.8±7.0 | 168.4±6.1 | *t* = 1.719 | 0.094 |
| Weight (cm) | 65.0 (60.0, 75.0) | 64.0 (58.0,70.0) | 68.0(62.5,80.0) | *z =1.605* | 0.108 |
| BMI (kg/m$^2$) | 24.2±3.4 | 23.7±2.1 | 24.9±4.2 | *t* = 1.134 | 0.266 |
| <18.5 [n(%)] | 2 (3.33%) | 0 (0.0%) | 0 (0.0%) | | 0.343 |
| 18.5– <25.0 [n(%)] | 37 (61.67%) | 14 (73.7%) | 13 (61.9) | | |
| 25.0– <30.0 [n(%)] | 17 (28.33%) | 5 (26.3%) | 5 (23.8%) | | |
| ≥30.0 [n(%)] | 4 (6.67%) | 0 (0.0%) | 3 (14.3%) | | |
| Type of burn [n(%)] | | | | | 0.607 |
| Scald | 4 (6.67%) | 2 (10.5%) | 1 (4.8%) | | |
| Fire | 54 (90.00%) | 17 (89.5%) | 18 (85.7%) | | |
| Other | 2 (3.33%) | 0 (0.0%) | 2 (9.5%) | | |
| TBSA (%) | 75.0 (63.5, 86.0) | 80.0 (75.0,88.0) | 80.0 (70.0,90.0) | *z =0.244* | 0.807 |
| TBSA shallow II (%) | 3.0 (0.0, 8.5) | 0.6 (0.0, 5.6) | 1.5 (0.0,5.0) | *z =0.049* | 0.961 |
| TBSA deep II (%) | 36.0 (23.8,43.9) | 30.8 (18.8,45.3) | 32.0 (17.3,46.6) | *z =0.063* | 0.950 |
| TBSA III (%) | 28.5 (17.4,46.2) | 43.0 (31.9,56.9) | 30.0 (26.0,62.8) | *z =0.665* | 0.506 |
| Time to initiate EN from injury (hours) | 17.0 (8.0, 28.4) | 14.0 (8.0,22.5) | 19.5 (8.0,30.0) | *z =0.989* | 0.323 |
| Operations within 28 d post-injury | | | | | |
| Number of people who had an operation [n(%)] | 58 (96.67%) | 19 (100.0%) | 21 (100.0%) | | |
| Number of operations | 1.0 (1.0, .02) | 2.0 (1.0,3.0) | 1.0 (1.0,3.5) | *z =0.416* | 0.677 |
| Length of ventilation (hours) | 132 (17, 214) | 132 (103, 204) | 192 (137, 612) | *z = 1.803* | 0.071 |
| ICU stay (days) | 19.5 (9.3, 42.3) | 38.0 (20.0,64.0) | 36.0 (15.5,48.5) | *z =1.057* | 0.291 |
| Mortality [n(%)] | | | | | |
| ICU | 4 (6.67%) | 0 (0.0%) | 4 (19.0%) | | 0.108 |
| 28 d | 0 (0.00%) | 0 (0.0%) | 0 (0.0%) | | |

BMI, body mass index; TBSA, total burn surface area; EN, enteral nutrition; ICU, intensive care unit.
Values as mean ± SD, median (Q1, Q3) or n (%).

**Table 2.** Total nutrition intake in different periods post-injury

| Days post-injury | 7 | 14 | 21 | 28 |
|---|---|---|---|---|
| Energy (kcal) | 2302±627 | 2501±903 | 2881±852 | 2680±843 |
| % of energy target (%) | 85.7±24.8 | 82.7±31.4 | 90.2±26.1 | 89.8 (60.6, 102.2) |
| Protein (g) | 69 (44, 89) | 84±48 | 99±46 | 100±49 |
| Protein (g/kg) | 1.1 (0.7, 1.4) | 1.3±0.8 | 1.5±0.7 | 1.5±0.8 |
| % of protein target (%) | 70.0 (47.0, 92.9) | 64.5±39.9 | 75.5±36.6 | 75.5±38.9 |
| Fat (g) | 80±31 | 82±39 | 95±46 | 84±42 |
| Carbohydrate (g) | 351±94 | 387±123 | 436±107 | 412±117 |
| % of total energy as protein (%) | 12.5±5.7 | 13.0±5.7 | 13.5±4.8 | 14.6±6.3 |
| % of total energy as fat (%) | 31.6 (28.3, 34.7) | 29.8 (25.8, 33.9) | 28.4±9.1 | 28.8 (22.5, 33.4) |
| % of total energy as carbohydrate (%) | 57.1±10.0 | 57.5 (51.8, 61.0) | 55.8 (51.3, 61.9) | 55.6 (52.7, 60.2) |
| Non-protein calorie nitrogen ratio | 193 (140, 262):1 | 173 (125, 247):1 | 168 (118, 232):1 | 153 (106, 210):1 |

Values as mean ± SD or median (Q1, Q3)..

**Table 3.** Enteral and parenteral nutrition intake in different periods post-injury

| Days post-injury | 7 | 14 | 21 | 28 |
|---|---|---|---|---|
| EN energy (kcal) | 1010±560 | 1266±796 | 1627±877 | 1674 (631, 2089) |
| EN protein (g) | 41 (19, 58) | 59±40 | 73±42 | 72±47 |
| PN energy (kcal) | 1292±360[a] | 1235±401[b] | 1242±420[c] | 1284 (1061, 1387)[d] |
| PN protein (g) | 25 (16, 29)[e] | 16 (13, 29)[f] | 16(13, 50)[g] | 16 (16, 53)[h] |
| Ratio of PN energy to total energy (%) | 58.6±18.2 | 47.3 (40.2, 69.7) | 46.4±19.0 | 44.7 (38.3, 64.5) |
| Ratio of PN protein to total protein (%) | 40.4±24.8[i] | 27.6 (16.2, 44.6)[j] | 30.8±21.3[k] | 21.3 (14.5, 62.5)[l] |

Values as mean ± SD or median (Q1, Q3). EN, enteral nutrition; PN, parenteral nutrition. Compared to EN energy on the same day post-injury, at = 3.284, p = 0.001; bt = 0.243, p = 0.809; ct = 2.503, p = 0.015; dz = 1.410, p = 0.159. Compared to EN protein on the same day post-injury, ez = 3.035, p = 0.002; fz = 4.199, p < 0.001; gz = 5.316, p < 0.001; hz = 3.516, p < 0.001. Compared to the ratio of PN energy to total energy on the same day post-injury, it = 4.576, p < 0.001; jz = 4.294, p < 0.001; kt = 3.449, p = 0.001; lz = 2.995, p = 0.003.

**Table 4.** Comparison of laboratory test results between the target and non-target groups on day 21 post-injury

| | Target group (n=19) | Non-target group (n=21) | Statistical value | *p* value |
|---|---|---|---|---|
| TBIL on day 7 (μmol/L) | 13.9 (12.7, 20.3) | 22.3 (14.8, 38.5) | *z = 2.303* | 0.021 |
| ALB on day 21 (g/L) | 35.9±3.9 | 32.0±6.3 | *t* = 2.283 | 0.028 |
| pALB on day 21 (mg/L) | 149.1±49.6 | 110.4±57.2 | *t* = 2.269 | 0.029 |
| CRP on day 14 (mg/L) | 108.4±46.2 | 143.2±48.1 | *t* = 2.052 | 0.049 |

BMI: body mass index; TBSA: total burn surface area; TBIL: total bilirubin; ALB: albumin; pALB: prealbumin; CRP: C-reactive protein
Values as mean ± SD or median (Q1, Q3).

**Table 5.** Multivariate logistic regression of risk factors for not meeting energy or protein targets on day 21 post-injury

| | B | Wald | OR | 95% CI | *p* value |
|---|---|---|---|---|---|
| Age (y) | 0.142 | 4.985 | 1.153 | 1.018–1.306 | 0.026 |
| Length of ventilation (h) | 0.007 | 4.090 | 1.007 | 1.000–1.014 | 0.043 |
| TBSA (%) | -0.105 | 3.681 | 0.900 | 0.808–1.002 | 0.055 |
| CRP on day 14 (mg/L) | 0.022 | 2.760 | 1.022 | 0.996–1.049 | 0.097 |

TBSA, total burn surface area; CRP, C-reactive protein; B, regression coefficient; OR, odds ratio; CI, confidence interval.