Determination of calorie and protein intake among acute and sub-acute traumatic brain injury patients

Mohd Ibrahim Abdullah a, Aryati Ahmad a,*, Sharifah Wajihah Wafa Syed Saadun Tarek Wafa a, Ahmad Zubaidi Abdul Latif b, Noor Aini Mohd Yusoff a, Muhammad Khalis Jasmiad a, Nujaimin Udinc, Kartini Abdul Karimd

a Faculty of Health Science, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Kuala Terengganu, Terengganu, Malaysia
b Faculty of Medicine, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Kuala Terengganu, Terengganu, Malaysia
c Neurosurgery Department, Hospital Sultanah Nur Zahirah, Ministry of Health Malaysia, Jalan Sultan Mahmud, 20400 Kuala Terengganu, Terengganu, Malaysia
d Dietetic and Food Service Department, Hospital Sultanah Nur Zahirah, Ministry of Health Malaysia, Jalan Sultan Mahmud, 20400 Kuala Terengganu, Terengganu, Malaysia

Article info

Article history:
Received 23 October 2019
Accepted 9 May 2020
Available online 24 April 2020

Keywords:
Malnutrition
Calorie intake
Protein intake
Traumatic brain injury

Abstract

Purpose: Malnutrition is a common problem among hospitalized patients, especially among traumatic brain injury (TBI) patients. It is developed from hypermetabolism and the condition may worsen under the circumstance of underfeeding or incompatible dietary management. However, the data of nutrient intake especially calorie and protein among TBI patients were scarce. Hence, this study aimed to determine the calorie and protein intake among acute and sub-acute TBI patients receiving medical nutrition therapy in hospital Sultanah Nur Zahirah, Terengganu.

Methods: This observational study involved 50 patients recruited from the neurosurgical ward. Method of 24 h dietary recall was utilized and combined with self-administered food diaries for 2–8 days. Food consumptions including calorie intake and protein intake were analyzed using Nutritionist PRO™ (Woodinville, USA) and manual calculation based on the Malaysian food composition database (2015).

Results: Patients consisted of 56% males and 44% females with the median age of 28.0 (IQR = 22.8–36.5) years, of which 92% were diagnosed as mild TBI and the remaining (8%) as moderate TBI. The Glasgow coma scale (GCS) was adopted to classify TBI severity with the score 13–15 being mild and 9–12 being moderate. The median length of hospital stay was 2 (IQR = 2.0–3.3) days. Calorie and protein intake improved significantly from day 1 to discharge day. However, the intake during discharge day was still considered as suboptimal, i.e. 75% of calorie requirement, whilst the median protein intake was only 61.3% relative to protein requirement. Moreover, the average percentages of calorie and protein intakes throughout hospitalization were remarkably lower, i.e. 52.2% and 41.0%, respectively.

Conclusion: Although the calorie and protein intakes had increased from baseline, hospitalized TBI patients were still at a risk to develop malnutrition as the average intakes were considerably low as compared to their requirements. Optimum nutrient intakes especially calorie and protein are crucial to ensure optimum recovery process as well as to minimize risks of infection and complications.

© 2020 Chinese Medical Association. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

Traumatic brain injury (TBI) can be defined as an intracranial injury due to an external force exerted on the brain. Acute and sub-acute TBI refer to the duration of post-injury ≤ 7 days, and 8 days–3 months, respectively. TBI patients who go to the emergency department usually need to be hospitalized at least a night for monitoring, in which an increase in severity or disability can prolong the length of stay (LOS). Malnutrition is expected as a common sequel among hospitalized patients. Previously, the prevalence of malnutrition in hospitalized patients was reported to range from 20% to 50%, but the prevalence of malnutrition among hospitalized TBI patients is still unknown. TBI patient is likely to develop malnutrition due to excessive protein break down and high calorie demand resulting in negative nitrogen balance, in addition to increased requirements of protein and calorie.

* Corresponding author.
E-mail address: aryatiahmad@unisza.edu.my (A. Ahmad).
Peer review under responsibility of Chinese Medical Association.
TBI results in primary and secondary injuries which may lead to temporary or permanent neurological deficits. Generally, the injury causes abnormality of cellular metabolism, hormonal changes, and systemic inflammation response. Calorie expenditure among TBI patients usually increase by 87%–200% above the usual requirement and may be elevated for 30 days due to metabolic changes. Hormonal changes increase the production of corticosteroids, counter-regulation hormones, and cytokines which may cause the patient to develop hypermetabolism state. Furthermore, a lot of physiological challenges may alter their calorie needs. The alteration of systematic catabolism of the body will lead to hyperglycemia, protein wasting and increased calorie demands.

The injuries could be avoided or minimized through early interventions including medical nutrition therapy (MNT) to restore optimal nutritional status, by providing sufficient nutrients for the recovery process and reducing the catabolic response and prolonged hypermetabolism. A previous study found that critically-ill patient who was on enteral feeding consumed approximately 50%–60% calorie and 56%–60% protein compared to their requirement. A recent study by Steward et al. among critically-ill patients in the United State revealed that approximately 20% of calorie and 17% of protein were consumed relatively to their requirements, respectively. Additionally, calorie and protein deficit among moderate to severe TBI (Glasgow coma scale (GCS) score 9–12 and 3–8, respectively) patients were accumulated at 18,242 kcal (1 kcal = 4.186 kJ) and 1315 g protein, respectively. However, the intake among mild to moderate acute TBI in the surgical ward was not established yet. Hence, this study aimed to determine the intake of calorie and protein as baseline data, so that early and appropriate MNT could be planned and prescribed according to the patients’ actual requirement.

Methods

The research was an observational cross-sectional study. Fifty respondents aged from 20 to 60 years, diagnosed with mild or moderate TBI were recruited from surgical ward in hospital Sultanah Nur Zahirah, Kuala Terengganu. Patients who were on parenteral nutrition, suffered multiple injuries or had a history of neurological or psychiatric problems were excluded.

After obtaining the written informed consent, a brief introduction of the study was given. Demography data including age, level of education (LOE) and occupation were interviewed and counter-checked with hospital information system for clarification. Anthropometry assessments such as body weight and height were measured. For immobilized or bedridden patients, body weight and height were estimated by predictive calculation using a proxy of knee height and mid-arm muscle circumference. Using body-weight, height and age, with appropriate injury and activity factor, calorie requirement was determined based on the researches of Benedict et al., and Mifflin et al., whereby protein requirement was calculated using a weight-based formula. Dietary intakes of patients were obtained from the 24 h dietary recall combined with a self-administered food diary to facilitate memorizing and counter-checking. The dietary intakes were recorded daily from day 1 until the discharge. Calorie and protein intake were analyzed from food analysis using Nutritionist PRO™ (Woodinville, USA) and manual calculation based on the Malaysian food composition database (2015).

Statistical analysis was conducted using SPSS software version 25 (IBM Corporation, USA). Descriptive analysis was done after checking the normality of data distribution. As the sample size was only 50 patients and the data were not normally distributed, results are presented in median and interquartile (IQR) and appropriate tests were done using non-parametric tests. The Wilcoxon signed-rank test was used to compare calorie and protein intake between day 1 and discharge day (the discharge day regardless of LOS). Comparison between gender, types of TBI, LOE, body mass index (BMI) category were done using Mann-Whitney or Kruskal Wallis test. The ethical clearance was granted by the Malaysian Research and Ethics Committee, Ministry of Health Malaysia [NMMR-16-1925-32387].

Results

Of 50 patients, 56% were male and 44% were female with a median age of 28.0 (IQR = 22.8–36.5) years. All were literate with the majority of them (80%) attained secondary education and 92% are working. The median height and body weights were 164.5 (IQR = 158.0–169.0) cm and 63.0 (IQR = 55.0–70.0) kg, respectively. The majority of respondents (56%) had a normal BMI (median BMI 23.2, IQR = 21.3–26.3). Forty-six respondents (92%) were suffering from mild TBI, whilst only four (8%) had moderate TBI, 88% of which had GCS of 15. The majority of them (92%) had TBI due to motor vehicle accidents whilst the remaining were due to violence and fall and were warded for 2 days (IQR = 2.0–3.3). Median calorie and protein requirements were 2232 kcal/day (IQR = 1977–2403) and 1213 g/day (IQR = 102.2–130.0), respectively. Baseline data are summarized in Table 1.

Comparison between the requirement, the intake of calorie and protein reached as low as 23.1% (approximately 516 kcal) and 14.8% (approximately 18.0 g) respectively on day 1. The rate increased to 75.0% (approximately 1674 kcal) and 61.3% (74.4 g) on the discharge day regardless of LOS. The average percentage of calorie and protein intakes throughout LOS was 55.2% and 41.3%. Median percentage of calorie and protein intake from day 1 to the discharge day is shown in Table 2.

Analysis of macronutrients showed that calorie consumed by respondents from carbohydrate was (55.5%), protein (17.3%) and fat (27.2%). Additionally, several factors were analyzed to explain any effect on calorie and protein intake (discharge day and the average) (Table 3). The percentage of calorie and protein intake were significantly associated with the type of TBI or severity, while gender only affected calorie intake of the discharge day.

Discussion

It was estimated that the prevalence of malnutrition was 50% and 43% among patients in the general ward and intensive care unit (ICU), respectively. Globally, it constitutes approximately 22%–43% of hospitalized patients. Upon admission, 15%–70% of patients were already suffering from malnutrition before hospitalization. Although the data of malnutrition among hospitalized TBI patients are sparse, it is expected that this group of patients has a tendency to develop malnutrition as they usually require high calorie and protein to cater hypermetabolism and hypercatabolism states. The calorie and protein intake are generally not meeting the required amount due to various limiting factors. However, the actual calorie and protein intake data were scarce. Study of moderate to severe TBI patients found that the calorie and protein intake in the ward were 1980 kcal/day (standard deviation (SD) = 915) and 89 g/day (SD = 41), respectively, and it was lower in ICU which were only 1798 kcal/day (SD = 800) and 79 g/day (SD = 47), respectively.

It may be difficult for TBI patients to achieve more than 80% of calorie intake due to pain and discomfort, and other co-injuries such as dental fractures, facial fractures, oral injuries and the need for prolonged cervical immobilization with a hard-cervical collar may delay initiation of an oral diet. Additionally, they
Data are presented as median (IQR) unless stated otherwise.

**Table 1**

| Variables | Value |
|-----------|-------|
| Age (year) | 28.0 (22.8–36.5) |
| Height (cm) | 164.5 (158.0–169.0) |
| Weight (kg) | 63.0 (55.0–70.0) |
| BMI | 23.2 (21.3–26.3) |
| Calorie requirement (kcal/day) | 2322 (1977.4–2403.1) |
| Protein requirement (g/day) | 121.3 (108.2–130.0) |
| LOS (day) | 2.0 (2.0–3.3) |
| Age group (year) | Early adult (20–40) 40 (80) Middle adult (41–60) 10 (20) |
| Gender | Male 28 (56) Female 22 (44) |
| LOE | Secondary 40 (80) Tertiary 10 (20) |
| Occupation | Odd job 12 (24) Student 11 (22) Housewife 11 (22) Government servant 7 (14) Labor 5 (10) Jobless 4 (8) |
| BMI class | Underweight 3 (6) Normal weight 28 (56) Overweight 16 (32) Obese 3 (6) |
| TBI severity | mTBI 46 (92) moTBI 4 (8) |
| GCS score | 9 1 (2) 10 1 (2) 11 1 (2) 12 1 (2) 13 1 (2) 14 1 (2) 15 44 (88) |
| Etiology | MVA 46 (92) Violence 2 (4) Fall 2 (4) |
| Main area of brain injury | Frontal 42 (84) Parietal 2 (4) Temporal 2 (4) Occipital 3 (6) Others 1 (2) |

BMI: body mass index, LOS: length of stay, LOE: level of education, BMI: body mass index, TBI: traumatic brain injury, mTBI: mild traumatic brain injury, moTBI: moderate traumatic brain injury, GCS: Glasgow coma scale, MVA: motor vehicle accident.

Data are presented as n (%) or median (IQR).

may experience eating behavior changes including loss of appetite secondary to psychological impairment, especially post-traumatic depression.31 Furthermore, TBI patients who can consume orally are at risk of malnutrition primarily due to interruption of feeding such as fasting for surgery or procedure and patient-related reasons.21 Inhibition of food intake also occurs due to physical aggression.22

This study aimed to determine the calorie and protein intake among TBI patients for an early and effective intervention which was tailored to their needs. Findings revealed that there was a remarkable increase of the calorie and protein intake from day 1 and day 2, which may be due to that the patients were allowed to resume meals after certain medical procedures or investigations. This was in line with the latest consensus recommendation that initiation of food or feeding should be within 24–48 h or within 72 h.33,34 Later, the calorie and protein intake became fluctuated due to limiting factors aforementioned and it took time to increase the intake again. Calorie intake achieved a minimum of 80% during day 5 as recommended,13,35,36 whereas protein intake though not clearly stated in the major recommendation, achieved 80% at day 6. Pillsbury et al.15 suggested that protein intake should achieve 1.0–1.5 g/kg body weight/day within the first two weeks of injury. The value was quite low if compared to other recommendations for protein and the duration was too long. Calorie and protein intake data was not valid as only one patient had LOS up to 8 days.

In this study, there was a significant difference in intake between day 1 and discharge day although the intake during discharge day was still below than requirement for both calorie and protein. This suboptimal intake of calories and protein may predispose them to develop malnutrition if no intervention or appropriate MNT is provided. The average intakes within a certain period of time are more precise compared to the individual daily intake.37,38

Table 2

| Day       | Calorie intake (%) | Protein intake (%) |
|-----------|--------------------|--------------------|
| 1 (n=50)  | 23.1 (0.0–53.8)   | 14.8 (0.0–40.6)    |
| 2 (n=50)  | 70.1 (45.7–81.5)  | 57.6 (36.8–67.8)   |
| 3 (n=21)  | 65.2 (44.4–75.3)  | 56.3 (33.8–62.0)   |
| 4 (n=11)  | 61.0 (41.3–72.4)  | 48.7 (28.2–59.4)   |
| 5 (n=4)   | 84.1 (49.3–107.4) | 62.1 (35.7–69.2)   |
| 6 (n=3)   | 97.1 (46.0–1)    | 80.7 (32.9–)       |
| 7 (n=1)   | 63.2 (63.2–63.2)  | 45.3 (45.3–45.3)   |
| 8 (n=1)   | 63.2 (63.2–63.2)  | 59.0 (59.0–59.0)   |
| Discharge daya | 75.0 (64.1–84.5) | 61.3 (53.6–70.4)   |

Average 55.2 (37.2–65.9) 41.3 (28.2–52.2) p value 0.000b 0.000b

| Factors   | Calorie intake | Protein intake |
|-----------|----------------|----------------|
|          | Discharge day  | Average        | Discharge day | Average |
| Age groupa | 0.356 | 1.000 | 0.039 | 0.807 |
| Genderb   | 0.006b | 0.159 | 0.118 | 0.253 |
| LOE       | 0.395 | 0.558 | 0.198 | 0.526 |
| BMI classb | 0.214 | 0.588 | 0.480 | 0.866 |
| TBI severityb | 0.142 | 0.017 | 0.070 | 0.013c |
| Etiologyc | 0.550 | 0.414 | 0.468 | 0.451 |
| Main area of brain injuryd | 0.172 | 0.727 | 0.212 | 0.630 |

LOE: level of education, BMI: body mass index, TBI: traumatic brain injury.

a Result of p value using Mann-Whitney test.
b Result of p value using Kruskal-Wallis test.
c Significant result (p < 0.05).

DISCUSSION

In this study, there was a significant difference in intake between day 1 and discharge day although the intake during discharge day was still below than requirement for both calorie and protein. This suboptimal intake of calories and protein may predispose them to develop malnutrition if no intervention or appropriate MNT is provided. The average intakes within a certain period of time are more precise compared to the individual daily intake because malnutrition does not occur within a day.37,38

Nonetheless, the patients consumed food with appropriate macronutrient distribution as they consumed mostly hospital food and do not dispose them to develop malnutrition if no intervention or appropriate MNT is provided. The average intakes within a certain period of time are more precise compared to the individual daily intake.37,38

In this study, there was a significant difference in intake between day 1 and discharge day although the intake during discharge day was still below than requirement for both calorie and protein. This suboptimal intake of calories and protein may predispose them to develop malnutrition if no intervention or appropriate MNT is provided. The average intakes within a certain period of time are more precise compared to the individual daily intake because malnutrition does not occur within a day.37,38

Nonetheless, the patients consumed food with appropriate macronutrient distribution as they consumed mostly hospital food which contains adequate nutrients.

This study also found that there was no effect of age, LOE, BMI class, etiology of TBI and main area of brain injury on calorie and protein intake. Thus, although LOE and BMI class generally have an influential effect on dietary intake, other factors such as procedural, physiological and pathological conditions in TBI may reduce food intake.39–41 Prior to this study, no published literature has revealed the effect of age, etiology of TBI and the main area of brain injury on...
dietary intake. This study, however, revealed that TBI patients had lower calorie and protein intakes compared to its requirement regardless of age group, etiology of TBI and the main area of brain injury.

We found some effects of gender on calorie and protein intakes in which male patients showed significantly higher intake compared to females but only on the discharge day. This finding was in line with a previous study of Elmadfa et al.43 which reported compared to females but only on the discharge day. This lower calorie and protein. The average calorie and protein intakes, i.e. moderate TBI consumed functional and nutritional status of both genders which resulted in that there were no significant differences in the calorie and protein intakes between males and females as head trauma affected the functional and nutritional status of both genders which resulted in a decrease of both intakes.

Besides we also discovered that TBI severity has an effect on average calorie and protein intakes, i.e. moderate TBI consumed lower calorie and protein. The finding was consistent with the previous study that showed calorie and protein intake were negatively affected by the severity of trauma27 as dysphagia and some cognitive issues that related dysphagia managements were more common on severer TBI15,46

TBI patients who consumed inadequate calorie and protein require appropriate MNT to prevent malnutrition during hospitalization or after hospital discharge. The patient should be recommended or prescribed with additional calorie and protein sources either by oral or enteral feeding through the provision of suitable oral nutrition supplementation. A study has shown that patients with TBI have the potential benefit from enteral nutrition.49 Previous research also discovered that collaborative efforts could improve patients’outcomes and reduce costs, whilst many professional and regulatory bodies may encourage interdisciplinary approach.50–52

Although the intakes of calorie and protein improved by days, TBI hospitalized patients were at a risk to develop malnutrition due to inadequate calorie and protein intakes related to various limiting factors. Overall, calorie and protein intake achieved less than 50% of their requirements. Further follow-up studies are warranted to observe the progression and pattern of nutritional status among TBI patients.

Funding
Nil.

Ethical Statement
The ethical clearance was granted by the Malaysian Research and Ethics Committee, Ministry of Health Malaysia [NMRR-16-1925-32387].

Acknowledgment
All authors made significant contributions to the study design, recruitment of patients, data collection, data analysis, preparing and revising of the manuscript for submission. This research was funded by the Fundamental Research Grant Scheme (FRGS) [FRGS/1/2016/STK02/UNISZA/02/1 Ministry of Education, Malaysia.

Declaration of Competing Interest
The authors declare that they have no conflicts of interest.

References
1. Edlow BL, Copen WA, Izzy S, et al. Diffusion tensor imaging in acute-to-subacute traumatic brain injury: a longitudinal analysis. BMC Neurol. 2016;16:2. https://doi.org/10.1186/s12883-015-0525-8.
2. Mayer AR, Quinn DK, Master CL. The spectrum of mild traumatic brain injury: a review. Neurology. 2017;89:623–632. https://doi.org/10.1212/WNL.0000000000004214.
3. Kang MC, Kim JH, Ryu SW, et al. Prevalence of malnutrition in hospitalized patients: a multicenter cross-sectional study. J Kor Med Sci. 2018;33:e10. https://doi.org/10.3346/jkms.2018.33.e10.
4. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. Int J Environ Res Publ Health. 2011;8:514–527. https://doi.org/10.3390/ijerph8020154.
5. Gout BS, Barker LA, Crowe TC. Malnutrition identification, diagnosis and di- etetic referrals: are we doing a good enough job? Nutr Diet. 2009;66:206–211. https://doi.org/10.11171/1174-0800.2009.01372.x.
6. Foley N, Marshall S, Pikul J, et al. Hypermetabolism following moderate to severe traumatic acute brain injury: a systematic review. J Neuroltrauma. 2008;25:1415–1431. https://doi.org/10.1089/neu.2008.0028.
7. Dickerson RN, Pitts SL, Maish GO, et al. A reappraisal of nitrogen requirements for patients with critical illness and trauma. J Trauma Acute Care Surg. 2012;73:549–557. https://doi.org/10.1097/TA.0b013e3182525d8b.
8. Galgano M, Tohleez G, Qiu X, et al. Traumatic brain injury: current treatment strategies and future endeavors. Cell Transplant. 2017;26:1118–1130. https://doi.org/10.1177/0963689717714102.
9. Costello L-AS, Lighthard GE, Gruen RL, et al. Nutrition therapy in the optimization of health outcomes in adult patients with moderate to severe traumatic brain injury: findings from a scoping review. Injury. 2014;45:1834–1841. https://doi.org/10.1016/j.injury.2014.06.004.
10. Dzubay-Pauly F, Stahl F, Xu W, et al. Cerebral energy metabolism during transient hyperglycemia in patients with severe brain trauma. Intensive Care Med. 2003;29:544–550. https://doi.org/10.1007/s00134-003-1690-3.
11. Lenz A, Franklin GA, Cheadle WG. Systemic inflammation after trauma. Injury. 2007;38:1336–1345. https://doi.org/10.1016/j.injury.2007.00.003.
12. Mashal D. The Change in Nutritional Status in Traumatic Brain Injury Patients: A Retrospective Descriptive a Retrospective Descriptive Study. 2016.
13. Cook AM, Peppard B, Magnuson B. Nutrition considerations in traumatic brain injury. Nutr Clin Pract. 2008;23:608–620. https://doi.org/10.1007/s00134-008-0160-0.
14. Bailey N. Caloric Intake Following Traumatic Brain Injury: The Influence of Food Consistency. 2007.
15. Krakau K, Hansson A, Karlson T, et al. Nutritional treatment of patients with severe traumatic brain injury during the first six months after injury. Nutrition. 2007;23:308–317. https://doi.org/10.1016/j.nut.2007.01.010.
16. Cahill NE, Dhaliwal R, Day AG, et al. Nutrition therapy in the critical care setting: what is "best achievable" practice? An international multicenter observational study. Crit Care Med. 2010;38:395–401. https://doi.org/10.1097/CCM.0b013e31818c2b3d.
17. Alberda C, Gramlich L, Jones N, et al. The relationship between nutritional intake and clinical outcomes in critically ill patients: results of an international multicenter observational study. Intensive Care Med. 2009;35:1728–1737. https://doi.org/10.1007/s00134-009-1567-4.
18. van den Broek PWJH, Rasmussen-Conrad EL, Naber AHJ, et al. What you think is for patients with critical illness and trauma. J Trauma Acute Care Surg. 2010;38:1336–1345. https://doi.org/10.1016/j.jtrauma.2009.07.003.
19. Mifflin MD, Jeor ST, Hill LA, et al. A new predictive equation for resting energy expenditure in healthy individuals. Am J Clin Nutr. 1990;51:241–247. https://doi.org/10.1093/ajcn/51.2.241.
20. Hoffer LJ, Bistrian BR. Appropriate protein provision in critical illness: a systematic and narrative review. Am J Clin Nutr. 2012;96:591–600. https://doi.org/10.3945/ajcn.111.013278.
21. McClave SA, Taylor BE, Martindale RG, et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (ASPEN). JPEN J Parenter Enter Nutr. 2016;40:159–211. https://doi.org/10.1016/j.pnyn.2016.01.007.
22. S armad M, Zeinali F, Habibi N, et al. Intake of dietary supplements and malnutrition in patients in intensive care unit. Int J Prev Med. 2016;7:90. https://doi.org/10.4103/2008-7802.186224.
