Research Article

An Open-label Clinical Study on Safety and Gastrointestinal Tolerance of Maxvida™ High Protein in Hospitalized Adults Requiring Isocaloric Enteral Feeding

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Abstract

Objective: This study aims to evaluate the safety and gastrointestinal tolerance of Maxvida™ high protein in hospitalized adult patients requiring an isocaloric high protein formula for enteral tube feeding.

Materials and methods: This was a prospective, twelve-day, single-centre, open-label clinical study, where the safety and gastrointestinal tolerance of Maxvida™ high protein (30 grams in 100 millilitres of water) were evaluated every day from Day 1 to the end of hospitalization or Day 12. The reconstituted amount was 116 ml (equivalent to 114 kcal {1 kcal in 1 ml}) and administered twice a day along with isocaloric kitchen feed (1 kcal in 1 ml) as per the patient's requirement or at the discretion of the investigator.

Results: All the participants received the feed twice a day during the study period. Two participants experienced vomiting during the study period. Gastric Residual Volume did not exceed 500 ml/day for any subjects. There was no safety issue encountered during the administration of Maxvida™ high protein.

Conclusion: Maxvida™ high protein was found to be a safe and well-tolerated enteral tube nutrition formula for hospitalized adults.

Keywords: Maxvida™ high protein; Enteral tube feed; High-protein isocaloric formula; Critically ill; Intensive Care Unit (ICU)

Introduction

Malnutrition is quite common in hospital settings and affects many inpatients. The prevalence of malnutrition varies from 20% to 50% in hospitalized patients [1,2]. Two-thirds of the patients hospitalized with malnutrition may experience further decrease in nutritional status, and malnutrition may also occur in one-third of well-nourished patients [3].

Malnutrition during hospitalization is often linked to adverse effects such as increased incidence of infection and complications, increased muscle wasting, delayed wound healing, extended hospital stays, impaired functional ability and quality of life, and higher rates of morbidity and mortality [4-7].

Patients often experience malnutrition in hospitals caused by decreased appetite due to age, underlying disease conditions such as diabetes, cancer, gastric illness, or due to medications [8,9]. Despite knowing the importance and the risks of associated complications of malnutrition, the problem is underdiagnosed, and hence, appropriate nutrition care in hospitalized settings often gets delayed and is not adequately treated [10]. Optimal management of malnutrition can reduce the length of hospital stay, associated hospitalization costs, and improve the quality of life and prognosis in patients with malnourishment [10,11].

Patients in critical care units are quite vulnerable to malnutrition. As per a systematic review of 1168 critically ill patients from 20 studies, the prevalence of malnutrition varied from 38% to 78%. Literature evidence suggests that patients with malnutrition experience poor clinical outcomes and are more susceptible to infections, have a higher incidence of overall complications, longer hospital stays, higher mortality, and costs [12-13].

In the initial phase of critical illness, there is a significant impact on the metabolism as the patient develops a hypermetabolic and catabolic state with increased energy demands and a rapid breakdown of muscle proteins in the body. This is followed by rapid muscle wasting and impaired immune system in the late phase, which further prolongs recovery from the illness[14].

Muscle wasting due to rapid protein catabolism is of particular concern as the immune system weakens, accelerating the incidence of hospital-acquired infections, and delayed wound healing can be seen. Weakening of the respiratory muscle and diaphragm can increase the risk of respiratory complications and the need for prolonged mechanical ventilation [15-17].

Enteral Nutrition (EN) is the preferred route for nutrition except in conditions with inadequate gut functioning [18,19]. Various studies suggest the beneficial role of EN over parenteral nutrition in hospitalized patients due to lesser infectious complications, shorter length of hospital stay, earlier gut function, and lower cost [20]. EN is regarded as more physiologically appropriate

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and essential for preserving gut integrity, which helps the immune system and prevents gut atrophy [21]. As per ESPEN recommendation, EN should be administered to all patients in the Intensive Care Unit (ICU) who are not anticipated to resume a complete oral diet within a three-day timeframe [22].

In critically ill patients, EN should be initiated within 24-48 hours after admission to the ICU and the onset of critical illness and should provide 25 to 30 kcal/kg/day13 [23,24]. Critical care nutrition guidelines 2018 by ESPEN-European Society for Clinical Nutrition and Metabolism, defines isocaloric nutrition that fulfils ≥ 70% of the estimated needs of the patient [25].

Many studies suggest that providing adequate protein to the critically ill patients is of great importance in the management of critically ill patients [26-28]. For the majority of critically ill patients, 2016 ASPEN-SCCM guidelines recommend a protein intake of 1.2-2 g/kg/day and higher amounts for patients with trauma, burns, and obesity [24]. ESPEN guidelines for clinical nutrition in the ICU recommend 1.3 g/kg/day protein to be provided progressively [22].

Some studies also suggest that providing higher protein (1.5-2.5 g/kg per day) as compared to standard protein intake (~ 0.8 g/kg per day) can improve clinical outcomes in critically ill patients [29,30].

Many enteral protein supplements are available that can be utilized to provide adequate protein to the patient without causing excessive caloric intake. However, it appears that these options are not widely utilized, as regular monitoring of both protein sufficiency and calorie intake is far from being a routine procedure. Clinicians should prioritize giving adequate protein to patients at high nutrition risk. Protein intake can be improved by utilizing high-protein EN formulas, incorporating protein supplements for patients already on EN, and adding parenteral amino acids [24,31].

Recently, there has been an increasing interest on the use and impact of β-Hydroxy β-methylbutyric acid (HMB), a leucine metabolite, on skeletal muscle mass and physical function in patients who are hospitalised, in cancer patients, and in critical care settings. HMB is a nutritional supplement with the potential to preserve lean body mass and improve skeletal muscle mass and strength [32]. HMB downregulates the key components of the ubiquitin-proteasome proteolytic pathway and inhibits protein degradation and stimulates protein synthesis [33].

In older patients, who were bedridden for 10 days, HMB preserved the lean body mass successfully. As patients with critical illness are bedridden for long periods, supplementation with HMB may be of benefit in attenuating muscle loss and weakness in critical care [34]. In a prospective randomized, placebo-controlled double blind trial (n=30), provision of HMB to the ICU patients on mechanical ventilation was associated with significantly reduced protein breakdown, improved amino acid metabolism, and overall health [35]. HMB appeared to be well-tolerated in humans at the doses of 3-6 g/d [36]. A series of studies ranging from 3 to 8 weeks in healthy young and old subjects taking HMB/d supplementation 3g/d and at the dose of 3 and 6 g/d for 8 weeks, no adverse effect was observed on blood glucose, hemoglobin, urea nitrogen, liver enzymes, lipid levels, leukocytes, and urine pH, glucose, and protein while total cholesterol and LDL levels were reduced [37,38].

Maxvida™ high protein is an isocaloric high protein formula for hospitalized adult/elderly patients requiring EN to provide nutrition based on energy expenditure with adequate protein and β-Hydroxy β-methylbutyric acid (HMB). This study aims to evaluate the safety and gastrointestinal tolerance (product compliance) of Maxvida™ high protein, an isocaloric high protein enteral feeding formula, in hospitalized adult/elderly patients.

Material and Methods

Study design

This prospective, twelve-day, single-centre, open-label, clinical study was conducted between September 2024 to October 2024 to evaluate the safety and gastrointestinal tolerance of Maxvida™ high protein in hospitalized adult patients who require isocaloric high protein formula for tube feeding. Signutra Inc. holds the product licence for Maxvida™ high protein.

The demographic details, including date of birth, sex, height, weight, body mass index, and medical history, including the nature, duration, and severity of the disease and detailed information regarding any prior and concomitant medications, were recorded at baseline. Various laboratory investigations done during the study period were haematology, blood biochemistry, lipid profile, and urine routine.

The study inclusion criteria were adult patients >18 years of age, of any sex, who required isocaloric ET feeding and were hospitalized in the ICU for at least two days, and informed consent was obtained from the patients or their legal representatives. The exclusion criteria included patients who received ET feeding before hospitalization; had any evidence of organ dysfunction, pregnant women,; or had known allergy to any constituent of Maxvida™ high protein were excluded from the study.

Ethical compliance

The study was conducted according to the Declaration of Helsinki and in compliance with good clinical practice guidelines by the International Conference of Harmonization. The study was approved by the Institutional Ethics Committee, Secunderabad, India, on 12th July 2024, confirmation on: KIMS/EC/BMHR/2024/82-01. The study was registered with the Clinical Trial Registry of India as CTRI/2024/06/068511. Written informed consent was taken from the participants or their legal representatives.

Intervention

Participants were administered Maxvida™ high protein twice a day at 0800 hours and 1600 hours from Day 1 to the end of hospitalization or Day 12. 30 grams of Maxvida™ high protein was diluted in 100 ml of water, and the reconstituted amount was 116 ml (equivalent to 114 kcal (1kcal in 1 ml)). The remaining energy requirements were fulfilled by the normal or hospital kitchen feed administered as per the patient's requirement or at

the investigator's discretion.

Table 1 shows energy and nutrient requirements met by dissolving 30 grams of Maxvida™ high protein in 100 millilitres of water.

Table 1: Nutritional profile of Maxvida™ high protein.

Nutrients	Unit	Per 100 g powder	Per 30 g powder	% RDA Per serving 30 g
Energy	Kcal	379	113.7	6
Total fat	G	2.8	0.84	1
Saturated fatty acid	G	0.88	0.264	1
MUFA	G	0.63	0.189	†
PUFA	G	1.3	0.39	†
Linoleic acid (Omega-6)	G	1.14	0.342	†
Alpha-Linoleic acid (Omega-3)	G	0.13	0.039	†
Trans Fat	G	0.02	0.006	0
Cholesterol	Mg	0	0	†
Carbohydrates	G	37	11.1	†
Added sugars (including sucrose)	G	0	0	0
Dietary fiber (AI)	G	3	0.9	†
Soluble Fiber	G	3	0.9	†
Prebiotic	G	3	0.9	†
Protein*	G	50	15	33
L-Lysine	Mg	3478	1043.4	†
L-Arginine	Mg	1840	552	†
L-Glutamine and L-Glutamic acid	Mg	9870	2961	†
L-Isoleucine	Mg	2268	680.4	†
L-Leucine	Mg	4013	1203.9	†
L-Valine	Mg	4217	1265.1	†
L-Carnitine	Mg	50.5	15.15	†
CaHMB##	G	1.5	0.45	†
Vitamins				
Vitamin A*	Mcg	570	171	20
Vitamin D3*	IU	360	108	18
Vitamin E*	IU	9	2.7	25
Vitamin K2 (Menaquinone-7)*	Mcg	40	12	22
Vitamin C*	Mg	52	15.6	24
Folic acid*^	Mcg	125	37.5	29
Vitamin B1 (Thiamin)*	Mg	1	0.3	21
Vitamin B2 (Riboflavin) *	Mg	1	0.3	16
Vitamin B3 (Niacin)*	Mg	7	2.1	19
Vitamin B6*	Mg	1	0.3	16
Vitamin B12*	Mcg	2	0.6	27
Pantothenic acid* (AI)	Mg	3.5	1.05	†
Minerals				
Iron*	Mg	14	4.2	14
Calcium*	Mg	900	270	27
Phosphorus*	Mg	225	67.5	7

Magnesium*	Mg	170	51	14
Zinc*	Mg	8	2.4	18
Iodine*	Mcg	90	27	19
Copper*	Mcg	700	210	12
Selenium*	Mcg	20	6	15
Chromium*	Mcg	15	4.5	9
Manganese*	Mg	2	0.6	15
Molybdenum**	Mcg	12.5	3.75	8
Sodium*	Mg	330	99	5
Potassium*	Mg	420	126	4
Chloride #(AI)	Mg	260	78	†

Note: % RDA (Recommended Dietary Allowance) calculated basis 2000 kcal energy for an average adult per day and % RDA expressed for sedentary women basis *Indian Council of Medical Research (ICMR) RDA 2020 guidelines; *Nutrients meet the ICMR RDA 2020 for sedentary adult men as well; Total Sugars-26g/100g; **Codex (CAC/GL 2-1985; Guidelines on nutritional labelling); #Food and Nutrition Board, IOM; RDA not established in ICMR/WHO; ^1 mcg Folic Acid=1.7 DFE (Dietary Folate Equivalent); AI: Adequate Intake; MUFA: Monounsaturated Fatty Acid; PUFA: Polyunsaturated Fatty Acid; †=ti

Endpoints

The study's primary endpoint was to assess the safety and gastrointestinal tolerance (product compliance) of Maxvida™ high protein. Gastrointestinal tolerance was assessed based on the episodes of diarrhoea, stomach irritation, regurgitation, abdominal bloating, vomiting, and Gastric Residual Volume (GRV) >500ml/day.

The secondary endpoints were to evaluate the change in weight, if any, and serum albumin levels between baseline and the end of hospitalization or Day 12. Adverse events were monitored and recorded based on clinical and laboratory parameters throughout the study.

Statistical analysis

SPSS version 26 was used to analyse the data. A p-value <0.05 was considered statistically significant,

Results

The demographics

The study included 30 subjects, though the final data was available for 29 patients. The average age of the subjects (+SD) was 55.90+17.71 years, and the average weight was 65.90+11.32 kgs. Out of 30 subjects, 18 were males and 12 were females; hospitalized for an average of 8.18 days for various medical conditions such as road traffic accident, shock, acute coronary syndrome, cerebrovascular accident, seizure disorder, lung carcinoma, and other critical conditions. The patient population comprised of patients who required mechanical ventilator support and also those who did not require mechanical ventilation.

Maxvida™ high protein feeding details

All participants received Maxvida™ high protein formula feed two times a day.

Table 2 shows the duration of feed (in days) for various participants during the study.

Table 2: The duration of feed (in days) for various participants during the study.

Number of days of tube-feeding	Frequency of patients
1	1
2	2
3	3
4	7
6	4
7	2
8	3
9	1
10	1
11	2
12	3
Total	29

Gastrointestinal tolerance

The majority of participants did not experience any gastrointestinal symptoms. Two participants had vomiting while taking the enteral feed. One experienced abdominal pain. No patient had GRV>500 ml/day. All the subjects had a GRV of <100 ml per day, except one patient, who had GRV of 100 ml on one occasion. No additional adverse events were experienced by the participants during the study period.

Effect of Maxvida™ high protein on weight and albumin level

Study results showed no statistically significant change in the participants' weight (p=0.972) and serum albumin levels (p=0.791) considering the short duration of intervention.

Administration of formula

There were no issues encountered during the preparation of Maxvida™ high protein while mixing with water and administration of the enteral feed. The feeding formulation easily passed through the tube and did not stick. It was of uniform consistency, and no blockage of the ET was experienced.

Adverse events: No Serious events were recorded in any of the participants. General events included Headache, Nausea, and Body pain.

Discussion

The present study suggests that Maxvida™ high protein, an isocaloric high-protein enteral feeding formula, is associated with good gastrointestinal tolerance and safety profile in adult hospitalized patients.

Patients in critical condition experience increased energy expenditure which increases their energy and protein requirement due to muscle loss under the influence of procatabolic inflammatory hormones [39]. In critical conditions, proteins and amino acids are also used as a source of energy, and protein deficit may be associated with infectious morbidity and high mortality [40]. Shifting of metabolism to a hypercatabolic state during the early phase of critical illness causes rapid degradation of body proteins and other reserves, leading to malnutrition and adverse clinical outcomes. Breakdown of the muscle protein is the main driver of catabolism rather than a decrease in protein synthesis; hence, prolonged catabolic state in critical illness causes skeletal muscle wasting [41,42].

This hypermetabolic state with increased protein breakdown can cause negative nitrogen balance in critical care patients and a higher protein intake can help to improve the nitrogen balance [43,44].

As per the Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines, protein is a key macronutrient necessary for wound healing, immune support, and preservation of lean body mass in critical care settings [45]. For the majority of critical care patients, the demand for protein is relatively higher than that for energy, making it difficult to fulfill the protein needs with standard enteral formulas. Estimated protein requirements are generally in the range of 1.2-2.0 g/kg of actual body weight and may be higher for multi-trauma, burn patients, the elderly, obese, and acute kidney injury patients [45,46]. Administration of Maxvida™ high protein led to the fulfillment of daily protein and micronutrient intake in hospitalized patients. Similarly, in a prospective observational cohort study of 113 intensive care patients in a tertiary care referral hospital, increased protein and amino acid intake was associated with lower mortality [47]. In another study with 211 mechanically ventilated patients admitted to a medical ICU, patients with adequate protein intake as compared to patients with insufficient protein intake had significantly lower rates of mortality in ICU (14.7%) and in hospital (23.5%) [48].

A randomized controlled trial of 73 critically ill patients with a minimum 7 day stay in the critical care unit suggested that high early protein intake in critical care patients may help improve their nutritional status, shorten the length of ICU stay, and improve mechanical ventilation. It is important to provide adequate energy and protein to the patients during critical illness [49].

As per a study including 2270 critically ill patients of sepsis/pneumonia, with ICU stay ≥ 3 days, mechanically ventilated within 48 hours of ICU admission, and only received enteral nutrition, an additional 30 g protein/day decreased the 60-day mortality and days of ventilator use [50].

A multicentre international study of 1584 patients who stayed in the ICU ≧ 12 days, the time to discharge alive was shorter in patients with adequate protein intake (≥ 80% goal amount) compared with those patients who were not (Hazard Ratio [HR], 1.25; 95% CI, 1.04-1.49) [17].

High mortality rate and poor prognosis are seen in critically ill patients with inadequate protein intake. Providing adequate protein to manage protein deficiency may improve the clinical outcomes. Various enteral feed formulations are available now; however, these differ in their micro and macronutrient content [41]. Most commonly, Isocaloric (1 kcal/ml) enteral feeds are recommended to achieve the desired caloric goals [51]. Maxvida™ HP is an isocaloric enteral feed enriched with high protein and HMB and is provided to cater to the needs of the hospitalized patients.

Use of HMB supplementation may help to improve nitrogen balance in critically injured patients [52]. A systematic review and meta-analysis of 15 RCTs (n=2137) suggested that although the effect size was small, use of HMB, or its supplements, can increase the muscle mass and strength and physical function in many clinical conditions associated with loss of skeletal muscle mass and weakness [32].

A prospective, randomized, blinded study included 100 trauma patients who received the standard tube feeds along with either HMB or HMB/arginine/glycine or placebo for 28 days. The data was collected for patients who received supplementation for minimum of 7 days (n=72). It was observed that from the first 7 to last 7 days of supplementation, the change in nitrogen balance was -4.3 g/d in patients given standard tube feeds and HMB, -5.6 g/d in HMB/arginine/glycine group, and -8.9 g/d in placebo group suggesting that HMB supplementation in critically injured patients may

attenuate negative nitrogen balance [52].

In a small, randomized placebo-controlled study, 34 COPD patients on mechanical ventilation were assigned to either HMB or placebo [53]. The study suggested anti-inflammatory and anticatabolic effects of HMB supplementation and improvement in pulmonary function in COPD patients in critical care [54].

Enteral feeds are generally delivered through nasogastric tubes. ET feeds can be associated with nausea, vomiting, diarrhoea, constipation, abdominal distension, cramps, tube dislodgement, clogging, regurgitation, and aspiration [55,56]. Hence, gastrointestinal intolerance can limit the use of enteral feed. In this study, Maxvida™ high protein was given as an ET feed, and the feed volume was prescribed by the treating physician. Maxvida™ high protein ET feed could be safely administered over 12 days, and no administration issues (mixing, consistency, feeding) were reported. There were no reports of tube obstruction.

Two patients reported vomiting after the enteral feed was started. One patient who experienced vomiting had a history of nausea and vomiting before the enteral feed. Nausea and vomiting are the most common adverse events associated with enteral feeds [23].

Selecting an appropriate formula, feeding method, frequency, and volume of feed, and the timing of administration can reduce the likelihood of these complications [57]. Also, as per the literature, formulas containing fiber might contribute to a decrease in the occurrence and intensity of diarrhea and gastrointestinal complications in critically ill patients, without raising the likelihood of other negative outcomes [53]. The formula of Maxvida™ high protein includes soluble fiber and prebiotics in its composition, which may contribute to the beneficial effects of reducing gastrointestinal intolerance.

Gastric Residual Volume (GRV) is a marker of gastric dysfunction and the severity of underlying disease conditions [58]. High GRV is considered a marker for impaired gastric emptying, gastric motility disorders, or enteral feed intolerance. Routine GRV assessment is not recommended now to monitor ICU patients receiving EN; however, if GRV is used for monitoring, then it is recommended to withhold EN for GRV>500 ml if there are no other signs of EN intolerance [24,59]. In this study, all the subjects provided with Maxvida™ high protein had a GRV of <100 ml per day, except one patient with a GRV of 100 ml on one occasion, showing excellent Gastric tolerability of Maxvida™ HP.

Conclusion

Maxvida™ high protein is a safe and well-tolerated high-protein isocaloric ET feed for hospitalized adult patients, as suggested by the absence of any serious adverse events.

Limitation

The main limitations of the study are its short duration and single-centred design. Further long-term and multi-centric studies should be planned to evaluate the potential efficacy and favorable safety profile of Maxvida™ high protein over longer periods and across diverse patient populations.

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All authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this manuscript, take responsibility for the integrity of the work and have given final approval for the version to be published.

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References

1. Wittenberg R, Sharpin L, McCormick B, Hurst J. The ageing society and emergency hospital admissions. Health Policy. 2017;121:923-928.
2. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. Clinical nutrition. 2008;27:5-15.
3. Cass AR, Charlton KE. Prevalence of hospital-acquired malnutrition and modifiable determinants of nutritional deterioration during inpatient admissions: A systematic review of the evidence. Journal of Human Nutrition and Dietetics. 2022;35:1043-1058.
4. Braunschweig C, Gomez S, Sheean PM. Impact of declines in nutritional status on outcomes in adult patients hospitalized for more than 7 days. Journal of the American Dietetic Association. 2000;100:1316-1322.
5. Pourhassan M, Rommersbach N, Lueg G, Klimek C, Schnatmann M, et al. The impact of malnutrition on acute muscle wasting in frail older hospitalized patients. Nutrients. 2020;12:1387.
6. Middleton MH, Nazarenko G, Nivison-Smith I, Smerdely P. Prevalence of malnutrition and 12-month incidence of mortality in two Sydney teaching hospitals. Internal medicine journal. 2001;31:455-461.
7. Van Nes MC, Herrmann FR, Gold G, Michel JP, Rizzoli R. Does the mini nutritional assessment predict hospitalization outcomes in older people?. Age and ageing. 2001;30:221-226.
8. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: Prevalence, identification and impact on patients and the healthcare system. International journal of environmental research and public health. 2011;8:514-527.
9. Harris CL, Fraser C. Institutionalized elderly: The effects on wound healing. Ostomy/wound management. 2004;5:54-63.
10. Bellanti F, Lo Buglio A, Quiete S, Vendemiale G. Malnutrition in hospitalized old patients: Screening and diagnosis, clinical outcomes, and management. Nutrients. 2022;14:910.
11. Tappenden KA, Quatrara B, Parkhurst ML, Malone AM, Fanjiang G, et al. Critical role of nutrition in improving quality of care: an interdisciplinary call to action to address adult hospital malnutrition. Journal of the Academy of Nutrition and Dietetics. 2013;113:1219-1237.

12. Lew CC, Yandell R, Fraser RJ, Chua AP, Chong MF, et al. Association between malnutrition and clinical outcomes in the intensive care unit: A systematic review. Journal of Parenteral and Enteral Nutrition. 2017;41:744-758.

13. Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clinical nutrition. 2003;22:235-239.

14. Singer P, Blaser AR, Berger MM, Alhazzani W, Calder PC, et al. ESPEN guideline on clinical nutrition in the intensive care unit. Clin Nutr. 2019;38:48-79.

15. Shetti AN. Nutritional support in critical care patients: Challenges, strategies, and recent advances. IP J Nutr Metab Health Sci. 2024;7:141-145

16. Genton Graf L, Romand JA, Pichard C. Basics in clinical nutrition: Nutritional support in trauma. Nutrition Metab. 2010;5:e107-109.

17. Rezaeian M, Monfared-Parizi S, Mousavi Shirazifard Z, Sayadi A, Khodadadi H, et al. Evaluation of nutritional intake and malnutrition in critically ill patients and its relationship with 28-day death. Sci Rep. 2025;15:15677.

18. Doley J. Enteral nutrition overview. Nutrients. 2022;14:2180.

19. Seron-Arbeloa C, Zamora-Elson M, Labarta-Monzon L, Mallor-Bonet T. Enteral nutrition in critical care. Journal of clinical medicine research. 2013;5:1.

20. Seres DS, Valcarcel M, Guillaume A. Advantages of enteral nutrition over parenteral nutrition. Therapeutic advances in gastroenterology. 2013;6:157-167.

21. Szefel J, Kruszewski WJ, Buczek T. Enteral feeding and its impact on the gut immune system and intestinal mucosal barrier. Gastroenterology Review/Przegląd Gastroenterologiczny. 2015;10:71-7.

22. Kreymann KG, Berger MM, Deutz NE, Hiesmayr M, Jolliet P, et al,. ESPEN guidelines on enteral nutrition: intensive care. Clinical nutrition. 2006;25:210-223.

23. Adeyinka A, Rouster AS, Valentine M. Enteric Feeding. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025

24. McClave SA, Taylor BE, Martindale RG, Warren MM, Johnson DR, 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. Journal of parenteral and enteral nutrition. 2016;40:159-211.

25. Lee JH, Kim M, Choi D, Kwon J, Park YK. Isocaloric nutritional support reduces ventilator duration time in major trauma patients. Nutrition&Dietetics. 2023;80:435-444.

26. Nicolo M, Heyland DK, Chittams J, Sammarco T, Compher C. Clinical outcomes related to protein delivery in a critically ill population: A multicenter, multinational observation study. JPEN J Parenter Enteral Nutr. 2016;40:45-51.

27. Weijs PJ, Stapel SN, de Groot SD, Driessen RH, de Jong E, et al. Optimal protein and energy nutrition decreases mortality in mechanically ventilated, critically ill patients: A prospective observational cohort study. JPEN J Parenter Enteral Nutr. 2012;36:60-68.

28. Caparrós T, Lopez J, Grau T. Early enteral nutrition in critically III patients with a high-protein diet enriched with arginine, fiber, and antioxidants compared with a standard high-protein diet. The effect on nosocomial infections and outcome. JPEN J Parenter Enteral Nutr. 2001;25:299-309.

29. Nakamura K, Nakano H, Naraba H, Mochizuki M, Takahashi Y, et al. High protein versus medium protein delivery under equal total energy delivery in critical care: A randomized controlled trial. Clin Nutr. 2021;40:796-803.

30. van Zanten AR, Petit L, De Waele J, Kieft H, de Wilde J, et al. Very high intact-protein formula successfully provides protein intake according to nutritional recommendations in overweight critically ill patients: A double-blind randomized trial. Crit Care. 2018;22:156.

31. Hurt RT, McClave SA, Martindale RG, Ochoa Gautier JB, Coss-Bu JA, et al. Summary points and consensus recommendations from the international protein summit. Nutrition in clinical practice. 2017;32:142S-51S.

32. Bear DE, Langan A, Dimidi E, Wandrag L, Harridge SD, et al. β-Hydroxy-β-methylbutyrate and its impact on skeletal muscle mass and physical function in clinical practice: A systematic review and meta-analysis. Am J Clin Nutr. 2019;109:1119-1132.

33. Smith HJ, Mukerji P, Tisdale MJ. Attenuation of proteasome-induced proteolysis in skeletal muscle by β-hydroxy-β-methylbutyrate in cancer-induced muscle loss. Cancer Res. 2005;65:277-283.

34. Deutz NE, Pereira SL, Hays NP, Oliver JS, Edens NK, et al. Effect of β-hydroxy-β-methylbutyrate (HMB) on lean body mass during 10 days of bed rest in older adults. Clin Nutr. 2013;32:704-712.

35. Wittholz K, Fetterplace K, Ali Abdelhamid Y, Presneill JJ, Beach L, et al. β-Hydroxy-β-Methylbutyrate (HMB) supplementation and functional outcomes in multi-trauma patients: A study protocol for a pilot randomised clinical trial (BOOST trial). Pilot Feasibility Stud. 2022;8:21.

36. Viana MV, Becce F, Pantet O, Schmidt S, Bagnoud G, et al. Impact of β- Hydroxy-β- Methylbutyrate (HMB) on muscle loss and protein metabolism in critically ill patients: A RCT. Clin Nutr. 2021;40:4878-4887.

37. Gallagher PM, Carrithers JA, Godard MP, Schulze KE, Trappe SW. Beta-hydroxy-beta-methylbutyrate ingestion, part II: Effects on hematology, hepatic and renal function. Med Sci Sports Exerc. 2000;32:2116-2119.

38. Nissen S, Sharp RL, Panton L, Vukovich M, Trappe S, et al. Beta-Hydroxy-Beta-Methylbutyrate (HMB) supplementation in humans is safe and may decrease cardiovascular risk factors. J Nutr. 2000;130:1937-1945.

39. Hasan KN, Youssef IA, Hassanein A. Protein supplementation during critical illness in ICU. Minia Journal of Medical Research. 2022;33:220-227.

40. Van Zanten AR. Should we increase protein delivery during critical illness?. Journal of Parenteral and Enteral Nutrition. 2016;40:756-762.

41. Hsu CC, Sun CY, Tsai CY, Chen MY, Wang SY, et al. Metabolism of proteins and amino acids in critical illness: From physiological alterations to relevant clinical practice. J Multidiscip Healthc. 2021:1107-1117.

42. Klaude M, Mori M, Tjäder I, Gustafsson T, Wernerman J, et al. Protein metabolism and gene expression in skeletal muscle of critically ill patients with sepsis. Clin Sci. 2012;122:133-142.

43. Dickerson RN. Nitrogen balance and protein requirements for critically ill older patients. Nutrients. 2016;8:226.

44. Dickerson RN, Pitts SL, Maish III GO, Schroeppel TJ, Magnotti LJ, et al. A reappraisal of nitrogen requirements for patients with critical illness and trauma. J Trauma Acute Care Surg. 2012;73:549-557.

45. McClave SA, Taylor BE, Martindale RG, Warren MM, Johnson DR, 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. Journal of parenteral and enteral nutrition. 2016;40:159-211.

46. Singer P. Protein metabolism and requirements in the ICU. Clinical nutrition ESPEN. 2020;38:3-8.

47. Allingstrup MJ, Esmailzadeh N, Knudsen AW, Espersen K, Jensen TH, et al. Provision of protein and energy in relation to measured requirements in intensive care patients. Clinical nutrition. 2012;31:462-468.

48. Song JH, Lee HS, Kim SY, Kim EY, Jung JY, et al. The influence of protein provision in the early phase of intensive care on clinical outcomes for critically ill patients on mechanical ventilation. Asia Pacific journal of clinical nutrition. 2017;26:234-240.

49. Wang Y, Ye Y, Xuan L, Xu L, Wang P, et al. Impact of early high protein intake in critically ill patients: A randomized controlled trial. Nutrition&Metabolism. 2024;21(1):39.

50. Elke G, Wang M, Weiler N, Day AG, Heyland DK. Close to recommended caloric and protein intake by enteral nutrition is associated with better clinical outcome of critically ill septic patients: Secondary analysis of a large international nutrition database. Crit Care. 2014;18:R29.

51. Preiser JC, Arabi YM, Berger MM, Casaer M, McClave S, et al. A guide to enteral nutrition in intensive care units: 10 expert tips for the daily practice. Critical Care. 2021;25:424.

52. Kuhls DA, Rathmacher JA, Musngi MD, Frisch DA, Nielson J, et al. β-Hydroxy-β-methylbutyrate supplementation in critically ill trauma patients. J Trauma. 2007;62:125-132.

53. Cara KC, Beauchesne AR, Wallace TC, Chung M. Safety of using enteral nutrition formulations containing dietary fiber in hospitalized critical care patients: A systematic review and meta-analysis. Journal of Parenteral and Enteral Nutrition. 2021;45:882-906.

54. Hsieh L, Chien S, Huang M, Tseng H, Chang C. Anti-inflammatory and anticatabolic effects of short-term beta-hydroxy-beta-methylbutyrate supplementation on chronic obstructive pulmonary disease patients in intensive care unit. Asia Pac J Clin Nutr. 2006;15:544-550.

55. Pancorbo-Hidalgo PL, García-Fernandez FP, Ramírez-Pérez C. Complications associated with enteral nutrition by nasogastric tube in an internal medicine unit. Journal of Clinical Nursing (Wiley-Blackwell). 2001;10.

56. Adeyinka A, Rouster AS, Valentine M. Enteric Feeding. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025

57. Wanden-Berghe C, Patino-Alonso MC, Galindo-Villardón P, Sanz-Valero J. Complications associated with enteral nutrition: CAFANE study. Nutrients. 2019;11:2041.

58. Deane A, Chapman MJ, Fraser RJ, Bryant LK, Burgstad C, et al. Mechanisms underlying feed intolerance in the critically ill: Implications for treatment. World journal of gastroenterology: WJG. 2007;13:3909.

59. Lindner M, Padar M, Mändul M, Christopher KB, Reintam Blaser A, et al. Current practice of gastric residual volume measurements and related outcomes of critically ill patients: A secondary analysis of the intestinal-specific organ function assessment study. Journal of Parenteral and Enteral Nutrition. 2023;47:614-623.