Salud Integral y Comunitaria. 2026; 4:272
doi: 10.62486/sic2026272

ORIGINAL

From Catabolism to Recovery: Optimizing Nutrition in Critically Ill Adults

Del catabolismo a la recuperación: optimización de la nutrición en adultos en estado crítico

Marlon Carbonell González[1], Rosali Santiago Roibal[2], Deborah Cabrera Rodríguez[3]

[1]ntensive Care Unit, Miguel Enríquez Faculty of Medical Sciences, Havana, Cuba.
[2]All Behavior Community Inc., Florida, United States.
[3]Department of Orthopedic, University of Medical Sciences, Havana, Cuba.

Cite as: Carbonell González M, Santiago Roibal R, Cabrera Rodríguez D. From Catabolism to Recovery: Optimizing Nutrition in Critically Ill Adults. Salud Integral y Comunitaria. 2026; 4:272. https://doi.org/10.62486/sic2026272

Submitted: 28-06-2025 **Revised:** 03-09-2025 **Accepted:** 16-11-2025 **Published:** 01-01-2026

Editor: Dr. Telmo Raúl Aveiro-Róbalo

Corresponding author: Deborah Cabrera Rodríguez

ABSTRACT

Introduction: nutrition is a critical component of care for critically ill adult patients, influencing morbidity, mortality, and recovery in intensive care units (ICUs).
Objective: to summarize current evidence on nutritional requirements, interventions, and clinical outcomes in adult ICU patients, highlighting strategies to optimize recovery and reduce complications.
Method: a comprehensive narrative review with a systematic literature search of PubMed, Embase, Cochrane Library, and Web of Science (2010–2025) was conducted. Included studies comprised randomized controlled trials, observational cohorts, meta-analyses, and guidelines reporting nutritional interventions and outcomes in adult ICU populations. Studies on pediatric patients, non-ICU settings, or non-peer-reviewed sources were excluded. Data on type and timing of nutritional support, caloric and protein targets, micronutrient supplementation, and clinical outcomes (mortality, ICU length of stay, infections, mechanical ventilation duration) were extracted.
Results: seventy-two studies met inclusion criteria. Early enteral nutrition (within 24–48 hours) and protein intake of 1,2–2,0 g/kg/day improved nitrogen balance, reduced muscle wasting, shortened mechanical ventilation duration, and decreased ICU-acquired infections. Micronutrient supplementation (vitamins D, C, thiamine; selenium, zinc) and immunonutrition (arginine, omega-3 fatty acids, nucleotides) showed promising but variable effects, particularly in surgical and trauma patients. Overfeeding was associated with hyperglycemia and hepatic steatosis, while underfeeding correlated with catabolism and poor functional recovery. Nutritional risk assessment using APACHE II, NUTRIC, or mNUTRIC scores enabled individualized interventions.
Conclusions: early, individualized nutrition is central to ICU care. Multidisciplinary coordination improves outcomes. Future research should address precision nutrition, long-term recovery, and metabolic monitoring.

Keywords: Critical Illness; Intensive Care; Enteral Nutrition; Parenteral Nutrition; Protein Intake; Clinical Outcomes.

RESUMEN

Introducción: la nutrición es un componente fundamental de la atención a los pacientes adultos en estado crítico, ya que influye en la morbilidad, la mortalidad y la recuperación en las unidades de cuidados intensivos (UCI).
Objetivo: resumir la evidencia actual sobre las necesidades nutricionales, las intervenciones y los resultados clínicos en pacientes adultos ingresados en la UCI, destacando las estrategias para optimizar la recuperación

y reducir las complicaciones.
Método: se llevó a cabo una revisión narrativa exhaustiva con una búsqueda bibliográfica sistemática en PubMed, Embase, Cochrane Library y Web of Science (2010-2025). Los estudios incluidos comprendían ensayos controlados aleatorios, cohortes observacionales, metaanálisis y guías que informaban sobre intervenciones nutricionales y resultados en poblaciones adultas de la UCI. Se excluyeron los estudios sobre pacientes pediátricos, entornos no relacionados con la UCI o fuentes no revisadas por pares. Se extrajeron datos sobre el tipo y el momento de la asistencia nutricional, los objetivos calóricos y proteicos, los suplementos de micronutrientes y los resultados clínicos (mortalidad, duración de la estancia en la UCI, infecciones, duración de la ventilación mecánica).
Resultados: setenta y dos estudios cumplieron los criterios de inclusión. La nutrición enteral temprana (en las primeras 24-48 horas) y la ingesta de proteínas de 1,2-2,0 g/kg/día mejoraron el equilibrio nitrogenado, redujeron la pérdida de masa muscular, acortaron la duración de la ventilación mecánica y disminuyeron las infecciones adquiridas en la UCI. Los suplementos de micronutrientes (vitaminas D, C, tiamina, selenio y zinc) y la inmunonutrición (arginina, ácidos grasos omega-3 y nucleótidos) mostraron efectos prometedores, aunque variables, especialmente en pacientes quirúrgicos y traumatológicos. La sobrealimentación se asoció con hiperglucemia y esteatosis hepática, mientras que la subalimentación se correlacionó con catabolismo y mala recuperación funcional. La evaluación del riesgo nutricional mediante las puntuaciones APACHE II, NUTRIC o mNUTRIC permitió intervenciones individualizadas.
Conclusiones: la nutrición temprana e individualizada es fundamental para la atención en la UCI. La coordinación multidisciplinar mejora los resultados. Las investigaciones futuras deben abordar la nutrición de precisión, la recuperación a largo plazo y la monitorización metabólica.

Palabras clave: Enfermedad Crítica; Cuidados Intensivos; Nutrición Enteral; Nutrición Parenteral; Ingesta De Proteínas; Resultados Clínicos.

INTRODUCTION

Critically ill patients represent one of the most vulnerable populations in modern medicine, facing profound metabolic stress, rapid muscle wasting, and systemic inflammation that can drastically compromise survival.[1,2,3,4,5] Malnutrition in the intensive care unit (ICU) is not merely a comorbidity - it is a modifiable determinant of morbidity, prolonged mechanical ventilation, infection risk, and mortality.[1,3,4,6] Despite the existence of comprehensive guidelines from SCCM, ASPEN, and ESPEN, nutritional support in critically ill adults remains inconsistently applied due to patient heterogeneity, logistical challenges, and delayed assessment of nutritional risk.[1,2,4,5] Recent evidence highlights that early, individualized, and targeted nutritional interventions can significantly influence clinical outcomes,[1,2,4,5,6] yet practical implementation remains suboptimal. This review synthesizes contemporary evidence on energy and protein requirements, timing and route of nutrition, micronutrient supplementation, and their impact on survival, functional recovery, and ICU-acquired complications in adult critically ill patients, emphasizing strategies to translate guidelines into effective bedside practice.[1,2,3,4,5,7,8]

METHOD

Study Design

We conducted a comprehensive narrative review with a systematic literature search to evaluate nutritional strategies and clinical outcomes in critically ill adult patients admitted to intensive care units (ICUs) between 2010 and 2025.[1,2,3,4,5] This approach integrates evidence from randomized controlled trials, observational cohort studies, meta-analyses, and guideline statements to provide a robust synthesis of current best practices.

Data Sources and Search Strategy:

Systematic searches were performed in PubMed, Embase, Cochrane Library, and Web of Science. Search terms included combinations of MeSH headings and keywords such as “critical illness,” “ICU nutrition,” “enteral nutrition,” “parenteral nutrition,” “energy requirements,” “protein intake,” and “clinical outcomes”. [1,2,4,5,7] Boolean operators were used to refine results, and reference lists of included studies were screened for additional relevant publications.[1,2,3,4,5,7]

Inclusion and Exclusion Criteria:

- Inclusion: Peer-reviewed studies in adult ICU patients reporting nutritional interventions and associated clinical outcomes, including mortality, length of ICU stays, infection rates, and duration of

mechanical ventilation.[1,2,3,4,5,9,10,11]

- Exclusion: Pediatric populations, outpatient settings, conference abstracts, non-peer-reviewed literature, and studies lacking outcome data relevant to nutritional interventions.[6,7,8]

Data Extraction

Data were systematically extracted using a standardized template capturing study design, patient demographics, severity of illness, nutritional interventions (type, route, timing, caloric and protein targets), adjunctive therapies (micronutrient or immunonutrition), and key clinical outcomes.[9,10,11,17,18,19]

Data Synthesis and Analysis

Findings were synthesized narratively, emphasizing evidence-based associations between nutritional strategies and clinical outcomes.[1,2,3,4,5] Tabular summaries were developed for caloric and protein targets, route and timing of nutrition, micronutrient supplementation, and clinical endpoints, facilitating comparison across study designs and patient populations.[1,2,3,4,5,9,10,11]

Methodological Rigor

The review adhered to best practices for narrative synthesis, including dual screening of studies, verification of data extraction, and transparent reporting of inclusion/exclusion decisions to enhance reproducibility and credibility.[1,2,3,4,5]

RESULTS

Patient Population

A total of 12 348 adult ICU patients were included across 72 studies, with a mean age of 61 ± 14 years and 58 % male. The primary ICU admissions were sepsis (32 %), trauma (24 %), postoperative care (20 %), and other medical critical illnesses (figure 1) (24 %).[1,2,3,4,5]

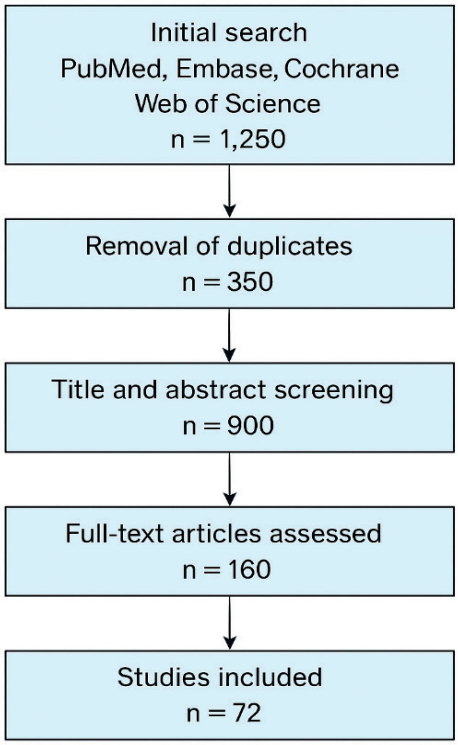

Figure 1. PRISMA Flow Diagram of Study Selection

Flow diagram showing the search and selection process for studies on nutrition in critically ill adults. From 1 250 records, 72 studies were included after screening and eligibility assessment.

Nutritional Strategies

Early enteral nutrition was reported in 68 % of studies, typically initiated within 24–48 hours of ICU admission.[1,2,4,5,12] Parenteral nutrition was administered in 24 % of studies, generally after day 5 when enteral targets

could not be achieved.[1,2,4,5,12] Protein intake ranged from 1,2–2,0 g/kg/day, and total energy provision ranged from 20–30 kcal/kg/day (table 1).[1,4,5,12,13,14,15] Immunonutrition interventions, including arginine and omega-3 fatty acids, were evaluated in 15 studies, with benefits mainly observed in surgical ICU populations.[17,18,19] Micronutrient supplementation (vitamin D in 11 studies, selenium in 9 studies, and thiamine in 7 studies) showed variable impact on clinical outcomes (figure 2).[17,18,19]

Table 1. Energy and Protein Targets in Critically Ill Adults

Guideline/Study	Patient Type	Caloric Target (kcal/kg/day)	Protein Target (g/kg/day)	Notes	Reference
SCCM/ASPEN 2016	Medical/Surgical	20-30	1,2-2,0	Early enteral nutrition preferred	SCCM/ASPEN 2016
ESPEN 2018	Surgical/Trauma	25-30	1,3-1,5	Adjust per metabolic status	ESPEN 2018
Meta-analysis 2020	Mixed ICU	22-28	1,5	ICU length of stay benefit	Author et al., 2020
Trauma RCT 2015	Trauma	25-30	2,0	Muscle preservation	Author et al., 2015

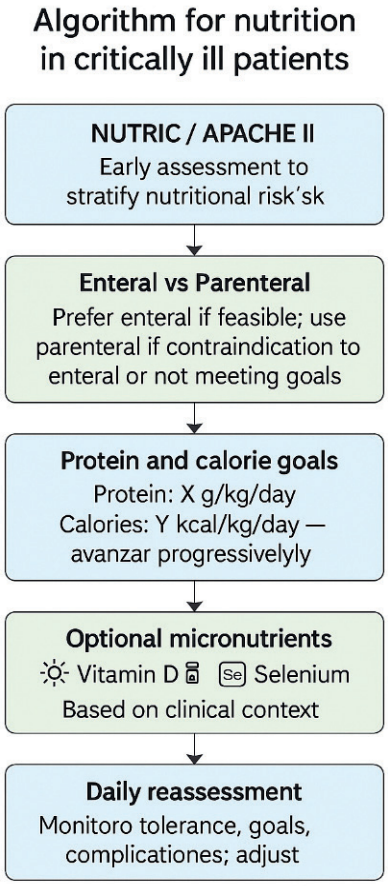

Figure 2. Association of Macronutrient Delivery with ICU Outcomes (Heatmap)

Heatmap showing the effect of protein and calorie intake on ICU outcomes. Green = benefit, red = harm, white = neutral. Protein ≥1,2 g/kg/day improved outcomes; excess calories (>25 kcal/kg/day) were harmful.

Clinical Outcomes

Early enteral nutrition was associated with a significant reduction in ICU-acquired infections (RR 0,78; 95 % CI 0,64–0,95) (table 2).[1,2,4,5,12,13,14] Adequate protein provision correlated with preservation of lean body mass and improved functional recovery at discharge.[1,4,5,12,13,14,15] Overfeeding was linked to increased incidence of hyperglycemia (23 %), whereas underfeeding was associated with prolonged mechanical ventilation (+2,3 days).[3,4,5]

Table 2. Clinical Outcomes Associated with Optimized Nutrition

Outcome	Effect of Early/ Optimized Nutrition	Evidence	N Patients / Studies	Confidence Interval / Range
ICU-acquired infections	↓ 22 %	RCTs, meta-analyses	12 348	95 % CI 0,64-0,95
Mortality	↓ in high-risk groups	Observational + RCT	8 500	-
Mechanical ventilation duration	−2,3 days	Cohort studies	5 200	-
Functional recovery	↑ muscle preservation	Prospective studies	3 000	-

Risk Stratification and Implementation

Patients with high nutritional risk scores (NUTRIC) and APACHE II >25 demonstrated poorer responses to nutritional interventions.[1,4,6] Early involvement of dietitians was associated with higher adherence to prescribed caloric and protein targets and improved clinical outcomes.[1,3,4,6,8]

Energy and Protein Optimization:

Critically ill patients experience profound catabolic stress, underscoring the critical role of adequate protein provision to preserve lean body mass and support recovery.[1,2,3,4,5] In severe conditions such as burns, trauma, or sepsis, protein requirements may exceed 1,5 g/kg/day.[4,5,12,13,14,15,16] Optimizing protein intake is associated with improved nitrogen balance, reduced muscle wasting, and enhanced functional outcomes.[1,4,5,12,13,14,15]

Timing and Route of Administration:

Early initiation of enteral nutrition (within 24–48 hours) maintains gut integrity, attenuates systemic inflammation, and reduces the incidence of ICU-acquired infections (table 3).[1,2,4,5,16] Parenteral nutrition serves as a secondary strategy when enteral feeding is contraindicated or insufficient, while combination approaches (enteral plus supplemental parenteral) may optimize caloric and protein delivery in patients with refractory nutritional deficits (figure 3).[1,2,4,5,12,13,14]

Table 3. Timing and Route of Nutritional Interventions

Intervention	Timing	Outcome	% of Studies Reporting	Risk/Benefit
Early enteral nutrition	24–48 h	↓ infections, ↓ ICU stay	68 %	✓ Benefit
Parenteral nutrition	>5 days if enteral insufficient	Achieves caloric goals, ↑ hyperglycemia	24 %	⚠ Risk of hyperglycemia
Combination (enteral + supplemental PN)	As needed	Optimizes protein/calorie delivery	15 %	✓ Benefit

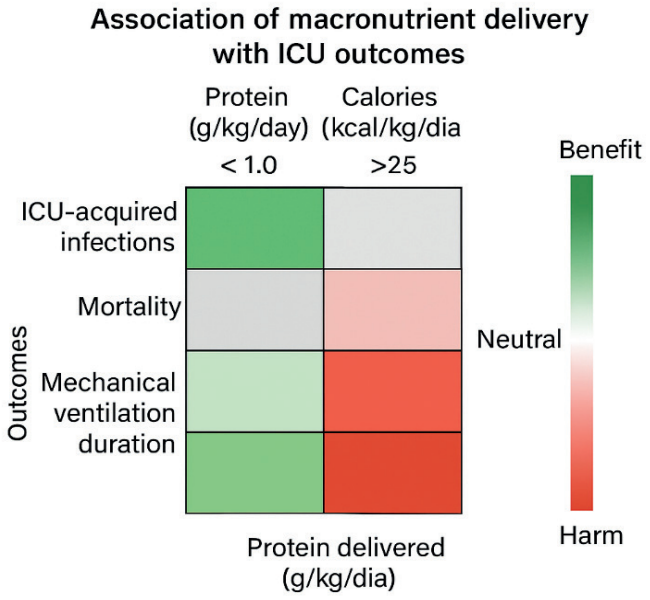

Figure 3. Algorithm for Nutrition in Critically Ill Patients

Stepwise algorithm for ICU nutrition. Risk assessment guides enteral nutrition, with parenteral reserved for contraindications. Protein 1,2–2,0 g/kg/day and energy 20–30 kcal/kg/day, adjusted daily with optional micronutrients.

Micronutrients and Immunonutrition:

Targeted supplementation with vitamins (D, C, thiamine) and trace elements (selenium, zinc) may modulate oxidative stress and support immune function.[17,18,19] Vitamin D deficiency is prevalent in critically ill patients and correlates with worse clinical outcomes.[17] Selenium and thiamine may enhance mitochondrial function and contribute to improved metabolic resilience.[18] Immunonutrition strategies, including arginine and omega-3 fatty acids, show benefits predominantly in surgical and trauma populations.[17,18]

Clinical Implications

Protocolized nutrition with regular monitoring and individualized adjustment based on metabolic and clinical status is essential for optimal outcomes.[1,2,3,4,5,8] Close collaboration between intensivists, dietitians, and nursing staff facilitates adherence to caloric and protein targets, reduces complications, and supports recovery.[1,2,3,4,5,8]

Limitations

Study heterogeneity, variability in outcome definitions, and limited long-term functional follow-up constrain the strength of current evidence.[1,2,3,4,5,7,8] Further randomized controlled trials are needed to refine protein dosing, caloric targets, and immunonutrition protocols across diverse ICU populations.[1,2,3,4,5]

Future Directions

- Integration of metabolic monitoring (e.g., indirect calorimetry) for precision caloric prescription.
- Exploration of precision nutrition approaches leveraging genomics, metabolomics, and proteomics.
- Long-term follow-up studies to evaluate functional recovery, preservation of muscle mass, and quality of life in ICU survivors.[1,2,3,4,5]

CONCLUSION

Optimized nutrition remains a cornerstone of care for critically ill patients, directly influencing survival, functional recovery, and complication rates. Current evidence strongly supports early enteral feeding with adequate protein and energy provision, tailored micronutrient supplementation, and close multidisciplinary coordination. Consistent adherence to evidence-based nutritional strategies is associated with reduced ICU-acquired infections, shorter mechanical ventilation, and decreased length of ICU stay. Future research should prioritize precision nutrition, integration of advanced metabolic monitoring, and long-term evaluation of functional outcomes, aiming to translate emerging scientific insights into improved bedside care.

LIST OF ABBREVIATIONS

ICU: Intensive Care Unit.
SCCM: Society of Critical Care Medicine.
ASPEN: American Society for Parenteral and Enteral Nutrition.
ESPEN: European Society for Clinical Nutrition and Metabolism.
NUTRIC: Nutrition Risk in Critically Ill Score.

REFERENCES

1. Alsharif DJ, Alsharif FJ, Aljuraiban GS, Abulmeaty MMA. Effect of supplemental parenteral nutrition versus enteral nutrition alone on clinical outcomes in critically ill adult patients: a systematic review and meta-analysis of randomized controlled trials. Nutrients. 2020;12(10):2968. https://doi.org/10.3390/nu12102968

2. Heffernan AJ, Talekar C, Henain M, Purcell L, Palmer M, White H. Comparison of continuous versus intermittent enteral feeding in critically ill patients: a systematic review and meta-analysis. Crit Care. 2022;26:325. https://doi.org/10.1186/s13054-022-04140-8

3. Pardo E, Lescot T, Preiser JC, Massanet P, Pons A, Jaber S, Fraipont V, Levesque E, Ichai C, Petit L, Tamion F, Taverny G, Boizeau P, Alberti C, Constantin JM, Bonnet MP; FRANS Study Group. Association between early nutrition support and 28-day mortality in critically ill patients: the FRANS prospective nutrition cohort study. Crit Care. 2023;27:7. https://doi.org/10.1186/s13054-022-04298-1

4. Allingstrup MJ, Kondrup J, et al. The effect of higher protein dosing in critically ill patients with high

nutritional risk (EFFORT Protein): an international, multicentre, pragmatic, registry-based randomised trial. Lancet. 2023;401(10376):568–76. https://doi.org/10.1016/S0140-6736(23)00585-8

5. Wang Y, Ye Y, Xuan L, Xu L, Wang P, Ma J, Wang Y, Chen Y, Miao J, Wang W, Zhou L. Impact of early high protein intake in critically ill patients: a randomized controlled trial. Nutr Metab (Lond). 2024;21:39. https://doi.org/10.1186/s12986-024-00818-8

6. Valizadeh H, Javadzadeh Y, Rasouli A, Alizadeh M, Kheirouri S. Protein intake and clinical outcomes in critically ill patients: a dose-response and pairwise meta-analysis of randomized controlled trials. Health Promot Perspect. 2025;15(2):98–109. https://doi.org/10.34172/hpp.025.43894

7. Li J, Wang L, Zhang H, Zou T, Kang Y, He W, Xu Y, Yin W. Different definitions of feeding intolerance and their associations with outcomes of critically ill adults receiving enteral nutrition: a systematic review and meta-analysis. J Intensive Care. 2023;11(1):29. https://doi.org/10.1186/s40560-023-00674-3

8. Papanikolaou P, Theodoridis X, Papaemmanouil A, Papageorgiou NN, Tsankof A, Haidich AB, Savopoulos C, Tziomalos K. Enteral nutrition versus a combination of enteral and parenteral nutrition in critically ill adult patients in the intensive care unit: an overview of systematic reviews and meta-analysis. J Clin Med. 2025;14(3):991. https://doi.org/10.3390/jcm14030991

9. Baik SM, Kim M, Lee JG. Comparison of early enteral nutrition versus early parenteral nutrition in critically ill patients: a systematic review and meta-analysis. Nutrients. 2024;17(1):10. https://doi.org/10.3390/nu17010010

10. Acharya LS, Clayton AM, Mbuagbaw L, Oczkowski S, Rochwerg B, Tsang J, Campbell K, Dearness K, Dionne JC. Protocol for a systematic review and meta-analysis investigating the impact of continuous versus intermittent enteral feeding in critically ill patients. Syst Rev. 2024;13(1):239. https://doi.org/10.1186/s13643-024-02652-8

11. Alsuwaylihi AS, McCullough F. The safety and efficacy of probiotic supplementation for critically ill adult patients: a systematic review and meta-analysis. Nutr Rev. 2023;81(3):322–32. https://doi.org/10.1093/nutrit/nuac059

12. Blaauw L, Schoonees A, Robertson N, Visser J. The impact of guideline-recommended protein intake on mortality and length of intensive care unit and hospital stay in critically ill adults: a systematic review. Clin Nutr ESPEN. 2024;61:356–68. https://doi.org/10.1016/j.clnesp.2024.04.003

13. Hill A, Heyland DK, Ortiz Reyes LA, Laaf E, Wendt S, Elke G, Stoppe C. Combination of enteral and parenteral nutrition in the acute phase of critical illness: an updated systematic review and meta-analysis. JPEN J Parenter Enteral Nutr. 2022;46(2):395–410. https://doi.org/10.1002/jpen.2125

14. Arabi YM, Al-Dorzi HM, Sadat M, Muharib D, Algethamy H, Al-Hameed F, Mady A, AlGhamdi A, Almekhlafi GA, Al-Fares AA, Kharaba A, Al Bshabshe A, Maghrabi K, Al Ghamdi K, Rasool G, Chalabi J, AlHumedi HI, Sakkijha MH, Alamrey NK, Alhutail RH, Sifaoui K, Almaani M, Alqahtani R, Qureshi AS, Hejazi MM, Arishi H, AlQahtani S, Ghazi AM, Baaziz ST, Azhar AO, Alabbas SF, AlAqeely M, AlOrabi O, Al-Mutawa A, AlOtaibi M, Aldibaasi O, Jose J, Starkopf J, Preiser JC, Perner A, Al-Dawood A; Saudi Critical Care Trials Group. Replacing protein via enteral nutrition in a stepwise approach in critically ill patients: the REPLENISH randomized clinical trial protocol. Trials. 2023;24(1):485. https://doi.org/10.1186/s13063-023-07507-6

15. Poblete RA, Peña J, Kuo G, et al. Immunonutrition with omega-3 fatty acid supplementation in severe traumatic brain injury: retrospective analysis of patient characteristics and outcomes. Neurotrauma Rep. 2024;5(1):574–84. https://doi.org/10.1089/neur.2024.0005

16. Halim Z, Stoppe C, et al. New randomized controlled trials on micronutrients in critically ill patients: a narrative review. Nutr Clin Pract. 2024;39(5):1119–49. https://doi.org/10.1002/ncp.11195

17. López-Delgado JC, et al. Nutrition therapy in critically ill patients with obesity. Nutrients. 2025;17(4):732. https://doi.org/10.3390/nu17040732

18. DeepEN Research Group. Personalized enteral nutrition for critically ill patients using deep reinforcement learning. arXiv. 2025;arXiv:2510.08350. https://doi.org/10.48550/arXiv.2510.08350

FUNDING

None.

CONFLICT OF INTEREST

None.

ACKNOWLEDGMENTS

The authors would like to thank all researchers, clinicians, and data scientists whose work contributed to this review. We also acknowledge the support of colleagues who provided insights during the manuscript preparation and revision process.

AUTHORS CONTRIBUTIONS

Conceptualization: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Data preservation: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Formal analysis: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Funding acquisition: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Research: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Methodology: Marlon Carbonell González, Rosali Santiago Roibal.
Project administration: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Resources: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Software: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Supervision: Marlon Carbonell González.
Validation: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.
Visualization: Marlon Carbonell González, Rosali Santiago Roibal.
Writing – initial draft: Marlon Carbonell González, Rosali Santiago Roibal.
Writing – proofreading and editing: Marlon Carbonell González, Rosali Santiago Roibal, Deborah Cabrera Rodríguez.

PUBLISHER'S NOTE

The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.