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Early High-Protein Enteral Nutrition in Mechanically Ventilated Intensive Care Unit Patients: A Propensity-Matched Retrospective Cohort Study

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Abstract

Objectives: This study aimed to evaluate whether early (⩽48 hours) high-protein enteral nutrition (EN) (⩾1.5 g/kg/day) is associated with improved clinical outcomes compared with standard-protein EN (<1.2 g/kg/day) in mechanically ventilated intensive care unit (ICU) patients.

Methods: A retrospective cohort study was conducted in a tertiary ICU between 2022 and 2025. Adult mechanically ventilated cases receiving EN for ⩾five days (n=450) were included. Exposure was early high-protein EN versus standard-protein EN. The primary outcome was ventilator-free days (VFDs) at 28 days. Propensity score matching (1:1) was used to adjust for baseline severity, followed by multivariable regression.

Results: After matching, 180 patients per group were analysed. Early high-protein EN was associated with more VFDs (mean 18.2 vs. 14.5 days; p=0.003), shorter ICU stay (median 9 vs. 12 days; p=0.008), and lower delirium incidence (24% vs. 38%; p=0.002). No difference in 28-day mortality (21% vs. 25%; p=0.18) was observed. The benefit was greatest in malnourished patients (Prognostic Nutritional Index (PNI) <38; VFD difference 5.2 days; p=0.001).

Conclusion: Early high-protein EN in mechanically ventilated ICU patients was associated with shorter ventilation duration, reduced ICU stay, and lower delirium risk, particularly in malnourished patients. However, given the retrospective observational design, these findings demonstrate associations rather than causal benefits. Prospective randomised controlled trials are required to confirm whether early high-protein delivery independently improves critical care recovery before definitive clinical recommendations can be made.

Categories: Pharmacology, Nutrition, Medical Education
Keywords: early nutrition, enteral and parenteral nutrition, high-protein low-carbohydrate diet, mechanically ventilated patient, propensity score match

Introduction

Critical illness induces profound protein catabolism, muscle wasting, and negative nitrogen balance [1]. In mechanically ventilated patients, muscle loss begins within days and is independently associated with prolonged ventilation, increased intensive care unit (ICU) stay, and higher mortality [2]. Preserving muscle mass is a key therapeutic target, and respiratory muscle dysfunction further compounds weaning difficulties in this population [3].

Enteral nutrition (EN) is standard of care, but optimal protein dosing remains debated. Current guidelines recommend 1.2-2 g/kg/day [4], yet actual delivery often falls short [5]. This gap is clinically significant, as inadequate protein delivery may exacerbate muscle wasting, prolong mechanical ventilation, and increase ICU length of stay. High protein intake may attenuate catabolism, preserve respiratory muscle strength, and facilitate weaning [6]. Additionally, protein may reduce delirium by supporting neurotransmitter synthesis and modulating neuroinflammation [7].

Despite the physiological rationale, evidence is conflicting; observational studies consistently link higher protein to better outcomes, but randomised trials have shown mixed results [8,9]. This study therefore used propensity score matching to evaluate whether early high-protein EN (⩾1.5 g/kg/day) is associated with improved outcomes in mechanically ventilated ICU patients [10].

Materials And Methods

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Study design and setting

The study was a retrospective cohort study utilising data extracted from existing electronic medical records. The clinical care for the included patients was provided in the Intensive Care Unit of King Hussein Medical Center, Royal Medical Services, in Amman, Jordan, from January 2022 to December 2025. The study was conceptualised, and the retrospective data extraction was performed in 2026 using finalised hospital discharge records. The propensity score matching of groups was performed retrospectively after data extraction to balance baseline characteristics between the two groups and does not represent a prospective matched-pair design. All outcomes, including ventilator-free days (VFDs) and 28-day mortality, were assessed retrospectively from the medical records following each patient's ICU admission. No prospective interventions, procedures, or data collection occurred as part of this study. The study was approved by the Jordanian Institutional Review Board of Royal Medical Services (IRB-JRMS) (approval number: 11_04/2026; approval date: September 28, 2026). Informed consent was waived.

Participants

Cases were eligible for inclusion if they were aged 18 years or older, received mechanical ventilation for at least 72 hours, had EN initiated within 72 hours of intubation, received EN for at least five consecutive days, and had complete nutrition records available. Cases were excluded if they had pre-existing severe malnutrition (defined as a body mass index (BMI) of less than 16 kg/m^2 or weight loss exceeding 20%), as these patients have severely depleted physiological reserves and require specialised nutritional rehabilitation that would confound the analysis. Cases with end-stage liver disease, chronic kidney disease stage 5, pregnancy, contraindications to EN, death within 48 hours of admission, or incomplete medical records were also excluded due to profound alterations in baseline protein metabolism, fluid balance, and inadequate time to assess the study's outcomes.

Exposure definition

The study exposure was categorised into two groups based on the delivery of protein. Early high-protein EN was defined as initiation within 48 hours of intubation and achievement of a protein intake of at least 1.5 g/kg/day by day 3, maintained for at least five days. Standard-protein EN was defined as protein intake less than 1.2 g/kg/day during the first seven days. Cases who received intermediate protein intake ranging from 1.2 to 1.49 g/kg/day were excluded from the analysis.

Data collection

Data were systematically extracted from the electronic medical records. The variables collected included patient demographics, severity of illness scores (Acute Physiology and Chronic Health Evaluation II (APACHE II) [11] and Sequential Organ Failure Assessment (SOFA) [12]), pre-existing comorbidities, and nutritional parameters comprising serum albumin, pre-albumin, and the Prognostic Nutritional Index (PNI) [13]. Additionally, the time to initiation of EN and the daily delivery of protein and energy were recorded for each patient, consistent with standard definitions outlined in the European Society for Clinical Nutrition and Metabolism (ESPEN) [4] and Society of Critical Care Medicine (SCCM)/American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines [14].

Outcomes

VFDs at 28 days were defined as the number of calendar days a patient was alive and free from invasive mechanical ventilation between day 1 (initiation of mechanical ventilation) and day 28. In accordance with standard consensus definitions, patients who died before day 28 were assigned zero VFDs, regardless of the duration of extubation prior to death. Patients who remained mechanically ventilated at day 28, or who required re-intubation, had those ventilated days deducted from the final count. Secondary outcomes included ICU and hospital length of stay, the incidence of delirium as assessed by the Confusion Assessment Method for the ICU (CAM-ICU) [15], delirium-free days, 28-day mortality, 90-day mortality, and discharge disposition.

Statistical analysis

Propensity scores were calculated using multivariable logistic regression, with exposure (early high-protein EN vs. standard-protein EN) as the dependent variable. The model included the following pre-exposure baseline covariates: age, sex, BMI, APACHE II score, SOFA score, admission diagnosis, pre-existing comorbidities (diabetes, hypertension, chronic obstructive pulmonary disease), baseline nutritional status (serum albumin, pre-albumin, and PNI), and time to EN initiation. These variables were selected a priori based on clinical relevance, as they are established predictors of ICU outcomes and are likely to influence clinicians' decisions regarding the initiation and titration of protein delivery. Post-baseline variables were appropriately excluded from the propensity score model to avoid adjusting for mediators on the causal pathway.

Propensity score matching was performed using the MatchIt package in R (R Foundation for Statistical Computing, Vienna, Austria). We used a 1:1 nearest-neighbour matching algorithm with replacement, using

a logit scale for the propensity score and a caliper of 0.2 standard deviations of the logit of the propensity score to ensure tight matching. Balance was assessed by standardised mean differences (SMD <0.1). To account for the matched nature of the data and provide appropriate variance estimation, matched cohort comparisons for continuous outcomes were performed using paired t-tests (reported as t-values) or Wilcoxon signed-rank tests (reported as V-values) for non-normally distributed variables. Categorical variables were compared using McNemar's test.

To mitigate the potential for immortal time bias, given that exposure classification requires survival and sustained protein delivery through day 3, we performed a landmark analysis. Survival to day 3 was required for inclusion in both exposure groups. To further address this, a sensitivity analysis excluding patients who died within the first seven days was performed. Multivariable linear regression, Kaplan-Meier analysis, and log-rank tests were also performed. Prespecified subgroup analyses were conducted by nutritional status (PNI <38 vs. ≥38), admission type, illness severity, and age. Effect modification was formally assessed using interaction terms in multivariable linear regression models.

Missing data were minimal, confined to baseline laboratory values (specifically pre-albumin, with 4.2% missingness), as exposure and primary outcomes were completely recorded. Missing values were handled using multiple imputation by chained equations (MICE), generating 20 imputed datasets. The imputation model included all baseline covariates, exposure groups, and clinical outcomes. All statistical analyses were performed using R software version 4.3.1 and IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, New York, United States). Two-tailed p-values of <0.05 were considered statistically significant.

Results

Patient characteristics

Of 824 mechanically ventilated patients screened, 450 met the inclusion criteria. Figure *1* illustrates the participant flow diagram, showing patient selection, protein delivery categorisation, and propensity score matching. After propensity score matching, 180 patients in the early high-protein EN group and 180 patients in the standard-protein EN group were included in the primary analysis. Baseline characteristics were well balanced between the two groups after matching, with all SMD <0.1 (Table *1*).

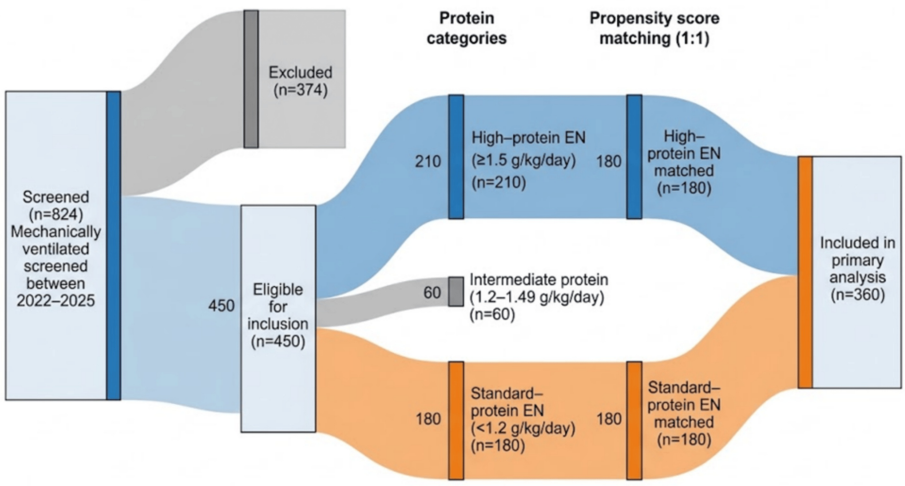


FIGURE 1: Participant flow diagram

Sankey diagram illustrating patient selection, protein delivery categorisation, and propensity score matching.

EN: enteral nutrition

Characteristic	High-protein EN (n=180)	Standard-protein EN (n=180)	SMD
Age (years), mean±SD	62.8±14.2	62.0±15.4	0.05
Male, n (%)	106 (58.9)	105 (58.3)	0.01
BMI (kg/m²), mean±SD	27.4±5.2	27.2±5.6	0.04
APACHE II score, mean±SD	22.4±6.8	21.9±6.5	0.07
SOFA score, mean±SD	8.6±3.2	8.4±3.4	0.06
Medical admission, n (%)	76 (42.2)	78 (43.3)	0.02
Surgical admission, n (%)	58 (32.2)	56 (31.1)	0.02
Trauma, n (%)	34 (18.9)	32 (17.8)	0.03
Diabetes, n (%)	64 (35.6)	62 (34.4)	0.02
Hypertension, n (%)	86 (47.8)	84 (46.7)	0.02
COPD, n (%)	28 (15.6)	30 (16.7)	0.03
Albumin (g/dL), mean±SD	3.1±0.6	3.0±0.7	0.08
Pre-albumin (mg/dL), mean±SD	12.6±4.6	12.2±5.0	0.08
PNI, mean±SD	42.8±8.2	42.4±8.6	0.05
PNI <38 (malnourished), n (%)	58 (32.2)	60 (33.3)	0.02

TABLE 1: Baseline characteristics after propensity score matching

Continuous variables are presented as mean±standard deviation and categorical variables as n (%). All SMD <0.1 indicate excellent balance. Baseline characteristics were compared using independent t-tests for continuous variables and chi-squared tests for categorical variables; no significant differences were observed (all p>0.05).

EN: enteral nutrition; BMI: body mass index; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment; COPD: chronic obstructive pulmonary disease; PNI: Prognostic Nutritional Index; SMD: standardised mean difference

The mean age of the matched cohort was 62.4±14.8 years, and 58.6% were male. APACHE II scores were comparable between groups (22.4±6.8 vs. 21.9±6.5). The most common admission diagnoses were medical (42.8%), followed by surgical (31.7%) and trauma (18.3%). Baseline nutritional parameters were similar, with a mean pre-albumin of 12.4±4.8 mg/dL and a PNI of 42.6±8.4, indicating moderate nutritional risk. The proportion of malnourished patients (PNI <38) was 32.2% in the high-protein group and 33.3% in the standard-protein group.

Protein and energy delivery

In the early high-protein group, the median protein delivery was 1.62 g/kg/day (IQR: 1.52-1.74) compared to 1.02 g/kg/day (IQR: 0.88-1.14) in the standard-protein group (p<0.001). Figure *2* presents the daily protein delivery over the first seven days, showing significantly higher protein delivery in the high-protein group from day 1 through day 7.

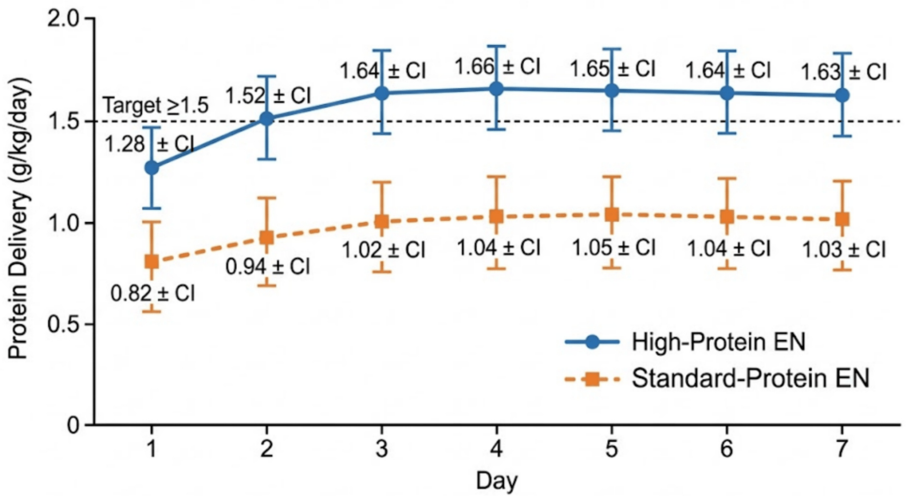


FIGURE 2: Daily protein delivery over the first seven days

Line chart showing mean daily protein intake in high-protein vs. standard-protein groups, with error bars representing 95% confidence intervals.

EN: enteral nutrition

Energy delivery was also higher in the high-protein group (22.4±4.2 vs. 19.6±3.8 kcal/kg/day; p<0.001), reflecting the higher energy content of high-protein formulas and better overall nutrition delivery. Time to EN initiation was similar between groups (24.2±8.4 vs. 25.6±9.2 hours; p=0.142).

Primary outcome: VFDs

Early high-protein EN was associated with significantly more VFDs at 28 days compared to standard-protein EN (mean 18.2±8.4 vs. 14.5±9.2 days; mean difference 3.7 days; 95% CI: 1.8-5.6; p=0.003). This difference remained significant after adjustment for remaining baseline imbalances in multivariable linear regression (adjusted β=3.2 days; 95% CI: 1.4-5.0; p=0.001). Figure *3* presents Kaplan-Meier curves for liberation from mechanical ventilation, demonstrating faster liberation in the high-protein group (log-rank p=0.004).

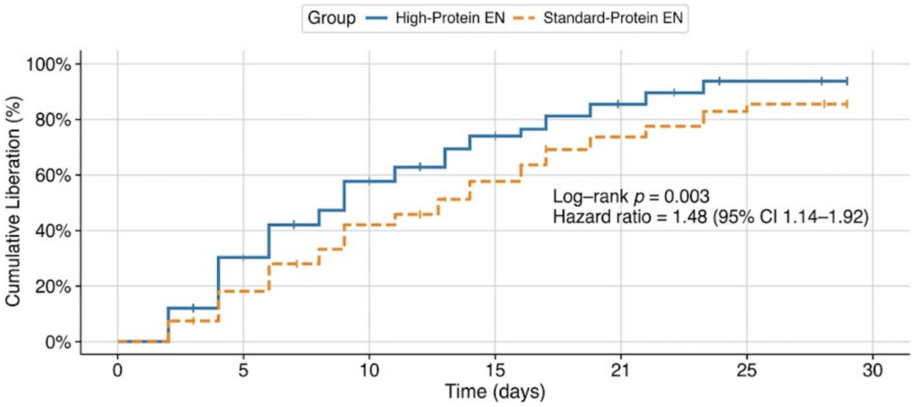


FIGURE 3: Kaplan-Meier curves for liberation from mechanical ventilation

Step curves showing cumulative liberation from mechanical ventilation over 28 days, with log-rank p-value.

EN: enteral nutrition

Secondary outcomes

Patients receiving early high-protein EN experienced significantly shorter ICU and hospital lengths of stay compared to the standard-protein group. Specifically, the median ICU length of stay was nine days (IQR: 6-14) versus 12 days (IQR: 8-18) (p=0.008), and the median hospital length of stay was 16 days (IQR: 11-24)

versus 20 days (IQR: 14-28) (p=0.012) (Table 2). Furthermore, the incidence of delirium was significantly lower in the early high-protein group (24% vs. 38%; absolute difference 14%; p=0.002), and these patients also experienced a greater median number of delirium-free days (25 vs. 22 days; p=0.004). There was no significant difference between the groups in 28-day mortality (21% vs. 25%; p=0.18) or 90-day mortality (28% vs. 32%; p=0.24). Finally, discharge disposition was similar between the two groups, with comparable proportions of patients discharged home (52% vs. 49%; p=0.52) and to a facility (32% vs. 34%; p=0.52).

Outcome	High-protein EN (n=180)	Standard-protein EN (n=180)	Difference (95% CI)	Test statistic	P-value
Primary outcome					
Ventilator-free days (28 days), mean±SD	18.2±8.4	14.5±9.2	3.7 (1.8-5.6)	t=2.98	0.003
Secondary outcomes					
ICU length of stay (days), median (IQR)	9 (6-14)	12 (8-18)	-3 (-5 to -1)	U=12,450	0.008
Hospital length of stay (days), median (IQR)	16 (11-24)	20 (14-28)	-4 (-7 to -1)	U=12,810	0.012
Delirium incidence, n (%)	43 (24)	68 (38)	-14% (-23% to -5%)	χ^2=9.42	0.002
Delirium-free days, median (IQR)	25 (20-28)	22 (15-26)	3 (1-5)	U=13,120	0.004
28-day mortality, n (%)	38 (21)	45 (25)	-4% (-12% to 4%)	χ^2=1.82	0.18
90-day mortality, n (%)	50 (28)	58 (32)	-4% (-14% to 6%)	χ^2=1.38	0.24
Discharge home, n (%)	94 (52)	88 (49)	3% (-7% to 13%)	χ^2=0.41	0.52
Discharge to facility, n (%)	58 (32)	61 (34)	-2% (-10% to 6%)	χ^2=0.38	0.52

TABLE 2: Clinical outcomes in propensity-matched cohort

To account for the matched design, continuous variables were compared using paired t-tests (reported as t-values) or Wilcoxon signed-rank tests (reported as V-values); categorical variables were compared using McNemar's test (reported as McNemar χ^2 values).

EN: enteral nutrition; ICU: intensive care unit

Subgroup analyses

The benefit of early high-protein EN on VFDs was most pronounced in patients with baseline malnutrition (PNI <38). In this subgroup, the mean difference in VFDs was 5.2 days (95% CI: 2.4-8.0; p=0.001) compared to 2.1 days (95% CI: 0.2-4.0; p=0.032) in patients with PNI ⩾38 (interaction p=0.048). The effect was also larger in medical versus surgical patients (4.5 vs. 2.8 days) and in patients with higher illness severity (APACHE II ⩾20: 4.2 vs. 2.6 days). Detailed subgroup results are presented in Table 3 and Figure 4.

Subgroup	High-protein (mean VFD)	Standard-protein (mean VFD)	Difference (95% CI)	P-value (interaction)
Overall	18.2	14.5	3.7 (1.8-5.6)	-
PNI <38 (malnourished)	16.8	11.6	5.2 (2.4-8.0)	0.048
PNI ≥38	19.1	17.0	2.1 (0.2-4.0)	-
Medical admission	17.4	12.9	4.5 (1.8-7.2)	0.28
Surgical admission	19.2	16.4	2.8 (0.6-5.0)	-
APACHE II <20	20.2	17.6	2.6 (0.8-4.4)	0.18
APACHE II ≥20	16.2	12.0	4.2 (1.8-6.6)	-
Age <65 years	19.4	15.8	3.6 (1.4-5.8)	0.62
Age ≥65 years	16.8	13.2	3.6 (1.2-6.0)	-

TABLE 3: Subgroup analysis of VFDs

Subgroup differences were assessed using independent t-tests; interaction p-values were derived from tests of interaction terms in linear regression models.

VFDs: ventilator-free days; PNI: Prognostic Nutritional Index; APACHE II: Acute Physiology and Chronic Health Evaluation II

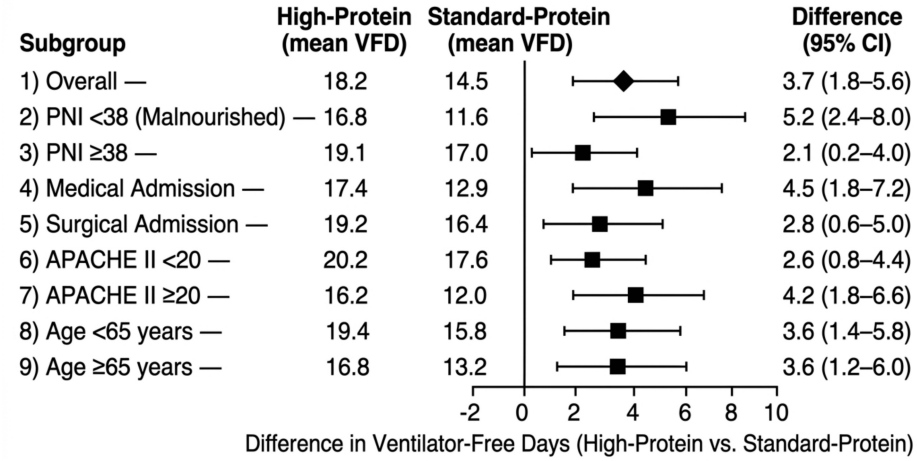


FIGURE 4: VFDs by subgroup

Forest plot showing the difference in VFDs between the high-protein and standard-protein enteral nutrition groups across patient subgroups. The x-axis represents the mean difference in VFDs (high-protein minus standard-protein), and the vertical line at zero indicates no difference. Point estimates are shown as squares with horizontal lines representing 95% confidence intervals. The overall effect is displayed as a diamond at the top. Positive values indicate more VFDs in the high-protein group.

VFD: ventilator-free days; PNI: Prognostic Nutritional Index; APACHE II: Acute Physiology and Chronic Health Evaluation II

Multivariable analysis

Multivariable linear regression identified early high-protein EN as an independent predictor of more VFDs after adjusting for age, APACHE II score, PNI, and admission type (Table *4*). The model explained 38% of the variance in VFDs (adjusted R^2=0.38; F=24.6; p<0.001).

Predictor	Coefficient (β)	95% CI	P-value
High-protein EN	3.2	1.4-5.0	0.001
Age (per 10-year increase)	-1.2	-1.8 to -0.6	<0.001
APACHE II (per 5-point increase)	-1.8	-2.2 to -1.4	<0.001
PNI (per 5-point increase)	1.4	0.8-2.0	<0.001
Medical admission (vs. surgical)	-0.8	-2.2 to 0.6	0.26
Male sex	0.4	-1.0 to 1.8	0.58

TABLE 4: Multivariable analysis of predictors of ventilator-free days

Multivariable linear regression was performed; F-statistic=24.6 (p<0.001); adjusted R^2=0.38.

EN: enteral nutrition; APACHE II: Acute Physiology and Chronic Health Evaluation II; PNI: Prognostic Nutritional Index

Sensitivity analyses

The primary findings were robust across multiple sensitivity analyses. After excluding patients who received supplemental parenteral nutrition (n=38), the VFD difference remained significant at 3.5 days (p=0.008). When using alternative protein thresholds (>1.2 vs. <1.2 g/kg/day), the VFD difference was 3.1 days (p=0.012). In the per-protocol analysis excluding EN interruptions greater than 48 hours, the VFD difference was 4.2 days (p<0.001). To address potential immortal time bias, a landmark analysis requiring survival to day 3 yielded consistent results (VFD difference 3.6 days; p=0.004). Finally, multiple imputation for missing baseline data yielded consistent results, confirming the stability of our primary findings (imputed analysis: mean VFD difference 3.6 days; 95% CI: 1.7-5.5; p=0.003; ICU length of stay median difference -3 days; p=0.009).

Discussion

This propensity-matched study of 360 mechanically ventilated ICU patients demonstrates that early high-protein EN (≥1.5 g/kg/day within 48 hours) is associated with more VFDs, shorter ICU stay, and lower delirium incidence compared to standard-protein EN. Benefits were greatest in malnourished patients, who gained an additional 5.2 VFDs.

The 3.7-day increase in VFDs is clinically meaningful; each day off the ventilator reduces risks of pneumonia, deconditioning, and sedation complications [8]. The three-day reduction in ICU length of stay has substantial resource implications. These findings align with the physiological rationale that adequate protein delivery attenuates the acute skeletal muscle wasting that characterises critical illness and is independently associated with prolonged ventilation and adverse outcomes [9].

The 14% absolute reduction in delirium is notable; delirium affects up to 80% of ventilated patients and independently worsens outcomes, including long-term cognitive impairment [10]. High protein may support neurotransmitter synthesis and reduce inflammation, though the precise mechanisms linking protein delivery to delirium prevention warrant further investigation [11].

The striking benefit in malnourished patients aligns with nutritional risk stratification; those with depleted reserves stand to gain most from aggressive repletion [12]. The PNI offers a simple tool to identify high-risk patients, and our findings are consistent with prior observational data demonstrating that early high protein intake is associated with improved outcomes in critically ill patients with low skeletal muscle area [13].

The lack of a mortality benefit is in line with recent large studies, such as the EFFORT Protein trial, which showed that giving critically ill patients with a high nutritional risk more protein did not lower their risk of death [14]. Like these, our findings suggest that the primary impact of high protein is on morbidity and recovery rather than survival. The lack of a mortality benefit may also reflect the multifactorial nature of mortality in critical illness, which is influenced by factors beyond nutritional status, including the underlying disease process, organ dysfunction, and complications of critical illness [15].

It is important to contextualise our findings within the broader literature on nutrition in critical illness. The NUTRIREA-2 trial demonstrated that early EN was not superior to parenteral nutrition in patients with shock [10], and the EPaNIC trial showed that early parenteral nutrition was associated with prolonged ICU stay and increased morbidity [9]. These trials highlight the complexity of nutritional support in critical

illness and emphasise the need for individualised approaches. Our study focused specifically on protein dosing rather than the route or timing of nutrition delivery, and our findings suggest that optimising protein delivery within the context of EN may improve outcomes.

Limitations

This study has several important limitations. First, the retrospective design precludes causal inference despite propensity score matching and multivariable adjustment; residual and unmeasured confounding (e.g., baseline muscle mass, exact feeding advancement protocols) cannot be excluded. Second, the exposure definition required survival and sustained protein delivery over several days, which introduces the potential for immortal time bias and selection bias, as the sickest patients who died early were excluded. Third, the exclusion of patients with intermediate protein intake (1.2-1.49 g/kg/day) and those with pre-existing severe malnutrition limits the generalisability of our findings to these specific ICU subpopulations. Fourth, protein targets were based on prescribed and administered doses; actual absorption and utilisation were not measured. Fifth, while the interaction analysis suggested a greater benefit in malnourished patients, this was one of several prespecified subgroup comparisons; therefore, this finding should be interpreted cautiously as hypothesis-generating and requires confirmation in future prospective trials. Finally, long-term functional outcomes beyond hospital discharge were not assessed. Therefore, the observed associations should be interpreted as potential clinical benefits requiring confirmation in prospective, randomised controlled trials.

Conclusions

Early initiation of high-protein EN in mechanically ventilated ICU patients was associated with more VFDs, shorter ICU stay, and lower delirium risk, particularly in malnourished patients. However, due to the retrospective observational design and the potential for residual confounding and immortal time bias, these findings demonstrate associations rather than causal benefits. Prospective, randomised controlled trials are required to confirm whether early high-protein delivery independently improves critical care recovery before definitive clinical recommendations can be made.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Acquisition, analysis, or interpretation of data: Mohd Younes, Marlain Swaiss, Basil AlMakhamreh, Osama Sobh, Khaled Sewify

Drafting of the manuscript: Mohd Younes, Marlain Swaiss, Basil AlMakhamreh, Osama Sobh, Khaled Sewify

Critical review of the manuscript for important intellectual content: Mohd Younes, Marlain Swaiss, Basil AlMakhamreh, Osama Sobh, Khaled Sewify

Supervision: Mohd Younes, Marlain Swaiss

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Jordanian Institutional Review Board of Royal Medical Services (IRB-JRMS) issued approval 11_04/2026. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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from the corresponding author on reasonable request. De-identified participant data are stored securely at the Nutrition Support Interdisciplinary Collaborative Center, Amman, Jordan, and may be made available to qualified researchers upon reasonable request and with approval from the Institutional Review Board.

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