ORIGINAL ARTICLE

Effect of dietitian-guided nutritional support on intensive care units length of stay and nutritional risk in critically Ill patients

Shakiba Rahimi[1], Omid Moradi-Moghadam[2], Mehdi Yadollahzadeh[3,4], Pardis Irandoost[5], Marzieh Nojomi[6], Mojtaba Mahjour[7], Parvin Hassanzadeh[8], Azadeh Mottaghi[1]

[1]Research Center for Prevention of Cardiovascular Diseases, Institute of Endocrinology Metabolism, Iran University of Medical Sciences, Endocrinology & Metabolism, Tehran, Iran, [2]Trauma and Injury Research Center, Iran University Medical Science, Tehran, Iran, [3]Department of Internal Medicine, School of Medicine, Firoozgar General Hospital, Iran University of Medical Sciences, Tehran, Iran, [4]Firoozgar Clinical Research Development Center, Iran University of Medical Sciences, Tehran, Iran, [5]Department of Nutritional Sciences, School of Public Health, Iran University of Medical Sciences, Tehran, Iran, [6]Preventive Medicine and Public Health Research Center, Psychosocial Health Research Institute, Iran University of Medical Sciences, Tehran, Iran, [7]Department of Internal Medicine, School of Medicine, Firoozgar Hospital, Iran University of Medical Sciences, Tehran, Iran, [8]Gastrointestinal and Liver Diseases Research Center, Iran University of Medical Sciences, Tehran, Iran

Background: Nutritional support is essential for the recovery of critically ill patients in intensive care units (ICUs). However, the clinical impact of dietitian-guided interventions, particularly on ICU length of stay and nutritional risk scores, remains underexplored. This study evaluated the effect of personalized, dietitian-guided nutritional support (DGNS) versus physician-directed care on ICU length of stay and nutritional status. **Materials and Methods:** In this quasi-experimental study conducted at two centers in Tehran between June 2022 and February 2023, adult ICU patients with an expected stay of five days or more received either DGNS or physician-directed care. The primary outcome was ICU length of stay. Secondary outcomes included changes in nutritional risk scores, assessed using the Nutrition Risk Screening (NRS-2002) tool and the Nutrition Risk in Critically Ill (NUTRIC) score. Parametric and nonparametric tests were used to compare the two groups, and multivariable linear regression was performed to adjust for potential confounders. **Results:** Among 107 patients (52 intervention, 55 control), adjusted analysis showed significantly shorter ICU stay in the intervention group β: −2.53; (95% confidence interval [CI]: −4.66, −0.39); $P = 0.021$. Nutritional risk scores improved more in the intervention group (median change in NRS-2002: −2.0 [interquartile range (IQR): −3.0 to − 1.0] vs. 0.0 [IQR: −1.0–0.0]; $P < 0.001$); NUTRIC: −1.0 [IQR: −2.0–0.0] vs. 0.0 [IQR: 0.0–0.0]; $P < 0.001$). New infections (7.7% vs. 38.2%) and pressure ulcers (3.8% vs. 18.2%) were less frequent in the intervention group ($P < 0.05$). No difference in 28-day mortality was noted. **Conclusion:** Dietitian-guided personalized nutrition reduced ICU stay and improved nutritional status, emphasizing dietitians' role in ICU care. Further randomized trials are warranted to confirm these findings.

Key words: Critically Ill patients, dietitian-guided nutritional support, intensive care units, length of stay, nutritional risk

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INTRODUCTION

The importance of dietitian-guided nutritional support (DGNS) and its crucial role in recovery, mortality rates, and length of hospitalization, particularly among critically ill patients in intensive care units (ICUs), has been widely recognized.[1] ICU patients experience a catabolic state accompanied by anorexia, inflammation, and endocrine stress responses, predisposing them to malnutrition, delayed recovery, and worsened clinical outcomes.[2] Consequently, approaches to providing

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Address for correspondence: Dr. Azadeh Mottaghi, Research Center for Prevention of Cardiovascular Diseases, Institute of Endocrinology and Metabolism, Iran University of Medical Sciences, Tehran, Iran.
E-mail: mottaghi.a@iums.ac.ir, mottaghi.azadeh@gmail.com
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sufficient protein and energy to meet metabolic demands have been extensively studied in ICU settings.[3]

While there has been a strong emphasis on delivering optimal nutrition to ICU patients, recent findings from large-scale randomized clinical trials indicate that full caloric and protein support during the early period of critical illness may paradoxically result in adverse clinical outcomes.[4-6] For instance, a recent study demonstrated that early calorie and protein restriction in ICU patients was associated with faster recovery and decreased complications.[7] Another trial demonstrated that early higher protein supplementation correlated with worse quality of life indicators and did not enhance clinical outcomes.[8] In addition, discrepancies exist between European and American guidelines for pragmatic and optimal nutritional strategies for critically ill patients. In contrast to the ASPEN guidelines, which advocate for increased caloric and protein intake based on weight, the ESPEN guidelines support a more personalized and conservative approach with gradual energy increases.[9,10] These discrepancies can result in conflicting therapeutic practices, complicating the provision of optimal nutritional treatment, particularly for patients with multiple comorbidities.

Recently, the role of nutritionists in ICU patient nutrition management has gained attention. However, clinical trials examining the direct impact of DGNS on patient outcomes remain scarce. A recent randomized controlled trial in China demonstrated that multidisciplinary nutrition management, incorporating clinical nutritionists, significantly improved nutritional indices and clinical outcomes in critically ill patients compared to routine care.[11] Another study revealed that support from a nutritional team significantly enhanced the achievement of dietary objectives in ICU patients.[12] Conversely, a study by Gonzalez-Granda *et al*. showed that DGNS did not reduce mortality, hospital length of stay, or adverse nutritional outcomes in ICU patients.[13] Nonetheless, there remains a significant knowledge gap regarding how dietitians, as certified professionals, can impact ICU patients' outcomes by actively delivering individualized nutritional treatment.

We conducted a quasi-experimental study to assess whether individualized DGNS, administered by a certified dietitian, would reduce ICU length of stay and improve nutritional and clinical outcomes compared with standard physician-directed care. We hypothesized that patients receiving dietitian-guided nutrition support would have a significantly shorter ICU stay, along with improved nutritional status and fewer ICU-acquired complications.

MATERIALS AND METHODS

Study design and setting

This double-center, 4-week, quasi-experimental study was conducted in two university hospitals of Tehran, Iran, from June 2022 to February 2023. The two centers were selected because they serve comparable patient populations and operate under similar ICU organizational structures, staffing models, and general clinical care standards. To enhance methodological uniformity, identical eligibility criteria, data collection procedures, outcome definitions, and nutritional assessment tools were applied across both hospitals. Nutritional care differed by study site, reflecting routine clinical practice: physician-directed nutrition without a standardized protocol at Firoozgar Hospital (control group) and protocolized DGNS at Rasool-Akram Hospital (intervention group), delivered according to ESPEN guidelines. This pragmatic, site-based approach allowed evaluation of DGNS under real-world conditions while maintaining consistency in study design and outcome assessment. Adult patients aged 18 years with an estimated stay of more than 5 days in the ICU were included in the study. The exclusion criteria were as follows: (1) severe hepatic dysfunction (Child–Pugh class C); (2) dialysis treatment; (3) recent coronary artery bypass graft surgery; and (4) failure to initiate DGNS within 48 h of ICU admission due to medical contraindications. Finally, a total of 107 patients were screened for eligibility and subsequently included in the study.

Ethics

The research was registered with the Iranian Clinical Trial Registry, (IRCT20200405046951N2). Ethical approval was obtained from the Ethics Committee of Iran University of Medical Sciences, (IR.IUMS.REC.1401.429). Since most patients had impaired consciousness and were unable to express their opinions, informed consent form was obtained from their first-degree relatives prior to enrollment.

Data collection and definitions

Data were gathered using standardized clinical questionnaires and a review of each patient's medical records. Collected variables included demographics, comorbidities, and laboratory and clinical parameters. The Acute Physiology and Chronic Health Evaluation (APACHE) II score and the Sequential Organ Failure Assessment (SOFA) scores were documented to evaluate disease severity and multiple organ failure in ICU patients, respectively.

Nutritional status was assessed using the Nutrition Risk Screening (NRS-2002) tool and the Nutrition Risk in Critically Ill (NUTRIC) Score. The NRS-2002 was developed as a validated instrument for identifying patients at nutritional risk.[14] This tool assesses two domains:

(1) nutritional status, scored on a 0–3 scale based on body mass index, recent unintentional weight loss, and reduced dietary intake during the preceding week, and (2) illness severity, scored similarly by evaluating metabolic stress from acute conditions (such as trauma, surgery, malignancy, and critical illness) or chronic comorbidities that increase nutritional demands. Total NRS-2002 scores are calculated by adding the nutritional status, illness severity, and age adjustment scores. Scores range from 0 to 7, where 0–3 indicates low risk, 4 indicates at-risk, and 5–7 indicates high risk, necessitating early DGNS.[15]

The NUTRIC Score assesses nutritional risk based on age, APACHE II score, SOFA score, number of comorbidities, days from hospital to ICU admission, and IL-6 levels, with scores ranging from 1 to 10. A score of 0–5 indicates low risk, while 6–10 indicates high risk requiring aggressive DGNS.[16]

Sample size calculation

According to a previous literature,[17] detecting a 5-day difference in ICU stay length with 80% power and a 0.05 significance level required at least 41 patients per group. Regarding potential dropouts during the trial, we decided to include 50 patients in each of the intervention and control groups. Although our prespecified sample size was 100 participants, chosen to allow for potential dropouts, consecutive enrollment resulted in a final sample of 107 participants; this retained adequate power for the primary outcome.

Intervention

Following recruitment, patients were allocated into intervention and control groups. Those admitted to the Firoozgar hospital (control group, $n = 55$) received nutritional care based on the physician's decision, while those at the Rasool-Akram hospital (intervention group, $n = 52$) received individualized nutrition support administered by a certified dietitian following ESPEN guidelines.

This pragmatic allocation reflected operational availability of a dedicated ICU dietitian at Rasool-Akram during the study period and allowed evaluation of real-world implementation.

About the control group, DGNS was determined at the discretion of the attending ICU physicians, relying on their individual clinical judgment and experience, and was not based on a specific protocol. The intervention group received individualized nutritional plans developed by a certified dietitian according to ESPEN guidelines for up to 28 days. Daily energy and protein targets were individualized based on clinical condition and gradually raised from day 1 to day 28, reaching a target intake of 25–30 kcal/kg/day for energy and 1.2–2 g/kg/day for protein, calculated using adjusted body weight. All subjects were administered DGNS through enteral route. Adherence to the dietitian prescription was monitored daily. The dietitian recorded prescribed versus delivered energy and protein each day and calculated the proportion of ICU days on which targets were met. Adherence reports and weekly audits were used to optimize delivery. Outcome data collection was performed by investigators blinded to intervention allocation.

It is worth mentioning that both hospitals followed the same national ICU standards, used comparable admission criteria, and provided similar levels of critical care, including staffing structure and the availability of diagnostic and therapeutic resources. To minimize center-related confounding, baseline demographic and clinical characteristics were carefully compared, and variables showing imbalance were adjusted for in multivariable regression analyses.

Primary and secondary outcomes

The primary outcome of this study was the impact of individualized DGNS on the duration of ICU stay. Secondary outcomes included changes in nutritional risk scores from baseline to the end of the ICU stay or up to 28 days. Additional secondary outcomes involved the incidence of ICU-acquired complications, including new pressure ulcers, infections occurring after 48 h of intervention, renal dysfunction, hepatic dysfunction, and the need for unplanned surgical or therapeutic procedures.

Urine output was recorded from nursing charts throughout the ICU stay. Renal dysfunction was defined as urine output <0.5 mL/kg/h for >6 consecutive hours or a glomerular filtration rate (GFR) <50 mL/min/1.73 m^2 at any point during the ICU stay. For outcome comparisons we recorded whether a patient ever met the renal dysfunction criterion during the observation period. Hepatic dysfunction was defined as a threefold increase in liver function tests (LFTs) or bilirubin levels >2.1 mg/dL.

Statistical analysis

Categorical variables are presented as frequency (percentage), and continuous variables are expressed as mean ± standard deviation, or medians with interquartile range (IQR), depending on the distribution. Normality of distributions was tested using the Shapiro–Wilk test and visual inspection of Q-Q plots and histograms. Depending on the distribution of continuous variables, parametric statistical tests or equivalent nonparametric statistical tests were used. Group comparisons were performed using independent samples *t*-tests or Mann–Whitney *U* tests for continuous variables and Chi-square tests or Fisher's exact test for categorical variables, as appropriate. The analysis of changes in numerical variables from the beginning to the end of the

intervention was conducted as follows: within each group, changes were assessed using paired samples *t*-tests or Wilcoxon signed-rank tests and for between groups, the magnitude of change (postintervention minus baseline) was compared using independent samples *t*-tests or Mann–Whitney *U* tests.

Chi-square tests or Fisher's exact test was used to assess relationships between nutritional status and clinical outcomes. To evaluate the association between the dietitian-guided support (intervention) and ICU stay duration, we first performed a simple linear regression to estimate the unadjusted effect. We then to further examine the independent association between the DGNS and ICU length of stay, a multiple linear regression analysis was performed adjusting sequentially for potential confounding variables, including age, insulin use, history of renal disease, heart attack, hyperlipidemia, and hypertension. Results of regression models are presented as unstandardized beta coefficients (β) and 95.0% confidence interval (CI) for β with corresponding *P* values. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., 2017. Armonk, NY, USA). A $P < 0.05$ was considered statistically significant.

RESULTS

A total of 107 patients met the inclusion criteria and were enrolled in the study, with 52 patients allocated to the intervention group and 55 to the control group.

Baseline characteristics

Table 1 summarizes the demographics and clinical characteristics of the participants. Slightly more than half of patients were male (53.3%, 57/107), and most were married (70%, 75/107). Patients in the control group were significantly older than those in the intervention group (mean age: 70.89 ± 14.23 years vs. 57.1 ± 16.11 years, $P < 0.001$). There were no significant differences in other baseline characteristics between the groups ($P > 0.05$ for all comparisons).

Several comorbidities were significantly more prevalent in the control group, including hypertension (70.9% vs. 42.3%, $P = 0.003$), hyperlipidemia (45.5% vs. 21.2%, $P = 0.008$), renal disease (20.0% vs. 3.8%, $P = 0.011$), a history of a heart attack (25.5% vs. 7.7%, $P = 0.014$), and insulin injection (27.3% vs. 9.6%, $P = 0.019$). While the prevalence of diabetes mellitus, liver disease, chronic obstructive pulmonary disease, autoimmune diseases, and asthma/allergies was similar across both groups (all $P > 0.05$). Given these baseline differences, subsequent analyses were adjusted for these potential confounders.

Changes in laboratory variables

Changes in laboratory parameters before and after the intervention are summarized in Table 2. Both groups experienced statistically significant weight loss over the study period; However, weight loss was less in the intervention group (−1.13 ± 1.60 kg) compared to the control group (−2.75 ± 1.86 kg, $P < 0.001$), indicating better nutritional preservation in patients receiving dietitian-guided support.

Systolic blood pressure (SBP) decreased significantly in the intervention group but remained unchanged in the control group, with a significant between-group difference ($P = 0.005$). The APACHE II score declined significantly only in the control group, with no significant between-group difference in the magnitude of change ($P = 0.074$).

Serum creatinine levels improved significantly in the control group but showed no significant change in the intervention group; however, the between-group difference was not statistically significant ($P = 0.108$). Hematocrit decreased significantly in the intervention group ($P < 0.001$), although the between-group difference did not reach statistical significance.

Alanine aminotransferase and aspartate aminotransferase (AST) levels increased significantly in the intervention group ($P = 0.009$ and $P = 0.028$, respectively), whereas AST decreased in the control group; however, no significant between-group differences were observed. Other parameters, including SOFA score, platelet count, bilirubin, and alkaline phosphatase, changed significantly only in the control group, without significant between-group differences.

Changes in nutritional risk scores

Significantly greater improvements in nutritional risk scores were observed in the intervention group compared to the control group. The NRS-2002 score decreased significantly in the intervention group (median before: 6.0 [IQR: 3.0] vs. after: 4.0 [IQR: 1.0]; $P < 0.001$), whereas the reduction in the control group was not statistically significant (median before: 5.0 [IQR: 2.0] vs. after: 5.0 [IQR: 3.0]; $P = 0.126$). The between-group difference in NRS-2002 score changes was highly significant ($P < 0.001$). Similarly, the NUTRIC score improved significantly in the intervention group (median before: 6.0 [IQR: 3.0] vs. after: 5.0 [IQR: 1.0]; $P < 0.001$), while no significant change was observed in the control group (median before: 8.0 [IQR: 1.0] vs. after: 8.0 [IQR: 1.0]; $P = 0.493$). This between-group difference was also statistically significant ($P < 0.001$) [Table 2].

Table 1: Demographics and clinical characteristics of study participants

Baseline characteristic	Total (*n*=107)	Intervention group (*n*=52)	Control group (*n*=55)	*P*[§]
Gender				
Male	57 (53.3)	31 (59.6)	26 (47.3)	0.201
Female	50 (46.7)	21 (40.4)	29 (52.7)	
Age (years)	64.19±16.61	57.10±16.11	70.89±14.23	<0.001
Marital status				
Single	27 (25.2)	18 (34.6)	9 (16.4)	0.055
Married	75 (70.1)	33 (63.5)	42 (76.4)	
Widow	5 (4.7)	1 (1.9)	4 (7.3)	
BMI (kg/m^2), median (IQR)	24.22 (4.86)	24.11 (4.10)	25.39 (4.92)	0.551
Cigarette smoking				
Yes	20 (18.7)	10 (19.2)	10 (18.2)	0.889
No	87 (81.3)	42 (80.8)	45 (81.8)	
Opium				
Yes	23 (21.5)	8 (15.4)	15 (27.3)	0.135
No	84 (78.5)	44 (84.6)	40 (72.7)	
Education				
Illiterate	19 (17.8)	4 (7.7)	15 (27.3)	0.052
Student	1 (0.9)	1 (1.9)	0	
Primary school	27 (25.2)	13 (25)	14 (25.5)	
6th degree	18 (16.8)	10 (19.2)	8 (14.5)	
Diploma	22 (20.6)	15 (28.8)	7 (12.7)	
Bachelor	18 (16.8)	9 (17.3)	9 (16.4)	
Master	2 (1.9)	0	2 (3.6)	
Job				
Unemployed	27 (25.2)	13 (25)	9 (25.5)	0.203
Government employer	13 (12.1)	6 (11.5)	9 (12.7)	
Freelancer	30 (28.0)	19 (36.5)	9 (20)	
Housekeeper	36 (33.6)	13 (25)	9 (41.8)	
Student	1 (0.9)	1 (1.9)	0	
Diabetes (yes)	35 (32.7)	15 (28.8)	20 (36.4)	0.407
Insulin use	20 (18.7)	5 (9.6)	15 (27.3)	0.019
Renal disease (yes)	13 (12.1)	2 (3.8)	11 (20.0)	0.011
Liver disease (yes)	6 (5.6)	1 (1.9)	5 (9.1)	0.107
Heart attack (yes)	18 (16.8)	4 (7.7)	14 (25.5)	0.014
Allergy/asthma (yes)	1 (0.9)	0	1 (1.8)	0.329
COPD (yes)	6 (5.6)	4 (7.7)	2 (3.6)	0.362
Autoimmune disease (yes)	2 (1.9)	0	2 (3.6)	0.165
Hyperlipidemia (yes)	36 (33.6)	11 (21.2)	25 (45.5)	0.008
Hypertension (yes)	61 (57.0)	22 (42.3)	39 (70.9)	0.003
History of diabetes or CVD in first-degree family (yes)	25 (23.4)	14 (26.9)	11 (20.0)	0.398
Multivitamin use (yes)	21 (19.6)	9 (17.3)	12 (21.8)	0.557

[§]Bolded values are significant at the <0.05 level. *P*<0.05 was considered statistically significant. Data are presented as *n* (%) for categorical variables and mean±SD for continuous variables. SD=Standard deviation; BMI=Body mass index; COPD=Chronic obstructive pulmonary disease; CVD=Cardiovascular disease; IQR=Interquartile range

Clinical outcomes

Table 3 outlines the clinical outcomes during the study. The occurrence of new pressure ulcers was significantly higher in the control group compared to the intervention group (18.2% vs. 3.8%, $P = 0.019$). Furthermore, the incidence of infections occurring 48 h after the start of the intervention was meaningfully greater in the control group (38.2% vs. 7.7%, $P < 0.001$). However, other clinical parameters, including reduced urine output, decreased GFR, elevated LFTs, or the need for unplanned surgical or therapeutic interventions did not show statistically significant differences between groups (all $P > 0.05$).

Regression analysis of intensive care unit stay duration (association between intervention and intensive care unit length of stay) (multiple linear regression analysis)

In the unadjusted (crude) simple linear regression model, allocation to DGNS was associated with a reduction in ICU length of stay of 3.28 days (β: −3.28; 95% CI for β: (−5.14, −1.41); $P = 0.001$). After adjustment for age (Model 1), the association persisted (β: −2.61; 95% CI for β: [− 4.65, −0.58]; $P = 0.012$). In the fully adjusted Multiple Linear Regression model controlling for age, insulin use, history of renal disease, prior myocardial infarction,

Table 2: Laboratory parameters before and after intervention

Laboratory parameters	Intervention group (*n*=52)			Control group (*n*=55)			*P*
	Before	After	*P*	Before	After	*P*	
Weight (kg)	71.38±13.57	70.25±13.77	<0.001[a]	67.65±10.62	64.91±10.21	<0.001[a]	<0.001[c]
SBP (mmHg)	127.50 (42)	120.00 (24)	<0.001[b]	120.00 (31)	120.00 (30)	0.723[b]	0.005[d]
APACHE II score	5.00 (7)	3.50 (8)	0.148[b]	19.00 (9)	17.00 (8)	0.005[b]	0.074[d]
Creatinine (mg/dl)	1.10 (0.5)	1.05 (1.6)	0.835[b]	1.33 (1.3)	1.14 (1.4)	0.009[b]	0.108[d]
Hematocrit (%)	36.12±7.06	32.15±6.74	<0.001[a]	33.71±7.78	32.16±5.97	0.059[a]	0.054[c]
White blood cell cunt (10^9 cells/L)	9.95 (4.0)	8.59 (5.2)	0.626[b]	9.90 (7.0)	9.50 (4.9)	0.179[b]	0.891[d]
GCS	11.00 (5)	13.50 (7)	0.014[b]	11.00 (6.0)	11.00 (6.0)	0.047[b]	0.120[d]
SOFA score	4.50 (4)	3.00 (6.0)	0.930[b]	9.00 (3.0)	8.00 (4.0)	0.025[b]	0.242[d]
Platelets (103/μL)	192.00 (105.0)	200.00 (106.0)	0.985[b]	199.00 (142.0)	167.00 (131.0)	0.023[b]	0.215[d]
Bilirubin (mg/dl)	0.70 (0.85)	0.90 (0.80)	0.126[b]	0.84 (0.50)	0.95 (0.44)	0.003[b]	0.893[d]
ALT (units/L)	22.00 (13)	28.00 (39.0)	0.009[b]	30.00 (25)	32.00 (28)	0.300[b]	0.114[d]
AST (units/L)	28.00 (20)	34.00 (25)	0.028[b]	35.00 (26)	34.00 (41)	0.007[b]	0.842[d]
ALP	216.00 (144)	211.00 (141)	0.436[b]	285.00 (184)	316.00 (185)	0.037[b]	0.059[d]
NRS-2002	6.00 (3)	4.00 (1)	<0.001[b]	5.00 (2)	5.00 (3)	0.126[b]	<0.001[d]
NUTRIC score	6.00 (3)	5.00 (1)	<0.001[b]	8.00 (1)	8.00 (1)	0.493[b]	<0.001[d]

[a]Paired samples *t*-test for within-group comparisons, [b]Wilcoxon signed-rank test for within-group comparisons, [c]Independent samples *t*-test for between-group comparisons of change scores, [d]Mann–Whitney *U*-test for between-group comparisons of change scores; [§]Bolded values are significant at the <0.05 level. Data are presented as mean±SD or median (IQR) for continuous variables. APACHE II=Acute Physiology and Chronic Health Evaluation II; GCS=Glasgow Coma Scale; SBP=Systolic blood pressure; SOFA=Sequential Organ Failure Assessment; ALT=Alanine aminotransferase; AST=Aspartate aminotransferase; ALP=Alkaline phosphatase; SD=Standard deviation; IQR=Interquartile range; NUTRIC=Nutrition Risk in the Critically Ill; NRS=Nutritional Risk Screening 2002

Table 3: The clinical outcomes of patients during intervention

Clinical outcomes	Intervention (*n*=52)	Control (*n*=55)	*P*[§]
ICU stay duration (days)	10.56±4.70	13.84±4.99	**0.001**
Urine volume ≤0.5 cc/kg for more than 6 h	19 (36.5)	14 (25.5)	0.215
GFR ≤50	22 (42.3)	17 (30.9)	0.221
Serum bilirubin ≥1.2 mg/dl	16 (30.8)	10 (18.2)	0.129
LFT tripled	11 (21.2)	15 (27.3)	0.461
New pressure ulcer	2 (3.8)	10 (18.2)	0.019
Surgery or unplanned therapeutic interventions need	8 (15.4)	4 (7.3)	0.184
Occurrence of infection 48 h after the start of the intervention	4 (7.7)	21 (38.2)	<0.001

[§]Bolded values are significant at the <0.05 level. *P*<0.05 was considered statistically significant. Data are presented as *n* (%) for categorical variables and mean±SD. GFR=Glomerular filtration rate; LFT=Liver function test; SD=Standard deviation; ICU=Intensive care unit

hyperlipidemia, and hypertension (Model 2), DGNS remained associated with a statistically significant shorter ICU stay of approximately 2.5 days (β: −2.53; 95% CI for β: [− 4.66, −0.39]; *P* = 0.021) [Table 4].

Outcomes by nutritional risk category

Clinical outcomes were further stratified based on nutritional risk categories [Table 5]. Patients classified as high-risk by the NRS-2002 score[5-7] had significantly higher rates of reduced urine volume (*P* = 0.016) and infections (*P* = 0.001). Similarly, patients classified as high-risk based on the NUTRIC score exhibited significantly higher rates of infection (*P* = 0.033). Notably, new pressure ulcers were significantly more prevalent among patients categorized "at risk" or "high risk" for malnutrition (*P* = 0.004).

Mortality

A total of 19 patients (17.8%) died during the study period. Mortality rates were nearly identical in both groups, with 18.2% (10/55) of patients in the control group and 17.3% (9/52) in the intervention group (*P* = 0.906), indicating no statistically significant difference in survival during the 28-day follow-up period.

DISCUSSION

Our findings indicate that individualized, DGNS was associated with a clinically meaningful reduction in ICU length of stay, even after adjustment for baseline differences in age and comorbid conditions. Patients in the intervention group remained in the ICU for an average of 2.5 fewer days compared to those receiving physician-directed care. This reduction underscores the potential utility of tailored nutritional strategies in improving ICU efficiency and resource utilization. In addition to the primary outcome, the intervention was associated with significant improvements in nutritional risk profiles, as measured by the NRS-2002 and NUTRIC scores, and with a lower incidence of ICU-acquired complications, including infections and pressure ulcers. These findings are consistent

with the EFFORT trial, in which personalized DGNS in medical inpatients significantly reduced complications and improved clinical outcomes, including mortality.[3]

Our results are in line with prior clinical trials evaluating structured DGNS. In a randomized trial, Shuxia *et al*. reported that a multidisciplinary nutrition management model, including ICU physicians, nurses, dietitians, pharmacists, and radiologists, significantly improved nutritional biomarkers and reduced ICU length of stay compared with standard physician-led care.[11,18] Although their model involved a broader multidisciplinary team, our results suggest that comparable clinical improvements can be achieved through targeted, dietitian-guided support, underscoring the value of dietitian expertise within the ICU multidisciplinary team. We acknowledge that successful nutrition care depends on coordinated contributions from physicians, nurses, pharmacists and dietitians; our results should not be interpreted as minimizing the role of other team members but rather as evidence that dedicated dietitian involvement may add measurable benefit. Similar benefits have been reported in neonatal intensive care settings, where Jeong *et al*. demonstrated that implementing a multidisciplinary nutrition support team was associated with improved nutrient delivery and a significant reduction in ICU length of stay. While the physiological profiles of neonatal and adult ICU patients differ, the observed effects reinforce the general principle that early, structured nutritional care supports both metabolic stability and recovery.[19] In contrast, Oh *et al*. reported improved caloric and protein delivery but found no difference in ICU stay or survival.[20] In support of protocolized implementation, Martinuzzi *et al*. observed that nutrition support teams enhanced adherence to energy and protein targets in surgical ICU populations, contributing to improved nutritional adequacy.[12] Gonzalez-Granda *et al*. found that multidisciplinary involvement did not significantly alter patient outcomes, underscoring that the presence of a nutrition team alone may be insufficient without individualized care, clinical autonomy, and consistent implementation.[13] These contrasting findings highlight the need to move beyond uniform protocols and instead adopt tailored strategies that account for the heterogeneity of ICU patients and their evolving metabolic demands.[21]

In line with our results, a previous study reported that critically ill patients with neurological disorders receiving multidisciplinary nutrition support had lower NUTRIC scores and higher pre-albumin levels compared to those receiving conventional care.[22] Similarly, Jo *et al*. demonstrated that the involvement of a multidisciplinary nutrition team in a medical ICU improved the adequacy of caloric and protein intake, promoted greater reliance on enteral nutrition, and was associated with improved nutritional outcomes at ICU discharge.[23]

In the NUTRIREA-3 trial, a restrictive approach to early calorie and protein delivery in ventilated patients reduced complications but did not impact survival.[7] Similarly, the PRECISe trial reported that high protein provision failed to improve functional recovery or reduce mortality in critically ill adults.[8] The EAT-ICU trial also found no benefit in physical quality of life or clinical outcomes from early, goal-directed nutrition tailored through indirect calorimetry and urinary urea excretion, suggesting that meeting theoretical energy and protein targets does not guarantee improved outcomes unless contextualized within a patient-specific metabolic framework.[24] In contrast, a large cohort study by Song *et al*. in critically ill COVID-19 patients demonstrated a 40% reduction in hospital mortality associated with the implementation of a structured multidisciplinary nutrition support team, highlighting the potential for benefit in highly catabolic

Table 4: Simple and multiple linear regression analysis of intensive care unit stay duration (association between intervention and intensive care unit length of stay)

	β	SE	P[$]	95.0% CI for β
Crude	−3.28	0.94	0.001	−5.14 to −1.41
Model 1[†]	−2.61	1.03	0.012	−4.65 to −0.58
Model 2[‡]	−2.53	1.07	0.021	−4.66 to −0.39

[†]Model 1: Adjusted for age; [‡]Model 2: Adjusted for age, insulin use, history of renal disease, prior myocardial infarction, hyperlipidemia, and hypertension; [$]Bolded values are significant at the <0.05 level. *P*<0.05 was considered statistically significant. CI=Confidence interval; SE=Standard error

Table 5: The clinical outcomes of patients during intervention based on nutritional status

Clinical outcomes	NRS-2002 (*n*=107)				NUTRIC score (*n*=107)		
	Low risk	At risk	High risk	P[$]	Low risk	High risk	P[$]
Urine volume ≤0.5 cc/kg for more than 6 h	8 (24.2)	5 (15.2)	20 (60.6)	0.016	8 (24.2)	25 (75.8)	0.471
GFR ≤50	12 (30.8)	6 (15.4)	21 (53.8)	0.085	9 (29.0)	30 (39.5)	0.309
Serum bilirubin ≥1.2 mg/dl	10 (25)	5 (20.8)	11 (25.6)	0.902	6 (19.4)	20 (26.3)	0.446
LFT tripled	10 (25)	4 (16.7)	12 (27.9)	0.584	7 (22.6)	19 (25.0)	0.791
New pressure ulcer	2 (5)	0	10 (23.3)	0.004	1 (3.2)	11 (14.5)	0.094
Surgery or unplanned therapeutic interventions need	2 (5)	3 (12.5)	7 (16.3)	0.259	3 (9.7)	9 (11.8)	0.748
Occurrence of infection 48 h after the start of the intervention	5 (12.5)	2 (8.3)	18 (41.9)	0.001	3 (9.7)	22 (28.9)	0.033

[$]Bolded values are significant at the <0.05 level. Data are presented as *n* (%) for categorical variables. NRS-2002=Nutritional Risk Screening 2002; NUTRIC=Nutrition Risk in the Critically Ill; GFR=Glomerular filtration rate; LFT=Liver function test

and uniformly high-risk populations.[25] The absence of a mortality difference should be interpreted in light of several factors: (1) the study was not powered to detect differences in mortality, which requires substantially larger sample sizes; (2) the follow-up period was limited to 28 days and longer-term effects on survival or functional recovery may not be captured; and (3) mortality in critically ill populations is determined by complex, multifactorial processes beyond nutrition alone. Residual confounding due to non-randomized allocation and center effects may also have had an influence. Moreover, mortality in ICU populations is driven by multifactorial determinants such as disease severity, organ dysfunction, and the intensity of supportive therapies, which may attenuate the measurable impact of DGNS.[26]

Protein-energy malnutrition is well established as a contributor to impaired immunity and delayed wound healing, consequences that are particularly detrimental in critically ill patients.[1,2] These findings support previous evidence that DGNS can modulate systemic inflammation and attenuate the adverse cascade of metabolic stress, a mechanism implicated in the chronic low-grade inflammation that drives residual cardiovascular risk.[3,4,27] Our findings are consistent with those of Heidegger *et al*., who, in a multicenter randomized trial, reported that protocolized supplemental enteral nutrition enhanced energy intake and led to a lower incidence of infectious complications.[28] Such DGNSs address critical micronutrient deficiencies that are pivotal for immune response and tissue healing, likely explaining the observed decrease in infection rates and pressure ulcers.[29] While improved nutrition supports wound healing and skin integrity and plausibly reduces pressure-ulcer risk, we emphasize that pressure ulcer development is also strongly influenced by nursing care, repositioning practices and pressure-relieving equipment. Differences in nursing practice between centers may have contributed to the observed difference in pressure ulcer rates and this remains a potential confounder.

Some secondary physiologic variables showed between-group differences. These findings should be interpreted cautiously: baseline differences in age and comorbidity burden, as well as intercurrent therapies, may contribute to short-term changes and could reflect regression to the mean rather than a direct effect of the nutritional intervention.

The greater weight loss observed in the control group may reflect suboptimal caloric intake, which could have exacerbated muscle catabolism and contributed to immunosuppression, whereas the intervention group's adherence to individualized targets likely preserved lean body mass and metabolic stability.[30] Furthermore, the nutritionist's choice of EN over PN in eligible patients aligns with evidence that EN preserves gut integrity, reduces bacterial translocation, and lowers infection risk.[31,32] These findings are further corroborated by a randomized trial by Wang *et al*., in which early high-protein enteral nutrition at 1.5 g/kg/day improved nutritional status, shortened ICU stay, and reduced 28-day mortality in septic patients, highlighting the clinical relevance and safety of individualized high-protein regimens during early critical illness.[33]

The improved SBP observed in the intervention group may reflect enhanced hemodynamic stability, potentially supported by adequate protein intake contributing to endothelial integrity and modulation of the inflammatory response.[26,34] However, the lack of significant differences in SOFA scores or liver dysfunction between groups implies that DGNS alone cannot fully counteract organ failure driven by sepsis or chronic disease, emphasizing the need for multimodal treatment strategies in high-risk patients.[35-39]

Given the variability in outcomes observed across clinical trials and cohort studies, a growing body of literature now advocates for a shift toward individualized, systemically integrated nutritional care in the ICU. Advances in critical care nutrition science increasingly emphasize the limitations of standardized, one-size-fits-all protocols and instead support approaches grounded in metabolic and clinical phenotyping. van Zanten has called for personalized nutrition strategies informed by metabolic tolerance and disease phase, cautioning against the risks inherent in generalized feeding regimens.[40] Our findings align with this evolving consensus, supporting a transition from static caloric prescriptions to dynamic, patient-specific nutritional targets that adapt to clinical status over time. This paradigm is echoed by Wischmeyer *et al*., who advocate for the routine use of indirect calorimetry, progressive protein titration, and muscle mass monitoring to tailor interventions with greater precision.[41] Yinusa *et al*. further emphasize that multidisciplinary collaboration, clear role delineation, and strong clinical leadership are essential for successful implementation of individualized nutritional strategies.[42] Expanding on this framework, Stoian *et al*. propose a future in which critical care nutrition is enhanced by artificial intelligence, metabolomics, and nutrigenomics – technologies that may allow for even more refined, real-time adaptation of therapy in metabolically complex ICU patients.[43] Together, these perspectives underscore a shared trajectory toward precision nutrition as a central component of modern critical care, one that integrates professional expertise, collaborative structure, and emerging tools to improve both short- and long-term outcomes.

Limitations

Several limitations of this study must be acknowledged. We recognize that allocation of subjects by center may introduce center-level confounding (differences in staffing, nursing practice, or local protocols); to address this, we adjusted outcome models for measured baseline differences and key comorbidities.

The control group's older age and higher prevalence of comorbidities such as hypertension and renal disease may have independently influenced outcomes. In addition, DGNS in the control group was not guided by a standardized protocol but was instead administered at the discretion of ICU physicians based on individual clinical judgment and experience, introducing potential variability in the quality and consistency of nutrition care across patients.

The 28-day follow-up period restricted the evaluation of long-term outcomes such as functional recovery or post-ICU complications, which are essential for understanding the holistic impact of DGNS. ICU-related malnutrition has well-established effects on muscle mass, immunity, and mortality extending beyond the immediate critical phase.[30,44] Fourth, exclusion of patients with severe hepatic dysfunction, dialysis dependency, or recent cardiac surgery limits the generalizability of the findings to these high-risk groups. These populations often represent high-risk ICU cohorts who might benefit most from aggressive DGNS.[16]

Despite these limitations, the study has several strengths. The pragmatic, dual-center design reflects real-world clinical settings, and the use of validated risk assessment tools (NRS-2002 and NUTRIC) enhances the reliability of nutritional risk stratification. Moreover, the inclusion of objective clinical endpoints and standardized severity scores provides a robust framework for evaluating the impact of individualized DGNS in critically ill patients.

Clinical implications

Although the quasi-experimental design and baseline disparities in age and comorbidity profiles limit the ability to infer causality, the results are consistent with existing guideline recommendations that advocate for the integration of nutrition experts into multidisciplinary ICU teams.[45] Given that nutritional risk scores are modifiable and independently associated with outcomes, early identification of high-risk patients and timely, targeted intervention may represent a key strategy for improving clinical trajectories. The routine application of validated tools such as the NRS-2002 and NUTRIC score should be incorporated into ICU admission protocols and repeated throughout the ICU stay to guide ongoing nutritional management.[15,46,47]

More broadly, our findings support the ongoing shift in critical care nutrition away from generalized protocols and toward individualized strategies. Precision nutrition approaches that incorporate patient-specific factors such as disease severity, comorbidity burden, and metabolic demands may offer a path toward optimizing recovery while minimizing the risks of overfeeding or under-nutrition.[21,29]

CONCLUSION

DGNS was associated with reduced ICU length of stay, improved nutritional risk scores, and fewer ICU-acquired complications. Although no mortality benefit was observed, the improvements in intermediate outcomes highlight the clinical value of personalized nutritional care. These findings highlight that the success of DGNS depends not only on its design but also on the degree of clinical integration and decision-making autonomy afforded to nutrition professionals. Further randomized studies are needed to confirm these results and explore long-term outcomes.

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Conflicts of interest

There are no conflicts of interest.

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