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Original article

Comparison of Different Types of Nutritional Support in Mechanically Ventilated Critically Ill Patients

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Abstract:

Background: Critically ill patients are exposed to severe physiological stress, which triggers multiple metabolic responses, including muscle wasting and stress-induced hyperglycemia. Adequate nutritional support is crucial in managing such patients. This study aimed to assess and compare the nutritional status and clinical outcomes of mechanically ventilated critically ill patients receiving different forms of nutritional support. **Methods:** This prospective observational study was conducted on 200 critically ill patients admitted to the Critical Care Medicine Department at Benha University Hospital during the study period. Patients were randomly assigned to two main groups based on the route and type of nutritional support. Group A (100 patients) was subdivided into: A1 – 50 patients receiving conventional enteral nutrition (EN), and A2 – 50 patients receiving modified EN. Group B (100 patients) was subdivided into: B1 – 50 patients receiving conventional total parenteral nutrition (TPN), and B2 – 50 patients receiving modified TPN. **Results:** The proportion of patients achieving their feeding goal differed significantly between the groups (P=0.012), with higher rates in the modified EN group (A2), followed by conventional EN (A1), compared to both TPN groups (B1 and B2). **Conclusion:** Modified EN was associated with more favorable clinical outcomes in mechanically ventilated critically ill patients compared to parenteral nutrition. Patients receiving EN had lower follow-up APACHE II scores, shorter stays in both the ICU and hospital, and fewer complications, including infections and sepsis. Overall, EN, particularly the modified form, proved to be a more effective, safer, and preferable nutritional strategy in this patient population.

Keywords: Nutritional Support, Mechanically Ventilated, Critically, Ill Patients.

Introduction

Critically ill patients are under stress which initiates a variety of metabolic responses like muscle wasting and stress hyperglycemia. Nutritional support in these patients helps attenuate these metabolic responses to stress [1, 2].

The prevalence of malnutrition is a common problem in hospitalized patients, especially in critically ill patients who are being ventilated mechanically. Mortality in critically ill patients is highly correlated with a variety of somatic and visceral expressions of protein-calorie malnutrition, including total lymphocyte count (TLC) and muscle cell mass, low serum albumin, and transferrin ([3, 4].

It has been hypothesized that malnutrition is one of the contributing causes of organ failure in the hospital. Malnutrition decreases the regeneration of respiratory epithelium, and it may prolong mechanical ventilation by failing to restore respiratory muscle strength and endurance. However, overnutrition may also prolong mechanical ventilation by increasing carbon dioxide production, which increases the amount of ventilation necessary to maintain a steady state of arterial blood gases [5].

Enteral nutrition (EN) is usually the main route for providing nutrition therapy in patients admitted to the intensive care unit (ICU), however, parenteral nutrition (PN) may be needed to avoid the development of malnutrition when EN is contraindicated or unfeasible [6].

EN is more physiological, with various non-nutritional benefits (e.g., maintenance of structural and functional gut integrity, preservation of gut microbiome) but also disadvantages related to potential lower nutritional adequacy, particularly in the acute disease phase and in the presence of gastrointestinal dysfunction [7].

Parenteral nutrition (PN) support refers to the provision of calories, amino acids, electrolytes, vitamins, minerals, trace elements, and fluids via a parenteral route [8].

The purpose of this study was to assess and compare the nutritional status of mechanically ventilated critical ill patients who were receiving different forms of nutritional support (conventional versus modified low carbohydrate high protein fat, enriched with natural source of glutamine, arginine and omega 3 plus).

Patients and methods

The study was a prospective observational study that included 200 critically ill patients admitted to the critical care medicine department, Benha University Hospital during the period of the study from December 2023 to December 2024

An informed written consent was obtained from the patients. Every patient received an explanation of the purpose of the study and had a secret code number. The study was done after being approved by the Research Ethics Committee, Faculty of Medicine, and Benha University.

Inclusion criteria were adult critically ill patients ages more than 20 years, completing the study and requiring at least 14 days of mechanical ventilation and unconscious during the study.

Exclusion criteria were clinically unstable during the study, Respiratory deformities and pneumothorax, laryngeal edema, having complications related to the formula or its administration (i.e. clogged feeding tube, aspiration pneumonia, or hemothorax, etc.) and incomplete clinical data.

Grouping: All patients under study were randomly divided into three groups based on the type of nutritional support they received groups as follows: Group A: included 100 patients were subdivided into: Group A1: included 50 patients receiving conventional enteral nutrition (EN) and Group A2: included 50 patients receiving modified EN, Group B: included 100 patients were subdivided into: Group B1: included 50 patients received conventional parenteral nutrition (TPN) and Group B2: included 50 patients received modified parenteral nutrition.

All studied cases were subjected to the following: **Full history taking** [Demographics: Age, sex, weight, height, BMI, presenting Illness: Reason for ventilation, duration, and pre-admission nutritional status, past medical history: Chronic diseases, surgeries, malnutrition history, medication history: Current drugs, prior nutritional support, nutritional history: Dietary habits, allergies, GI disorders, social history: Alcohol, smoking, functional status and family history: Metabolic or nutritional disorders]. **Physical examination including** [General Appearance: level of consciousness, signs of distress and cachexia or obesity, vital signs: temperature, heart rate, blood pressure, respiratory rate, oxygen saturation, anthropometric measurements: weight, height, mimid-upper arm circumference (MUAC), head and neck examination: signs of dehydration (e.g., dry mucous membranes, sunken eyes) and temporal wasting, cardiovascular examination: signs of fluid overload (e.g., edema, jugular venous distension), respiratory examination: auscultation for breath sounds, signs of respiratory distress, abdominal examination: distension, tenderness, bowel sound presence of nasogastric or feeding tubes, musculoskeletal examination: Muscle wasting, strength assessment, skin examination: Pressure ulcers, rashes, or signs of micronutrient deficiencies (e.g., pallor, bruising)]. **Lab investigations including** [Blood health: complete blood count (CBC), total leukocyte count (TLC), nutritional status: serum albumin, prealbumin, iron metabolism: total iron binding capacity (TIBC), transferrin, ferritin, Kidney function: blood urea nitrogen (BUN), creatinine, 24-hour urinary creatinine excretion, liver function: aspartate aminotransferase (AST), alanine aminotransferase (ALT)].

APACHE score

The acute physiology and chronic health evaluation (APACHE) score was used when patients admitted to ICU. APACHE II uses a point score based upon initial values of 12 routine physiologic measurements, age, and previous health status to provide a general measure of severity of disease. An increasing score (range 0 to 71) was closely correlated with the subsequent risk of hospital death for 5815 intensive care admissions from 13 hospitals (9).

Estimation of basal and total energy expenditure

The basal energy expenditure (BEE) of mechanically ventilated critically ill patients was estimated using the Harris-Benedict Equation (HBE), which considered weight, height, and age. For male patients, BEE was calculated using the formula: BEE (kcal/day) = 66.47 + (13.75 × weight in kg) + (5.003 × height in cm) - (6.775 × age in years), while for female patients, the equation used was: BEE (kcal/day) = 655.09 + (9.563 × weight in kg) + (1.85 × height in cm) - (4.676 × age in years). The total energy expenditure (TEE) was determined by incorporating stress and activity factors based on the patient's clinical condition and the type of nutritional support administered.

Nutritional intake assessment

Nutritional support was provided based on the clinical assessment and recommendations of the treating physicians. Patients received enteral nutrition (EN) through a nasogastric tube, with enteral formulas selected based on individual nutritional needs. In cases where enteral feeding was insufficient or contraindicated, total parenteral nutrition (TPN) was administered as a continuous infusion via a central venous catheter.

Daily macronutrient intake, including carbohydrate, lipid, and protein, was meticulously recorded. These data were obtained from enteral nutrition, total parenteral nutrition, and intravenous crystalloid infusions, which were routinely documented by ICU nurses and dietitians. This approach facilitated an accurate

comparison of different types of nutritional support in mechanically ventilated critically ill patients.

Anthropometric and biochemical measurements

Anthropometric and biochemical measurements were obtained on both the 1st day and 14th day of ICU admission at Benha University Hospital. Weight was measured using a Seca (model 777) personal scale to the nearest 0.1 kg, while height was determined using a standard measuring tape to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Additional assessments included triceps skinfold thickness (TSF) and mid-arm circumference (MAC) to evaluate body composition. TSF was measured at the midpoint between the elbow and the acromial process of the scapula, while MAC was recorded at the midpoint between the acromion and olecranon processes.

Assessment of muscle mass and ideal body weight

Ideal body weight (IBW) was calculated using the Huang et al. formula, which adjusted for sex differences. The formula used was: IBW (kg) = (Height [cm] – 80) × 0.7 for men and IBW (kg) = (Height [cm] – 70) × 0.6 for women. Muscle mass was further assessed using mid-arm muscle circumference (MAMC), calculated as MAMC (cm) = MAC (cm) – (TSF [cm] × 3.14). Additionally, arm muscle area (AMA) was determined using the formula: AMA (mm^2) = [(MAC [mm] – (TSF [mm] × 3.14)]^2 / 4π].

Creatinine-height index (CHI) and nutritional status

To further evaluate muscle mass and protein breakdown, the creatinine-height index (CHI) was measured using 24-hour urinary creatinine excretion. This index provided insight into the patient's protein catabolism and overall nutritional status in relation to different nutritional support strategies.

Malnutrition assessment: The Maa strict index

Malnutrition was assessed using the Maastricht Index (MI), which was calculated using the formula: MI = 20.68 – (0.24 × albumin [g/L]) – (19.21 × prealbumin [g/L]) – (1.86 × lymphocytes [10^9/L]) – (0.04 × percentage of ideal weight). Patients with an MI greater than 0 were classified as malnourished. This index allowed for a comparative evaluation of the nutritional impact of different types of nutritional support in mechanically ventilated critically ill patients (10).

Outcomes

Primary outcomes: Acute physiology, and chronic health evaluation II (APACHE II) score, overall hospital length of stay and secondary outcomes: In hospital mortality, medical cost, determine several predictors of successful extubation and survival and determine the effect of nutrition on successful waning from mechanical ventilation.

Sample size estimation

Based on past review of literature estimated the incidence of mechanically ventilated critical ill patients admitted to intensive critical care unit (ICU), making a total prevalence of 10%, sample size has been calculated using the following equation: n-(X2 x P x Q)/D2 at CT 95% and they were 200 participants (50 for each group) to achieve power of 80%.

Approval Code:13-122023

Statistical analysis

Statistical analysis was done by SPSS v27 (IBM©, Armonk, NY, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric data were presented as mean and standard deviation (SD) and were analyzed by ANOVA (F) test with post hoc test (Tukey). Quantitative non-parametric data were presented as median and interquartile range (IQR) and were analyzed by Kruskal-Wallis test with Mann Whitney-test to compare each group. Qualitative

variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test. A two tailed P value < 0.05 was considered statistically significant.

Results

There was an insignificant difference between both groups regarding the baseline characteristics (age, sex, weight, height, BMI and residence), The associated comorbidities including DM, HTN, CVD, IHD, chronic renal failure and liver disease and laboratory investigations including (Hb, TLC, platelets, ALT, AST, serum albumin, serum creatinine and CRP). **Table 1**

There was an insignificant different between both groups regarding the diagnosis and The APACHE II score on admission, the vasopressor support, Maastricht index, dialysis and the incidence of bowel ischemia and incidence of mortality. The length of ICU stay, duration of MV and length of hospital stay, the daily calorie intake and total protein intake, APACHE II score at follow-up, regarding the outcome, patients who attained the feed goal, the incidence of infections, sepsis, hypokalemia, and hypophosphatemia and the gastrointestinal complications including vomiting and diarhea were significantly in group A compared to group B **Table 2**

There was an insignificant difference between among the studied subgroups regarding the baseline characteristics (age, sex, weight, height, BMI and residence), the associated comorbidities, including DM, HTN, CVD, IHD, chronic renal failure and liver disease and laboratory investigations including (Hb, TLC, platelets, ALT, AST, serum albumin, serum creatinine and CRP). **Table 3**

There was an insignificant different between studied subgroups regarding the diagnosis on admission, APACHE II score on admission, the duration of MV and vasopressor support, Maastricht index. The length of ICU stay and hospital stay were significantly shorter in group A1 compared to group B1 and group B2 (P<0.05), were significantly shorter in group A2 compared to group B1 and group B2 (P<0.05), with no signifcnat difference between group A1 and A2 and between group B1 and B2. **Table 4**

The daily calorie intake and the total protein intake were significantly lower in group A1 compared to group B1 and group B2 (P<0.05), were significantly lower in group A2 compared to group B1 and group B2 (P<0.05), with no signifcnat difference between group A1 and A2 and between group B1 and B2. APACHE II score at follow up was significantly lower in group A1 compared to group B1 and group B2 (P=0.004, 0.008), was significantly lower in group A2 compared to group B1 and group B2 (P<0.001, 0.001), with no signifcnat difference between group A1 and A2 and between group B1 and B2. Regarding the outcome, patients who attained the feed goal was significnatly different among the studied groups (P=0.012), being higher in group A2 and A1 respectively compared to group B1 and B2. The incidence of infections, sepsis, and hypokalemia was significantly different among the studied subgroups (P=0.039, 0.016, 0.002), being lower in group A1 and group A2 compared to group B1 and B2. While the incidence of vomiting and diarrhea was significantly different among the studied subgroups (P=0.047, <0.001), being higher in group A1 and group A2 compared to group B1 and B2. There was an insignificant difference among the studied subgroups regarding the patients receiving prokinetic drugs and dialysis, hypophosphatemia and bowel ischemia and mortality. **Table 5**

Table 1: Baseline characteristic, comorbidities and laboratory investigations of the studied groups

		Group A (n=100)	Group B (n=100)	P value
Age (years)	**Mean± SD**	61.4 ± 8.18	60.3 ± 9.29	0.389
	Range	43 - 78	43 - 79	
Sex	**Male**	52 (52%)	54 (54%)	0.776
	Female	48 (48%)	46 (46%)	
Weight (Kg)	**Mean± SD**	78.3 ± 11.27	77.4 ± 11.66	0.567
	Range	60 - 97	55 - 100	
Height (m)	**Mean± SD**	1.7 ± 0.05	1.7 ± 0.04	0.526
	Range	1.58 - 1.74	1.59 - 1.74	
BMI (Kg/m^2)	**Mean± SD**	28.2 ± 4.42	28 ± 4.44	0.723
	Range	20.05 - 37.25	19.49 - 36.73	
Residence	**Urban**	51 (51%)	47 (47%)	0.571
	Rural	49 (49%)	53 (53%)	
Comorbidities				
DM		36 (36%)	34 (34%)	0.776
HTN		50 (50%)	47 (47%)	0.671
CVD		19 (19%)	23 (23%)	0.487
IHD		22 (22%)	18 (18%)	0.479
Chronic renal failure		14 (14%)	14 (14%)	1.000
Liver disease		6 (6%)	7 (7%)	0.774
Laboratory investigations				
Hb (g/dL)	**Mean± SD**	11.84 ± 1.13	11.95 ± 1.04	0.471
	Range	10 - 13.9	10 - 13.7	
TLC ($*10^9/L$)	**Mean± SD**	12.42 ± 2.43	12.56 ± 2.24	0.677
	Range	8.7 - 19.6	8.8 - 18.6	
Platelets ($*10^9/L$)	**Mean± SD**	296.4 ± 37.79	298.2 ± 34.49	0.715
	Range	220 - 360	240 - 355	
ALT (U/L)	**Mean± SD**	36.98 ± 18	37.16 ± 17.7	0.943
	Range	20 - 116	20 - 109	
AST (U/L)	**Mean± SD**	36.53 ± 17.23	38.17 ± 19.91	0.534
	Range	20 - 108	20 - 124	
Serum albumin (mg/dL)	**Mean± SD**	4.15 ± 0.45	4.14 ± 0.48	0.915
	Range	3.3 - 5	3.4 - 5.2	
Serum creatinine (mg/dL)	**Mean± SD**	1.57 ± 1.55	1.64 ± 1.61	0.744
	Range	0.8 - 6.7	0.8 - 6.9	
	Median (IQR)	1 (0.9-1.1)	1 (0.9-1.2)	
CRP (mg/L)	**Mean± SD**	102.4 ± 43.61	104.8 ± 45.22	0.706
	Range	59.9 - 274.3	55.7 - 321.5	

BMI: Body mass index. DM: diabetes mellitus, HTN: hypertension, CVD: cardiovascular disease, IHD: ischemic heart disease. Hb: Hemoglobin, TLC: total leukocyte count, ALT: Alanine transaminase, AST: aspartate transaminase, CRP: C - reactive protein.

Table 2: Diagnosis, APACHE II score on admission, clinical data, maastricht index (MI), clinical management, APACHE II score at follow-up, outcome, complications and mortality of the studied groups.

		Group A (n=100)	Group B (n=100)	P value
Diagnosis on admission	**Acute neurologic pathology**	21 (21%)	20 (20%)	0.637
	Sepsis	30 (30%)	36 (36%)	
	Severe metabolic/renal disease	12 (12%)	10 (10%)	
	Cardiac arrest	13 (13%)	17 (17%)	
	Trauma	23 (23%)	16 (16%)	
	Acute neurologic pathology	21 (21%)	20 (20%)	
APACHE II score on admission	**Mean± SD**	28.7 ± 6.12	29.2 ± 6.4	0.636
	Range	18 - 40	17 - 42	
Clinical data				
Length of ICU stay (days)	**Mean± SD**	15.8 ± 4.59	21.3 ± 5.76	**<0.001***
	Range	9 - 24	11 - 31	
Duration of MV (days)	**Mean± SD**	7.4 ± 2.21	8.1 ± 2.54	**0.031***
	Range	4 - 14	5 - 14	
Length of hospital stay (days)	**Mean± SD**	27.8 ± 8.12	33.1 ± 10.77	**<0.001***
	Range	14 - 40	17 - 50	
Vasopressor support	**Norepinephrine alone**	71 (71%)	73 (73%)	0.243
	Epinephrine alone	19 (19%)	11 (11%)	
	Dobutamine alone	4 (4%)	9 (9%)	
	Two or three drugs	5 (5%)	6 (6%)	
Maastricht index (MI)	**Mean± SD**	3.2 ± 1.71	3.2 ± 1.83	0.968
	Range	1 - 7	1 - 7	
Clinical management				
Daily calorie intake (kcal/kg)	**Mean± SD**	1709.7 ± 237.42	2046.1 ± 325.4	**<0.001***
	Range	1330 - 2400	1498 - 3100	
Total protein intake (g/kg)	**Mean± SD**	4.3 ± 1.16	5.1 ± 1.22	**<0.001***
	Range	2.3 - 6.3	3.1 - 7.4	
Patients receiving prokinetic drugs		28 (28%)	16 (16%)	**0.040***
Dialysis		26 (26%)	32 (32%)	0.350
APACHE II score at follow-up	**Mean± SD**	20.6 ± 5.49	24.4 ± 6.37	**<0.001***
	Range	11 - 33	11 - 37	
Outcome				
Patients who attained the feed goal	**Yes**	78 (78%)	59 (59%)	**0.003***
	No	22 (22%)	41 (41%)	
Complications				
Infections		13 (13%)	29 (29%)	**0.005***
Sepsis		3 (3%)	13 (13%)	**0.009***
Hypokalemia		25 (25%)	50 (50%)	**<0.001***
Hypophosphatemia		5 (5%)	15 (15%)	**0.018***
Gastrointestinal	**Vomiting**	40 (40%)	22 (22%)	**0.006***
	Diarrhea	30 (30%)	7 (7%)	**<0.001***
	Bowel ischemia	1 (1%)	0 (0%)	0.316
Mortality	**Yes**	24 (24%)	31 (31%)	0.267
	No	76 (76%)	69 (69%)	

ICU: intensive care unit, MV: mechanical ventilation, APACHE II: Acute Physiology and Chronic Health Disease Classification System II. ICU: intensive care unit, MV: mechanical ventilation, *: statistically significant as p value <0.05.

Table 3: Baseline characteristic, comorbidities and laboratory investigations of the studied subgroups

		Group A1 (n=50)	Group A2 (n=50)	Group B1 (n=50)	Group B2 (n=50)	P value
Age (years)		62 ± 8.11	60.7 ± 8.28	59.3 ± 8.84	61.2 ± 9.73	0.479
		46 - 76	43 - 78	45 - 75	43 - 79	
Sex	**Male**	25 (50%)	27 (54%)	23 (46%)	31 (62%)	0.421
	Female	25 (50%)	23 (46%)	27 (54%)	19 (38%)	
Weight (Kg)		77.9 ± 11.58	78.7 ± 11.05	78 ± 11.71	76.7 ± 11.7	0.859
		60 - 95	62 - 97	60 - 100	55 - 98	
Height (m)		1.67 ± 0.05	1.66± 0.04	1.67 ± 0.04	1.66 ± 0.04	0.362
		1.6 - 1.74	1.58 - 1.74	1.6 - 1.74	1.59 - 1.74	
BMI (Kg/m^2)		27.8 ± 4.47	28.6 ± 4.39	28.1 ± 4.66	27.8 ± 4.24	0.862
		20.05 - 36.65	22.41 - 37.25	21.01 - 36.73	19.49 - 35.88	
Residence	**Urban**	27 (54%)	24 (48%)	21 (42%)	26 (52%)	0.641
	Rural	23 (46%)	26 (52%)	29 (58%)	24 (48%)	
Comorbidities						
DM		19 (38%)	17 (34%)	20 (40%)	14 (28%)	0.604
HTN		23 (46%)	27 (54%)	22 (44%)	25 (50%)	0.757
CVD		9 (18%)	10 (20%)	12 (24%)	11 (22%)	0.895
IHD		9 (18%)	13 (26%)	8 (16%)	10 (20%)	0.625
Chronic renal failure		8 (16%)	6 (12%)	9 (18%)	5 (10%)	0.645
Liver disease		2 (4%)	4 (8%)	1 (2%)	6 (12%)	0.182
Laboratory investigations						
Hb (g/dL)		11.9 ± 1.1	11.8 ± 1.16	11.8 ± 1.05	12.1 ± 1.03	0.493
		10.2 - 13.7	10 - 13.9	10 - 13.7	10.2 - 13.6	
TLC ($*10^9/L$)		12.5 ± 2.6	12.3 ± 2.28	12.2 ± 2.15	12.9 ± 2.28	0.436
		8.7 - 19.6	8.7 - 16	8.8 - 17.5	9 - 18.6	
Platelets ($*10^9/L$)		300.5 ± 38.28	292.2 ± 37.2	299.5 ± 35.63	297 ± 33.62	0.664
		220 - 360	230 - 359	240 - 354	242 - 355	
ALT (U/L)		34.4 ± 15.52	39.5 ± 20.02	33.9 ± 10.55	40.4 ± 22.37	0.145
		20 - 104	20 - 116	20 - 88	20 - 109	
AST (U/L)		36 ± 15.55	37.1 ± 18.9	34.7 ± 14.91	41.6 ± 23.54	0.266
		20 - 108	20 - 105	20 - 124	20 - 118	
Serum albumin (mg/dL)		4.1 ± 0.44	4.2 ± 0.46	4.2 ± 0.45	4.1 ± 0.5	0.390
		3.4 - 5	3.3 - 4.9	3.4 - 5.1	3.4 - 5.2	
Serum creatinine (mg/dL)		1.6 ± 1.53	1.5 ± 1.58	1.8 ± 1.83	1.5 ± 1.35	0.605
		0.8 - 6.7	0.8 - 6.7	0.8 - 6.6	0.8 - 6.9	
		1.05 (0.9-1.1)	1 (0.9-1.1)	1 (0.9-1.2)	1.05 (0.9-1.2)	
CRP (mg/L)		102.9 ± 46.06	101.9 ± 41.48	104.8 ± 44.04	104.8 ± 46.82	0.969
		59.9 - 270.3	61.7 - 274.3	55.7 - 298.3	60.2 - 321.5	

Data presented as mean ± SD or frequency (%). BMI: Body mass index. DM: diabetes mellitus, HTN: hypertension, CVD: cardiovascular disease, IHD: ischemic heart disease. Hb: Hemoglobin, TLC: total leukocyte count, ALT: Alanine transaminase, AST: aspartate transaminase, CRP: C - reactive protein.

Table 4: Diagnosis and APACHE II score on admission, clinical data and maastricht index (MI) of the studied subgroups

	Group A1 (n=50)	Group A2 (n=50)	Group B1 (n=50)	Group B2 (n=50)	P value
Acute neurologic pathology	9 (18%)	12 (24%)	9 (18%)	11 (22%)	0.855
Sepsis	17 (34%)	13 (26%)	21 (42%)	15 (30%)	
Severe metabolic/renal disease	5 (10%)	7 (14%)	5 (10%)	5 (10%)	
Cardiac arrest	6 (12%)	7 (14%)	6 (12%)	11 (22%)	
Trauma	13 (26%)	11 (22%)	9 (18%)	8 (16%)	
Acute neurologic pathology	9 (18%)	12 (24%)	9 (18%)	11 (22%)	
APACHE II score on admission	28.6 ± 6.51 18 - 40	28.9 ± 5.76 19 - 39	29.3 ± 6.44 17 - 41	29 ± 6.41 18 - 42	0.955
	Clinical data				
Length of ICU stay (days)	15.6 ± 4.45 9 - 23	16 ± 4.76 9 - 24	21.8 ± 5.77 11 - 30	20.8 ± 5.78 11 - 31	**<0.001***
	P1=0.634, **P2<0.001*, P3<0.001, P4<0.001*, P5<0.001*,** P6=0.427				
Duration of MV (days)	7.6 ± 2.18 4 - 13	7.1 ± 2.22 4 - 14	8.2 ± 3.01 5 - 14	8 ± 1.97 5 - 11	0.106
Length of hospital stay (days)	26.8 ± 7.91 14 - 40	28.8 ± 8.29 14 - 40	33.7 ± 11.34 17 - 50	32.5 ± 10.25 17 - 50	**0.003***
	P1=0.225, **P2=0.001*, P3=0.003, P4=0.015*, P5=0.050*,** P6=0.427				
Vasopressor support	**Norepinephrine alone**	34 (68%)	38 (76%)	35 (70%)	0.609
	Epinephrine alone	10 (20%)	9 (18%)	6 (12%)	
	Dobutamine alone	2 (4%)	2 (4%)	5 (10%)	
	Two or three drugs	4 (8%)	1 (2%)	4 (8%)	
Maastricht index (MI)	3.3 ± 1.72 1 - 7	3 ± 1.7 1 - 7	3.3 ± 1.88 1 - 7	3.1 ± 1.78 1 - 7	0.838

APACHE II: Acute Physiology and Chronic Health Disease Classification System II. Data presented as mean ± SD, or frequency (%). ICU: intensive care unit, MV: mechanical ventilation, *: statistically significant as p value <0.05, P1: p value between group A1&A2, P2: p value between group A1&B1, P3:p value between group A1&B2, P4: p value between group A2&B1, P5: p value between group A2&B2, P6: p value between group B1&B2,

Table 5: Clinical management, APACHE II score at follow up, outcome, complications and mortality of the studied subgroups

		Group A1 (n=50)	Group A2 (n=50)	Group B1 (n=50)	Group B2 (n=50)	P value
Daily calorie intake (kcal/kg)		1718 ± 250.56	1701.4 ± 225.75	2068.1 ± 362.28	2024 ± 285.81	**<0.001***
		1377 - 2400	1330 - 2094	1498 - 3100	1527 - 2493	
		P1=0.729, **P2<0.001*, P3<0.001, P4<0.001*, P5<0.001*,** P6=0.501				
Total protein intake (g/kg)		4.4 ± 1.23	4.2 ± 1.09	5.1 ± 1.33	5.1 ± 1.11	**0.003***
		2.3 - 6.2	2.3 - 6.3	3.2 - 7.4	3.1 - 6.8	
		P1=0.411, **P2=0.007*, P3=0.005, P4<0.001*, P5<0.001*,** P6=0.896				
Patients receiving prokinetic drugs		16 (32%)	12 (24%)	7 (14%)	9 (18%)	0.147
Dialysis		12 (24%)	14 (28%)	19 (38%)	13 (26%)	0.420
APACHE II score at follow up		20.9 ± 5.86	20.2 ± 5.12	24.6 ± 6.31	24.3 ± 6.49	**<0.001***
		11 - 33	11 - 32	11 - 37	12 - 37	
		P1=0.526, **P2=0.004*, P3=0.008, P4<0.001*, P5=0.001*,** P6=0.815				
		Outcome				
Patients who attained the feed goal	**Yes**	36 (72%)	42 (84%)	27 (54%)	32 (64%)	**0.012***
	No	14 (28%)	8 (16%)	23 (46%)	18 (36%)	
		Complications				
Infections		7 (14%)	6 (12%)	16 (32%)	13 (26%)	**0.039***
Sepsis		2 (4%)	1 (2%)	9 (18%)	4 (8%)	**0.016***
Hypokalemia		14 (28%)	11 (22%)	27 (54%)	23 (46%)	**0.002***
Hypophosphatemia		3 (6%)	2 (4%)	9 (18%)	6 (12%)	0.083
Gastrointestinal	**Vomiting**	21 (42%)	19 (38%)	12 (24%)	10 (20%)	**0.047***
	Diarrhea	16 (32%)	14 (28%)	4 (8%)	3 (6%)	**<0.001***
	Bowel ischemia	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0.389
Mortality	**Yes**	14 (28%)	10 (20%)	18 (36%)	13 (26%)	0.394
	No	36 (72%)	40 (80%)	32 (64%)	37 (74%)	

Data presented as mean ± SD, or frequency (%). *: statistically significant as p value <0.05, P1: p value between group A1&A2, P2: p value between group A1&B1, P3:p value between group A1&B2, P4: p value between group A2&B1, P5: p value between group A2&B2, P6: p value between group B1&B2,

Discussion

The present study revealed that there were no statistically significant differences between the groups in terms of baseline demographic characteristics, including age, sex, weight, height, body mass index (BMI), and residence. Our results are consistent with the findings of El Meligy et al. [(11)] who aimed to compare the outcomes of early EN with early PN in critically ill patients. A total of 180 patients were included in their study: Group 1 (90 patients) received early EN with no contraindication to enteral nutrition, while Group 2 (90 patients) received early PN. They found that no significant differences were observed between the PN and EN groups in terms of age and baseline weight.

In the present study, we also demonstrated that there were no statistically significant differences between the groups regarding associated comorbidities, including diabetes mellitus (DM), hypertension (HTN), cardiovascular disease (CVD), ischemic heart disease (IHD), chronic renal failure, and liver disease. Moreover, there was no statistically significant difference between the groups regarding the admission diagnoses.

Our findings are in line with Garbino et al. [(12)] who showed that 79 patients received enteral nutrition, and 31 received total parenteral nutrition (PN), with 10 patients

not meeting the inclusion criteria. Both subgroups were similar in terms of comorbidities (P > 0.05). In contrast, our findings differed from those of El Meligy et al. [11], who observed significant differences in admission diagnoses (bronchiolitis and pneumonia) (P = 0.01, 0.001).

In the current study, we found that the APACHE II score on admission was insignificantly different between both groups. Similarly, the Maastricht index did not differ significantly between the groups. However, the APACHE II score at follow-up was significantly lower in Group A compared to Group B (P < 0.001). Our results are consistent with the findings of Singh et al., (13) who reported no significant differences between the PN and EN groups in terms of the APACHE II score on admission. However, the APACHE II score at follow-up was significantly lower in the EN group.

In our study we found that there was an insignificant difference between both groups regarding the laboratory investigations including (Hb, TLC, platelets, ALT, AST, serum albumin, serum creatinine and CRP). This came in accordance with El Meligy et al. (11) determined that as regards laboratory assessment, there were no statistically significant differences between the groups as regard TLC, CRP, ALT, serum creatinine, ALT, AST, and urea.

In the current study we demonstrated that the length of ICU stay, duration of MV and length of hospital stay were significantly shorter in group A compared to group B (P<0.001, 0.031, <0.001), with no significant difference between both groups regarding the vasopressor support. This came in accordance with Baik et al., (14) who compared early enteral nutrition (EEN) and early parenteral nutrition (EPN) to evaluate their efficacy in adult critically ill patients. EEN was associated with a modest reduction in ICU-LOS compared to EPN (p = 0.01). Additionally, EEN significantly reduced H-LOS (p < 0.001). These findings suggest that EEN may contribute to faster recovery and shorter hospitalization for critically ill patients with stable gastrointestinal function. However, the clinical significance of the ICU-LOS reduction remains modest. While in contrast, no significant difference in MV duration between EEN and EPN groups (p = 0.81).

In disagreement with the present study, El Meligy et al. (11) determined that no significant difference was observed between both groups as regard ICU stay length and MV stay length.

Regarding the clinical management, we reported that the daily calorie intake and total protein intake were significnatly lower in group A compared to group B (P<0.001, <0.001). The number of patients receiving prokinetic drugs was significnatly higher in group A compared to group B (P=0.040). There was an insignifcant difference between both groups regrading dialysis.

As well, our findings in line with Shariff et al. [15] reported that total protein intake showed significant differences, particularly from day 2 onward. On day 2, the PN group had a mean protein intake of 0.9 g (SD=0.70) compared to 0.5 g (SD=0.25) for the EN group, with a significant P-value of 0.001. In contrast, our findings disagreed with Elke et al. [16] reported that according to the caloric intake across groups, the significant difference was not observed where caloric intake was similar between EN and PN groups (P = 0.60).

Regarding the outcome, patients who attained the feed goal were significantly higher in group A compared to group B (P=0.003). As well, our findings in line with Shariff et al. (15) reported that nutritional interruption occurred more frequently in the EN group (63.7%) compared to the PN group (P=0.001).

Regarding the complications, the incidence of infections, sepsis, hypokalemia, and hypophosphatemia was significantly lower in group A compared to group B (P<0.05),

while the gastrointestinal complications, including vomiting and diarhea were significantly higher in group A compared to group B (P=0.006, <0.001), with no significant difference between both groups regarding the incidence of bowel ischemia. Similarly, the current study in agreement with Baik et al., [14] revealed that GI complications were reported as vomiting, diarrhea, ileus, GI intolerance, and bowel ischemia were significantly increased in EEN ($p <$ 0.0001). EEN reduced bloodstream infections (OR 0.73, 95% CI 0.57–0.93)

Furthermore, Patsiou et al. [17] showed that the EN is related to less blood bacterial infections and reduction in the time of hospitalization. On the other hand, it causes more gastrointestinal complications.

In our study we revealed that there was an insignificnat difference between both groups regarding the incidence of mortality. Similarly, the current study in agreement with Baik et al., [14] revealed that the overall mortality difference between EEN and EPN was not statistically significant (p = 0.58).

In the current study we found that the APACHE II score on admission was insignificantly different among the studied subgroups. There was an insignificant difference among the studied subgroups regarding the Maastricht index (MI).

Our results in consistent with Vahabzadeh et al., [18] who aimed to compare the influence of fat-based enteral nutrition in comparison with glucose-based ones on clinical outcomes in critically ill patients. Eighty-eight patients were randomly allocated to a standard (protein 20%, fat 30%, and carbohydrate 50%) or high-fat (protein 20%, fat as equal amount of olive and sunflower 45%, and carbohydrate 35%) kitchen formulas. They found that there were no significant differences between groups in APACHE II score on admission.

In the current study we demonstrated that the length of ICU stay and hospital stay were significantly shorter in group A1 compared to group B1 and group B2 (P<0.05), were significantly shorter in group A2 compared to group B1 and group B2 (P<0.05), with no signifcnat difference between group A1 and A2 and between group B1 and B2. There was an insignificant difference among the studied subgroups regarding the duration of MV and vasopressor support. Our results in consistent with Vahabzadeh et al., (2019) [18] reported that the duration of MV showed no significant difference between the two groups.

Regarding clinical management, the daily calorie intake and the total protein intake were significantly lower in group A1 compared to group B1 and group B2 (P<0.05), were significantly lower in group A2 compared to group B1 and group B2 (P<0.05), with no signifcnat difference between group A1 and A2 and between group B1 and B2. There was an insignificant difference among the studied subgroups regarding the patients receiving prokinetic drugs and dialysis.

Our results in consistent with Gautier et al. [19] showed that enteral formulas were placed into the categories of standard protein (SF), high protein (HP), or very high protein (VHP) based on the percentage of the calories in the formula provided by protein. Calories and protein delivered were measured daily through the first 7 ICU days. A gradual increase in calorie and protein intake was observed for all patients regardless of the EN formula used. Patients on SF received higher amounts of EN calories per EN nutrition days compared to other formulas (all p < 0.0001).

Regarding the outcome, patients who attained the feed goal was significnatly different among the studied groups (P=0.012), being higher in group A2 and A1 respectively compared to group B1 and B2. Our findings in line with Casaer et al. [20] found that early initiation of EN in critically ill patients was associated with better tolerance and higher likelihood of

reaching daily caloric goals compared to late PN.

Regarding complications, the incidence of infections, sepsis, and hypokalemia was significantly different among the studied subgroups (P=0.039, 0.016, 0.002), being lower in group A1 and group A2 compared to group B1 and B2. While the incidence of vomiting and diarrhea was significantly different among the studied subgroups (P=0.047, <0.001), being higher in group A1 and group A2 compared to group B1 and B2. There was an insignificant difference among the studied subgroups regarding hypophosphatemia and bowel ischemia.

Our findings in line with Patsiou et al. [17] showed that the EN is related to less blood bacterial infections and reduction in the time of hospitalization. On the other hand, it causes more gastrointestinal complications. In contrast, Ohbe et al. [21] reported that no significant differences were observed in diarrhea, or gastric residual volume between the two groups.

In the current study we found that there was an insignificnat difference among the studied subgroups regarding the incidence of mortality. Our findings in line with Ohbe et al. [21] reported that the effects of high-fat, low-carbohydrate enteral nutrition on mortality did not significantly differ from those of standard enteral nutrition (P = 0.47).

Limitations were the study was conducted in a single center; sample size may not fully represent the diverse critically ill patient population, the study did not account for long-term outcomes beyond hospital discharge, differences in clinical practices and patient management between groups may have introduced bias and the study did not include a nutritional assessment of patients prior to admission, which could have affected baseline comparisons.

Conclusion

From the findings of our study, it can be concluded that modified enteral nutrition was associated with better clinical outcomes in critically ill, mechanically ventilated patients compared to parenteral nutrition. Patients receiving enteral nutrition had lower follow-up APACHE II scores, shorter ICU and hospital stays, and fewer complications such as infections and sepsis. However, gastrointestinal side effects like vomiting and diarrhea were more common. Overall, enteral nutrition—especially the modified form proved to be a more effective and safer nutritional approach in this patient population.

Future studies should involve multi-center trials to increase the generalizability of the findings; larger sample sizes and long-term follow-up. Further research is needed to explore the optimal management of gastrointestinal side effects in patients receiving modified enteral nutrition and more detailed assessment of patients' nutritional status prior to admission could improve baseline comparisons and outcomes.

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Conflicts of interest

No conflicts of interest

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