Original Article

Comparison of Energy and Nutrient Contents of Commercial and Noncommercial Enteral Nutrition Solutions

Abstract

Background: Nutritional support plays a major role in the management of critically ill patients. This study aimed to compare the nutritional quality of enteral nutrition solutions (noncommercial vs. commercial) and the amount of energy and nutrients delivered and required in patients receiving these solutions. **Materials and Methods:** This cross-sectional study was conducted among 270 enterally fed patients. Demographic and clinical data in addition to values of nutritional needs and intakes were collected. Moreover, enteral nutrition solutions were analyzed in a food laboratory. **Results:** There were 150 patients who fed noncommercial enteral nutrition solutions (NCENS) and 120 patients who fed commercial enteral nutrition solutions (CENSs). Although energy and nutrients contents in CENSs were more than in NCENSs, these differences regarding energy, protein, carbohydrates, phosphorus, and calcium were not statistically significant. The values of energy and macronutrients delivered in patients who fed CENSs were higher ($P < 0.001$). Energy, carbohydrate, and fat required in patients receiving CENSs were provided, but protein intake was less than the required amount. In patients who fed NCENSs, only the values of fat requirement and intake were not significantly different, but other nutrition delivered was less than required amounts ($P < 0.001$). CENSs provided the nutritional needs of higher numbers of patients ($P < 0.001$). In patients receiving CENSs, nutrient adequacy ratio and also mean adequacy ratio were significantly higher than the other group ($P < 0.001$). **Conclusion:** CENSs contain more energy and nutrients compared with NCENSs. They are more effective to meet the nutritional requirements of entirely fed patients.

Keywords: *Critically ill patients, enteral nutrition solutions, nutritional status, nutritional support*

Nahid Ramezani Jolfaie[1], Mohammad Hossein Rouhani[1], Maryam Mirlohi[2], Mina Babashahi[2], Saeid Abbasi[3], Peiman Adibi[4], Ahmad Esmaillzadeh[1,5], Leila Azadbakht[1,5,6]

From the [1]Food Security Research Center and Department of Community Nutrition, School of Nutrition and Food Sciences, Isfahan University of Medical Sciences, [2]Food Security Research Center and Department of Food Science and Technology, School of Nutrition and Food Science, Isfahan University of Medical Sciences, [3]Department of Anesthesiology and Critical Care, School of Medicine, Isfahan University of Medical Sciences, [4]Department of Internal Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, [5]Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, [6]Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

Address for correspondence:
Prof. Leila Azadbakht, Department of Community Nutrition, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: azadbakht@hlth.mui.ac.ir

Introduction

Intensive Care Unit (ICU) is a special department in the hospital where critically ill patients are admitted for receiving constant and close monitoring by specially trained staffs.[1] Most patients admitted to the ICU are unable to take nutrition orally due to acute conditions or unconsciousness. Therefore, nutritional support is the main part of critically ill patient's care, which plays the significant role in their recovery.[2] Unfortunately, lack of adequate nutritional support has been led to incidence and progress of malnutrition among ICU patients.[3,4] Malnutrition is related to several complications such as increase in disease severity, immune system impairment, infection, wound healing delay, and prolonged ventilator dependence.[5-7] Consequently, it leads to significant increased length of hospital stay as well as more care costs.[8,9] It has been reported that around 15%–70% of patients are not in a suitable nutritional status at the time of hospital admission.[10,11] The prevalence of malnutrition in ICU patients has been estimated approximately 43%.[10] Although there are no comprehensive statistics on malnutrition prevalence in Iran's hospitals, it has been reported around 25%–48% in most surveys.[12-14]

On the other hand, inadequate nutritional support in these patients can result in deterioration of nutritional status and progress of malnutrition during hospitalization.[15-17] In summary, nutritional status monitoring and optimal nutritional delivery are essential practice in the critically ill patients which can reduce morbidity, mortality, and hospitalization costs.[18,19]

Enteral feeding is a kind of feeding method used for critically ill patients requiring nutritional support, in which a food mixture is administered through a tube or a catheter into digestive tract.[20,21] Although commercial enteral nutrition solutions (CENSs) with defined

How to cite this article: Jolfaie NR, Rouhani MH, Mirlohi M, Babashahi M, Abbasi S, Adibi P, *et al.* Comparison of Energy and Nutrient Contents of Commercial and Noncommercial Enteral Nutrition Solutions. Adv Biomed Res 2017;6:131.

Received: December, 2015. **Accepted:** September, 2016.

Access this article online

Website: www.advbiores.net

DOI: 10.4103/2277-9175.216784

Quick Response Code:

composition are commonly used in hospitals around the world for over 20 years, some institutions prefer the use of non-CENSs (NCENS) for enterally fed patients.[22] NCENSs or blenderized tube feeding are food mixtures prepared manually in hospital kitchens containing egg, milk or yogurt, poultry or chicken meat, rice water, fruits, vegetables, and sometimes cooked nuts.[23] Despite supposed benefits of NCENSs (i.e., low-price and natural ingredients), there are several concerns about these solutions. It has been observed that there is high microbial contamination in NCENSs and consequently substantial risk for developing serious nosocomial infections which result in increased morbidity and mortality.[24,25] However, CENSs are made sterilely and if used properly there is no possibility of their contamination.[26] On the other hand, caloric and nutrients contents of NCENSs as well as their ability in meeting the patients' nutritional objectives have been remained a matter of concern. The aims of this study were to compare the nutritional quality of enteral nutrition solutions (NCENSs vs. CENSs) and to assess the amount of energy and nutrients delivered and required in critically ill patients receiving these solutions.

Materials and Methods

Study population and design

This cross-sectional study was conducted in four hospitals in Isfahan, Iran, that selected through convenience sampling (from December 2014 to November 2015). We used this formula: $Z\ (1-\alpha/2)^2 \times SD^2/d^2$ suggesting to calculate the sample size of cross-sectional studies,[27] where α (type 1 error) was 0.05, standard deviation (SD) of sodium was 7.10,[28] and *d* (difference in mean of sodium) was 0.84. The sodium was considered as the principal outcome variable. According to the formula, 270 patients were needed to participate in our study.

Inclusion criteria were patients aged ≥18 years, patients receiving enteral feeding, patients having length of ICU stay ≥3 days, and those patients whom their relatives agreed to complete a written informed consent. Exclusion criteria were death or discharge before 3 days, patients with no enteral feeding up to 48 h after admission to the ICU, patients with diabetes, liver diseases, kidney disorders, and burns (due to the specificity of the enteral nutrition solutions), and brain death patients. Finally, 270 patients who met these criteria were selected among the entire population of critically ill patients.

Data collection

Information regarding the admission diagnosis, age, and sex was collected from the patient's record. Height was measured by a nonelastic tape to the nearest 0.1 cm in the supine position. If it was not possible to measure the height in this position, forearm length from the tip of the olecranon process to the most distal end of the ulna styloid process was measured as an alternative measurement. Weight was measured by bed scale, and if the beds had not any scale, ideal body weight was calculated for patients. Midupper arm circumference (MUAC) was measured using a nonelastic tape to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). Acute Physiology and Chronic Health Evaluation II (APACHE II) score is a known severity of disease classification system for hospitalized adult patients. This index is calculated using 3 main parts: score based on acute physiologic variables and Glasgow coma scale, score based on age grouping of patients, and score based on chronic health problems and one or more organ failure in patient.[29] Finally, the points calculated for these parts were summed and used for rating patients in terms of disease severity.

Energy and macronutrients assessment

The values of energy and protein requirements were calculated based on 25–30 kcal/kg/day and 1.2–2 g/kg/day formulas, respectively.[30] The rest of the daily caloric requirements were divided between carbohydrates and fats (48%–55% for carbohydrates and 23%–30% for fats).

The volume and type of enteral nutrition solution administered to each patient were recorded daily. These values were summed and total used volume of enteral nutrition solution during hospitalization was calculated. Then, using the energy and macronutrients values obtained from the chemical analyses, the average daily intake of energy, protein, carbohydrate, and fat was calculated according to the mean amount of enteral nutrition solution received by the patient in 24 h.

Micronutrient assessment

Using the micronutrients values obtained from the chemical analyses, the daily intake of each micronutrient (Vitamin C, phosphorus, calcium, magnesium, zinc, and copper) was estimated according to the mean amount of enteral nutrition solution received by the patient in 24 h. Then, nutrient adequacy ratio (NAR) was calculated by dividing daily patient intake to dietary recommended intake for each micronutrient. Finally, the sum of all calculated values divided by the number of NARs presented as a mean adequacy ratio (MAR).[31]

Chemical analysis of enteral nutrition solutions

Four hospitals in Isfahan, Iran, were selected for participation in the present study. One NCENS sample was randomly collected from each hospital, except in one of hospitals which prepared two types of NCENSs for patients. Moreover, two types of CENSs were used in these hospitals. Totally, five NCENSs and two CENSs samples were analyzed in terms of macronutrients and some micronutrients in the Food Laboratory of Food Security Research Center and School of Nutrition and Food Sciences, Isfahan University of Medical Sciences, Isfahan, Iran.

Protein, carbohydrate, and fat were measured using Kjeldahl, copper reduction, and Folch methods, respectively. These values were reported as gram per 100 ml sample. The energy content was calculated as 4, 4, and 9 kcal/g carbohydrate, protein, and fat, respectively, which reported for per 100 ml sample. The values of some micronutrients such as Vitamin C, phosphorus, calcium, magnesium, zinc, copper, sodium, and potassium were measured and reported as mg/100 ml. Phosphorus, calcium, and Vitamin C were measured using vanadate colorimetric, permanganate titration, and iodine titration methods, respectively. Sodium and potassium were determined by flame photometry. Spectroscopy method was used for measuring magnesium, zinc, and copper.

Statistical analysis

Data were reported as mean ± SD. The normal distribution of variables was tested by the Kolmogorov–Smirnov test and histogram curve. Comparisons were made using independent samples *t*-test and Mann–Whitney U-test for normally and nonnormally quantitative variables, respectively. Chi-square test was used for evaluating the qualitative variables. To compare the variations of continuous variables of nutritional intakes, we used analysis of covariance which was adjusted for amount of enteral nutrition solution intake because different amount of solutions intake can lead to bias our estimates of patients' nutritional intakes. Wilcoxon's rank-sum test was applied for comparing the paired data. All statistical analyses were performed with SPSS software version 16, IBM Corporation. The statistical significant level was considered as $P < 0.05$.

Results

Among 270 patients involved in the present study, there were 150 patients who fed NCENS and 120 patients who fed CENS. The demographic and clinical characteristics of patients have been reported in Table 1. The mean age for patients receiving NCENS and CENSs were 55.46 and 53.13 years, respectively ($P = 0.29$). There were no significant differences between two groups with regard to age, sex, weight, BMI, and MUAC. Patients in both groups had male sex predominately. Although APACHE II scores for patients administered NCENS was higher than another group, this difference was not statistically significant ($P = 0.49$). The number of patients in each group on the basis of admission diagnoses was comparable.

According to results obtained from chemical analyses of NCENSs and CENs, as shown in Table 2, no significant difference was observed in respect of energy ($P = 0.43$), protein ($P = 0.61$), and carbohydrate ($P = 0.79$). The mean concentration of fat in NCENSs and CENSs was 3.55 and 4.54 g/100 ml, respectively, indicating a marginally significant difference (P = 0.05), although the fat amount based on percentage of energy was not significantly different among these solutions ($P = 0.64$). All micronutrients values were higher in CENSs compared with NCENSs, except for phosphorus ($P = 0.66$) and calcium ($P = 0.63$) with no significant difference and a marginally significant difference for potassium ($P = 0.05$). Moreover, high variation range of nutritional composition was observed in NCENSs versus CENSs. The standard values for energy and protein content of enteral nutrition solutions have been estimated to be 1–1.2 kcal/ml and 16%–32%, respectively.[30] The average content of energy for NCENSs and CENSs were calculated 0.96 and 1.12 kcal/ml, respectively. Therefore, it is observed that the value regarding NCENSs is not in the standard range. Furthermore, the mean amount of protein in both solutions was reported to be 14%, which is lower than the estimated standard value.

Table 1: Demographic and clinical characteristics of patients who fed noncommercial and commercial enteral nutrition solutions

Variable	Patients fed NCENS (*n*=150)	Patients fed CENS (*n*=120)	*P**
Age (year)	55.46±20.19†	53.13±20.35	0.29
Sex (male/female)	93/57	79/41	0.51
Weight (kg)	69.04±11.56	67.90±10.72	0.45
BMI (kg/m^2)	24.56±3.55	24.06±3.21	0.07
MUAC (cm)	28.82±3.89	28.44±4.08	0.38
APACHE II score	15.33±8.06	16.04±7.99	0.49
Admission diagnosis, *n* (%)			
Trauma	26 (17.3)	27 (22.5)	0.28
Neurologic	34 (22.7)	28 (23.3)	0.89
Respiratory	17 (11.3)	10 (8.3)	0.41
Cancer	38 (25.3)	32 (26.7)	0.80
Surgery	29 (19.3)	19 (15.8)	0.45
Sepsis	4 (2.7)	3 (2.5)	0.93
Other	2 (1.3)	1 (0.8)	0.69

**P* values computed by Mann–Whitney U-test for quantitative variables and Chi-square for qualitative variables, †Values are mean±SD or frequency (%). NCENS: Noncommercial enteral nutrition solution, CENS: Commercial enteral nutrition solution, BMI: Body mass index, MUAC: Midupper arm circumference, APACHE II: Acute Physiology and Chronic Health Evaluation II, SD: Standard deviation

Table 3, comparing values of energy and macronutrients requirements and intakes between patients receiving NCENSs and CENSs, illustrates that although nutritional needs of patients in two groups were not significantly different, all values related to nutritional deliveries in patients who fed CENSs were significantly higher than another group ($P < 0.001$). Moreover, within group comparisons indicated that the amounts of intake and requirement of energy (1450 vs. 1855.2 kcal/day; $P < 0.001$) and carbohydrate (181.3 vs. 236.13 g/day; $P < 0.001$) were significantly different in NCENSs receiving group. On the contrary, there was no

Table 2: Comparison of energy, macronutrients, and some micronutrients content in 100 ml noncommercial and commercial enteral nutrition solutions

Variable	NCENS (*n*=5)	Range	CENS (*n*=2)	Range	*P**
Energy (kcal)	96.86 (24.03)†	68.52-130.89	112.36 (9.36)	105.74-118.98	0.43
Protein (g)	3.49 (1.2)	2.24-4.69	4.11 (1.89)	2.78-5.46	0.61
Protein (percentage of energy)	0.14 (0.05)	0.07-0.21	0.14 (0.05)	0.11-0.18	0.90
Carbohydrate (g)	12.72 (4.99)	8.68-20.97	13.75 (0.2)	13.61-13.90	0.79
Carbohydrate (percentage of energy)	0.52 (0.14)	0.4-0.7	0.49 (0.03)	0.47-0.51	0.64
Fat (g)	3.55 (1.29)	1.26-4.34	4.54 (0.1)	4.47-4.62	0.05
Fat (percentage of energy)	0.32 (0.1)	0.17-0.43	0.36 (0.02)	0.35-0.38	0.64
Vitamin C (mg)	5 (1.88)	3.04-7.33	11.44 (1.79)	10.18-12.71	<0.01
Phosphorus (mg)	59.81 (22.23)	32.14-93.90	68.4 (21.31)	53.33-83.48	0.66
Calcium (mg)	82.55 (25.44)	56.25-119.54	92.4 (12.42)	83.62-101.19	0.63
Magnesium (mg)	11.31 (3.87)	7.46-16.19	26.75 (6.14)	22.40-31.10	<0.01
Zinc (mg)	0.61 (0.21)	0.27-0.83	1.27 (0.24)	1.10-1.45	0.01
Cooper (mg)	0.02 (0.03)	0.00-0.08	0.14 (0.06)	0.10-0.19	0.01
Sodium (mg)	35.67 (19.47)	32.83-66.42	128.71 (24.37)	116.53-140.90	<0.01
Potassium (mg)	60.59 (42.05)	50.16-126.90	133.34 (14.3)	126.19-140.49	0.05

**P* values computed by independent samples *t*-test, except for fat that computed by Mann-Whitney U-test, †All values are mean (SD) except for sodium and potassium that are median (IQR). NCENS: Noncommercial enteral nutrition solution, CENS: Commercial enteral nutrition solution, SD: Standard deviation, IQR: Interquartile range

Table 3: Comparison of nutritional requirements and intakes between patients who fed noncommercial and commercial enteral nutrition solutions

Variable	Patients who fed NCENS	Patients who fed CENS	*P*
Energy requirement (kcal/day)	1855.2±246.08*	1839.5±221.4	0.74†
Energy intake (kcal/day)	1450±510.25	1895±510.31	<0.001§
P‖	<0.001	0.08	
Protein requirement (g/day)	107.94±14.40	107.03±12.88	0.76
Protein intake (g/day)	59.62±26.66	80.15±26.66	<0.001
P	<0.001	<0.001	
Carbohydrate requirement (g/day)	236.13±31.16	234.54±28.22	0.81
Carbohydrate intake (g/day)	181.3±73.82	240.4±73.83	<0.001
P	<0.001	0.11	
Fat requirement (g/day)	53.77±7.22	53.14±6.39	0.61
Fat intake (g/day)	55.89±25.21	71.12±25.21	<0.001
P	0.46	<0.001	

*All values are mean±SD, †Reflects the difference between groups by Mann-Whitney U-test, §Reflects the difference between groups by ANCOVA, adjusted for amount of enteral nutrition solution intake, ‖Reflects the difference within each group by Wilcoxon's test. NCENS: Noncommercial enteral nutrition solution, CENS: Commercial enteral nutrition solution, SD: Standard deviation, ANCOVA: Analysis of covariance

significant difference between these values in CENSs receiving group ($P = 0.08$ for energy and $P = 0.11$ for carbohydrate). In addition, the results showed that in both groups, the protein delivery of patients was markedly lower than their requirements ($P < 0.001$). Furthermore, although it was observed that the fat intake in patients who fed CENSs was significantly higher than their requirement (71.12 ± 25.21 vs. 53.14 ± 6.39 g/day; $P < 0.001$), there was no significant difference between these values in patients who fed NCENSs ($P = 0.46$). Overall, adequacy intake of energy and macronutrients was observed in significant greater percent of patients administered CENSs compared with NCENSs receiving group [Table 4].

Analyses of micronutrient deliveries demonstrated that in patients receiving CENSs, NAR for all micronutrients as well as MAR was significantly higher than patients in NCENSs group ($P < 0.001$) [Table 5]. Although NARs for magnesium (0.43), zinc (0.97), copper (0.21), and also MAR (0.88) were lower than 1 in NCENSs receiving group, all NARs values were higher than 1 in the other group. Moreover, the comparison of sodium and potassium intakes in Table 6 shows a significant difference between two groups ($P < 0.001$).

Table 4: Nutritional adequacy in patients who fed noncommercial and commercial enteral nutrition solutions

Variable	Patients fed NCENS *n* (%)	Patients fed CENS *n* (%)	*P**
Energy adequacy	49 (32.7)	83 (69.2)	<0.001
Protein adequacy	38 (25.3)	64 (53.3)	<0.001
Carbohydrate adequacy	38 (25.3)	76 (63.3)	<0.001
Fat adequacy	93 (62)	99 (82.5)	<0.001

**P* values computed by Chi-square test. NCENS: Noncommercial enteral nutrition solution, CENS: Commercial enteral nutrition solution

Table 5: Nutrient adequacy ratio and mean adequacy ratio of some micronutrients intake in patients who fed noncommercial and commercial enteral nutrition solutions

Variable	Patients fed NCENS	Patients fed CENS	*P**
NAR			
Vitamin C	1.04±0.58[†]	2.41±0.59	<0.001
Phosphorus	1.37±6.49	1.75±6.46	<0.001
Calcium	1.28±0.55	1.55±0.54	<0.001
Magnesium	0.43±0.33	1.26±0.33	<0.001
Zinc	0.97±0.61	2.31±0.61	<0.001
Cooper	0.21±0.82	2.72±0.82	<0.001
MAR	0.88±0.44	2±0.43	<0.001

**P* values computed by ANCOVA, adjusted for amount of enteral nutrition solution intake, [†]All values are mean±SD. NCENS: Noncommercial enteral nutrition solution, CENS: Commercial enteral nutrition solution, SD: Standard deviation, ANCOVA: Analysis of covariance, NAR: Nutrient adequacy ratio, MAR: Mean adequacy ratio

Table 6: Daily intakes of sodium and potassium in patients who fed noncommercial and commercial enteral nutrition solutions

Variable	Patients fed NCENS	Patients fed CENS	*P**
Sodium (mg/day)	642.9±509.84[†]	2288±509.89	<0.001
Potassium (mg/day)	1078±641.48	2363±641.55	<0.001

**P* values computed by ANCOVA, adjusted for amount of enteral nutrition solution intake, [†]All values are mean±SD. NCENS: Noncommercial enteral nutrition solution, CENS: Commercial enteral nutrition solution, SD: Standard deviation, ANCOVA: Analysis of covariance

Discussion

The present study demonstrated that CENSs contain more energy and nutrients compared with NCENSs which can better meet the patients' nutritional requirements. To the best of our knowledge, this is the first study examining the quality of different types of enteral nutrition solutions (NCENSs and CENSs) and their capability to provide nutritional requirements in patients, which can be helpful in choosing the proper enteral nutrition solution for enterally fed patients.

Although chemical analyses of NCENSs and CENSs showed that the average of energy and macronutrients content in these solutions were not significantly different, it is noteworthy that variation range of these values in NCENSs was greater than CENSs. Indeed, none of NCENSs had balanced macronutrient composition in which the amount of one macronutrient was higher than optimal value, but other values were lower than expected. On the contrary, macronutrients content of CENSs was balanced and no extensive variations were observed in them. As a result, calculated energy content for these two types of solutions was similar partially, whereas energy content of NCENSs included a range of higher and lower than standard values. In fact, these extensive variations of NCENSs compositions have led to close mean energy and macronutrients content of these solutions to CENSs values. A wide range for micronutrients concentration was also observed in NCENSs and the mean micronutrients content of these solutions was lower than CENSs.

High variability of nutritional composition of NCENSs has also been reported in other studies.[22,23,32] There are several likely sources for this variability including nutrient compositions of foodstuffs which can differ according to the geographical origin, the season and stage of maturity when the food was harvested, storage conditions, and methods employed during processing and cooking.[23,32] In addition, there is no standard formulation for NCENSs preparation and hospitals use different foodstuffs to provide these solutions.[23]

On the other hand, findings regarding nutritional status showed that energy and macronutrients deliveries in patients receiving CENSs were significantly higher than patients fed NCENSs. Although protein intake in patients who fed CENSs were higher than the other group, these solutions did not provide their protein requirement. Further analyses indicated that patients in CENSs group who have not been met their protein requirements had received standard CENS mostly, but in patients who fed high protein CENS, protein delivery was in the range of protein requirements (data not shown). Overall, CENSs provided the requirement values of energy, carbohydrate, and fat and NCENSs could not meet the patients' nutritional needs, except for fat.

Despite various potential advantages of enteral feeding compared with other feeding types in ICU patients,[21,33] there are several limitations which lead to inadequate delivery of energy and nutrients in the number of enterally fed patients as previously observed in the most studies assessing the enteral nutrition in ICU patients.[34-37] Airway management, diagnostic procedures, gastrointestinal dysfunction, and intolerance, in addition to inadequate timing in stopping and restarting enteral feeding, may limit the daily volume of enteral nutrition prescribed via the gastrointestinal tract.[38,39] In this study, insufficient energy and macronutrients delivery was also observed in some patients. The number of patients who have not been met their nutritional goals was significantly higher in NCENSs receiving group. These comparisons have been adjusted for amount of enteral nutrition solution intake; therefore, the same amount of CENSs versus NCENSs can meet the nutritional needs of higher number of patients.

On the other hand, comparing NARs illustrated higher values in patients fed CENSs. The NARs for all micronutrients were higher than 1 in CENSs, indicating the capability of these solutions to provide the micronutrient requirements of patients. NCENSs did not provide magnesium, zinc, and copper requirements. In addition, sodium and potassium intakes of patients in this group were significantly lower than patients in CENSs group. Since chemical analyses of enteral nutrition solutions showed that the amounts of all micronutrients were higher in CENSs, higher NARs in CENSs receiving group seem reasonable. Electrolyte disorders in ICU patients have been associated with increased morbidity and mortality due to their important roles in various metabolic and homeostatic functions.[40] For instance, magnesium is an important electrolyte and hypomagnesemia has been related to increased length of stay and mortality in ICU patients in several studies.[41-43] Therefore, the use of NCENSs in critically ill patients which have been provided only 43% of magnesium requirements is a cause for concern.

The present study has some limitations. There are differences in nutritional needs of patients admitted to the ICU due to variation of admission diagnosis or disease stage which were not considered. Indeed, nutritional goals of patients with regard to general recommendations were estimated. Further, chemical analyses were performed for a small number of enteral nutrition solutions samples and their microbial content was not examined. This study also has several strengths. Nutritional deliveries were exactly calculated based on compositions of enteral nutrition solutions obtained from chemical analyses. Moreover, besides energy and macronutrients, a proper comparison was performed between requirements and intakes of some important micronutrients in ICU patients through the NARs values calculating. Overall, in this study, a relatively complete comparison was done between different types of enteral nutrition solutions and values of nutritional requirements and intakes in the patients receiving these solutions were examined separately.

Conclusion

Due to hypermetabolic state of most patients admitted to the ICU, lack of attention to their nutritional goals can lead to occurrence and progress of malnutrition and its complications. Therefore, selection of proper nutritional formula to meet patient nutritional needs has a great importance, which can play a significant role in patient recovery. The results of the present study demonstrate that the use of CENSs which contain more energy and nutrients compared with NCENSs is more effective in providing nutritional requirements of enterally fed patients. Further researches assessing the more samples of enteral nutrition solutions and higher number of patients are needed to reach more reliable conclusions.

Acknowledgments

This study was extracted from MSc dissertation which was approved by School of Nutrition and Food Sciences, Isfahan University of Medical Sciences (code 394005). We express our thankfulness to relatives of patients and ICUs medical team.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Halpern NA, Pastores SM, Greenstein RJ. Critical care medicine in the United States 1985-2000: An analysis of bed numbers, use, and costs. Crit Care Med 2004;32:1254-9.
2. Fernández-Ortega JF, Herrero Meseguer JI, Martínez García P; Metabolism and Nutrition Working Group of the Spanish Society of Intensive Care Medicine and Coronary Units. Guidelines for specialized nutritional and metabolic support in the critically-ill patient: Update. Consensus SEMICYUC-SENPE: Indications, timing and routes of nutrient delivery. Nutr Hosp 2011;26 Suppl 2:7-11.
3. McWhirter JP, Pennington CR. Incidence and recognition of malnutrition in hospital. BMJ 1994;308:945-8.
4. Waitzberg DL, Caiaffa WT, Correia MI. Hospital malnutrition: The Brazilian national survey (IBRANUTRI): A study of 4000 patients. Nutrition 2001;17:573-80.
5. Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clin Nutr 2003;22:235-9.
6. Heyland DK, Dhaliwal R, Drover JW, Gramlich L, Dodek P; Canadian Critical Care Clinical Practice Guidelines Committee. Canadian clinical practice guidelines for nutrition support in mechanically ventilated, critically ill adult patients. JPEN J Parenter Enteral Nutr 2003;27:355-73.
7. Parrish CR, McCray SF. Nutrition support for the mechanically ventilated patient. Crit Care Nurse 2003;23:77-80.
8. McVay-Smith C. Nutrition assessment. Nutrition 2001;17:785-6.
9. Kubrak C, Jensen L. Malnutrition in acute care patients: A narrative review. Int J Nurs Stud 2007;44:1036-54.
10. Neelemaat F, Kruizenga HM, de Vet HC, Seidell JC, Butterman M, van Bokhorst-de van der Schueren MA. Screening malnutrition in hospital outpatients. Can the SNAQ malnutrition screening tool also be applied to this population? Clin Nutr 2008;27:439-46.
11. Prins A. Nutritional assessment of the critically ill patient. S Afr J Clin Nutr 2010;23:11-8.
12. Ahsan B, Khaledi S. Knowledge and mortality of ICU impatients

in Tohid Hospital of Sanandaj in 2001. Med Sci Kordestan Univ 2005;9:20-5.
13. Daneshzad E, Azadbakhat L, Neamani F, Abasi S, Shirani F, Adibi P. Nutritional assessment of ICU impatients in Alzahra Hospital. J Health Syst Res 2014;10:655-68.
14. Shayesteh F, Poudineh S, Mohammad-Zadeh M, Pouryazdanpanah-Kermani M, Sadat Ayoudi S, Norouzy A. Assessment of nutritional intake in intensive care unit patients of Ghaem Hospital. Med J Mashhad 2015;58:217-24.
15. Arabi YM, Haddad SH, Aldawood AS, Al-Dorzi HM, Tamim HM, Sakkijha M, *et al.* Permissive underfeeding versus target enteral feeding in adult critically ill patients (PermiT Trial): A study protocol of a multicenter randomized controlled trial. Trials 2012;13:191.
16. Hajishafiee M, Azadbakht L, Adibi P. Energy and nutrient requirements in the intensive care unit inpatients: A narrative review. J Nutr Sci Diet 2015;1:63-70.
17. Kalantari H, Barekat SM, Maracy MR, Azadbakht L, Shahshahan Z. Nutritional status in patients with ulcerative colitis in Isfahan, Iran. Adv Biomed Res 2014;3:58.
18. Mnuter PA. Nutritional assessment of the critically ill patient. S Afr J Clin Nutr 2010;23:11-8.
19. Berger MM, Revelly JP, Cayeux MC, Gersbach P, Chioléro RL. Malnutrition and intensive care: Discussion on a difficult case. Rev Med Suisse Romande 2003;123:383-6.
20. Lochs H, Allison SP, Meier R, Pirlich M, Kondrup J, Schneider S, *et al.* Introductory to the ESPEN guidelines on enteral nutrition: Terminology, definitions and general topics. Clin Nutr 2006;25:180-6.
21. Cangelosi MJ, Auerbach HR, Cohen JT. A clinical and economic evaluation of enteral nutrition. Curr Med Res Opin 2011;27:413-22.
22. Mokhalalati JK, Druyan ME, Shott SB, Comer GM. Microbial, nutritional and physical quality of commercial and hospital prepared tube feedings in Saudi Arabia. Saudi Med J 2004;25:331-41.
23. Sullivan MM, Sorreda-Esguerra P, Platon MB, Castro CG, Chou NR, Shott S, *et al.* Nutritional analysis of blenderized enteral diets in the Philippines. Asia Pac J Clin Nutr 2004;13:385-91.
24. Jalali M, Sabzghabaee AM, Badri SS, Soltani HA, Maracy MR. Bacterial contamination of hospital-prepared enteral tube feeding formulas in Isfahan, Iran. J Res Med Sci 2009;14:149-56.
25. Sullivan MM, Sorreda-Esguerra P, Santos EE, Platon BG, Castro CG, Idrisalman ER, *et al.* Bacterial contamination of blenderized whole food and commercial enteral tube feedings in the Philippines. J Hosp Infect 2001;49:268-73.
26. Lucia Rocha Carvalho M, Beninga Morais T, Ferraz Amaral D, Maria Sigulem D. Hazard analysis and critical control point system approach in the evaluation of environmental and procedural sources of contamination of enteral feedings in three hospitals. JPEN J Parenter Enteral Nutr 2000;24:296-303.
27. Lindell MK, Whitney DJ. Accounting for common method variance in cross-sectional research designs. J Appl Psychol 2001;86:114-21.
28. Zhang LN, Wang XT, Ai YH, Guo QL, Huang L, Liu ZY, *et al.* Epidemiological features and risk factors of sepsis-associated encephalopathy in intensive care unit patients: 2008-2011. Chin Med J (Engl) 2012;125:828-31.
29. Polderman KH, Jorna EM, Girbes AR. Inter-observer variability in APACHE II scoring: Effect of strict guidelines and training. Intensive Care Med 2001;27:1365-9.
30. Mahan LK, Escott-Stump S, Raymond JL, Krause MV. Krause's Food and the Nutrition Care Process. 13th ed. USA: Elsevier Health Sciences; 2012.
31. Mahan LK, Raymond JL, Escott-Stump S, editors. Nutrition assessment, intake: Analysis of the diet. In: Krause's Food and the Nutrition Care Process. 13th ed. Philadelphia, PA: Saunders; 2011.
32. Borghi R, Dutra Araujo T, Airoldi Vieira RI, Theodoro de Souza T, Waitzberg DL. ILSI task force on enteral nutrition; estimated composition and costs of blenderized diets. Nutr Hosp 2013;28:2033-8.
33. Moore FA, Feliciano DV, Andrassy RJ, McArdle AH, Booth FV, Morgenstein-Wagner TB, *et al.* Early enteral feeding, compared with parenteral, reduces postoperative septic complications. The results of a meta-analysis. Ann Surg 1992;216:172-83.
34. Berger MM, Chioléro RL, Pannatier A, Cayeux MC, Tappy L. A 10-year survey of nutritional support in a surgical ICU: 1986-1995. Nutrition 1997;13:870-7.
35. Binnekade JM, Tepaske R, Bruynzeel P, Mathus-Vliegen EM, de Hann RJ. Daily enteral feeding practice on the ICU: Attainment of goals and interfering factors. Crit Care 2005;9:R218-25.
36. Drover JW, Cahill NE, Kutsogiannis J, Pagliarello G, Wischmeyer P, Wang M, *et al.* Nutrition therapy for the critically ill surgical patient: We need to do better! JPEN J Parenter Enteral Nutr 2010;34:644-52.
37. Kemper M, Weissman C, Hyman AI. Caloric requirements and supply in critically ill surgical patients. Crit Care Med 1992;20:344-8.
38. De Jonghe B, Appere-De-Vechi C, Fournier M, Tran B, Merrer J, Melchior JC, *et al.* A prospective survey of nutritional support practices in intensive care unit patients: What is prescribed? What is delivered? Crit Care Med 2001;29:8-12.
39. Hegazi RA, Wischmeyer PE. Clinical review: Optimizing enteral nutrition for critically ill patients – A simple data-driven formula. Crit Care 2011;15:234.
40. Kraft MD, Btaiche IF, Sacks GS, Kudsk KA. Treatment of electrolyte disorders in adult patients in the intensive care unit. Am J Health Syst Pharm 2005;62:1663-82.
41. Escuela MP, Guerra M, Añón JM, Martínez-Vizcaíno V, Zapatero MD, García-Jalón A, *et al.* Total and ionized serum magnesium in critically ill patients. Intensive Care Med 2005;31:151-6.
42. Safavi M, Honarmand A. Admission hypomagnesemia – Impact on mortality or morbidity in critically ill patients. Middle East J Anaesthesiol 2007;19:645-60.
43. Soliman HM, Mercan D, Lobo SS, Mélot C, Vincent JL. Development of ionized hypomagnesemia is associated with higher mortality rates. Crit Care Med 2003;31:1082-7.