Review Article

Energy and nutrient requirements in the intensive care unit inpatients: A narrative review

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A B S T R A C T

Background: Malnutrition has been the most prevalent problem in hospitalized patients during recent years, which accentuate the paramount importance of comprehensive nutritional support among these patients. This study aimed to provide a review of the recent literature about intensive care unit (ICU) inpatients and their nutritional care.

Methods: This review on energy and nutrient requirements for feeding the ICU inpatients focused on literature in English language. An on-line search using the keywords “nutritional support, malnutrition, ICU inpatients, micronutrient deficiencies, critically ill” in ISI web of science, PubMed, Scopus journals published during the years (June 1979-November 2014) was run. The cross-sectional and prospective studies, as well as the clinical trials, were recruited into this investigation.

Results: Recent studies propose energy provision with 20-25 Kcal/Kg/day or 25-35 Kcal/Kg/day for critically ill patients. The recommended carbohydrate and protein intakes are 2-4 g/Kg/day, 1.2-1.5 g/Kg/day, respectively. The suggested fat intake is 25-30% of a total calorie. The latest studies stressed the need for antioxidant vitamins and trace elements such as A, C, β-carotene, E, selenium, magnesium and zinc among ICU inpatients.

Conclusion: High prevalence of malnutrition among ICU inpatients caution to provide a nutritional health care team, including professionals and dietitians who evaluate the effectiveness of treatment and supplementations. Energy requirement should be determined according to their nutritional and clinical status; then macro and micronutrient needs should be considered for ICU inpatients.

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Introduction

Malnutrition has been the most prevalent problem in hospitalized patients during recent years, which characterized by subjective global assessment scores and accentuates the importance of comprehensive nutritional support among these patients [1-3]. About 50% of patients at hospital admission notably in intensive care unit (ICU) are reported to be malnourished worldwide [4, 5]. In addition, this rate is 43% among Iranian ICUs [6]. Many studies have shown that the prevalence of

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malnutrition is quiet high among patients who suffer from chronic diseases like cancers; however, it is approximately 20% among patients with gynecologic cancer upon admission to the ICU [7, 8]. In addition, the occurrence of malnutrition among pediatric ICU inpatients ranges from 15% to 65% [9-11]. About 87% of malnourished cases have been reported by Korean ICUs [12, 13]. Some studies have reported that the most of ICU beds are occupied by elderly patients [12, 14]. ICU malnutrition leads to prolonged and complicated evolution [15, 16], which causes a succession of complications such as infection, atrophy, poor healing wounds, and death [2, 4, 17], which raise care cost. Nutritional status exacerbates during the stay in ICU because of inadequate nutrient intake and different physiological stresses [5]. The major cause of malnutrition among ICU inpatients is inflammatory responses motivated by surgery, trauma or sepsis, which leads to a higher metabolism, energy expenditure and protein catabolism [5, 14, 18]. These conditions are characterized by depletion of visceral protein stores [7], gastrointestinal malabsorption, negative energy balance [15] and a decrease in lean body mass [5]. Nutritional support is defined as enteral and parenteral artificial feeding that aims to provide protection of the lean body mass, induce high immune function and be cost effective [14, 15, 19, 20]. Although early enteral nutrition (EN) within the first 24-48 hours of ICU care is preferred [21, 22], parenteral feeding could play a protective role in nutritional deficiencies when EN is insufficient [13, 23-25]. Nutritional support should fulfill macro and micronutrients requirements mutually [26]. Provision of optimal nutritional support in ICU can be eradicated by various factors such as inadequate assessment of nutritional status at hospital admission, delay in initiating, physical intolerance of feeding and gastric dysfunction [4, 13, 15, 18, 23, 27]. There are different methods to assess nutritional status of ICU patients at admission represented by guidelines. Anthropometric indices (i.e. body mass index, triceps skinfold thickness and arm circumference), serum protein factors (i.e. albumin, pre-albumin, transferrin and retinol-binding protein) are some of these methods [7, 15]. The present study aimed to provide a review of the recent literature about ICU inpatients and their nutritional care.

Methods

This review on energy and nutrient requirements for feeding the ICU inpatients focused on literature in English language. An on-line search using the keywords “nutritional support, malnutrition, ICU inpatients, micronutrient deficiencies, critically ill” was conducted in medical databases, including PubMed, ISI web of Science, Google scholar and Scopus up to November 2014. Our search retrieved 72 articles. of which 53 articles left after screening title/abstracts. After reading full-texts, 4 articles were excluded because they were reviewed and did not meet the inclusion criteria. The cross-sectional, retrospective and prospective studies, as well as the clinical trials, were recruited into this investigation. The authors selected accessible epidemiological articles, which have concerned different nutritional supports and formulas, energy and nutrient needs and effect of nutrient and antioxidants supplementation among ICU inpatients. The chosen clinical trials have examined the influence of interventions that contain provision energy needs, nutrient supplementation besides dietitian presence. The study populations of above-mentioned papers ranged from expected patients to stay more than 3 days in ICU to surgical patients. They have focused on the effect of interventions on different outcomes containing hospital mortality, length of mechanical ventilations, ICU stay and incidence of infections. Some of the prospective studies have compared malnutrition status among surgical and medical patients. Others have appraised average and near energy target for the first 7 days among traumatic ICU inpatients. The outcomes included 30 days mortality, ICU-acquired infections, biochemical factors, and anthropometric measures within ICU stay. Remained retrospective studies have assessed the role of energy deficiencies, timing of nutritional support on the length of ICU stay and ventilation among children and surgical patients. Cross-sectional studies have evaluated required energy need and supplementation effectiveness among ICU inpatients staying more than 7 days in ICU. The study selection process is illustrated in figure 1

Results

Energy requirements and recommendations

A number of similar studies have suggested early nutrition support that has been defined as 24-48 hours within the ICU care among underfeed inpatients who have negative energy balance [14, 24, 28]. Although, there are some recommendations about measuring energy needs among which indirect calorimetry is considered as a global standard, Harris–Benedict equation, Hamwi method or Broca's index are more pragmatic [1, 29, 30]. Recent studies propose energy provision with 20-25 Kcal/Kg/day [1, 31] or 25-35 Kcal/Kg/day [26, 32] and increasing energy intake, respectively. However, even this amount may not meet the needs entirely [1, 31]. Recent studies on surgical and medical ICU patients confirmed that early energy intake is insufficient and less than their real needs specially among surgical patients [33] though a gradual increase should be considered during the 1st day [4, 5, 34-36]. However, an investigation done in Korea' ICUs showed a worsened status during stay in ICU among patients although EN was provided [13]. Singer et al. have proved that, nutritional support adjusted by repeated measures of energy expenditures compared to energy goal based on a single determination of a weight-based formula, lowers hospital mortality [27]. A randomized controlled trial done by Arabi et al. revealed that raising near-target energy intake is independently correlated with an increasing number of hospital mortalities, length of ICU stays and duration of mechanical ventilations [37].

Macronutrient requirements

As far as the pathophysiology is concerned, depletion of glycogen stores in the liver and skeletal muscle is caused by surgery, sepsis and trauma [18]. The body utilizes muscle protein as an alternative to fulfill tissues glucose requirement by the gluconeogenesis pathway [1]. So a raised protein catabolism and amino acid flux are observed, respectively [31]. To avoid hyperglycemia, imposing a limit on carbohydrate provision is needed [1, 18, 26]. The recommended carbohydrate intake is 2-4 g/Kg/day [26]. Dextrose monohydrate, the most common carbohydrate source, is administrated parenterally. Fructose, sorbitol, xylitol, and glycerol are those others which are being discussed. Alongside carbohydrate provision, adequate protein provision as a source of energy is necessity [1]. Usually, attention should be paid to protein requirement according to patient's clinical and physiological status [26, 38]. The recommended protein requirement is 1.2-1.5 g/Kg/day, which could reduce the body protein loss [27, 39]. Branched chain amino acids are preferred in sepsis and surgery due to the improvement of protein synthesis [1, 40].

Glutamine as an indispensable amino acid in the form of dipeptides is primarily found in parenteral formulas and is thought to improve nitrogen balance, reduce ICU stay and mortality [31, 41]. According to recent studies and guidelines, glutamine should be prescribed in 0.2-0.4 g/Kg/day for severe catabolic patients such as trauma and burn who receive EN [31, 42].

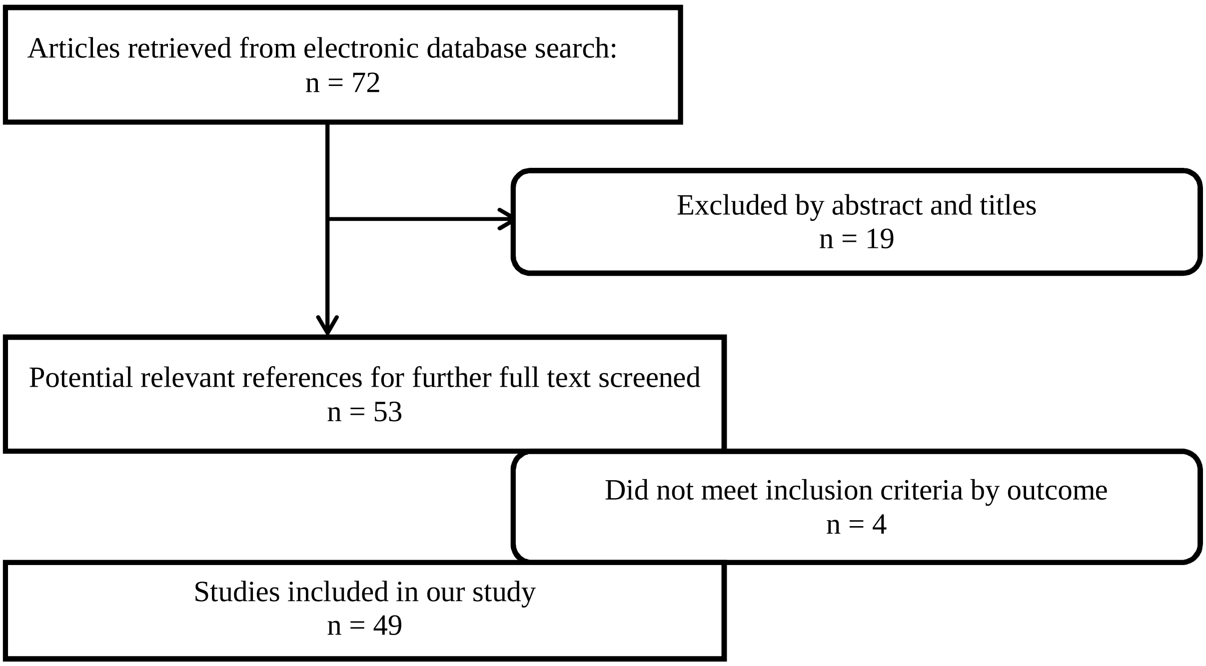

Figure 1. Flow of study selection process

Arginine and leukine known as immunomodulating macronutrients are supplemented in enteral and parenteral formulas [31]. Arginine in trauma, acute respiratory distress syndrome and mild sepsis ICU patients in the pre-and post-operative state is recommended [42]. By the year of 2011, Mercadal et al. within a quasi-experimental study showed that parenteral pre-operative glutamine supplementation is beneficial to decline morbidity, which is related to malnutrition. In addition, the incident of infection and ICU stay alleviated following glutamine intake [43]. Fat is considered as third macronutrient, which is used to supply energy and prevent essential fatty acids deficiencies [31]. The suggested fat intake is 1-1.5 g/Kg/day, which is about 25-30% of total energy [26]. Soybean, safflower oil and egg yolk are included in the total parenteral nutrition as lipid sources [1]. Omega-3 and omega-6 are contained in the most nutritional formulas that could modulate immune responses through an anti-inflammatory activity [18, 31, 44]. Although omega-6 intake should be treated with caution due to its immunosuppressive potential [1], the omega-3 enteral administration can be used in the pre- and post-operative state and for ICU patients [42]. Umali et al. observed that carbohydrate, protein and fat intake of Philippines ICU inpatients does not satisfy their needs, leading to increase in the number of malnourished patients [4].

Micronutrient requirements

Latest studies focused on the need for micronutrient supplementation including vitamins and also trace elements among critically ill patients [1, 26, 42, 45]. Oxidative stress caused by oxidative imbalance worsens ICU patients' status, making antioxidant nutrients required. However, there is not a unanimous agreement on its dosing and timing which should be administrated according to patient's individual need [26, 45-47]. Multivitamins prescription is advocated by numerous investigations [1, 26, 42]. Antioxidant vitamins prescription like A, C, β-carotene and E is a necessity among severe burned patients [26, 42]. Though, the vitamins requirement is recommended by guidelines [1, 48], the precise need should be ascertained in various sort of patients [26, 42, 46]. Copper, zinc and selenium are the most concentrated antioxidant elements in parenteral nutrition supplementations [1, 42]. Initiating selenium loading with high dose of 500-1600 μg/day could play a significant role to get better clinical outcomes in systematic inflammatory response syndrome (SIRS) illness [45], whereas the recommended dose is 50-100 μg in parenteral solutions [1]. Like selenium, zinc produces the same effects in immune system improvement, wound healing and enzyme reactions [45, 49]. Within a study, Duncan et al. reported that zinc measurement is a regular laboratory test among UK ICU wards. They notified that low zinc plasma concentration does not reveal its shortage because it falls independently of nutrition deficiencies in SIRS. In addition, its high-dose supplementation is not well-documented among ICU patients [49]. The neurological and neuromuscular irritability may be related to magnesium deficiency [1, 50]. Two studies were done on ICU patients with close findings discovered that the admission of hypomagnesemia is highly important and deeply related to mortality rate, length of hospital stay and organ dysfunction. In addition, they mentioned that inspection of serum magnesium as a diagnostic and therapeutic tool is advisable [50, 51]. Over a randomized trial, Berger et al. provided early antioxidant supplements contained selenium 270 μg, zinc 30 mg, vitamin C 1.1 g, and vitamin B(1) 100 mg for cardiac surgery, major trauma, and subarachnoid hemorrhage patients. Eventually, a significant decline in inflammatory response but no differences in organ dysfunction among study and control groups were observed [47]. In addition, it has been shown that pre-operative micronutrient supplementation, including the combination of alpha-ketoglutaric acid and 5-hydroxymethylfurfural may reduce complications, shorten recovery, and thereby lower costs among surgery inpatients [52]. A summary of carried out studies regarding energy needs, macro and micronutrients among ICU inpatients is shown in table 1.

Discussion

This study focused on reviewing facts about the nutritional support among malnourished ICU inpatients. The correlation between nutritional support and energy balance has already been defined, although its specific requirement is yet contentious [1, 26, 31]. In addition, contrast result approved worsened outcomes by increased energy intake [37], A less macronutrient provision during the catabolic period and more in recovery would be wise [18]. The influence of nutritional support on protein metabolism is

Table 1. A summary of carried out studies about energy needs, macro and micronutrients in ICU inpatients

Author (references)	Publication year	Study	Number of participants	Exposure	Outcome	Result
Soguel et al. [34]	2012	Prospective interventional	572	Bottom-up implementation of feeding guideline, additional presence of an ICU dietitian	Anthropometric data, ICU severity scores, energy delivery, energy balance, length of ICU and hospital stay and mortality	A bottom-up protocol got better nutritional support. The ICU dietitian made a significant progression related to early introduction, route of feeding and gained better energy balance
Singer et al. [27]	2011	Prospective, randomized, single-center, pilot clinical trial	130	EN administration with an energy target determined by repeated indirect calorimetry measurements or 25 kcal/kg/day	Hospital mortality	Near target energy requirements provision based on repeated energy measurements was achievable in a general ICU and may be correlated with lower hospital mortality
Arabi et al. [37]	2010	Nested cohort within a randomized controlled trial	523	Average caloric intake/target for the first 7 ICU days	ICU and hospital mortality, ICU-acquired infections, duration of mechanical ventilation and ICU and hospital length of stay	Near-target caloric intake is related to significantly increased hospital mortality, ICU-acquired infections, mechanical ventilation duration, and ICU and hospital length of stay
Mercadal et al. [43]	2011	Quasi-experimental	67	(1) Without glutamine dipeptide supplementation of during the perioperative period, (2) glutamine dipeptide (0.4 g/kg/day) after surgery only, (3) glutamine dipeptide (0.4 g/kg/day) in the perioperative period	Post-operative morbidity and mortality	Perioperative glutamine dipeptide decreased morbidity associated with malnutrition. It improved blood glucose modulation and declined infection and ICU stay
Berger et al. [47]	2008	Prospective, randomized, double-blind, placebo-controlled, single-center trial	200	Intravenous supplements (selenium, zinc, vitamin C and vitamin B(1) with a double-loading dose on days 1 and 2 or placebo	Sequential organ failure assessment score, C-reactive protein, length of hospital stay	The intervention did not reduce early organ dysfunction but significantly reduced the inflammatory response in cardiac surgery and trauma patients
Matzi et al. [52]	2007	Prospective randomized	32	Combination of a-ketoglutaric acid (alpha-KG) and 5-HMF	Exercise capacity and oxidative stress	VO_2 max and Watt's in study group raised. Determination of oxidative stress significantly reduced in study group. The length of hospital and ICU stay decreased

ICU= Intensive care unit, EN= Enteral nutrition, 5-HMF= 5-hydroxymethylfurfural not clearly self-evident [31]. However, specialists developed different guidelines for nutritional supplementation for ICU inpatients [1, 18]. Regarding the ICU micronutrient requirement, dietitians should pay attention to the physiological status of patients [1, 26, 42, 46]. Oxidant-antioxidant imbalance induces more critical situations and higher mortality rate respectively, for this reason antioxidant micronutrients included vitamins and minerals is a necessity [26, 45-47]. The weakness of retrospective studies included in this review was their invalid and unavailable medical records and maybe small sample size [7, 35, 36, 51, 53]. While, the cross-sectionals lacked precise anthropometric measures [1, 13], the interventions were not respected by critically ill patients or nurses [15, 52]. A few studies underlined the value of energy intake monitoring [4]. Most of the studies and practical guidelines have acknowledged the significant role of early nutritional support in critical illness [14, 24, 31]. However, due to limited number of investigations about different aspects of nutritional support in the ICU done on humans and the contradictory results, more controlled clinical trials are needed to be designed.

Conclusion

The given results of our study represent that the high prevalence of malnutrition among ICU inpatients caution to provide a nutritional health care team including professionals and dietitians who evaluate the effectiveness of treatment and supplementations. The ICU inpatients energy requirement should be determined according to their nutritional and clinical status, and then macro and micronutrient needs should be considered.

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Conflict of interest

None of the authors had any personal or financial conflicts of interest.

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