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Original Article

Nutritional assessment in critically ill patients

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A B S T R A C T

Background: Nutritional care is of special importance in the control of the rate of mortality among intensive care unit (ICU) patients. Therefore, anthropometric and biochemical assessment are important among ICU patients. We intend to report the anthropometric and biochemical indices, as well as the energy intake among ICU patients in Isfahan, Iran.

Methods: This descriptive study was carried out in Isfahan, Iran on 100 patients admitted to the ICU. Height, weight, mid arm circumference, and energy requirements were measured in this population. Some biochemical factors, such as albumin, creatinine, lymphocytes count, sodium, potassium, phosphorus, and magnesium, were measured twice within a week interval by biochemical tests. Any kind of disease, having infection or bedsore, taking oral ventilation and the kind of nutrition has been assessed in each patient.

Results: Serum albumin level was less than normal range in 67% of patients based on measurements in the first day of staying in ICU. The prevalence increased to 77% in the seventh day of hospitalization in ICU ($p = 0.040$). There was a significant reduction in the mean of mid arm circumference after 1 week staying in ICU ($p = 0.001$). There were significant differences between energy intake and the amount of energy requirements in these patients ($p = 0.035$).

Conclusion: ICU patients have been exposed to lower energy intake compared to their requirements and their mid arm circumference reduced significantly after 1 week staying in hospital. Therefore, they require special nutritional care.

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Introduction

Patients with a lot of difficulties in one or more critical organs are usually hospitalized in the intensive care unit (ICU) [1, 2]. There is limited evidence regarding nutritional status among these patients [3]. The mortality

rate in ICU has been reported around 5 up to 35% while this range is 18.1 up to 29.3% for patients in other wards [4]. Nutritional care is of special importance in the control of the rate of mortality among ICU patients [5-9]. According to the recent reports, two-thirds of patients during hospitalization are afflicted with malnutrition [10]. Nutritional laboratory indices are important and necessary for assessment of clinical and subclinical deficiencies [11, 12]. In malnutrition situation, there is relative reduction in albumin level and the reduction of urinary excretion of urea, electrolytes level, especially potassium, and magnesium [11]. Albumin with antioxidant and anti-inflammatory properties is the main protein that is responsible for plasma colloid osmotic pressure and has an important role in ICU patients specially for bedsore healing [11]. Electrolytes, such as potassium and magnesium, are involved in many metabolic and homeostatic functions [13].

Based on some reports, malnutrition occurs around 30-50% in hospitalized patients. It is determined that more than 50% of ICU patients take nutrients less than their needs [14]. Malnutrition rate has been reported about 25-48% at most studies in Iran [2, 15]. Fat free mass and muscle catabolism reduction occur with malnutrition; therefore, it results in mortality because of physical activity reduction and also protein deprivation [16]. Therefore, accurate estimation of nutritional needs of these groups in terms of calories and macronutrients, and continuous controlled condition of these patients are of special importance [17, 18]. In fact, malnutrition could cause disorders in the function of immune system, delay in wound healing, increase complication after surgery, prolongation of hospitalization and increase morbidity and mortality in ICU patients. Anthropometric and Biochemical assessment could prevent malnutrition. We are not aware of any publication in Iran that reports the total energy intake as well as the anthropometric and biochemical indices among the ICU patients. Therefore, we intend to assess the anthropometric and biochemical indices, as well as energy intake among ICU patients in Isfahan, Iran in this study.

Methods

The present study is a descriptive study approved by the Isfahan University of Medical Sciences Isfahan, Iran. This study was carried out on 100 ICU patients in Al-Zahra Hospital. Patient recruitment was done from April 2010 until July 2011. For considering the sample size, we just included those patients in ICU who had the biochemical data for at least baseline and then the seventh day of impatient. Written informed consent was completed for all patients by one of their relatives. Questionnaires of demographic and anthropometric characteristics, food intake, and biochemical situation were completed. Each patient was visited twice within a week interval, therefore those subjects whose questionnaires were not completed for any reason such as not being available because of death or releasing from hospital and or whose anthropometric or biochemical indices and assessment of the second stage were not measured, were excluded from this study. The data related to the tests have derived from the patient's vital signs, and in case of not being mentioned in card, are derived from the hospital computer software system. All data that are derived from vital signs card are taken as a note right at 9 O'clock in the morning.

Anthropometric measures were included height, weight, gender, age and mid arm circumference. Height was measured use of meter in the form of lying down on the hospital bed. Weight was measured using beds equipped with scale, considering that some beds were not equipped with scale, and the experienced expert has estimated the subject's weight. We considered number 23 for patients that sounded have a normal body mass index (BMI) and calculated the weight using height. For measuring the mid arm circumference, the distance between their shoulder and elbow was measured, and the point in the middle of arm was marked and then the mid arm circumference from that point was measured use of a tape measure [11]. The type of nutrition and the amount of the received energy of each patient are derived from the vital sign card. The energy requirement for each patient was calculated and derived by Harris-Benedict Formula [19]. Based on this formula male's energy expenditure

calculated by this form: 66.5 ± 13.75 ($Weight_{kg}$) ± 5 ($Height_{cm}$) − 6.78 (Age_{year}). This variable for women calculated by this form: 655.1 ± 9.56 ($Weight_{kg}$) ± 1.85 ($Height_{cm}$) − 4.68 (Age_{year}). Then, the energy requirement for each patient was calculated considering to each patient's physical activity coefficient and stress factors coefficient, e.g., Infection, bedsore, surgery, trauma, sepsis, severe burns, and some other factors [20], and the rate of the required protein for each patient was determined by considering the illness or having bedsore [21].

Fasting blood samples (5 ml) were taken at baseline and after 1 week at Alzahra Hospital laboratory in an early morning after an overnight fast. Laboratory values for albumin, creatinine, and potassium; total counting of lymphocytes, sodium, phosphorus, and magnesium were considered as biochemical indices. The values of magnesium, albumin, and phosphorus were derived by Pars Kit Test (from Pars Azmoon Company, Karaj, Iran). The method of Photometric Xylidyl Blue, Photometric Bromocresol Green, and Photometric UV Test used for determination of serum magnesium [22], albumin [23], and phosphorus [24], respectively. Serum levels of potassium and sodium were measured using biochemical kit by Flame Photometry [25]. The total counting of lymphocytes and white blood cells was done using Electrode method and by use of SIS MEX KX-21m Kit (from Pars Azmoon company, Karaj, Iran).

The data were analyzed statistically by SPSS 16 software (SPSS Inc., Chicago, IL, USA). Descriptive data includes frequency, mean, standard deviation, and minimum and maximum of the variables rate were determined. Qualitative data were compared by χ^2 test. Comparison between the first and seventh day was done by paired-sample t-test.

Results

This study was carried out on 100 patients (55 men and 45 women). Participants were aged 4-89 years. The mean age of the participants was 50.0 ± 21.5 years. The causes of hospitalization in ICU are mentioned in table 1. Thirty-six of impatiens had surgery. Anthropometric indices of patients are shown in table 2. BMI of 43% of patients was in the normal range. Mid arm circumference decreased in the seventh day compared to the first day of staying in ICU (p = 0.001).

Table 1. Frequency of patients on the basis of clinical diagnosis in ICU in Al-Zahra Hospital 2010-2011 (n = 100)

Diagnosis	Number	Male (n)	Female (n)
Surgery	36	26	10
Inflammation	22	15	7
Brain and nerves disease	22	6	16
Cardiovascular disease	9	5	4
Cancers	6	4	2
Kidney disease	3	-	3
Respiratory disease	2	-	2

n = Number

Table 2. Average of anthropometric and body temperature indices of patients hospitalized in ICU of Al-Zahra Hospital during 2010-2011 (n = 100)

Variables	Frequency (%)	Average	SD	Maximum	Minimum	p value[1]
Height (centimeter)		166.08	11.49	190	100	-
Weight (kg)		71.38	15.47	124.2	25	-
Age (year)		49.99	21.54	89	4	-
BMI (kg/m^2)		25.77	5.15	40.58	14.6	-
BMI						-
< 18.5	5					
18.5-24.9	43					
> 25	52					
Mid arm (First day)		28.36	4.6	40	16	-
Mid arm (seventh day)		27.47	4.83	39	15	-
Difference of mid arms		-0.89	1.62	4	-7	0.001
Temperature (First day)		36.35	2.77	39.2	24	-
Temperature (Seventh day)		36.68	2.49	39.5	22.7	-
Temperature difference		0.31	2.97	13.3	-14.1	0.270

[1]p values are reported for comparing the mid arm circumference and body temperature between first day and seventh day of staying in ICU. BMI = Body mass index, ICU = Intensive care unit, SD = Standard deviation

Table 3. Comparison of biochemical indices at first day and seventh day of staying in ICU among patients (n = 100)

Variables	First day				Seventh day				p value[1]
	Maximum	Minimum	SD	Average	Maximum	Minimum	SD	Average	
Albumin (g/dl)	4.8	1.9	0.54	3.17	4.5	1.9	0.53	3.14	0.570
Total count of lymphocytes (cell/mm^3)	16464	120	1877.1	1.69	386.6	84	3996.8	2.15	0.240
Sodium (meq/l)	156	117	6.1	1.36	176	125	6.8	1.37	0.530
Potassium (mg/dl)	7	2.6	0.69	4.04	6.1	2.4	0.69	4.06	0.790
Phosphorus (mg/dl)	7	1.8	0.91	3.43	6.8	1.6	0.94	3.54	0.300
Magnesium (meq/l)	3.5	1.1	0.41	1.95	3.1	0.9	0.39	1.97	0.760

[1]p values are resulted from paired sample t-test in SPSS16 software. ICU = Intensive care unit, SD = Standard deviation

Table 4. Frequency of patients in the normal or deficient or over amounts of indices at first and seventh day (n = 100)

Variables	First day (%)			Seventh day (%)			p value		
	Less	Normal	More	Less	Normal	More	Less	Normal	More
Albumin (3/5-5 g/dl)[1]	67	33	-	77	23	-	0.04	0.110	> 0.001
Sodium (135-145 meq/l)	38	57	5	32	61	7	0.20	0.020	0.100
Potassium (3/6-5 mg/dl)	21	72	7	26	65	9	0.06	0.030	0.070
Phosphorus (3-4/5 mg/dl)	33	57	10	24	68	8	0.1	0.050	0.030
Magnesium (1/4-2/3 meq/l)	11	76	13	6	79	15	0.18	0.010	0.040

[1]Numbers in parenthesis indicate the normal range

Table 3 shows the mean of biochemical indices at the first day and seventh day of staying in ICU. There were no significant differences regarding the mean of biochemical indices between the first and seventh day of staying in ICU.

Table 4 shows the distribution of patients based on the serum levels of albumin or serum levels of minerals at the first day and seventh day of hospitalization in ICU. This table shows that how many percent of patients were in the normal range and the distribution of patients in less or more amounts of intake. Comparison between the required energy and total energy intake is shown in table 5. 61% of the patients had received less than their required energy and only 39% of them were supplied with enough energy. Among 39 patients that were supplied with enough energy 29 of them were supplied more than their needs and 10 of them supplied the exact amount of energy that estimated. Table 6 shows the results of binary logistic regression on the potential determinant of malnutrition in ICU impatiens. After adjusting the energy intakes of impatiens in three models, we saw a significant relationship between low level of plasma phosphorus in the first day and low energy intake ($p < 0.030$). Furthermore, there was a significant relationship between appropriate level of plasma magnesium in the first day and appropriate energy intake ($p < 0.002$). Totally, 66% of patients were on ventilator. 54% of patients were fed by tube. 94% of patients received antibiotics. 39% of patients were on no feeding situation.

Discussion

The results of the present study showed that high percent of patients in ICU had serum albumin level lower than normal range. Mid arm circumference was also reduced after seven day impatiens in ICU. However, this reduction was not significant. We also found a significant difference between energy intake and the real amounts of energy requirements among inpatients. Few studies have been carried out in the field of assessment of malnutrition in ICU patients in Iran [2, 15, 18]. Inadequate nutritional support could increase the risk of malnutrition in the hospitalized patients in ICU while optimal energy receiving can deliver best clinical outcomes [26, 27]. The results of the present study showed a notable difference between energy intake and energy need among ICU inpatients. Considering that the most ICU patients were in a hyper-metabolism and hyper-catabolism situation, and in case of the lack of suitable nutritional protocol and sufficient and exact cares, it is not a faraway expectation that

Table 5. Comparison of required amounts of energy and received energy in patients hospitalized in ICU (n = 100)

Variables	Average	SD	Maximum	Minimum	p value[1]
Received energy	1298.26	107.03	3000	0	
Required energy	2060.22	31.92	3200	1400	
Difference of above values	-761.96	105.03	700	-3000	0.035

[1]p values are resulted from paired sample t-test in SPSS16 software. ICU = Intensive care unit

Table 6. The results of multivariable ordinal logistic regression on the potential determinant of malnutrition in ICU impatiens (n = 100)

Models	Variable	β	SE	OR (95% CI)	p value[1]
Model 1	Gender				
	Female	0.075	0.543	1.078 (0.372-3.123)	0.890
	Age	-0.019	0.013	0.981 (0.956-1.006)	0.138
	Antibiotic giving	0.274	0.966	1.315 (0.198-8.740)	0.777
	Having bed sore	0.562	0.594	1.753 (0.547-5.617)	0.344
	Having ventilation	0.131	0.679	1.140 (0.301-4.315)	0.847
	Temperature difference	-0.008	0.073	0.992 (0.859-1.145)	0.911
	NPO (Type of receiving energy)	-2.371	1.418	0.093 (0.006-1.503)	0.094
	Gavaj (Type of receiving energy)	1.043	1.053	2.839 (0.360-22.366)	0.322
Model 2	Height	0.132	0.091	1.142 (0.956-1.364)	0.145
	Weight	-0.217	0.119	0.805 (0.637-1.017)	0.069
	Mid arm circumference differences	0.002	0.157	1.002 (0.736-1.364)	0.989
	Body mass index	0.407	0.31	1.502 (0.818-2.760)	0.190
Model 3	Albumin (First day)	0.568	0.814	1.765 (0.358-8.711)	0.485
	Albumin (Seventh day)	-1.102	0.838	0.332 (0.064-1.715)	0.188
	Creatinine (First day)	0.934	0.902	2.546 (0.435-14.904)	0.300
	Creatinine (Seventh day)	-1.725	0.99	0.178 (0.026-1.240)	0.081
	Total lymphocyte count (First day)	0	0	1.000 (1.000-1.001)	0.252
	Total lymphocyte count (Seventh day)	0	0	1.000 (1.000-1.000)	0.894
	Sodium (First day)	-0.025	0.057	0.976 (0.873-1.091)	0.664
	Sodium (Seventh day)	-0.003	0.045	0.997 (0.913-1.089)	0.950
	Potassium (First day)	-0.719	0.5	0.487 (0.183-1.298)	0.150
	Potassium (Seventh day)	0.164	0.464	1.178 (0.475-2.925)	0.723
	Phosphorus (First day)	-1.058	0.496	0.347 (0.131-0.918)	0.033
	Phosphorus (Seventh day)	0.659	0.414	1.932 (0.858-4.348)	0.112
	Magnesium (First day)	2.279	0.743	9.766 (2.276-41.905)	0.002
	Magnesium (Seventh day)	-0.31	0.736	0.734 (0.173-3.104)	0.674

[1]p values are resulted from binary logistic regression test in SPSS16 software. Model 1: Adjusting energy intake by gender, age, antibiotic intake, bedsore, having ventilation, temperature difference and types of energy intake. Model 2: Adjusting energy intake by anthropometric indices. Model 3: Adjusting energy intake by biochemical indices. ICU = Intensive care unit, SE = Standard error, OR = Odds ratio, CI = Confidence interval

most of them in a short time become afflicted with severe malnutrition. The study of Salehifar and colleagues [19] showed that lack of sufficient supplying of calorie and protein in patients could cause the outbreak of malnutrition in these patients. Energy intake less than amount of needing results in malnutrition and more than needing results in increasing blood sugar risk. Patients, who are in critical status and have higher BMI, are exposed in high risk of glucose intolerance, edema, dependence on ventilation, and bedsore. Patients with less BMI are exposed in malnutrition if they do not get amount of energy needing [28].

39% of patients were on no feeding situation in the present study. This condition could be one of the reasons of malnutrition in these patients. Nutrition has important effect on clinical outcomes in ICU patients. Patients who are putting on no feeding situation or taking less than calorie needing, have more risk for affinity of ventilation, increasing duration of hospitalization in ICU and increasing mortality risk compare with other patients. Respiratory muscles strength decrease after no feeding situation or taking less than calorie needing for a few days. Furthermore, no feeding situation is related to bedsore in patients [29]. The status of the biochemical indices is also effective in determination of the status of malnutrition and the improvement trend of ICU patients [30-33]. Magnesium deficiency usually will result in disrupting of the balance of the size of micronutrients in the body (the outbreak of

hypoglycemia, hypophosphatemia, hypokalemia, and hyponatremia) and could cause the weakness of skeletal and respiratory muscles, tetany, and spasm among patients [34]. In the recent study, the prevalence of magnesium deficiency was not in a high rate among inpatients. Usually, magnesium reduction was occurred with increase of death and mortality risk and also the increase of hospitalization. The reduction of the other laboratory indices including the level of serum albumin, phosphorus and total counting of lymphocytes could be a sign for being unsatisfactory of patient's nutritional situation [31, 32, 35]. In the present study, the prevalence of the patients with low amounts of serum albumin level were high and even after 7 days this prevalence increased among inpatients.

In the study of Sungurtekin et al. [36] and Thuo et al. [37] in the presence and developing in infections in ICU patients had significant effect in developing of malnutrition. Some factors that have severe effects on bedsore are disability and reduced activities in each patient, because in critical status anorexia and anemia can results to disability of patient. Age, fever that relates to main diseases, body sense reduction, inadequate nutrition, encopresis and enuresis are some other causes [38, 39].

Other indices in the present study include the measuring of weight and mid-arm circumference which have to be measured and compared for exact diagnosis in two stages in the interval. In this study, the mid arm circumference was measured in two stages with seven days interval in which a meaningful reduction was observed. The subjects' weight was not measured twice, considering that some beds were not equipped with scale, and the estimation of weight by expert in two stages caused much errors in the study, therefore the expert reported the weight only for one time. Mid arm circumference could be a good index of malnutrition [40]. Based on Gerasimidis study and colleagues [41], it was determined that the reduction in mid arm circumference was associated with malnutrition. The recent study was carried out for evaluating of nutritional status of ICU patients, which assessed series of anthropometric and biochemical factors besides investigation of body temperature which would certainly complete more the interpretation of the results. Because of the lack of valid information of the percentage of macronutrients in patients' diet, the rate of macronutrients was not considered, and the received energy was only estimated. It seems that if a longer interval was considered between measuring, we had obtained meaningful results, but short period of study caused a reduction seen in some indices which this was not meaningful [42]. In addition, losing samples, short duration of hospitalization, transferring toward, death of patients and inadequate equipment in ICU were effective on the results obtained from study. The execution of the studies with more time and better control of intervening factors could complete this study. Identifying and control of effective nutritional factors in incidence of malnutrition in ICU could help reducing mortality rate and quick improvement of patients.

In this study after adjusting the energy intakes of impatiens in three models, we did not observe a significant relationship between level of energy intake and age and gender. Based on Ebrahimi [43] and Banks et al. [44] studies, gender is not an important factor on malnutrition. Although Ebrahimi et al. [43] study showed inappropriate nutrition in the elderly people than other ages. Different results may be due to different sample size and mean ages, maybe. Low level of plasma phosphorus in the first day and low energy intake had a significant relationship. Hypophosphatemia maybe resulted from sepsis conditions, decreased intestinal absorption and renal losses [45]. Furthermore, there was a significant relationship between appropriate level of plasma magnesium in the first day and appropriate energy intake. The amount of plasma magnesium is affected by some factors in ICU patients like other electrolytes, for example trauma, surgery, infection, sepsis, burns, and malnutrition [45].

There were some limitations in the current study. As this study was conducted only in one hospital, we could not generalize the results to all the patients in all hospitals. Therefore, we should consider this limitation while interpreting the results of the present study. In this study, the subjects' weight was measured at the first day only, considering that some beds were not equipped with scale, therefore, estimation of reduced weight and comparison with first day was not available. Moreover, albumin should be measured at least 21 days after admission regarding to its half-life duration, but we had the random levels that have been mentioned on patients file.

Conclusion

The results of the present study showed the high percent of patients in ICU had low serum

level of albumin, and the frequency of patients with low levels of albumin increased after seven days staying in the hospital. The mid arm circumference decreased in the seventh day of ICU impatient. There was a notable difference between energy intake and energy requirement among ICU inpatients.

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Conflict of interest

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

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