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Determinants of malnutrition in critically ill patients admitting to ICU in Iran: results from a cross-sectional study

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Summary. *Background:* The anatomic site of increased body fat is important because of its effects on the body. DASH diet have positive effects on body composition through its effects on weight. Our objective of this investigation was to assay the effects of adherence to DASH diet on body fat distribution. *Methods:* A total of 256 healthy participants were included in the current cross-sectional study. Complete body composition analysis was done whereby for all the cases. BC-418MA (Tanita UK Ltd, Middlesex, United Kingdom) was used. Dietary intake was assessed with a semi-quantitative food frequency questionnaire that consisted of 147 foods and beverages (with standard serving sizes commonly consumed by Iranians. We constructed the DASH score based on 8 foods and nutrients. FM and FFM indexes defined based on fat mass and free fat mass. *Results:* Obese individuals with more adherence to DASH diet had lower FFMI (P=0.04). Lowe trunk fat was strongly associated to more adherence to DASH diet (P=0.02). Moreover, individuals those had more adherence to DASH diet had lower waist circumference (P=0.03). *Conclusions:* The current study suggests that adherence to DASH diet is highly associated with weight loss in obese individuals and may be associated to FMI and FFMI which is depended to sex.

Key words: DASH diet, Fat distribution, Fat mass index, Fat free mass index

Introduction

Patients in ICU face with major challenges including malnutrition, immune dysfunction, severe infections, multiple organ dysfunction and death (1-4). The hyper-metabolic state of these patients which is characterized by increased depletion of lean mass as well as adipose tissue and maintaining metabolic requirements through increased protein break down may lead to malnutrition (2,3,5,6). About 50% of patients at hospital admission notably in ICUs are reported to be malnourished, worldwide (7,8). Furthermore, this rate is 43% for Iranian ICUs (9). Malnutrition causes some complications such as infections, impaired response to treatment and decreased immune response which results in reduced quality of life, longer hospital stay and increased health care costs (5,6,10,11). It has been mentioned that nutritional status and nutritional supplementation plays an important role in ICU inpatients outcomes (1). Accurate nutritional screening and assessment are parts of the clinical evaluation of hospitalized specifically ICU patients (11-13). Nutritional assessment among ICU inpatients is comprised of biochemical markers, anthropometric indices and immunological tests which can be completed using Subjective Global Assessment (SGA). However, the inherent limitations of these conventional methods are approved (11,12). Body mass index is one of the most common anthropometric indices of nutritional status which is related to under-nutrition in clinical conditions (1). While, it can be adversely affected by the presence of generalized edema (12). The most frequently used biochemical marker for nutritional assessment in critically ill patients is the serum level of albumin which is also considered as an indicator of severity of illness (1). There is a relative reduction in albumin concentration in critically ill patients suggesting a poor nutritional status and prolonged physiological stress associated with illness process (1). Serum levels of potassium, magnesium and phosphorus are routine health indicators to monitor nutritional status of ICU inpatients (1). Low levels of magnesium and phosphorus result in energy deficiency, cardiac and neuromuscular disorders (14). Reduction in potassium levels is accompanied with severe muscle pains and even arrhythmia and finally cardiac arrest (15). Some factors other than nutrition including physiological stress, increased catabolic rate and protein depletion may limit albumin use as an indicator in ICU inpatients (1,12). The identification of more appropriate markers for field use in critical care wards is needed. Numerous investigations have been conducted regarding nutritional assessment in ICU inpatients in different countries. However, limited data is available in Iran. Moreover, these studies did not assesse malnutrition determinants according to biochemical and anthropometric values. This study was therefore undertaken to evaluate the nutritional status and determine malnutrition markers in ICU patients receiving nutritional support in Isfahan, Iran.

Subjects and methods

This cross sectional study was conducted at Al-Zahra university Hospital of Isfahan University of Medical Sciences, Isfahan, Iran. Patients admitted to medical and surgical ICU wards enrolled in this study from February 2012 till the end of April 2012. Patients included those of 18 years of age or older and had an ICU station of at least 5 days. Those patients were included in study who had the biochemical data for the fifth day of ICU station. Finally, the data on 100 critically ill patients were gathered. This study was approved by Isfahan Regional Bioethic Committee.

Anthropometric assessment

Nutritional status was assessed via measuring anthropometric indices, laboratory data and medical history by a registered dietitian. ICU patients were bedridden and unable to stand up. Therefore, height was indirectly measured by knee-to-ankle height (15). Due to lack of standard scales in ICUs, actual body weight was estimated by considering all patients' appearance, height and body size. Ideal body weight was calculated by Devine's method (16). Body mass index was calculated as weight (kg) divided by height (m^2) (14). Mid-arm circumference was measured in centimeters halfway between the acromion process of the scapula and the olecranon process at the tip of the elbow (15).

Biochemical assessment

All biochemical indicators representing blood values, glycemic status and lipid profile, pulmonary, hepatic and renal function as part of the routine clinical care were measured at the fifth day of admission in ICU. No dietary assessment on energy intake and nutritional support was done. Malnutrition definition

In the current study, malnutrition was assessed according to albumin levels and ideal body weight (1) within 4 categories. In the first category (more than 90% of ideal body weight), patients had a good nutritional status if the albumin levels were more than 3.5 gr/dl. Albumin levels of 3.1-3.5 gr/dl and less than 3 gr/dl were mild malnutrition and protein malnutrition in the above-mentioned category, respectively. In the second category (76-90% of ideal body weight), albumin levels of more than 3 gr/dl were mild malnutrition and less than it were moderate malnutrition. Patients in third category (60-75% of ideal body weight) had energy malnutrition (i.e. marasmus) if albumin levels were more than 3.5 gr/dl. Albumin levels of 2.5-3.5 gr/dl were moderate malnutrition. While, less than 2.5 gr/dl was protein energy malnutrition. In the last category(less than 60% of ideal body weight), albumin levels more than 3.5 gr/dl, 3.1-3.5 gr/dl and less than 3.1 gr/dl were energy malnutrition, moderate malnutrition and protein energy malnutrition, respectively (15).

Statistical analysis

Mean±SD as well as range for quantitative variables were presented and qualitative data was expressed as percent. Analysis of variance was used to examine the differences of various quantitive demographic, anthropometric measurements and biochemical values of ICU inpatients across the different categories of malnutrition based on albumin levels and ideal body weight. Relationships between different levels of malnutrition (as ordinal dependent variable), in each group of ideal body weight, and demographic, anthropometric and biochemical measurements as the potential risk factors were evaluated using multivariable ordinal logistic regression. During fitting of ordinal logistic regression, the proportional odds assumption or parallel lines test was evaluated using chi-square test and then the cumulative probabilities of ordered categories response variables (i.e. levels of malnutrition) were modeled as a linear function of the covariates. All statistical analyses were performed using the Statistical Package for Social Sciences version 16 (SPSS Corp, Chicago. IL, USA). P-values less than 0.05 were considered statistically significant.

Results

This study was carried out on 100 patients (57 men (%) and 43 women (%)) admitted in ICU with the average age of 46±18.82 years old. Demographic, anthropometric measurements and biochemical values of ICU inpatients are shown in Table 1. Reasons for ICU admission were surgery (42.9%), trauma (32.8%) and cancer (24.3%). The average of BMI and albumin concentration was 24.2±3.94 (kg/m^2) and 2.7±0.86 (g/dl) among ICU inpatients which indicated lower levels of albumin compared with normal ranges (3.5-5 g/dl). The average of BUN and creatinine levels were 21.8±16.13 (mg/dl) and 1.18±0.34 (mg/dl), respectively. Regarding glycemic status, the average of fasting blood sugar was 147.2±60.17(mg/dl). The hepatic enzymes levels including ALT and AST were 78.6±205.95 (IU/L) and 75.5±161.73 (IU/L), respectively, which represented high metabolic status of critically ill patients leading to incrsead transaminases levels.

Table1. Demographic, anthropometric measurements and biochemical values of ICU inpatients

Subjects (n=100)	Mean±SD	Range (Max-Min)
Anthropometric		
Age (year)	46±18.82	90-12
Height (cm)	170±9.09	187-145
Weight(kg)	69.3±10.35	112-45
IBW(kg)	68.6±10.78	92.4-37
BMI(kg/m^2)	24.2±3.94	37.3-17.1
MAC(cm)	27.7±3.18	39-21
WA(cm)	17.8±1.37	22-15
Biochemical values		
Renal function		
BUN(mg/dl)	21.8±16.13	90-2.3
Creatinine(mg/dl)	1.18±0.34	9-0.3
Na(mEq)	139.7±7.59	191-116
K(mEq)	3.7±0.56	5-2.3
Ca(mEq)	9.7±8.72	93-2.9
Mg(mEq)	2±0.42	4-1.3
P(mEq)	3.8±4.30	43-2
Glycemic status and lipid profile		
FBS(mg/dl)	147.2±60.17	444-18
TG(mg/dl)	109.2±85.54	615-11
Chol(mg/dl)	132.9±46.97	298-33
HDL(mg/dl)	38.4±12.42	75-15
LDL(mg/dl)	72.6±34.34	180-8.4
Pulmonary function		
PT(Seco)	18.2±8.22	75-4.6
PTT(Seco)	42±27.31	120-28
Blood values		
Hb(g/dl)	11.4±3.38	35-4.3
HCT(%)	34±7.34	50-9.7
MCV(fL)	90.6±9.76	104-9.1
WBC(n/mm^3)	13848±17033.55	149000-2700
Alb(g/dl)	2.7±0.86	4-1
Protein T(g/dl)	5.8±0.95	8.5-3.5
Hepatic function		
ALT(IU/L)	78.6±205.95	1615-7
AST(IU/L)	75.5±161.73	1330-11

IBW: ideal body weight, BMI: Body mass index, MAC: Mid arm circumference, WA: Wrist around.

Table2. Functional characteristics and biochemical values of ICU inpatients[1]

Subjects	>90% of Ideal body weight (n= 68) (Mean±SD)*¶				P value	76-90% of Ideal body weight (n=27) (Mean±SD)**				P value
	1	2	3	4		1	2	3	4	
Age(year)	43.6±20.77	55.2±15.40	51±15.72	40.5±17.45	0.11	71±18.73	39.3±17.04	40.1±17.78	35.8±21.93	0.38
Height(cm)	160±13	160±1	160±6	160±1	0.92	170±2	170±9	170±8	170±5	0.64
Weight(kg)	75.4±23.66	72.5±9.43	72.5±7.42	71.5±7.17	0.91	58.3±6.11	60.3±8.54	65.5±7.01	63.3±7.05	1.10
IBW(kg)	66.4±13.71	65.7±11.87	66.7±9.18	61.6±9.96	0.64	70.3±2.51	71.6±10.28	76.4±8.82	76.7±6.90	0.68
BMI	26±6.32	25.7±3.51	25.9±2.90	26.8±3.07	0.88	20.3±2.51	20±1.23	20.6±1.15	20.7±1.50	0.30
MAC(cm)	29.4±6.18	28.9±3.15	27.9±2.80	27.5±2.19	0.49	27.6±1.52	25.7±2.13	27.6±4.58	26.1±1.56	0.58
BUN(mg/dl) (normal range:7-20)	31.8±14.78	23±16.37	24.5±16.91	12.7±6.01	0.13	39±36.76	19±9.87	21±24.68	15±6.78	0.87
Creatinine(mg/dl) (normal range:0.5-1.2)	1.5±0.96	0.9±0.34	1.3±1.60	0.8±0.22	0.43	1.2±0.35	1.9±1.87	1.3±1.82	0.7±0.15	0.43
Na(mEq) (normal range:135-145)	143.8±3.63	140.2±5.43	140.9±10.17	138.7±4.20	0.69	135±4.24	135.8±13.07	138.1±5.81	138.5±5.18	0.93
K(mEq) (normal range:3.5-5)	3.7±0.55	3.5±0.60	3.7±0.63	4±0.18	0.23	4.4±0.35	3.9±0.71	4±0.51	3.6±0.41	0.44
Ca(mEq) (normal range:8.5-10.2)	9±0.16	8.9±0.31	9±0.36	9.2±0.43	0.18	8.2±0.63	7.6±2.66	9±0.30	8.6±1.90	0.52
Mg(mEq) (normal range:1.7-2.2)	2±0.36	2±0.47	2.1±0.35	2.1±0.32	0.58	2±0.35	2.4±0.94	2±0.23	2±0.33	0.51
P(mEq) (normal range:2.5-4.5)	3.3±0.83	3.1±1.01	4.8±7.41	3.6±0.98	0.70	3.9±1.83	3.9±1.01	3.1±0.77	3.3±0.40	0.038
FBS(mg/dl)	120.8±45.40	150.5±46.45	160.8±80.93	152.1±48.50	0.63	234.5±106.77	140±72.13	131.5±31.57	114.4±12.88	0.001
TG(mg/dl)	177.4±85.19	108.5±86.02	112.4±66.45	161.7±172.43	0.29	79±15.55	102.2±63.34	73.7±30.55	77.54±45.09	0.72
Chol(mg/dl)	106.2±34.14	123±38.91	146.1±41.48	166.6±31.66	0.01	113.5±67.17	158.6±86.51	130.8±63.99	112.9±32.92	0.42
HDL(mg/dl)	25±9.24	34.4±10.60	42.3±12.06	44±12.02	0.005	33.5±19.09	42.4±20.37	45±8.26	35.4±10.67	0.24
LDL(mg/dl)	45.6±28.58	65.5±27.08	80.5±34.08	86.4±28.51	0.05	64.2±51.19	95.7±55.66	84.3±44.62	60.8±24.35	0.27
PT(Seco)	22.4±4.79	20.9±12.40	17.7±8.83	13.9±3.98	0.22	20±5	16.7±3.18	16.4±0.96	17.1±4.14	0.15
PTT(Seco)	51.4±38.93	38.8±26.41	35.2±11.03	49.6±39.88	0.30	102.6±30.02	44.8±36.89	39.3±23.68	34.9±12.64	0.001
Hb(g/dl)	12±3.03	10.2±2.36	11.8±4.75	12.2±2.26	0.36	11.4±3.00	12.3±3.00	12±0.54	11.6±2.70	0.88
Hct(%)	37.9±6.86	31.3±7.93	33.7±7.05	37.3±5.71	0.10	35.7±10.34	34.9±8.70	36.1±7.25	35.2±6.86	0.97
MCV(fL)	92.4±3.28	87.5±18.59	92.2±2.90	89.2±5.89	0.45	93.3±5.67	96.7±7.13	91±3.61	90.4±3.74	0.08
WBC(n/mm^3)	14280±7511.45	15213±29433.93	11490±4608.20	14667±11087.60	0.09	41000±49636.57	12600±4399.54	12678±3849.60	11255±2580.06	0.93
Alb(g/dl) (normal range:3.5-5.5)	1.4±0.54	2	3±0.17	4	<0.001	1	2	3	4	0.002
Total protein(g/dl) (normal range:6-8.3)	5.1±0.75	5.3±0.70	5.9±1.05	6.7±0.87	0.001	4.5±1.48	5.5±0.63	6.2±0.86	6.1±0.37	0.003
ALT(IU/L)	37.6±698.14	43.6±43.45	70.4±208.02	52.4±59.40	0.037	29±8.48	27.8±18.46	45.5±30.38	93.7±127.51	0.37
AST(IU/L)	34.9±564.19	48.3±46.68	60.1±139.84	43.7±27.68	0.007	33±5.65	33.5±30.72	86.1±78.33	56.8±33.21	0.29

IBW: Ideal body weight, BMI: Body mass index, MAC: Mid arm circumference; ¶ (%) of Ideal body weight: (normal weight/ideal weight)*100; *1,2: protein malnutrition, 3: mild malnutrition, 4: good nutritional status; **1,2: moderate malnutrition, 3,4: mild malnutrition; 1All values are mean±SD; 2Obtained from ANOVA.

Functional characteristics of ICU inpatients are summarized in Table2. Using 3 malnutrition categories according to ideal body weight and albumin levels as well as considering the patients with more than 90% of ideal body weight, 76-90% of ideal body weight and 60-75% (few number of patients, data not shown) of ideal body weight, we evaluated the functional characteristic of patients in different subcategories including protein malnutrition, moderate malnutrition, mild malnutrition and good nutritional status. No significant differences in BMI, creatinine, BUN, potassium range and magnesium were observed among different subcategories in each group. Albumin and total protein levels were significantly different within 4 subcategories of patients with more than 90% of ideal body weight. Patients with good nutritional status had higher albumin and total protein levels than malnourished ones (p<0,001). It was also significant in other categories(76-90% and 60-75% of ideal body weight) (p<0.05). Phosphorus levels were statistically significant within different subcategories of patients with 76-90% of ideal body weight (p<0.05).

In the final stage of analysis, we investigated relationships between different categories of malnutrition and major potential determinants of malnutrition. The results are shown in Tables 3 and 4. Reduced BUN levels(OR=0.96; 95% CI= 0.0.92-1.00, P<0.05) and increased total protein (OR=3.69; 95% CI= 1.83-7.45, P<0.001)were associated with a greater chance of being in the subcategory of good nutritional status among patients with more than 90% of ideal body weight. Patients with 76-90% of ideal body weight who had a raise in total protein were more likely to have good nutritional status (OR=4.01; 95% CI= 1.01-16.1, P<0.05).

Table3. The results of multivariable ordinal logistic regression on the potential determinant of malnutrition in ICU inpatients with more than 90% of ideal body weight

Variable	B	S.E	OR(95% CI)	P value
Creatinin	0.22	0.27	1.24(0.72,2.13)	0.42
BUN	-0.04	0.02	0.96(0.92,1.00)	0.04
Total protein	1.31	0.35	3.69(1.83,7.45)	<0.001
Time admission difference*	-0.07	0.05	0.92(0.83,1.02)	0.13
Supplementation**	0.51	0.33	1.66(0.87,3.17)	0.12
Diseases history	0.11	0.65	1.11(0.31,3.99)	0.86

*Time admission difference was calculated according to date of hospitalization and ICU admission.

**Supplemetation included vitamin B-complex, folic acid and albumin.

Disscussion

In our cross-sectional study of assessing nutritional status of ICU patients, we found the important determinants of malnutrition. In the recent study, decreased level of albumin, total protein and phosphorus were related to malnutrition. Albumin and total protein levels were significantly different within 4 subcategories of patients with more than 90% of ideal body weight. Patients with good nutritional status had higher albumin and total protein levels than malnourished ones. No significant relationship between BMI, creatinine, BUN, potassium, magnesium and malnutrition was observed. Although no data on dietary intake and nutritional supplementationwas gathered, the observed relationship hypothesized thatenergy intake in patients was lower than their nutritional needs in the present study (17). In the published studies, the most important causes of malnutrition among ICU inpatients include calorie intake deficiency during the first days of admission and mechanical ventilation which usually resultin higher metabolic rate and more complications (18,19). In the present study, in contrast to anthropometric data, laboratory indicators showed that after 5 days of hospital stay, most of the patients in our study were suffering from considerable deficits of albumin and hemoglobin. The explanation could be that most of our patients were admitted from

Table4. The results of multivariable ordinal logistic regression on the potential determinant of malnutrition in ICU inpatients with 76-90% of ideal body weight

Variable	B	S.E	OR(95% CI)	P value
Creatinin	-0.57	0.56	0.56(0.18,1.70)	0.31
BUN	0.14	0.11	1.15(0.92,1.46)	0.21
Total protein	1.39	0.71	4.01(1.01,16.1)	0.04
Time admission difference	0.52	0.41	1.68(0.76,3.74)	0.19
supplementation	0.42	0.71	1.52(0.38,6.21)	0.54
age	-0.05	0.03	0.95(0.88,1.01)	0.13

hospital's emergency department which could increase the severity of their illness. Implementation of nutritional support is needed to raise this major challenge as specialists also developed different guidelines for nutritional supplementation for ICU inpatients (20). According to our knowledge this is the first study in this regard in Isfahan.

In accordance with the current study Abiles et al (21) studied all patients admitted to the Intensive Care Unit of Virgen de las Nieves Hospital from January to December of 2003. They demonstrated that proteins, fats, and carbohydrates intake were lower than 50% of the requirements for both genders. They showed adequacy of vitamins intake at recommended does for sick patients, however, the intake was lower than 25% of the requirements in all cases, and these deficiencies significantly interfered with wound healing, the immune, cardiovascular and nervous systems, as well as with metabolism of the remaining macronutrients leading to an unbalanced situation of the antioxidant system, worsening the patient's clinical status. Moreover, Rodrigo et al (22) showed that malnutrition and low muscle mass reduce the ability of patients to fight critical illness. Low serum creatinine is a better surrogate marker of low muscle mass than a low body mass index and has been associated with poor outcome in some patient populations. They conducted a survey on consecutive critically ill patients >18 years of age admitted to three ICUs of two tertiary care hospitals from January 2003 to December 2006. When adjusted for APACHE III-predicted mortality age, gender, postoperative state, and body mass index, low baseline creatinine was associated with increased mortality in a dose-response manner: odds ratio 2.59 (95% confidence interval, 1.82-3.61) for baseline creatinine< or =0.6 mg/dL (p <0.001) and OR 1.28 (95% CI, 1.03-1.60) for baseline creatinine 0.6-0.8 mg/dL (p = 0.023). Adjusted intensive care length of stay in survivors was 0.48 days (95% CI, 0-0.98) longer for patients with baseline creatinine<or =0.6 mg/dL (p =0.058). Low baseline serum creatinine concentrations increased the risk of mortality in critically ill patients.

The strengths of our study include well-established design and using standard instruments to measure biochemical values. However, It should be noted that our study had several limitations. As with all cross-sectional studies, no cause-and-effect relations could be determined. We assessed patients only 5 days after their admission to ICU and they were not monitored until discharge. No dietary assessment was done according to energy intake and nutritional support. Since we conducted this study in one hospital, our results coud not be generalized to all hospitalized patients.

In conclusion, malnutrition has the detrimental impact on rehabilitation and mobilization of the patients and extends time of hospitalization. Nutritional status should be monitored and corrected since the start of disease, preferably in intensive care unit. Since, our results indicated that malnutrition is prevalent among ICU patients, providing better information about organizational factors that affect nutrition management and the effect of nutritional adequacy on hospital outcomes seems to be a necessity. Therefore, further studies are necessary to determine the best methods to define nutritional status of patients. In addition, well-designed clinical trials are needed to clarify all aspects of nutritional supplementation.

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