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The relationship between nutritional indices and hemodialysis adequacy in hemodialysis patients

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Взаимосвязь между показателями питания и адекватностью гемодиализа у пациентов, находящихся на гемодиализе

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Key words: *Hemodialysis, Malnutrition, Nutritional Indices, Anthropometric Indices, Dialysis adequacy*

Abstract

Introduction: **Malnutrition is one of the most common causes of mortality and morbidity in dialysis patients. This study aimed to evaluate the correlation between nutritional indices and hemodialysis adequacy.**

Material & Methods: **This descriptive cross-sectional study was performed on 257 patients undergoing chronic hemodialysis in 6 dialysis centers in Zanjan province, Iran. Patients were selected by convenience sampling. Blood samples were examined in a single laboratory. Anthropometric indices included BMI, TSF, MAC and MAMC. Data were analyzed using descriptive statistics, t-test, and Spearman correlation coefficient with SPSS software version 22.**

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Results: **The nutritional indices in hemodialysis patients were in an acceptable range. The mean BMI of patients was 23.38±4.11 kg/m². The mean serum albumin index was 4.18±0.91 g/dl. Serum total protein index was 7.2±1.11 mg/dL. In 90.3% of patients the creatinine (Cr) was <12 mg/dL. The arm circumference (MAC) index was between 60-90 percent of normal. Mid-arm muscle circumference (MAMC) in >50% of the patients was between 60-90% of normal. The skinfold thickness of the triceps (TSF) was 9.33±4.52 mm. BMI had negative correlation with kt/v (r=-0.17, P=0.005) and URR (r=-0.15, P=0.01). There was a positive correlation between protein index and URR (r=0.14, P=0.02).**

Conclusion: **Some nutritional indices in hemodialysis patients are related to dialysis adequacy. This finding shows the need for careful monitoring of patients' nutritional status between dialysis sessions. The findings of the study on the nutritional status and adequacy of dialysis indicate the proper planning of dialysis centers with skilled professionals and the existence of up-to-date technology.**

Резюме

Введение. **Синдром недостаточного питания – одна из наиболее частых причин смертности и заболеваемости диализных пациентов. Это исследование было направлено на оценку корреляции между показателями питания и адекватностью гемодиализа.**

Материалы и методы. **Это описательное перекрестное исследование было проведено с участием 257 пациентов, проходящих хронический гемодиализ в 6 диализных центрах в провинции Зенджан, Иран. Пациенты отбирались методом удобной выборки. Образцы крови исследовали в объединенной лаборатории. Антропометрические индексы питания включали BMI, TSF, MAC и MAMC. Данные были проанализированы с использованием описательной статистики, t-критерия и коэффициента корреляции Спирмена с программным обеспечением SPSS версии 22.**

Результаты. **Показатели питания у пациентов, находящихся на гемодиализе, находились в приемлемом диапазоне. Средний ИМТ пациентов составил 23,38±4,11 кг/м². Средний индекс сывороточного альбумина составил 4,18±0,91 г/дл. Общий белковый индекс сыворотки составил 7,2±1,11 мг/дл. У 90,3% пациентов креатинин (Cr) был <12 мг/дл. Индекс окружности руки (MAC) составлял 60-90 процентов от нормы. Окружность мышц средней руки (MAMC) у>50% пациентов составляла 60-90% от нормы. Толщина кожной складки трицепса (ТСФ) составила 9,33±4,52 мм. ИМТ имел отрицательную корреляцию с kt/v (r=-0,17, P=0,005) и URR (r=-0,15, P=0,01). Между белковым индексом и URR была положительная корреляция (r=0,14, P=0,02).**

Заключение. **Некоторые показатели питания гемодиализных пациентов связаны с адекватностью диализа. Это открытие показывает необходимость тщательного мониторинга состояния питания пациента между сеансами диализа. Результаты исследования состояния питания и адекватности диализа свидетельствуют о надлежащем планировании диализных центров с квалифицированными специалистами и наличии современных технологий.**

Ключевые слова: *гемодиализ, недоедание, показатели питания, антропометрические показатели, адекватность диализа*

Introduction

Hemodialysis (HD) represents the global treatment for patients with chronic kidney disease. Malnutrition is a commonly under-diagnosed and under-treated condition in hospital patients [1]. Malnutrition is a multifactorial and common problem in patients with end-stage renal disease (ESRD) undergoing hemodialysis which is associated with a greater risk of mortality [2]. In these patients, morbidity arising from malnutrition severely affects the quality of life, frailty, and increased risk of infections and death [3]. Evaluation of nutritional status in patients with end-stage renal disease is one of the important issues that should be considered by health care providers at frequent intervals. Dietary restrictions for patients, excretion of amino acids, peptides, and minerals during the dialysis process as well as increased protein catabolism have a negative impact on the condition and nutritional adequacy of hemodialysis patients. Therefore, efforts to prevent malnutrition are especially important in the first few weeks of treatment [4]. Evaluating nutritional status is a critical component of physiologic health and fundamental to identifying protein-energy wasting in patients undergoing hemodialysis [5]. The nutritional care process includes assessing nutritional status, diagnosing existing problems, nutritional interventions, and monitoring expected outcomes [6]. Protein-energy malnutrition is a common problem in hemodialysis patients. Studies report a different prevalence (18-70%) of malnutrition in patients with end-stage renal disease (ESRD) [7]. For example, in assessing the prevalence of malnutrition among hemodialysis patients in Jordan it found that 56.2% of patients were moderately malnourished, and 5.6% were severely malnourished [8]. In the study of YapGharavian et al. (2011), only 25% of hemodialysis patients had a good nutritional status and 75% had mild to moderate malnutrition [9]. The difference in the prevalence of malnutrition and its associated factors in different studies can be due to differences in assessment methods for malnutrition [2], criteria used to assess malnutrition, disease status, and different interpretations of malnutrition in hemodialysis patients [10]. For example, Akhlaghi et al. (2021) in a study on 540 HD patients from 15 dialysis centers in Iran evaluated the nutritional status of the patients by Subjective Global Assessment (SGA), Dialysis Malnutrition Score (DMS), and Malnutrition Inflammation Score (MIS). This study showed HD patients had protein-energy wasting and energy and protein intake in these patients was less than the minimum recommended amount [11]. However, evaluating nutritional status is often overlooked in many dialysis centers while simple methods of nutritional assessment could have a positive impact on patient management [12]. As mentioned, protein loss is a major cause of malnutrition in patients with chronic kidney disease (CKD). Protein-deficient malnutrition refers to plasma albumin. Albumin <3.5 g/dL and pre-albumin <300 mg /L are independent cause of mortality [13].

Malnutrition along with dialysis inadequacy is associated with resistance to erythropoietin, which is a common problem in hemodialysis patients and is one of the causes of anemia [14-16]. Carrero et al. (2013) showed protein-energy depletion syndrome refers to catabolic and nutritional changes in CKD patients that are associated with morbidity and mortality. Anorexia and a progressive decrease in food absorption due to uremic accumulation have been reported in this syndrome [17]. The number and timing of dialysis sessions can affect the adequacy of dialysis and the amount of daily energy intake through food and, consequently, nutritional indicators. As shown in the study by Supasyndh et al. (2005), patients who undergo dialysis three times a week have better dialysis adequacy [18] but less daily energy intake than those who undergo dialysis twice a week [19].

More studies show that nutritional counseling [20, 21] and improving patients' nutritional intake play a crucial role in their nutritional status. Efficient dialysis sessions and improving dialysis adequacy also seem to be effective in improving their nutritional indices. Better clearances are associated with improved food ingestion and adequate nutritional intake. Well-dialyzed patients present improved levels of general well-being and, consequently, better food intake [22]. Considering the importance of nutritional assessment and its known relationship with morbidity and mortality in hemodialysis patients, this study designed to investigates the correlation between nutritional indices and dialysis adequacy among hemodialysis patients.

Methods

This is a descriptive cross-sectional study. Confirmation of the research was obtained from the ethics committee of Zanjan University of Medical Sciences. Written informed consent was also obtained from patients. The setting was all patients undergoing chronic hemodialysis referred to dialysis centers in Zanjan province, Iran. Samples were 257 hemodialysis patients. Emergency patients with acute renal failure were not included in the study. Demographic information including age, sex, level of education, dialysis appointment, comorbidities, number of dialysis sessions per week, type of dialysis filter, and type of vascular access was collected by a researcher-made questionnaire. Biochemical data collection tools included unit kits (manufactured by Pars Azmun Co, Iran) in the reference laboratory (Valiasr Hospital). Anthropometric data collection tools included Beurer PS240 Digital Scale, tape measure, and caliper (Arian model). The accuracy of these tools was evaluated before the study and the same tools were used for all patients. To obtain accurate and reliable data, measurements were performed according to the conditions in the method. Also, all measurements were performed by the first author. To determine the reliability of the instrument, one of the patients was randomly selected and measured three times. Biochemical indicators of nutrition included pre-dialysis BUN, creatinine, albumin, and total serum protein. To evaluate BUN and creatinine before hemodialysis, 1 ml of the blood clot was drawn from the arterial line after connecting the patient to the hemodialysis machine and before returning the purified blood to the patient. To prevent blood thinning by normal saline in the arterial line, samples were taken one minute after the patient was connected to the machine. Blood samples after dialysis were used to check the level of total protein and albumin. After an effective dialysis session, 2 ml of blood clot sample was drawn from the arterial line. Appropriate measures have been taken to prevent contamination of blood samples and damage during transport to the laboratory in full compliance with international protocols and recommendations.

To evaluate anthropometric indices, skin fold thickness of triceps (TSF), mid-arm circumference (MAC), mid-arm muscle circumference (MAMC), and BMI were measured. MAMC was calculated from the equation: MAC-(0.314×TSF) [23]. Patients' height and weight were measured 10 minutes after dialysis with minimal clothing, without shoes, a standard scale, and a same measuring tape. BMI was considered in three categories: <18.5 (weight loss), 18.5-24.9 (normal), and ≥25 (overweight). Normal values of TSF, MAC, MAMC, for men were 25.3 cm, 29.3 cm and 12.5 mm and for women were considered 23.2 cm, 28.5 cm and 16.5 mm, respectively. These values were classified as <60%, 60-90% and >90%. Albumin levels: >4.5, 3.5-4.5 and <3.5 g/dl, BUN: <60, 60-100 and >100 mg/dL, creatinine: <12, 12-20 and >20 mg/dL, total protein: <6, 6-8 and >8 g/dL [24]. All anthropometric measurements were performed after effective dialysis on uncovered limbs. Anthropometric and biochemical indices of each patient were measured in one day. The dialysis machines used in the dialysis centers were Fresenius, B-Braun, Nipro. The dialysate for all dialysis cases was bicarbonate. Data were analyzed using descriptive statistics (Mean and standard deviation), and Spearman correlation coefficient using SPSS software version 22.

Results

There were 257 hemodialysis patients, of which 138 (53.7%) were men and 119 (46.3%) were women. The mean age of patients was 60.44±15.12 years. The most common causes of end-stage renal disease (ESRD) were hypertension (41.2%) and diabetes (35.8%) [Table 1].

Regarding nutritional indices in hemodialysis patients, the results showed that the mean BMI of patients was 23.38±4.11 kg/m^2. Regarding albumin level, 44 patients (1.17%) had less than normal albumin (<3.5 g/dL) and most of them (n=152, 59.1%) were in the normal range (3.5-4.5 g/dL). The mean albumin in men was 4.13±0.82 and in women was 4.23±1.01. Total serum protein in the majority of patients (n=185, 72%) was between 6-8 g/dl. The mean of total serum protein in men was 7.14±1.07 and in women, it was 7.27±1.16 g/dL. Most patients (n=121, 47.1%) had BUN <6 mg/dL before hemodialysis. Also, 58(22.6%) patients had BUN >100 mg/dL. In male the BUN before dialysis was 72.32±35.51 mg/dL and 76.61±65 mg/dL in female patients. The findings of this study showed that in most patients (n=232, 90.3%) the creatinine (Cr) level is <12 mg/dl. The mean creatinine in men was 8.08±2.75 and in women was 7.38±2.76 mg/dL.

In this study, the most of HD patients in relation to the arm circumference (MAC) index were between 60-90 percent of normal. Independent t-test did not show a significant difference between men and women in MAC index (P=0.054) (24.76±2.45 cm in men vs. 25.71±3.72 cm in women). Skin fold thickness of triceps (TSF) in HD patients was 9.33±4.52 mm. Independent t-test showed a significant difference between men and women (P<0.05) (8.3 mm in men vs. 10.68 in women). More than half of the patients with Mid-arm muscle circumference (MAMC) were between 60-90% of normal. The mean of this index was 22.11 cm in men and 22.47 cm in women. Independent t-test did not show a significant difference for MAMC between men and women (22.11cm in men vs. 22.47 in women) (P=0.397). The result of the correlation coefficient between nutritional indices and dialysis adequacy indices of patients undergoing chronic hemodialysis showed that BMI had a significant negative correlation with kt/v (index of the removal efficiency per dialysis session) (r=-0.17, P=0.005) and urea reduction ratio (URR) (r=-0.15, P=0.01). Also, there was a positive and significant correlation between protein index and URR index (r=0.14, P=0.02) [Table 2, 3].

Table 1 | **Таблица 1**

Distribution of patients' demographic and clinical characteristics

Распределение демографических и клинических характеристик пациентов

Variables	Categories	%	N
Gender	Male	53.7	138
	Female	46.3	119
Income	Poor	13.6	35
	Intermediate	84	216
	Good	2.3	6
Education	Illiterate	79	203
	Diploma	19.8	51
	Academic	1.2	3
Job	Unemployed	82.9	213
	Employed	11.3	29
	Retired	5.8	15
Dialysis shift	Morning	35.8	92
	Evening	32.7	84
	Night	24.5	63
	Morning or evening	7	18
Activity	Limited activity	78.6	202
	Intermediate activity (Walking)	14.8	38
	Active	6.6	17
Dialysis order	Once/week	0.4	1
	Twice/week	8.6	22
	Thrice/week	91.1	234
Vascular access	AVF	84.4	217
	Shaldon	8.6	22
	Graft	7	18
Interdialytic weight gain (kg)	<2	29.2	75
	2-4	57.2	147
	>4	13.6	35

Discussion

The aim of this study was to evaluate the status of nutritional indices in hemodialysis patients and its association with dialysis adequacy. Finding show most patients have acceptable range of the nutritional indices. In the present study, the BMI of patients is in normal range. In the study of Sedhain et al. (2015) the average of this index was 19.57±3.19 [25]. Also, in the study of Chen et al. (2013) the BMI was reported 21.6±3.1 kg/m^2 and showed that BMI had a strong correlation with the nutritional status [26]. In the study of Zaki et al. (2019), BMI was 27.3±4.3 kg/m^2. Compared to the present study this index can be due to the lower age of patients in the study (50.5±12.5) because the improvement of nutritional indices is inversely related to the age of patients [27]. Reyes et al. (2020) in evaluation of nutritional status in HD patients report about 55% of these patients had a normal range of BMI [28].

In this study, the mean serum albumin was 4.18±0.91 g/dL. Similarly, albumin index was 41±3.67 in the study of biberashvili et al. (2016) [29]. The present study shows that the BUN and creatinine index of hemodialysis patients are 74.3±51.24 and 7.76±2.77 mg/dL, respectively. Other studies in Iran

Table 2 | Таблица 2

Distribution of patients' nutritional indices

Распределение показателей питания пациентов

Indices	N	%	Mean ± SD
Albumin (gr/dL)			
<3.5	44	17.1	4.18±0.91
3.5-4.5	152	59.1	
>4.5	61	23.7	
Total serum protein (gr/dL)			
<6	26	10.1	7.2±1.11
6-8	185	72	
>8	46	17.9	
BUN (mg/dL)			
<60	121	47.1	74.3±51.24
60-100	78	30.4	
>100	58	22.6	
Cr (mg/dL)			
<12	232	90.3	7.76±2.77
12-20	25	9.7	
>20	-	-	
BMI (kg/m²)			
<18.5	27	10.5	23.38±4.11
18.5-24.9	155	60.3	
>25	75	29.2	
TSF (mm)			
<60%	126	49	9.33±4.52
60-90%	79	30.7	
>90%	52	2	
MAMC (Cm)			
<60%	1	0.4	22.28±3.36
60-90%	132	51.4	
>90%	124	48.2	
KT/V			
<1.2	103	40.1	1.26±0.34
1.2-1.4	93	36.2	
>1.4	61	23.7	
URR			
<65%	126	49	63.55±9.5
>65%	131	51	

report relatively different numbers. For example, Faleh Hassen et al. (2018) reported a a significant increase ($p<0.01$) in the serum urea, creatinine [30]. Also Amirkhanloo et al. (2016) creatinine index was 3.16±9.53 mg/dL [31]. In the present study, TSF is reported 9.33±4.52 mm, while 20.2% of the subjects are >90% of normal. In line with this finding, Reyes et al. (2020) shows 26% of hemodialysis patients have a TSF in the normal range [28]. In the study of Oliveira et al. (2010) the percentage of the adequacy of the TSF was a bad method for nutritional assessment, because of the high prevalence of malnutrition even in patients assessed as normal by use of all other parameters. However, fat depletion, estimated by TSF is the predominant type of malnutrition in hemodialysis patients[32]. In this study, the serum total protein index is 7.2±1.11 mg/dL. In this regard, in the study of Kawai et al. (2019), this index is 6.3±0.4 mg/dL (23). In this study, the relationship between dialysis adequacy and biochemical and anthropometric nutritional indices was investigated.

The present study showed that BMI index has a significant inverse correlation with dialysis adequacy (kt/v) and urea reduction ratio (URR). This can be due to the negative correlation between the dialysis adequacy index and the volume of urea distribution (V) in the dialysis adequacy calculation formula, which justifies the negative correlation between BMI index and dialysis adequacy. This finding contradicts the study of Davenport et al. (2013) that there is a positive correlation between dialysis adequacy and anthropometric indices[33]. In this study, there is a positive but no significant correlation between serum albumin index and dialysis adequacy. Similarly, Teixeira Nunes et al. (2008) and El-Sheikh & El-Ghazaly (2015) showed that there is a positive correlation between serum albumin level and dialysis adequacy(Kt/V and URR) due to patient's adjustment in their protein intake automatically according to the dose of HD delivered and probably improvement in uremic symptoms (e.g., nausea, anorexia, and vomiting) [22, 34]. Abedi-Samakoosh (2018) determined that the correlation between the albumin and hemodialysis

Table 3 | Таблица 3

Correlation between nutritional indices and dialysis adequacy (n=257)

Корреляция между показателями питания и адекватностью диализа (n=257)

Nutritional indices	Dialysis adequacy			
	Kt/V		URR	
	Spearman correlation coefficient	P-value	Spearman correlation coefficient	P-value
Album	0.04	0.51	0.079	0.2
Protein	0.11	0.06	0.14	0.02
BUN	0.039	0.53	-0.03	0.56
Creatinine	-0.06	0.33	-0.03	0.56
BMI	-0.17	0.005	-0.15	0.01
MAC	0.06	0.31	0.028	0.65
MAMC	0.07	0.23	0.02	0.65
TSF	0.01	0.8	0.03	0.61

adequacy is very significant [35]. The present study showed that there is a positive significant correlation between protein and URR. Consistent with this finding, Stolik et al. (2010) show a positive correlation between dialysis adequacy indices and serum protein levels due to increased uptake of food to improve uremic symptoms [36]. Also, Hemayati et al. (2015) showed a positive correlation between dialysis adequacy and protein catabolism. They concluded that improving dialysis adequacy could improve nutritional status [37]. In this study, no significant correlation was found between BUN and dialysis adequacy indices. This finding is consistent with the findings of Eloot et al. (2013) [38]. Also, there is no correlation between MAMC and MAC nutritional indices with dialysis adequacy. In this regards, Kaya et al. (2016) in determining the relationship between Kt/V and various nutritional parameters in hemodialysis patients suggest a significant negative correlation between single-pool Kt/V (spKt/V $\geq$1.4) and MAMC. However, MAC as an anthropometric measurements was significantly lower in the spKt/V $\geq$1.4 patients [39]. Our findings do not show a significant correlation between TSF and dialysis adequacy indices. Accordingly, the triceps skinfolds (TSF) in Kaya et al. (2016) study was not related to target hemodialysis dose of spKt/V urea in HD patients [39]. In this study, no significant relationship was found between creatinine and dialysis adequacy indices. This finding contradicts the findings of Eloot et al.(2013) which showed that there is an inverse correlation (r=-0.237, P=0.048) between creatinine and dialysis adequacy [38]. This study show that most of the nutritional indices in hemodialysis patients, including protein, albumin and BMI, are in good condition. Ebrahimzadeh Kerr et al. (2011) suggest 75% of HD patients have mild to moderate malnutrition [40]. a study by Freitas et al. (2014) showed that about 23% of patients were malnourished. However, the overall mean BMI and albumin in these patients were appropriate, which is consistent with the present study [41]. Dinmohammadi (2002) shows 44% of HD patients have moderate to severe albumin loss (the mean serum albumin 3.7±0.7 g/dl). The mean BMI was 21.3±3.6 and 38% of patients were underweight (BMI<19.5) [42]. However, in the present study, the mean of albumin was 4.18±0.91 g/dl and in the case of BMI, It was 23.38±4.11 kg/m^2, which shows improvement in nutritional status over time. This probably is due to the correlation of nutritional indicators with dialysis adequacy. That is, increasing dialysis adequacy improves the nutritional status of HD patients.

Conclusion

This study shows in the patients undergoing permanent hemodialysis, some biochemical and anthropometric indices have a correlation with dialysis adequacy. Therefore, by improving dialysis adequacy; we can help improve nutritional status and patients' health. Also, it was shown that the nutritional status and adequacy of dialysis in the patients are at an acceptable level. This can be related to the improvement of dialysis treatment technologies, skilled caregivers, and proper planning of health officials in dialysis centers. The results of this study can have valuable results in the fields of education, clinical care, and nursing management in hemodialysis patients. The findings of this study emphasize the importance of evaluating nutritional indices between dialysis sessions. Dialysis adequacy can be improved by addressing the nutritional status of HD patients. At the same time, the quality of life of patients will improve.

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