RESEARCH ARTICLE

F.U. Med.J.Health.Sci.
2022; 36 (2): 101 - 108
http://www.fusabil.org

The Relationship between Malnutrition, Inflammation and Atherosclerosis Components in Hemodialysis Patients

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Objective: This study aimed to investigate the relationship between malnutrition, inflammation and atherosclerosis components in hemodialysis patientswith end-stage renal failure.

Materials and Methods: The study was carried out in 49 volunteer hemodialysis patients in 18-65 years with end-stage renal failure. Anthropometric measurements of the patients [(body weight (kg), height (cm), waist circumference (cm), hip circumference (cm)] and body composition analysis were performed by the researcher, and malnutrition inflammation score (MIS) questionnaire was applied. Serum C-reactive protein (CRP) levels were recorded and carotid intima-media thickness (CIMT) was measured.

Results: The median age of the patients was 49 years. Median CIMT was 0.6, median MIS was 11, CRP level was 0.6 mg/dL. There was a significant negative correlation between patients' body weight, body mass index (BMI), waist circumference, hip circumference, waist-height ratio, total body fat, lean body mass values and MIS ($p<0.05$). There was a positive significant correlation between age, BMI, waist circumference, hip circumference, percentage of total body fat and CIMT ($p<0.05$).

Conclusion: In this study, while a significant relationship was not observed between the MIS and CRP and CIMT of patients, a significant relationship was found with some anthropometric measurement and body composition parameters that may be the indicator of malnutrition. Since the relationship between malnutrition and inflammation poses a risk for atherosclerosis in hemodialysis patients, this patient group should be evaluated in terms of malnutrition and preventive measures should be taken.

Key Words: *Malnutrition, inflammation, atherosclerosis, nutrition, hemodialysis*

Hemodiyaliz Hastalarında Malnütrisyon, İnflamasyon ve Ateroskleroz Bileşenleri Arasındaki İlişki

Amaç: Bu çalışmanın amacı, son dönem böbrek yetmezliği olan hemodiyaliz hastalarında malnütrisyon, inflamasyon ve ateroskleroz komponentleri arasındaki ilişkiyi araştırmaktır.

Gereç ve Yöntem: Çalışma 18-65 yaş arası son dönem böbrek yetmezliği olan 49 gönüllü hemodiyaliz hastası üzerinde gerçekleştirildi. Araştırmacı tarafından hastaların antropometrik ölçümleri [(vücut ağırlığı (kg), boy uzunluğu (cm), bel çevresi (cm), kalça çevresi (cm)] ve vücut kompozisyon analizi yapılmış, malnutrisyon inflamasyon skoru (MİS) anketi uygulanmıştır. Serum C-reaktif protein (CRP) seviyeleri kaydedilmiş ve karotis intima-media kalınlığı (CIMT) ölçülmüştür.

Bulgular: Hastaların medyan yaşı 49.00 yıl, medyan CIMT değeri 0.6 mm, medyan MİS 11.00, CRP seviyesi 0.6 mg/dL idi. Hastaların vücut ağırlığı, beden kütle indeksi (BKİ), bel çevresi, kalça çevresi, bel-boy oranı, toplam vücut yağı, yağsız vücut kütlesi değerleri ile MİS arasında negatif yönde anlamlı bir ilişki vardı ($p<0.05$). Yaş, BKİ, bel çevresi, kalça çevresi, toplam vücut yağ yüzdesi ile CIMT arasında pozitif yönde anlamlı bir ilişki bulunmuştur ($p<0.05$).

Sonuç: Bu çalışmada hastaların MİS ile CRP ve CIMT değerleri arasında anlamlı bir ilişki gözlenmezken, malnütrisyon göstergesi olabilecek bazı antropometrik ölçümler ve vücut kompozisyonu parametreleri ile anlamlı ilişki bulundu. Hemodiyaliz hastalarında malnütrisyon ve inflamasyon ilişkisi ateroskleroz için risk oluşturduğundan bu hasta grubu malnutrisyon yönünden değerlendirilmeli, koruyucu önlemler alınmalıdır.

***Anahtar Kelimeler*:** *Malnütrisyon, inflamasyon, ateroskleroz, beslenme, hemodiyaliz*

Received : 23.09.2021
Accepted : 02.03.2022

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Introduction

Malnutrition is the nutritional status of inadequate, excessive or unbalanced protein, energy or other nutrients caused by measurable side effects on tissue, all body functions and clinical outcomes. Various factors contribute to the development of malnutrition in patients with end-stage renal disease (ESRD) (1). The prevalence of malnutrition is 23-76% in hemodialysis patients and 18-50% in peritoneal dialysis patients (2).

Inflammation is a protective physiological response of the body in order to limit damage to tissue or trauma, or to eliminate the cause of damage, and renal failure triggers inflammatory processes through a number of mechanisms (3, 4). Some of these causes lead to malnutrition, creating a causal relationship between malnutrition and inflammation. Therefore, two different types of malnutrition have been identified as a cause of protein-energy malnutrition (PEM) in patients with ESRD, where reduced food intake and inflammation are at the forefront (4, 5).

Cardiovascular diseases (CVD) are the most outstanding cause of mortality in chronic renal failure (CRF), and they begin to occur from the very early stages of CRF before reaching the stage of ESRD, and the risk of CVD increases as the CRF progresses (6, 7).

Atherosclerosis is an inflammatory, fibrotic and focal disease of the arterial intima. Atherosclerotic changes in the carotid artery indicate atherosclerosis. It is seen as an early indicator of cardiovascular morbidity and mortality in the general population and patients with ESRD (8, 9). In particular, carotid intima-media thickness (CIMT) is a good indicator of the presence and severity of atherosclerosis (10).

Stenvinkel et al. (11) demonstrated that the baseline of malnutrition-inflammation-atherosclerosis (MIA) syndrome or hypothesis has been associated with increased serum proinflammatory cytokine levels in patients with ESRD and the development of atherosclerosis, the development of malnutrition and inflammation in the axes responsible for mortality and morbidity. There is a strong correlation between malnutrition, inflammation and atherosclerosis in patients with ESRD, and there may be one, two or all three components of the MIA syndrome (12). It has been shown that mortality due to cardiovascular complications increases with MIA (13).

The purpose of this study is to investigate the presence of malnutrition, inflammation and atherosclerosis components in hemodialysis patients with ESRD.

Materials and Methods

Research and Publication Ethics: "Ethics Committee Approval" with BEAH KAEK 2016/2-25 decision numbered and 19/01/2016 dated was given by Clinical Research Ethics Committee. Written consent forms were obtained from the patients that they voluntarily participated in the study.

This study was performed on hemodialysis patients with a diagnosis of 49 end-stage renal failure, 25 males and 24 females, aged between 18-65, who were treated at the hemodialysis unit of a regional training and research hospital.

The demographic features of the patients, CRF and other diseases were obtained by the researcher by using the questionnaire form with face to face interview method. After determining the patients to be included in the study, all measurements of the patients were made by the researcher after a single dialysis session to determine the current malnutrition, inflammation and atherosclerosis status (Figure 1).

Exclusion Criteria: This study was carried out with patients who have not previously been diagnosed with CVD by the doctor, who do not have chronic inflammatory disease, who do not use anti-inflammatory drugs.

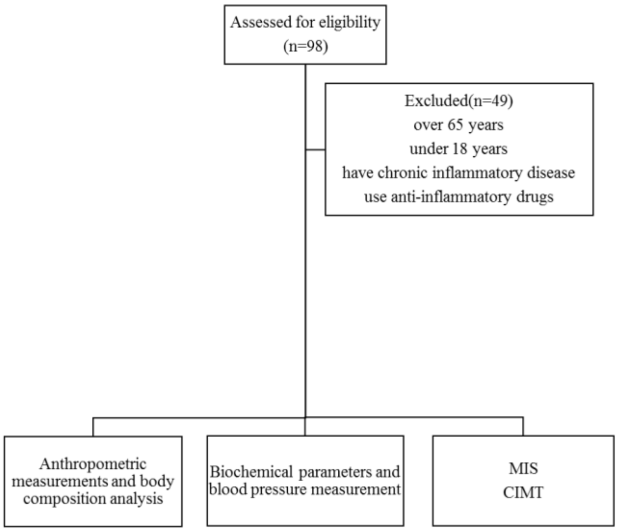

Figure 1. Flow diagram of patient inclusion process

Anthropometric Measurements and Body Composition Analysis: Anthropometric measurements [height (cm), body weight (kg), hip circumference (cm), waist circumference (cm)] and body composition of the patients were made by the researcher after the dialysis session. All anthropometric measurements and body composition measurements of the patients were made by the researcher after a single dialysis session to determine the current malnutrition status.

Height-length, waist circumference and hip circumference were measured with non-stretching tape measure by the researcher. Body mass index (BMI) was calculated for all individuals from body weight/height length (kg/m^2) equation. The classification of the World Health Organization (WHO) was used to classify individuals according to their BMI. Accordingly, the BMI; <18.5 kg/m^2 underweight, 18.5-24.9 kg/m^2 normal, 25.0-29.9 kg/m^2 overweight and >30.0kg/m^2 obese (14).

Body composition measurements (total body fat, total body fat percentage, lean body mass, total body water) were analyzed after dialysis using the TBF-300 brand bioelectric impedance device (BIA). In addition to the body components of individuals, body weight and BMI values were determined by BIA measurement. Each patient met the conditions for BIA measurement (15).

Biochemical Parameters and Blood Pressure Measurement: Serum CRP level [0-5 (mg/dL)] and blood pressure measurement were retrospectively taken from patient files. All laboratory data of patients were studied as monthly routine examinations in hospital biochemistry laboratory and measured by standard methods. Blood samples were taken before dialysis after at least 8 hours of fasting in the first week of the month. All Biochemical parameters and blood pressure measurement of the patients were taken from patient files by the researcher only a dialysis session to determine the current malnutrition and inflamatıon status. These measurements were evaluated according to the hospital reference value (Table 1).

Table 1. Hematological Biochemical and Blood Pressure Measurements Reference Values

	Reference Values
TIBC (mg/dL)	120-370
Albumin (g/dL)	3.5-5.0
CRP(mg/dL)	0-5
CIMT (mm)	0.25-1

CIMT: Carotid İntima-Media Tickness; MIS: Malnutrition Inflammation Score; CRP: Serum C-Reactive Protein; TIBC: Total Iron Binding Capacity

Measurement of Carotid Intima Media Thickness: Ultrasonography was measured by a radiologist who was unaware of the patient's clinical and laboratory information. For the carotid artery B-mode ultrasonography, a 7.5-MHz high-resolution linear transducer and a color Doppler ultrasonography device were used. Measurements were made according to the medical ultrasonography association practice guide. Carotid intima media thickness was calculated from the mean of the measurement from both carotid arteries (16). In healthy individuals, normal intima media thickness is considered as 0.25-1.0 mm and increases by 0.01-0.02 mm per year. In this study, values over 1.0 mm were considered abnormal.

Malnutrition-Inflammation Score: Malnutrition-inflammation scoring includes dry weight changes in the last 6 months, dietary intake, gastrointestinal symptoms, functional capacity, presence of comorbid conditions, subcutaneous adipose tissue, muscle loss, body mass index, serum albumin level, and serum total iron binding capacity. This scoring consists of 10 basic questions and each question consists of 4 steps from good to bad. The value of a total of 10 MIS questions increases from 0 to 30, and as the number increases, the severity of malnutrition also increases (17). Individuals' malnutrition inflammation status was evaluated by the researcher using the MIS form.

Statistical Analyses: The sample of the study was calculated by using the g power 3.0 program. The power of the study was 80%, the effect size was 0.35, calculated with a margin of error of 0.05, and it was found to be 44 patients. Considering that data may be missing and data losses during the study process were considered, 49 individuals were included in the study.

Statistical package program SPSS 22.00 was used for the statistical evaluation of the data (18). Appropriate descriptive values are given for qualitative and quantitative variables. Quantitative variables are expressed as median (Interquartile Range (IQR)) and qualitative variables are expressed as percentage (%). Continuous variables were compared with nonparametric (Mann-Whitney U) tests. Pearson chi-square test for qualitative variables or Fisher's exact chi-square test (Fisher's Exact Test) was applied in cases where the expected values in cross tables are less than 5. The relationship between the variables was investigated with a two-way correlation test (Pearson). The significance level was accepted as 0.05 in all statistical tests.

Results

Gender, educational status, marital status and occupational status of the patients are shown in Table 2. When the educational status of the patients was evaluated, it was seen that 50.00% of the female patients and 12.00% of the male patients were illiterate. When the marital status of the patients was evaluated, 77.50% were married and 20.00% were single. 30.60% of the patients were not working, 87.50% of the female patients were housewives.

The median age, anthropometric measurements and body composition parameters of the patients are shown in Table 3. As may be seen in table, median age which affecting the risk of morbidity and mortality was found to be 48.00 years for male, 50.00 years for female. The duration of dialysis for male patients was 4.00 years, and 3.25 years for female patients.

The malnutrition status of the patients according to MIS is shown in Table 4. 80% of male patients and 91.7% of female patients were found to have malnutrition.

The median CIMT, MIS, serum CRP levels, TIBC and albumin of the patients are shown in Table 5. The median CIMT of the patients was 0.6 mm, the median MIS value was 11.00 and the mean CRP level was 11.00 mg/dL, the median TIBC was 121.00 mg/dL and albumin was 3.70 g/dL ($p>0.05$).

BMI classification and evaluation of CRP and CIMT according to references are shown in Table 6. The CIMT value of 98.0% of the patients was less than 1 mm. The CRP value of 93.9% of patients was normal. There was no significant between gender in BMI, CRP and CIMT ($p>0.05$).

The correlation of age, anthropometric measurements, body compositions, serum CRP levels and dialysis time with CIMT and MIS is shown in Table 7. It can be seen that, a significant positive correlation was found between CIMT and age, BMI, waist circumference, hip circumference and total body fat percentage ($p<0.05$). A significant negative correlation was found between the body weight, BMI, waist circumference, hip circumference, waist-to-height ratio, total body fat, total body fat percentage, lean body mass, total body water, and MIS ($p<0.05$). It was determined that there is a positive correlation between CRP and CIMT and MIS, but the results are not significant ($p>0.05$).

Table 2. Demographic features

	Male (n=25)		Female (n=24)		Total (n=49)	
General features	**n**	**%**	**n**	**%**	**n**	**%**
Educational status						
Illiterate	3	12.0	12	50.0	15	30.6
Literate	-	-	1	4.2	1	2.0
Elementary school	14	56	10	41.6	24	48.9
High school	4	16.0	1	4.2	5	10.2
Junior college	3	12.0	-	-	3	6.1
College	1	4.0	-	-	1	2.0
Marital status						
Married	20	80.0	18	75.0	38	77.5
Single	5	20.0	6	25.0	11	22.5
Occupational status						
Not working	13	52.0	2	8.3	15	30.6
Government employee	1	4.0	-	-	1	2.0
Retired	11	44.0	1	4.2	12	24.5
Housewife	-	-	21	87.5	21	42.9

Table 3. Age, BMI, anthropometric measurements and body composition of the patients

	Male (n=25)		Female (n=24)		
	Median	**IQR**	**Median**	**IQR**	**P**
Age (years)	48.00	23.00	50.00	15.00	0.689
Dialysis age (years)	3.00	5.09	4.25	6.13	0.336
Bodyweight (kg)	63.70	18.55	59.25	23.28	0.222
Height (m)	170.00	8.50	155.00	6.00	0.001
BMI (kg/m²)	22.60	6.45	24.35	9.38	0.200
Waist circumference (cm)	92.00	17.00	91.50	26.25	0.667
Hip circumference (cm)	99.00	10.50	98.50	17.00	0.944
Waist-hip ratio	0.92	0.07	0.88	0.11	0.667
Waist-height ratio	0.55	0.09	0.566	0.16	0.194
Total body fat (kg)	8.10	12.10	19.20	19.10	0.005
Total body fat (%)	13.50	13.30	31.80	19.30	0.001
Lean body mass (kg)	53.70	8.10	41.45	6.43	0.001
Total body water (kg)	39.30	5.90	30.35	4.65	0.001

BMI: Body Mass Index; $p<0.05$

Table 4. The ratıos of patients according to MIS

MIS value	Male (n=25)		Female (n=24)		Total (n=49)		
	n	%	n	%	n	%	**P**
Malnutrition (MIS>7)	20	80	22	91.7	42	85.7	0.243
Well-nourished (MIS<7)	5	20	2	8.3	7	14.3	

MIS: Malnutrition Inflammation Score; $p<0.05$

Table 5. CIMT, MIS, CRP, albumin and TIBC findings of patients by gender

	Male (n=25)		Female (n=24)		Total (n=49)		
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**P***
CIMT (mm)	0.55	0.23	0.60	0.33	0.60	0.27	0.343
MIS	12.00	6.50	10.50	5.75	11.00	6.00	0.599
CRP (mg/dL)	0.64	0.94	0.97	2.74	0.68	1.43	0.202
Albumin (g/dL)	3.79	0.62	3.60	0.30	3.70	0.52	0.337
TIBC (mg/dL)	127.00	47.50	118.00	50.25	121.00	48.00	0.361

CIMT: Carotid Intima-Media Tickness; MIS: Malnutrition Inflammation Score; CRP: Serum C-Reactive Protein; TIBC: Total Iron Binding Capacity; $p<0.05$*Female and Male Mann Whitney U Test

Table 6. Evaluation of patients according to BMI classification and references of CRP and CIMT

	Male (n=25)		Female (n=24)		Total (n=49)		P
	n	%	n	%	n	%	
CIMT (mm)							
<1 mm	24	96.0	24	100.0	48	98.0	0.322
≥1 mm	1	4.0	-	-	1	2.0	
CRP (mg/dL)							
Normal	24	96.0	22	91.7	46	93.9	0.527
Over	1	4.0	2	8.3	3	6.1	
BMI (kg/m²)							
Underweight (<18.5)	4	16.0	2	8.3	6	12.3	0.175
Normal (18.5-24.9)	12	48.0	11	45.8	23	46.9	
Overweight(25-29.9)	8	32.0	5	20.8	13	26.6	
Obese (>30)	1	4	6	25	7	14.3	

CIMT: Carotid Intima-Media Tickness; CRP: Serum C-Reactive Protein; BMI: Body Mass Index

Table 7. Correlation of anthropometric measurements, body compositions, serum CRP levels and dialysis time with CIMT and MIS

	CIMT (mm)		MIS	
	r	p	r	P
Age(years)	0.550	0.001	0.039	0.792
Bodyweight (kg)	0.255	0.076	-0.534	0.001
Height (m)	-0.132	-0.365	-0.039	0.793
BMI (kg/m²)	0.324	0.023	-0.518	0.001
Waist circumference (cm)	0.340	0.017	-0.430	0.002
Hip circumference (cm)	0.290	0.044	-0.417	0.003
Waist-hip ratio	0.240	0.095	-0.239	0.098
Waist-height ratio	0.369	0.090	-0.401	0.004
Total body fat (kg)	0.380	0.071	-0.380	0.007
Total body fat (%)	0.404	0.004	-0.281	0.051
Lean body mass (kg)	-0.039	0.791	-0.384	0.007
Total body water (kg)	-0.039	0.788	-0.383	0.007
CIMT (mm)	1	1	-0.027	0.854
CRP (mg/dL)	0.137	0.346	0.235	0.104
Dialysis age (years)	-0.124	0.0396	0.385	0.006
CKD diagnosis time (year**)**	-0.042	0.776	0.182	0.240

CIMT: Carotid İntima-Media Tickness; MIS: Malnutrition Inflammation Score; CRP: Serum C-Reactive Protein; BMI: Body Mass Index; CKD: Chronic Kidney Disease; p<0.05,

Discussion

This study was carried out to detect the relationship between MIA components in 49 patients who had ESRD with hemodialysis, between the ages of 18 and 65, who have not previously been diagnosed with CVD, do not have chronic inflammatory disease, do not use antinflammatory drugs.

Studies have been conducted that patients who undergo dialysis for 5 years or more have a negative impact on their life expectancy and quality of life (19, 20). Age is an important factor affecting the quality of life and mortality risk (20). In a study conducted on patients undergoing hemodialysis, CVD death risk is most common in the age group 45 and older (21). Increasing age together with the time to undergo hemodialysis also constitutes a strong risk factor for CVD (22). For these reasons, age is considered to be a risk factor for CVD and mortality in this study as well.

The MIS has been shown to be associated with hospitalization time, mortality, nutrition, inflammation and anemia in patients with hemodialysis. As the MIS increases, the nutritional status of the patient deteriorates and malnutrition also increases (17). There is no MIS specific intersection value to determine malnutrition. As'habi et al. (23) determined the cut-off for MIS as 8 points in their study. Kara et al. (24) determined the cut-off MIS as 6.5 points. In this study; MIS median of the patients was 11.00 and there was no difference between the genders. Akgül et al. (25) stated that MIS is an independent determinant of survival in their study with 124 hemodialysis patients. Patients with MIS<5 have been shown to have a significantly better survival rate compared to patients with MIS>11 after 20 months of follow-up. Borges et al. (26) stated the MIS cut-off as 7 points as an independent marker of mortality in their study with 215 hemodialysis patients. In our study, the MIS value was accepted as 7 and it was found that 85.7% of the patients were malnourished.

Serum CRP value is a positive acute phase reactant and is a good indicator of inflammation (4). Zimmerman et al. (27) demonstrated that age and CRP are the strongest independent predictors of cardiovascular mortality. In a study by Stenvinkel et al. (28) patients with high CRP levels were reported a significant increase in carotid artery intimacy and carotid plaque frequency compared to normal patients. Kalantar-Zadeh et al. (29) could not find a significant relationship between MIS and serum CRP in their study of hemodialysis patients. Similarly with this study, the inflammatory parameter CRP did not show a significant correlation with the MIS, suggesting that the MIS was associated with malnutrition more than inflammation. However, only the CRP was evaluated as an inflammatory marker. The other inflammatory markers such as IL-6, TNF-α which are prognostic significance have not been evaluated. This may be a deficiency. In this study; There was no significant relationship between CRP and MIS, but there was a positive relationship.

Atherosclerotic changes in the carotid artery indicate atherosclerosis. It is seen as an early indicator of cardiovascular morbidity and mortality in the general population and patients with ESRD (8, 9, 29). For this reason, determination of intima-media thickness (CA-IMT) in the carotid artery ultrasonographically is important in the detection of atherosclerotic plaque, degree of calcification and arterial lumen diameters, asymptomatic atherosclerotic findings (9). In the Atherosclerosis Risk In Communities Study (ARIC); A strong correlation has been found between individuals between the ages of 45 and 65, with risk of acute myocardial infarction and CIMT, even after excluding risk factors such as race, age, hypercholesterolemia, diabetes, hypertension, and smoking (30). In this study, the median CIMT of the patients was 0.60 mm, 98% of them were in the risk-free group and no difference was between the genders. In addition, no significant correlation was found between the CIMT and CRP of the patients and the MIS.

The lean mass, hydration status, phase angle, resistance and body cell mass values obtained by body composition analysis are used to evaluate malnutrition status (31).

In the correlation analysis, a positive significant correlation was found between age, BMI, waist circumference, hip circumference, and total body fat percentage and CIMT. There was a negative correlation between CIMT and MIS, but the results were not significant. It was determined that there was a positive correlation between CRP and CIMT and MIS, but the results were not significant. Mahmoud et al. (32), in their study investigating the relationship between CIMT and malnutrition, showed that the presence of malnutrition in HD patients was associated with CIMT. They found a significant positive correlation between the MIS value and CIMT but they could not find a significant relationship between total body fat, total body water, total muscle mass and CIMT.

In this study, all anthropometric and body composition measurements of individuals were found to be inversely related to MIS. Among these measurements, a significant negative correlation was found between body weight, BMI, waist circumference, hip circumference, waist-height ratio, total body fat, lean body mass, total body water and MIS. Sohrabi et al. (33) found a non-significant negative relationship between BMI and albumin values and MIS in hemodialysis patients. In this study, these parameters related to malnutrition (body weight, BMI, waist circumference, hip circumference, waist height ratio, total body fat, lean body mass) were found to be significant with MIS, and CRP was not significant with MIS. This suggests that it is associated with malnutrition.

As the dialysis time of hemodialysis patients increases, their quality of life decreases and malnutrition may develop as one of the most important complications of hemodialysis (20). Kalantar-Zadeh et al. (34) demonstrated the relationship between the MIS and dialysis time. Malnutrition and inflammation increase with increasing age on dialysis. In this study, a positive and significant relationship was found between dialysis age and MIS.

In conclusion the increase in serum proinflammatory levels and the relationship between malnutrition which are frequently seen in these patients, and atherosclerosis are shown as MIA syndrome in hemodialysis patients with end-stage renal failure. Therefore, monitoring the nutritional status of these patients is important. Also, end-stage renal disease is a chronic inflammatory state. So inflammation-related malnutrition may develop. Since it is quite difficult to improve nutritional status in inflammatory malnutrition, it is necessary to correct comorbid status or chronic inflammation in these patients.

In this study, while a significant relationship was not observed between the MIS and CRP and CIMT of patients, a significant relationship was found with some anthropometric measurement and body composition parameters that may be the indicator of malnutrition. An increase in CIMT value, which is seen as an early finding of cardiovascular morbidity and mortality, with age, poses a serious risk for MIA component atherosclerosis. Since hemodialysis patients have a high cardiovascular risk, multidisciplinary studies should be conducted for patients in order to reduce these traditional, kidney and nutritional risks. Therefore, the components of MIA syndrome should be examined separately for each hemodialysis patient. Our goal should be to investigate patients for MIA risk factors and to reduce the rate of atherosclerosis with proper diet, exercise and treatment. In order to prevent malnutrition and inflammation, appropriate individual nutrition plans should be established for patients. Patients should be followed regularly. It is thought that the data to be obtained from this study may guide future studies. The study had some limitations. The study was a cross-sectional and single-center study. The small number of patient participants and the similar characteristics of the patients participating in the study were among the limitations of the study. Consequently, larger randomized clinical trials examining the effectiveness of nutritional interventions in patients with end-stage renal failure MIA syndrome will be useful in medical nutrition therapy applications.

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