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Original Article

Assessment of nutritional parameters in elderly hemodialysis patients

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ABSTRACT

Aims: Malnutrition is a common and important condition in hemodialysis patients, associated with increased mortality and morbidity. This study aimed to identify parameters that may be associated with the level of malnutrition in elderly hemodialysis patients and to determine the most reliable parameter for detecting malnutrition in the elderly hemodialysis patient population.

Methods: This single-center, cross-sectional study evaluated 136 patients aged ≥65 years who were undergoing hemodialysis across four different units. We evaluated sociodemographic characteristics, laboratory parameters, and comorbidities. The Controlling Nutritional Status (CONUT), body-mass index (BMI), Geriatric Nutritional Risk Index (GNRI), Malnutrition Inflammation Score (MIS), subjective global assessment (SGA), and normalized protein nitrogen appearance (nPNA) scales were applied to assess the nutritional status of patients.

Results: The median age was 73 (IQR:69-77) years, hemodialysis duration was 4 (IQR:2-7) years, and BMI was 25.28 (IQR:22.08-28.39) kg/m². According to SGA, malnourished patients were older and had significantly lower abdominal skinfold thickness (ASF), triceps skinfold thickness (TSF), and waist circumference (all p<0.01). Malnutrition was detected in 22.8% of patients by BMI, 49.3% by MIS, 44.1% by SGA, 66.2% by CONUT, and 11.8% by GNRI. There was no significant difference between the malnourished and well-nourished groups regarding nPNA and hemodialysis duration (p>0.05).

Conclusion: MIS was found to be near-ideal tests for detecting malnutrition in elderly hemodialysis patients. GNRI was usable in identifying the healthy population. The validity of the CONUT test was weak. When anthropometric measurements were evaluated for detecting malnutrition in elderly hemodialysis patients, TSF and ASF were close to ideal.

Keywords: Malnutrition, chronic kidney disease, anthropometry

INTRODUCTION

Malnutrition is a common condition in end-stage renal disease (ESRD) patients, with a reported global prevalence of 28-54% in hemodialysis patients.[1] Malnutrition has a multifactorial origin and is strongly associated with increased mortality, morbidity and decreased quality of life.[2]

As a result of increased life expectancy, the world's population is aging. The elderly population (aged 65 and over) with chronic diseases who are dependent on others have difficulty ensuring healthy nutrition. Malnutrition is a significant health problem most seen in the elderly population.[3]

In the diagnosis of malnutrition, anthropometric measurements, biochemical tests, combined assessments of dietary intake and compliance, and combined nutritional indices can be used to evaluate body compartment status.[4]

This study aimed to determine the level of malnutrition in patients over 65 years of age undergoing hemodialysis treatment and to identify related laboratory parameters, comorbidities, medications used, and sociodemographic characteristics, and to compare malnutrition parameters. The aim was to find the most reliable parameter for detecting malnutrition in the elderly hemodialysis patient population.

METHODS

This study was conducted with the approval of the Non-interventional Clinical Researches Ethics Committee at Sivas Cumhuriyet University (Date: 27.07. 2022, Decision No: 2022-07/07). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Written informed consent was obtained from all individual participants prior to their inclusion in the study.

Our cross-sectional, single-center study evaluated 136 patients aged 65 years and older who underwent hemodialysis treatment across four different units between August 1, 2022, and August 1, 2023. Patients under 65 years of age, those who did not sign the informed consent form, patients with malignancy, active inflammation, or oral feeding disorders, and patients receiving nutrition via percutaneous endoscopic gastrostomy (PEG) were excluded from the study. Patients were evaluated on dialysis days, prior to their dialysis sessions.

We recorded the patients' sociodemographic characteristics (age, gender, marital status, educational status, income status, place of residence, living environment, and smoking status) and clinical data, including comorbidities (diabetes mellitus [DM], hypertension [HT], coronary artery disease [CAD],

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chronic obstructive pulmonary disease [COPD], and the primary cause of chronic kidney disease). Additionally, we evaluated components of the Malnutrition Inflammation Score (MIS), such as weight change in the last 3 months, dietary intake, gastrointestinal symptoms, and functional capacity.[5] Physical examination findings (body weight, height, triceps skinfold thickness (TSF), abdominal skinfold thickness (ASF), waist circumference, and average interdialytic weight gain in the last month) and routine laboratory parameters (blood urea nitrogen [BUN], creatinine, total protein, albumin, complete blood count, lipid profile, and iron status) were obtained from the patient records.

Using the obtained data, the Controlling Nutritional Status (CONUT), Geriatric Nutritional Risk Index (GNRI), MIS, subjective global assessment (SGA), and normalized protein nitrogen appearance (nPNA) scales were applied to assess malnutrition.

Body-Mass Index (BMI)

BMI (kg/m²) is calculated using the formula: Body weight (kg)/height² (m²).[6]

Based on previous studies associating BMI<22 kg/m² with increased mortality risk in hemodialysis patients, this value was selected as the cut-off point for malnutrition diagnosis.[6]

Skin Fold Thickness Measurement

TSF and ASF were measured using a skinfold caliper according to standard anthropometric guidelines to assess body fat reserves.[7]

Waist Circumference Measurement

Waist circumference is an indicator of regional fat distribution. In older adults, waist circumference measurements have been shown to correlate highly with visceral and total fat amounts determined by computed tomography.[8]

Malnutrition Inflammation Score (MIS)

The MIS is a semi-quantitative scale assessing 10 components related to medical history, physical examination, and laboratory parameters. The total score ranges from 0 to 30, where higher scores indicate more severe malnutrition.[9]

Subjective Global Assessment (SGA)

SGA includes medical history, weight changes, changes in eating status, gastrointestinal symptoms lasting more than 2 weeks, and changes in 14 functional capacities. The physical examination assesses loss of subcutaneous fat tissue, muscle loss, ankle/sacral edema, and the presence of ascites. Patients were categorized into one of three groups: 'well-nourished' (A), 'moderately or possibly malnourished' (B), and 'severely malnourished' (C).[10]

SGA was established as the reference standard in this study, as it is a well-validated and widely recommended clinical tool by international guidelines for comprehensively assessing the nutritional status of patients with end-stage renal disease.[11]

Controlling Nutritional Status (CONUT)

CONUT is a practical and easy-to-use score that assesses patients' nutritional status using laboratory values (albumin, lymphocytes, cholesterol).

CONUT score 0-1=Normal; 2-4=Mild; 5-8=Moderate; 9-12=Severe malnutrition.[12]

Geriatric Nutrition Risk Index (GNRI)

GNRI, requires the evaluation of serum albumin and the calculation of ideal body weight using the Lorentz formula. The score is obtained according to the following equation.[13]

GNRI=(1.489×albumin (g/L))+(41.7×weight/ideal body weight)

Note: When weight exceeds ideal body weight, a score of 1 point is assigned based on the weight/ideal body weight ratio.

GNRI<92: Severe/moderate risk

GNRI=92-98: Low risk

GNRI>98: No risk

Normalized Protein Nitrogen Appearance (nPNA)

nPNA was calculated using the urea kinetic modeling approach described by Depner and Daugirdas to estimate daily protein intake. Based on the findings of the National Cooperative Dialysis Study (NCDS), an nPNA greater than 1.0 g/kg/day was accepted as adequate.[14]

Statistical Analysis

The data were analyzed using SPSS 23.0 and R Studio. The Kolmogorov-Smirnov test was used to assess normality of distribution. Since the data did not meet the assumptions of normal distribution, non-parametric tests were utilized. For the comparison of two independent groups, the Mann-Whitney U test was used. The Kruskal-Wallis test was used for non-parametric comparisons of multiple groups. Categorical variables were analyzed using the Chi-square test. When the assumption of expected frequencies was violated (expected count <5 in >20% of cells), the Likelihood ratio test was used. For descriptive statistics and baseline group comparisons, well-established literature cut-offs for nutritional indices and anthropometric measurements (e.g., BMI <22 kg/m², categorical CONUT scores, standard GNRI risk groups, and 25th percentiles for TSF and ASF) were utilized. Furthermore, to determine the maximum diagnostic accuracy specifically for this elderly hemodialysis cohort, ROC analysis was performed to evaluate the diagnostic performance of these parameters against SGA as the reference standard. The optimal cut-off values for each parameter were determined using the Youden index. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the curve (AUC) with 95% confidence intervals (CI) were calculated. Pairwise comparisons of the AUC values to determine statistical superiority among the indices were conducted using the DeLong test. Multivariate logistic regression analysis was performed to identify independent predictors of malnutrition. Our data are presented in tables as median, interquartile ranges (IQR, 25th-75th percentiles), number of individuals, and percentage, with a significance level of 0.05.

RESULTS

Our study included 136 patients aged 65 years and older undergoing hemodialysis treatment, with a median age of 73 (IQR: 69-77) years. Most patients (71.3%) were over 70 years of age. 51.5% of the patients were female. 82.4% of the patients had hypertension, 46.3% had DM, 37.5% had CAD, and 13.2%

had asthma/COPD. 86.8% of patients had been receiving hemodialysis treatment for more than 1 year, with a median dialysis duration of 4 (IQR: 2-7) years. DM (33.1%) was the most common etiology of chronic kidney disease among patients. Only 14.7% of patients were high school or university graduates. Only 14% had sufficient income.

In 22.8% of patients, BMI was below 22 kg/m², in 27.9% TSF was below the 25th percentile, and in 25% ASF was below the 25th percentile. Malnutrition was detected in 49.3% of patients according to MIS, 44.1% according to SGA, and 66.2% according to CONUT. Malnutrition risk was detected in 11.8% according to GNRI.

When sociodemographic characteristics were evaluated according to the SGA, statistically significant relationships were observed between the presence of malnutrition and both age groups (p=0.012) and smoking status (p=0.017). The prevalence of malnutrition was relatively lower in the 65-69 and 70-74 age groups (35.9% and 31.9%, respectively), but markedly increased in advanced age categories, reaching 68.2% in patients aged 80 years and older. Similarly, malnutrition was notably higher in current smokers (87.5%) compared to patients who had never smoked (45.3%) and former smokers (35.8%) (**Table 1**).

Patients with malnutrition according to SGA were found to be older (p=0.001). They had significantly lower BMI, TSF, ASF, and waist circumference (all p<0.01). While the duration of hemodialysis, HDL, nPNA, Kt/V, and urea reduction ratio (URR) did not differ, malnourished patients had lower lymphocyte counts (p<0.001), total cholesterol (p=0.012), LDL (p=0.001) and triglycerides (p=0.012) (**Table 2**).

To further identify the independent clinical predictors of malnutrition, a multivariate logistic regression analysis was performed including age, diabetes mellitus, dialysis duration, C-reactive protein (CRP), albumin, phosphorus, parathyroid hormone (PTH), and Kt/V. The analysis confirmed that advanced age was the only independent risk factor significantly associated with the presence of malnutrition (OR: 1.114, 95% CI: 1.040-1.194, p=0.002). Notably, while CRP and parathormone demonstrated statistically significant associations with malnutrition in the univariate analysis, they lost their significance in the multivariate model and were not independent predictors (p>0.05). Other variables in the model did not demonstrate statistical significance (**Table 3**).

The median age was 71 (IQR: 67-77) years for male and 74 (IQR: 70-78) years for female (p>0.05). BMI was significantly higher in female (25.73 [IQR: 23.09-29.65]) compared to men (24.12 [IQR: 21.62-27.35]) (p=0.021). TSF and waist circumference were lower in men, while ASF was higher in men, but no statistically significant differences were found (all p>0.05). The MIS score was significantly higher in female (7 [IQR: 4-9]) compared to male (4.5 [IQR: 2.75-7]) (p<0.01). GNRI was 108.5 (IQR: 102-116) in male and 113 (IQR: 104.75-121.75) in female (p>0.05).

Malnutrition according to SGA was found in 47.1% of female and 40.9% of men, but there was no statistically significant difference (p>0.05).

Among patients with SGA-defined malnutrition, 88.3% and 83.3% also had malnutrition according to MIS and the CONUT score, respectively (p<0.001 for both). Nutritional risk according to GNRI was identified in 18.3% of the patients with SGA-defined malnutrition (p=0.035). When anthropometric measurements were analyzed, TSF was below the 25th percentile in 56.7% and ASF was below the 25th percentile in 53.3% of the patients with SGA-defined malnutrition (p<0.001 for both). Furthermore, BMI was<22 kg/m² in 45% of the patients with SGA-defined malnutrition (p<0.001). No statistically significant relationship was found between SGA-defined nutritional status and gender (p>0.05) (**Table 4**).

The diagnostic performance, validity, and optimal cut-off points of the nutritional indices and anthropometric measurements were evaluated using ROC curve analysis according to SGA. The ROC curves of these analyses are illustrated in **Figure 1**. Furthermore, detailed diagnostic metrics such as sensitivity, specificity, PPV, NPV, and overall accuracy at the determined cut-off points are visually

Table 1. Evaluation of patients based on their sociodemographic characteristics and SGA

		SGA (malnutrition)		p
		Absent	Present	
		n (%)	n (%)	
Age (years)	65-69	25 (64.1)	14 (35.9)	0.012*
	70-74	32 (68.1)	15 (31.9)	
	75-79	12 (42.9)	16 (57.1)	
	>80	7 (31.8)	15 (68.2)	
Gender	Male	39 (59.1)	27 (40.9)	0.464*
	Female	37 (52.9)	33 (47.1)	
Marital status	Married	53 (55.8)	42 (44.2)	0.974*
	Single	23 (56.1)	18 (43.9)	
Education status	Illiterate	20 (50)	20 (50)	0.495†
	Literate	9 (69.2)	4 (30.8)	
	Elementary school	33 (56.9)	25 (43.1)	
	Middle school	2 (40)	3 (60)	
	High school	10 (55.6)	8 (44.4)	
	University	2 (100)	0 (0)	
Place of residence	Own residence	54 (58.7)	38 (41.3)	0.604*
	With family	9 (47.4)	10 (52.6)	
	Tenant	13 (52)	12 (48)	
Living arrangement	Alone	8 (61.5)	5 (38.5)	0.405†
	With family	68 (55.7)	54 (44.3)	
	With a caregiver	0 (0)	1 (100)	
Smoking	Non-smoker	41 (54.7)	34 (45.3)	0.017*
	Smoker	1 (12.5)	7 (87.5)	
	Ex-smoker	34 (64.2)	19(35.8)	
Hemodialysis duration (years)	<1	13 (72.2)	5 (27.8)	0.160*
	1-4	30 (51.7)	28 (48.3)	
	5-9	24 (63.2)	14 (36.8)	
	>10	9 (40.9)	13 (59.1)	
ESRD etiology	Unknown	14 (50)	14 (50)	0.090*
	DM	32 (71.1)	13 (28.9)	
	Hypertension	13 (50)	13 (50)	
	Other	17 (45.9)	20 (54.1)	

*Pearson Chi-square test was used. † Likelihood Ratio test was used. SGA: Subjective global assessment, BMI: Body-mass index, TL: Turkish lira, DM: Diabetes mellitus, ESRD: End-stage renal disease

Table 2. Comparison based on numerical measurements obtained from patients. laboratory parameters and SGA

	All patients	SGA (malnutrition)		
		Absent	Present	
	Median (IQR)	Median (IQR)	Median (IQR)	P
Age (years)	73 (69-77)	71 (68-74.75)	75.5 (70.25-79.75)	0.001
HD duration (years)	4 (2-7)	4 (1.16-7)	4 (2-8.75)	0.319
BMI (kg/m^2)	25.28 (22.08-28.39)	27.04 (24.26-30.39)	22.39 (19.74-25.39)	<0.001
TSF (mm)	7.5 (5-10)	10 (7.25-12)	5 (4-6)	<0.001
ASF (mm)	10 (6-14.75)	14 (10.25-17)	6 (5-9)	<0.001
Waist circumference (cm)	98 (90.25-108)	103.5 (96-115)	92 (80-100)	<0.001
Interdialytic weight gain (kg)	2.5 (2-3)	2.75 (2-3.375)	2 (2-3)	0.052
MIS	5 (3.25-8)	4 (2-5)	8 (7-11)	<0.001
GNRI	110.5 (102.25-117)	115 (107.25-124.75)	105 (99-112)	<0.001
KT/V	1.46 (1.32-1.62)	1.41 (1.31-1.58)	1.54 (1.36-1.63)	0.083
nPNA (g/kg/day)	1.13 (0.94-1.28)	1.11 (0.91-1.289)	1.14 (0.98-1.33)	0.46
URR (%)	70.31 (66.83-74.11)	68.96 (65.21-73.78)	71.87 (67.83-74.6)	0.051
WBC (10^9/L)	6.635 (5.18-8.16)	6.86 (5.26-8.315)	6.19 (4.76-8.06)	0.22
Neutrophils (10^9/L)	4.13 (3.13-5.49)	4.33 (3.13-6.3)	3.68 (3.28-5.35)	0.551
Lymphocytes (10^9/L)	1.41 (0.99-1.75)	1.62 (1.28-1.88)	1.15 (0.83-1.52)	<0.001
Hemoglobin (g/dl)	11.1 (10.07-12)	11.2 (10.13-12)	10.7 (9.8-11.8)	0.15
Hematocrit (%)	34.25 (30.3-37.335)	34.9 (31.7-37.475)	33.5 (29.5-36.38)	0.176
Platelets (10^9/L)	186 (141.25-226.75)	181.5 (142.25-224.25)	192.5 (139.5-236.5)	0.334
Total cholesterol (mg/dl)	156 (137-179.75)	164 (139.5-196.5)	148.5 (127.5-166)	0.001
Triglycerides (mg/dl)	135.5 (104.25-211.5)	160 (116.25-232.75)	120.5 (92-175.5)	0.012
HDL (mg/dl)	38 (31-45)	38.5 (31-44)	36.5 (30.25-46.75)	0.951
LDL (mg/dl)	83 (66-103.5)	92.5 (73.25-118.75)	79 (60-93.75)	0.002
Ferritin (ug/L)	536 (269.5-725.75)	521.5 (248-702.25)	551.5 (276.25-804.25)	0.383
TS (%)	31.5 (21.25-40)	32 (20.25-42.5)	29.5 (22-38.75)	0.658
BUN (mg/dl)	69.04 (56.07-81.19)	69.19 (55.02-82.01)	68.22 (56.5405-80.4)	0.801
Creatinine (mg/dl)	6.87 (5.6-8.62)	7.16 (5.81-8.775)	6.43 (5.11-8.11)	0.128
Total protein (mg/dl)	70 (66-74.7)	70.12 (66-74.75)	69.91(65.835-74.71)	0.779
Albumin (mg/dl)	41 (37.63-44.96)	41.08(38-46.69)	40.79 (37.225-44.8)	0.372
Phosphor (mg/dl)	4.8 (3.91-5.26)	4.89 (4.05-5.25)	4.73 (3.9-5.34)	0.375
C-reactive protein (mg/L)	5.79 (1.7-17.84)	4.3 (1.06-13.72)	9.44 (2.11-34.91)	0.018
Parathormone (ng/L)	257 (169.25-409)	312 (185-467.25)	213(148.5-363.5)	0.037

SGA: Subjective global assessment, IQR: Interquartile range, HD: Hemodialysis, BMI: Body-mass index, TSF: Triceps skinfold thickness, ASF: Abdominal skinfold thickness, GNRI: Geriatric Nutritional Risk Index, nPNA: Normalized protein nitrogen appearance, WBC: White blood cell, MIS: Malnutrition Inflammation Score, URR: Urea reduction ratio, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TS: Transferrin saturation, BUN: Blood urea nitrogen

Table 3. Multivariate logistic regression analysis for predictors of malnutrition based on the SGA

	β	SE (β)	Wald	P	OR	%95 CI (lower-upper)
Age	0.108	0.035	9.447	0.002	1.114	1.040-1.194
DM	-0.528	0.412	1.642	0.200	0.590	0.263-1.323
HD duration	0.037	0.042	0.774	0.379	1.038	0.956-1.126
Kt/V	1.042	0.740	1.983	0.159	2.835	0.665-12.091
Albumin	-0.013	0.031	0.166	0.684	0.987	0.928-1.050
Phosphor	-0.093	0.183	0.260	0.610	0.911	0.637-1.304
CRP	0.011	0.006	3.075	0.080	1.011	0.999-1.024
Parathormone	0.000	0.001	0.435	0.510	1.000	0.998-1.001

SGA: Subjective global assessment, SE: Standard error, OR: Odds ratio, CI: Confidence interval, DM: Diabetes mellitus, HD: Hemodialysis, CRP: C-reactive protein

compared in **Figure 2** and comprehensively presented in **Table 5**.

When evaluated according to SGA:

- MIS found a PPV of 79.1%, an NPV of 89.9%, sensitivity of 88.3%, specificity of 81.6%, accuracy of 84.6% and AUC 0.934 for cut-off 5.5.
- TSF found a PPV of 78.0%, an NPV of 81.8%, sensitivity of 76.7%, specificity of 82.9%, and accuracy of 80.1% and AUC 0.878 for cut-off 6.5.
- ASF found a PPV of 72.5%, an NPV of 85.1%, sensitivity of 83.3%, specificity of 75.0%, and accuracy of 78.6% and AUC 0.872 for cut-off 10.5.
- BMI found a PPV of 67.2%, an NPV of 78.3%, sensitivity of 75.0%, specificity of 71.1%, and accuracy of 72.8% and AUC 0.792 for cut-off 25.2.
- GNRI found a PPV of 65.6%, an NPV of 73.3%, sensitivity of 66.7%, specificity of 72.4%, and accuracy of 69.8% and AUC 0.734 for cut-off 109.5.

Table 4. Comparison of nutritional parameters and scoring systems according to SGA malnutrition status

		SGA (malnutrition) (n)		
		Absent	Present	p
Gender	Male	39	27	0.464
	Female	37	33	
BMI (kg/m²)	<22	4	27	<0.001
	≥22	72	33	
MIS (malnutrition)	Absent	62	7	<0.001
	Present	14	53	
TSF (percentile)	<25	3	34	<0.001
	25-75	33	22	
	>75	40	4	
ASF (percentile)	<25	3	32	<0.001
	25-75	42	25	
	>75	31	3	
GNRI (risk)	Absent	71	49	0.035
	Present	5	11	
CONUT (malnutrition)	Absent	37	10	<0.001
	Present	39	50	

SGA: Subjective global assessment, BMI: Body-mass index, MIS: Malnutrition Inflammation Score, TSF: Triceps skinfold thickness, ASF: Abdominal skinfold thickness, GNRI: Geriatric Nutritional Risk Index, CONUT: Controlling nutritional status

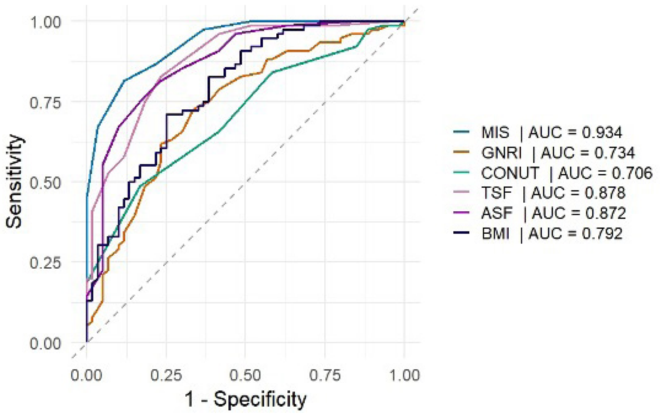

Figure 1. ROC curve analysis of various nutritional scores and anthropometric parameters for predicting malnutrition

ROC: Receiver operating characteristic, MIS: Malnutrition-inflammation score, GNRI: Geriatric Nutritional Risk Index, CONUT: Controlling nutritional status, TSF: Triceps skinfold thickness, ASF: Abdominal skinfold, BMI: Body-mass index, AUC: Area under the curve

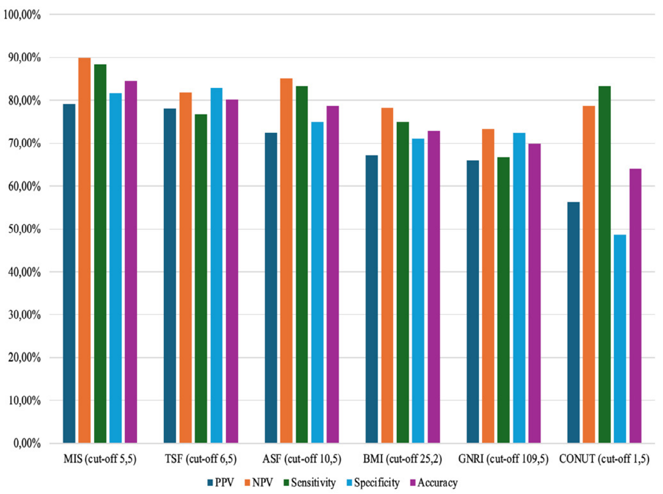

Figure 2. Evaluation of the validity of malnutrition parameters according to SGA

SGA: Subjective global assessment, MIS: Malnutrition-inflammation score, TSF: Triceps skinfold thickness, ASF: Abdominal skinfold, BMI: Body mass index, GNRI: Geriatric Nutritional Risk Index, CONUT: Controlling nutritional status, PPV: Positive predictive value, NPV: Negative predictive value

- CONUT found a PPV of 56.2%, an NPV of 78.7%, sensitivity of 83.3%, specificity of 48.7%, and accuracy of 64% and AUC 0.706 for cut-off 1.5.

Finally, to compare the diagnostic performance of these parameters, the area under the ROC curves (AUC) was compared using the DeLong test. The analysis revealed that the AUC of the MIS was significantly higher than those of the GNRI, BMI and CONUT (all p<0.001) scores; however, the difference between the AUC of the MIS and other anthropometric measurements (TSF, ASF) did not reach statistical significance (p>0.05) (Table 6).

DISCUSSION

In this study, using the SGA as the reference standard, the MIS was identified as the most robust tool for assessing malnutrition in elderly hemodialysis patients, demonstrating the highest diagnostic validity. Furthermore, anthropometric measurements-specifically TSF and ASF-exhibited high diagnostic accuracy, presenting as viable and less time-consuming alternatives for clinical practice. While the BMI and GNRI provided high specificity, making them useful for confirming a well-nourished status, their clinical utility in detecting malnutrition is limited by suboptimal sensitivity. Conversely, although the CONUT score demonstrated high sensitivity, its overall diagnostic performance was compromised by low specificity, resulting in a higher rate of false positives compared to the other evaluated indices.

Malnutrition is commonly observed in hemodialysis patients, with a prevalence of 28-52% found in a meta-analysis study.[15] Many tests have been used to detect malnutrition in this patient population, but there are differing data on which one is superior.[12,16,17] In a study conducted on hospitalized patients, it was noted that the CONUT score is as useful as SGA in determining malnutrition.[12] Another study indicated that GNRI is a reliable assessment system for detecting malnutrition.[18] However, the diagnostic accuracy of these tools can vary significantly depending on the specific patient population. In our study, by utilizing SGA as the clinical reference standard, we clarified these literature discrepancies in the elderly hemodialysis population. Our findings demonstrate that the MIS is a near-ideal tool for assessing malnutrition, and that anthropometric measurements (TSF and ASF) also exhibit high diagnostic accuracy, whereas the overall diagnostic utility of the GNRI and CONUT is limited.

Studies have shown that malnutrition rates in hemodialysis patients range from 41.1% to 70% according to SGA.[19,20] According to the SGA, malnutrition was detected in 44.1% of our patients, of whom 24.3% had mild malnutrition, 17.6% had moderate malnutrition, and 2.2% had severe malnutrition.

In a study conducted by Kang et al.[21] on hemodialysis patients, it was stated that a MIS value below 5 is associated with mortality. In another study conducted in China with 257 hemodialysis patients, the MIS cut-off value was set at 5, and it was reported that mortality increased by more than 80% at MIS values above 5.[22] In a study conducted by Alipoor et al.[23] on hemodialysis patients, the MIS cut-off value was set at 8, and malnutrition was detected in 59% of patients. In our study, the MIS cut-off value was set at 5.5, and malnutrition was detected in 49.3% of patients. The lack of a

Table 5. ROC analysis of nutrition score results predicting malnutrition according to SGA

	Cut-off	Sensitivity	Specificity	PPV	NPV	Youden	AUC	95% CI (lower-upper)
MIS	5.5	0.883	0.816	0.791	0.899	0.699	0.934*	0.898-0.971
GNRI	109.5	0.667	0.724	0.659	0.733	0.390	0.734*	0.649-0.820
CONUT	1.5	0.833	0.487	0.562	0.787	0.320	0.706*	0.621-0.790
TSF	6.5	0.767	0.829	0.780	0.818	0.596	0.878*	0.821-0.935
ASF	10.5	0.833	0.750	0.725	0.851	0.583	0.872*	0.812-0.933
BMI	25.2	0.750	0.711	0.672	0.783	0.461	0.792*	0.716-0.867

*p<0.05

SGA: Subjective global assessment, PPV: Positive predictive value, NPV: Negative predictive value, AUC: Area under the curve, CI: Confidence interval: MIS: Malnutrition Inflammation Score, GNRI: Geriatric Nutritional Risk Index, CONUT: Controlling nutritional status, TSF: Triceps skinfold thickness, ASF: Abdominal skinfold thickness, BMI: Body-mass index

Table 6. ROC DeLong test

	AUC 1	AUC 2	Z	p
MIS-GNRI	0.934	0.734	4.629	<0.001
MIS-CONUT	0.934	0.706	5.481	<0.001
MIS-TSF	0.934	0.878	1.740	0.081
MIS-ASF	0.934	0.872	1.190	0.055
MIS-BMI	0.934	0.792	3.420	<0.001
GNRI-CONUT	0.734	0.706	0.542	0.587
GNRI-TSF	0.734	0.878	-3.213	0.001
GNRI-ASF	0.734	0.872	-3.080	0.002
GNRI-BMI	0.734	0.792	-1.540	0.122
CONUT-TSF	0.706	0.878	-3.560	<0.001
CONUT-ASF	0.706	0.872	3.640	<0.001
CONUT-BMI	0.706	0.792	-1.570	0.116
TSF-ASF	0.878	0.872	0.235	0.814

ROC: Receiver operating characteristic, MIS: Malnutrition Inflammation Score, GNRI: Geriatric Nutritional Risk Index, CONUT: Controlling nutritional status, TSF: Triceps skinfold thickness, ASF: Abdominal skinfold thickness, BMI: Body-mass index

universally accepted cut-off value for MIS can be considered a shortcoming of this test.

In our study, ASF and TSF were found to be below the 25th percentile in 25% and 25.7% of patients, respectively. TSF and ASF were significantly lower in those with malnutrition according to SGA. In a study conducted with patients aged 20-63 at the only hemodialysis center in İstanbul, the mean was found to be 26.6±6.3 mm, and the difference between this and our study supports the loss of adipose tissue with aging.[24] In a study conducted by Pembegül Yiğit[25] and colleagues on elderly hemodialysis patients, a significant difference was found between TSF and ASF, similar to the findings in our study. We detected malnutrition in 91.9% of our patients below the 25th percentile of TSF and in 91.4% of patients below the 25th percentile of ASF according to SGA. The accuracy rates of 80.1% and 78.6% for both parameters indicate that these two tests may be ideal for detecting malnutrition.

The median age of the patients included in our study was similar to the age found in the study by Pembegül Yiğit et al.[25] on malnutrition in elderly hemodialysis patients in our country. Similarly to this study, a higher average age was found among those with malnutrition in our study, and a relationship was determined between age and malnutrition.[2]

The duration of hemodialysis treatment may be an effective factor in malnutrition. A study conducted in Palestine indicated that malnutrition was more prevalent in patients undergoing hemodialysis for more than 4 years.[26] However, in our study, no relationship was found between dialysis duration and malnutrition.

In our study, triglyceride levels were found to be 120.5 (IQR: 92-175.5) mg/dl and 160 (IQR: 116.25-232.75) mg/dl in malnourished and non-malnourished patients, respectively, according to SGA, and a statistical difference was detected. In a study conducted by Lee et al.[27] on hemodialysis patients, similarly to our study, lower triglyceride levels (81.5±30.9 mg/dl; 139±85.3 mg/dl) were found in malnourished patients. It is thought that evaluating the malnutrition status of patients using triglyceride levels would be beneficial.

Hypoalbuminemia has been reported to serve as a potential indicator of mortality and nutritional status in the hemodialysis patient population.[17] A study involving malnourished and non-malnourished patients have shown that serum albumin levels are similar.[28] In our study, we found that the serum albumin level was 41 (IQR: 37.63-44.96) mg/dl on average, and no significant difference was found according to SGA.

Although nPNA is a widely used marker reflecting recent dietary protein intake and nitrogen balance, we found no significant difference in nPNA levels between malnourished and well-nourished patients according to SGA (p>0.05). This finding suggests that while nPNA may indicate acute dietary compliance, it may not adequately capture the chronic, cumulative, and multifactorial tissue loss associated with malnutrition in the elderly hemodialysis population. Comprehensive tools like MIS and anthropometric measurements appear to be more reliable than recent protein intake markers for identifying true malnutrition in this age group.

In our study, when patients were examined according to CONUT, mild malnutrition was detected in 54.4%, moderate malnutrition in 9.6%, and severe malnutrition in 1.5% of patients, with a total of 65.4% of patients having malnutrition. In a study conducted on dialysis patients in our country, the CONUT score cut-off value was calculated as 2.5.[29] In a study conducted by Yılmaz Aydın and colleagues[30] in hemodialysis patients, the CONUT score cut-off value was calculated as 4.5. Both studies found a relationship between the CONUT score and malnutrition and mortality.[29,30] In our study, the defined values of the CONUT score (0-1: normal, 2-4: mild, 5-8: moderate, 9-12: severe) were used, and the optimal cut-off value was calculated as 1.5 based on ROC curve analysis. Further studies are needed to determine the cut-off value and the applicability of the CONUT score in hemodialysis patients.

Limitations

Although this study yielded important results in determining the most useful methods for detecting malnutrition in elderly hemodialysis patients, it has limitations such as a small number of cases, a single-center and cross-sectional design, and the lack of longitudinal mortality or follow-up outcome data.

CONCLUSION

As a result, the most useful information for detecting malnutrition in the elderly hemodialysis patient population may be provided by the MIS and anthropometric measurements such as TSF and ASF. BMI and GNRI are more suitable for identifying the well-nourished (healthy) population due to their high specificity. The effectiveness of the CONUT in detecting malnutrition is low. Although we determined specific optimal threshold values for nutrition scores in this population in our study, larger-scale research is needed to validate these threshold values in broader clinical settings.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was conducted with the approval of the Non-interventional Clinical Researches Ethics Committee at Sivas Cumhuriyet University (Date: 27.07. 2022, Decision No: 2022-07/07).

Informed Consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. Participants were fully informed about the study's aims, procedures, potential risks and benefits, and their rights-including the right to withdraw at any time without consequence. All participants voluntarily signed a written informed consent form.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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Author Contributions

Concept: MFA, YK; Design: MFA, YK; Control: MFA, YK; Data Collection and/or Processing: MFA; Analysis and/or Interpretation: MFA; Literature Review: MFA; Article Writing: MFA, YK; Critical Review: All Authors.

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