Original article

Geriatric Nutrition Risk and Creatinine Indexes in Estimating the Nourishment Situation of Elderly Hemodialysis Patients

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Abstract. *Objective:* Malnutrition is a common complication in hemodialysis (HD) patients, although it cannot be evaluated adequately due to the limitations of available malnutrition screening tools. The aim of our study is to evaluate the relationship between Mini nutritional Assesment-Short Form (MNA-SF) and objective malnutrition tool Geriatric Nutritional Risk Index (GNRI) and Creatinine Index (CI) in HD patients. *Methods:* This is a cross-sectional study of 129 patients aged 65 years and older (female=61 (47.3%) and male=68 (52.7%), 68.88 ± 7.24 years) receiving maintenance HD therapy. Malnutrition was diagnosed with MNA-SF. GNRI and CI were calculated using existing formulas. *Results:* Of the participants, 26 (20.15%) were diagnosed with severe malnutrition, 25 patients (19.4%) were at risk of malnutrition and 78 (60.45%) were diagnosed with normal nutritional status. The optimal cut-off value for GNRI <95 was determined in predicting malnutrition with GNRI, sensitivity and specificity 85.4% and 88.6%, respectively. CI (< 20) was not found effective in determining malnutrition patients due to its low sensitivity and specificity (sensitivity and specificity of 35.9% and 45.0%, respectively). GNRI (<95) is a better predictor of malnutrition screening than CI (<20). *Conclusions:* In the evaluation of undernourished elderly HD patients, GNRI was as effective as MNA-SF, but CI was insufficient in detecting malnutrition individuals.

Key words: GNRI, CI, hemodialysis, elderly

Introduction

Malnutrition in the elderly is associated with increased morbidity and mortality, and its timely recognition and management are of great importance (1). Therefore, different tools have been developed for serial assessment of nutritional status for the detection and management of malnutrition. The Mini Nutritional Assessment (MNA) is a valid nutritional screening and assessment tool that is easily applied to clinically appropriate elderly adults who are admitted to the outpatient clinic and recommended by the European Society of Clinical Nutrition and Metabolism (ESPEN) for routine geriatric evaluations (1, 2). It contains questions specific to the elderly population regarding nutrition and general health status (3). Rubenstein and colleagues developed the MNA short form (MNA-SF), which has high sensitivity, specificity, and correlation with full MNA, for use in time-constrained conditions (4). Holvoet et al. confirmed that MNA-SF is a useful routine screening tool for malnutrition screening in HD patients (5).

Elderly hemodialysis (HD) patients are likely to develop nutritional problems. Early detection of malnutrition risk is important in order to prevent consequences such as deterioration in general health status,

physical and cognitive functional status, increased need for health services, and death that may occur following malnutrition (6). Many nutritional screening tools have been developed to evaluate nutritional risk in HD patients. Geriatric nutrition risk index (GNRI) is recommended as one of the simplest risk indexes for evaluating nutritional status in HD patients (7). Estimation of lean body mass using the creatinine index (CI) derived from conventional creatine kinetic modeling (CKM) has been validated as a reliable method for muscle mass assessment (8). CI formula; Based on age, sex, pre-dialysis serum creatinine concentrations and spKt/V urea. It is therefore a simple, precise and cost effective tool for the nutritional assessment of HD patients.

Current nutritional assessment methods are mostly subjective and time consuming. The aim of our study is to evaluate the relationship between MNA-SF with objective malnutrition tool GNRI and CI in HD patients.

Materials and Methods

Patients and Study Design

A total of 129 patients with oliguria on HD were enrolled in a single tertiary center from April to June 2021. All patients were older than age 65 and undergoing maintenance HD therapy for end-stage renal disease for more than 3 months. Participants were dialyzed 3 times weekly for more than 4 hours per session and using high-flux membranes. Renal transplant patients were not included in our study, and the patients who were diagnosed with malnutrition and under 65 years of age, with high infection markers who used nutritional supplements were also excluded from the study.

The study was conducted according to the criteria of the Helsinki declaration and approved by the local ethical committee. Informed consent was obtained from all the patients included in the study.

Evaluation of Malnutrition

Demographic information and medical histories of all participants were obtained from hospital records, and dialysis treatment parameters such as dialysis vintage (monthly), blood flow rate and single pool Kt / V were evaluated. Nutritional markers such as total protein, albumin and total cholesterol levels were determined. All pre-examination blood samples were taken for routine monthly laboratory evaluation using the standard techniques.

Different steps are needed to fully evaluate malnutrition in HD patients. Anthropometric measurements such as weight, height and calf circumference (CC) were performed in the morning and after urination, and without shoes according to standard protocols. CI and GNRI scores were calculated by the nephrologist based on clinical data for April 2021. MNA-SF was evaluated by a geriatrician.

The patients were divided into malnutrition, risky and normal groups using MNA-SF (5). MNA-SF consists of six items determined to be highly correlated with conventional nutritional assessment. In MNA-SF, the patient was scored by calculating the change in appetite, weight loss, mobility, psychological distress or acute illness in the last 3 months, the presence of neuropsychological problems, and body mass index. According to the patients' MNA-SF score; normal nutrition (12-14), at-risk (8-11) or severe malnutrition ($\leq$7) (9).

GNRI was calculated from baseline albumin level and body weight using the formula below (10). Body weight was calculated as the average weight after the previous three dialysis sessions in kilograms. Ideal body weight was calculated by multiplying 22 by the square of height in meters, based on body mass index (BMI) 22.

$$\text{GNRI} = [14.89 \times \text{albumin (g / dL)} + [41.7 \times (\text{body weight / ideal body weight})]$$

The simple formula for CI estimation calculated from dialysis dose and patient demography was developed through mixed regression models from CI derived from the measured creatinine kinetic model (11).

$$\text{CI (mg/kg/day)} = 16.21 + 1.12 \times [\text{male 1; female 0}] - 0.06 \times \text{age (years)} - 0.08 \times {}_{sp}Kt/V_{urea} + 0.009\ 3\ Cr_{pre}\ (\mu\text{mol/L})$$

Statistical Analysis

Continuous variables were used to compare the 3 groups and were evaluated by ANOVA. Pearson's chi-squares were used for categorical variables. Receiver operating characteristic (ROC) curves were generated. The area under the ROC curve (AUC) was calculated to evaluate the ability of both GNRI and CI to predict undernutrition. Pairwise comparison of AUC values was performed using a method recommended by MedCalc software (MedCalc Sobvba, Ostend, Belgium).

Results

The study consisted of 68 (52.7%) men and 61 (47.3%) women aged 65 years and over (mean = 68.88 ± 7.24). Table 1 shows the demographics of hemodialysis patients according to nutritional status. Dialysis vintage of 129 patients was 58.4 ± 47.4 (minimum 4 months, maximum: 204 months) months. Twenty-six patients (20.5%) were categorized under severe malnutrition and 78 (60.45%) showed normal nutrition (Table 1). Compared to the severe malnutrition group, the normal and at-risk groups had significantly higher

Table 1. Demographics of hemodialysis patients according of nutritional status (n=129)

Variables	Normal	At Risk	Severe malnutrition	P value
n (%)	78 (60.45%)	25 (19.4%)	26 (20.15%)	
Age (y)	67.93±5.95	70.92±8.85	69.76±8.76	0.15
Diseases (n, %)	2.48±1.22	2.64±1.35	2.96±1.21	0.24
Dialysis vintage (m)	50.88±38.05	55.64±43.95	61.78±51.41	0.57
BMI (kg/m^2)	27.63±4.53	23.03±2.59	18.81±1.86	<0.001*
Albumin (g/dL)	3.65±0.27	3.58±0.34	3.55±0.47	0.37
Total Cholesterol (mg/dL)	145.8±65.7	149.3± 62.2	146.7± 67.1	0.41
BUN (mg/dL)	54.7±6.1	52.4±6.9	53.0±5.8	0.35
Creatinine (mg/dL)	8.76± 3.02	8.37± 2.89	8.67± 2.72	0.84
Uric acid	5.97±1,18	6.13±0,89	5.18±0.80	0.002*
Hemoglobin (g/dL)	11.05±1.36	10.704 ± 1.23	10.3923 ± 2.20	0.24
Na	135.68 ±3.09	136.40± 2.84	135.46± 3.2647	0.49
K	5.16 ± 0.82	5.158 ± 0.74	5.07± 0.92	0.88
Ca	9.10±0.86	8.96 ± 0.99	9.05±0.84	0.76
P	4.9 ± 1.40	4.82 ± 1.0632	1.205 ± 4.6	0.79
PTH	397.85±185.09	328.94±166.03	640.01±472.10	0.01*
Kt/V	1.7124 ± 0.4111	1.6968 ± 0.2434	1.7773±0.1916	0.36
Calf Circumference	27.32 ± 4.17	26.04± 3.95	25.88 ± 4.17	0.19
GNRI	106.76± 9.90	97.03 ± 6.79	88.57 ± 8.43	<0.001
Creatinin indexi	19.47 ± 2.52	19.10 ± 2.39	19.60 ± 2.47	0.75
Men	19.96 ± 2,12	19.55 ± 2.52	20.18 ± 2.15	0.69
Women	18.93 ± 2.55	19.78 ± 3.73	18.27 ±2.38	0.23

BMI= body mass index; BUN= blood urea nitrogen; CI= creatinine index; GNRI = geriatric nutritional risk index; IBW = ideal body weight; Kt/V = 2ln(R20.008 3 t) 1 (4 2 3.5 3 R) 3 0.55UF/V; PTH= Parathormone

BMI and GNRI levels. There was no significant difference in albumin, total cholesterol and hemoglobin among the groups. Although it did not reach a statistically significant level, the calf circumference in the group with malnutrition was lower from the others.

The area under the ROC curve in GNRI (AUC_{GNRI}) in determining malnutrition patients was 0.909, and the area under the ROC curve (AUC_{CI}) in CI was 0.526. Based on the ROC curve analysis, the optimal cut-off values defined by the highest sum of sensitivity and specificity of predicting factors of malnutrition are described in Table 2. The optimal cut-off value for GNRI <95 was determined in predicting malnutrition with GNRI, sensitivity and specificity 85.4% and 88.6%, respectively (Figure 2). In the normal group, a sensitivity of 70.5% and a specificity of 84.7% were found, respectively, according to the GNRI> 100 cut-off value (figure 3). Individuals with GNRI levels between 95 and 100 were shown as the group at risk for malnutrition. CI (< 20); It was not found effective in determining malnutrition patients due to its low sensitivity and specificity (sensitivity and specificity of 35.9% and 45.0%, respectively) (Figure 4). GNRI (<95) is a better predictor of malnutrition screening than CI (<20).

Table 3 shows the correlation of GNRI and CI with other variables. According to this; the albumin level was positively correlated with both GNRI and CI ($r = 0.548$, $p < 0.001$ and $r = 0.203$, $p = 0.021$, respectively). In addition, while weight was positively correlated with GNRI, no significant correlation was found with CI ($r = 0.785$, $p < 0.001$ and $r = 0.013$, $p = 0.884$, respectively). A positive correlation was also found between MNA-SF and GNRI ($r = 0.243$, $p = 0.003$).

Discussion

In our cross-sectional study, it was determined that GNRI was effective in identifying elderly HD patients with malnutrition, risk and normal nutritional status with MNA-SF, but CI was insufficient in determining malnutrition patients. In addition to defining the GNRI cut-off point (95) for elderly HD patients defined as malnutrition in MNA-SF, we defined the risk range for individuals (95-100). We found a positive correlation between GNRI score with plasma albumin level, body weight and MNA-SF.

Today, with the technological developments in HD treatment, the number of elderly patients receiving HD treatment is increasing day by day. Despite these developments, HD patients are at risk of mortality and morbidity due to malnutrition (12). In many previous studies, Subjective Global Assessment (SGA) was used in the assessment of nutritional status in HD patients (13,14). However, the subjectivity of the SGA is the potential issues for reproducibility and the need for time and expertise to evaluate. Therefore, there is a need for new test tools that allow faster and more objective evaluation (15,16). Holvoet et al. Found that MNA-SF in HD patients performed well for routine use as a regular screening tool in the intensive dialysis unit (5). The prevalence of nutritional deficiency in

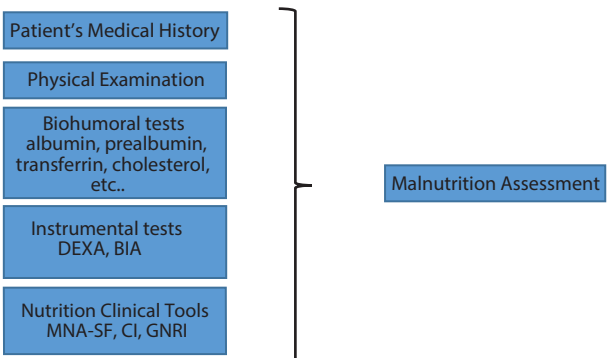

Figure 1. Different steps are needed to fully evaluate malnutrition in HD patients. HD, hemodialysis; DEXA, Dual Energy X-ray Absorptiometry; BIA, Bioelectrical Impedance Analysis; MNA-SF, mini nutritional assessment; CI, creatinine index; GNRI, Geriatric Nutrition Risk Index

Table 2. Areas under ROC curve and cutoff values of GNRI and CI with sensitivity and specificity for prediction of malnutrition

Parameters	Area under of ROC curve	Cut off value	Sensitivity (%)	Specificity (%)
GNRI	0.909	<95	85.4	88.6
CI	0.526	<20	35.9	45.0

GNRI = geriatric nutritional risk index; CI = creatinine index

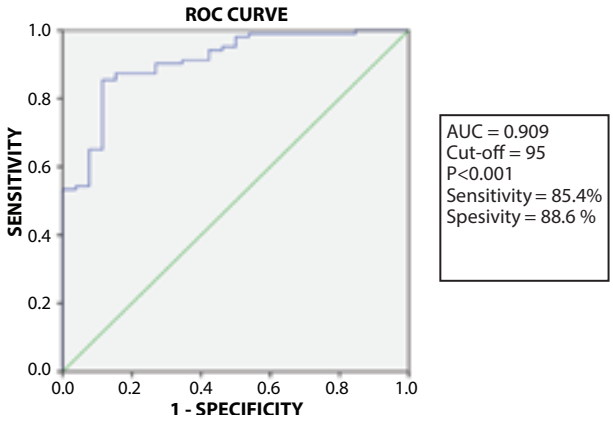

Figure 2. ROC curve of sensitivity and specificity, and also geriatric nutrition risk index for estimation of the group with malnutrition

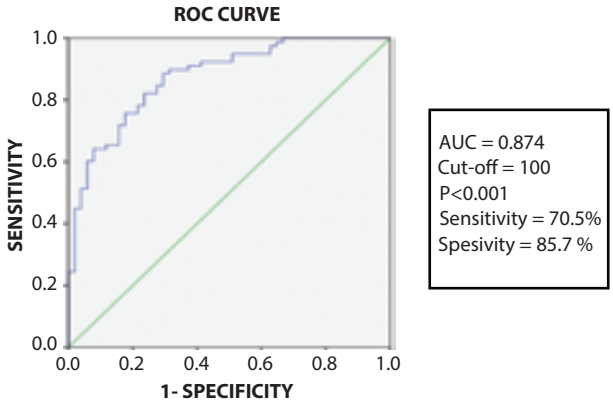

Figure 3. ROC curve of the geriatric nutrition risk index with sensitivity and specificity for estimation of the nutritional status normal group

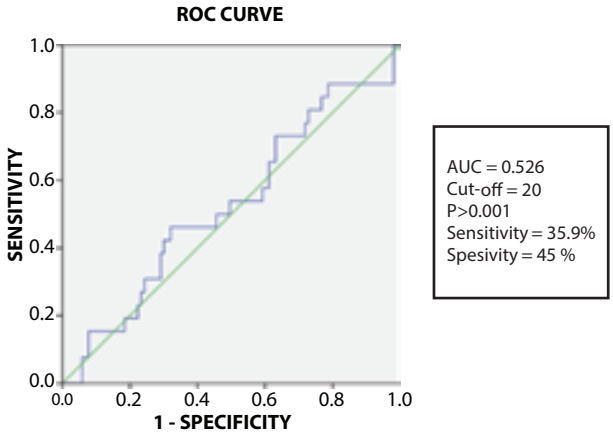

Figure 4. ROC curve of sensitivity and specificity, and creatinine index for prediction of patients with a diagnosis of malnutrition

elderly HD patients is a common problem at 28-54%, and regular screening and follow-up is essential as it can change rapidly. (17). In our study, we found the frequency of malnutrition in elderly HD patients as 20.15% using the MNA-SF screening test. The reason why our malnutrition rate was found to be lower compared to other studies may be due to the exclusion of patients using nutritional supplements from the study.

Detailed evaluation of iatrogenic and non-iatrogenic causes affecting nutrition in HD patients is important. Of the iatrogenic factors for each patient; Urea decrease, dialysis adequacy, dialysis frequency and duration, metabolic acidosis status should be reviewed separately. Approximately 6-12 g of amino acids and 7-8 g of protein are lost in each dialysis session, which contributes to the development of hypoalbuminemia (18, 19). In addition, insufficient removal of uremic load inhibits protein metabolism (20). In our study, there was no significant difference between the dialysis durations of all three groups. There was a positive correlation between GNRI and plasma albumin level. This is an expected result because albumin is used in the GNRI calculation. One of the CI components is Kt / V urea. There was no significant difference between the Kt / V urea levels of the three groups. Based on this, we believe that the reason for the effective detection of CI in detecting the group with nutritional deficiency may be Kt / V urea related.

Recently, it has been reported that nutritional status is important in chronic HD patients and is associated with mortality as well as morbidity (21). Therefore, the use of tools such as CI and GNRI as an objective and rapid assessment tool other than MNA-SF can be considered as an alternative in HD patients. The ability of both GNRI and CI to detect malnutrition was evaluated in the study, and it was found that GNRI facilitates the differential diagnosis of malnutrition elderly HD patients. GNRI is an index developed to predict nutritional assessment and adverse outcomes in the elderly (10). In the study of De Oliveira et al., it was reported that 31.6% of HD patients were considered malnutrition according to GNRI (22). Yamada K et al. used GNRI in nutritional screening of HD patients and showed that GNRI is the simplest and most accurate risk index compared to many other nutrition screening tools (7). In another study, it was found that GNRI is not an effective tool to screen malnutrition

Table 3. Correlation between indices and biochemical parameters

Title	GNRI	CI	Urea (mg/dL)	Dialysis vintage (m)	Creatinin (mg/dL)	Albumin (mg/dL)	Age (m)	Weight(kg)	MNA-SF
GNRI cc p	1	0.004 0.963	-0.182* 0.039	0.079 0.372	0.049 0.585	0.548** 0.000	-0.145 0.100	0.785** 0.00	0.243** 0.003
CI cc p		1	0.296* 0.001	0.079 0.373	0.952** 0.000	0.203* 0.021	-0.277 0.001	0.013 0.884	0.124 0.132
Urea (mg/dL) cc p			1	0.039 0.658	0.305** 0.000	-0.181* 0.040	0.005 0.957	-0.121 0.172	0.057 0.489
Dialysis vintage (m) cc p				1	0.048 0.591	-0.045 0.614	-0.042 0.410	0.152 0.086	0.073 0.376
Creatinin (mg/dL) cc p					1	0.193* 0.028	-0.077 0.388	-0.023 0.800	-0.014 0.869
Albumin (mg/dL) cc p						1	-0.155 0.080	0.101 0.286	0.169* 0.039
Age (y) cc p							1	-0.177* 0.045	-0.218* 0.007
Weight (kg) cc p								1	0.169* 0.038
MNA-SF cc p									1

P values were calculated by Pearson bivariate correlation analysis.
CI; creatinine index, GNRI; geriatric nutritional risk index, MNA-SF; Mini Nutrritional Assesment-short form.
*The correlation was significant at 0.05 level (both sides).
**The correlation was significant at 0.01 level (both sides).

due to its low sensitivity in detecting malnutrition patients. Similar to our study, patients were evaluated with MNA-SF in this study, and it was found that GNRI and MNA-SF were moderately correlated (23). Studies in the current literature show that GNRI is widely used in the evaluation of nutrition in HD patients and it has a good performance in HD patients.

In our study, we determined GNRI cut-off values for nutritional evaluation to detect both the malnutrition (<95) and the risky group (95-100). Bouillanne et al. specified GNRI with four cut-off values to indicate nutritional risk: GNRI <82, major risk associated with nutrition; GNRI 82 to <92, moderate dietary risk; GNRI 92 to 98, risk associated with low nutrition; GNRI 98>, no risk (10). Different cutting values have been used in different studies. Zhang et al. identified malnutrition individuals using a cut-off value of <98 for GNRI, while the cut-off value for GNRI <92 was used in other studies (24-26). However, there is no exact cut-off value for GNRI, and the best cut-off value may differ for ethnic populations. Although different values were used in different studies, levels close to each other were studied. It should be known clearly that; the lower the GNRI value, the greater the risk.

Studies with larger centers are needed to determine the best cut-off value of GNRI.

Creatinine Index is a useful nutritional parameter that reflects dietary protein intake and skeletal muscle mass of the patient, and it is possible to have an idea about nutritional status in HD patients using a simple equation (11). In addition, it is one of the important advantages that the parameters used in CI calculation are not affected in cases such as hydration and obesity. Yamada et al. In the study in which he evaluated a large database of HD patients, he reported that CI is a low-cost tool that can be used in evaluation of nutrition in HD patients (7). In the study by Hwang et al., in which 88 HD patients were evaluated, CI was found to be superior to GNRI in detecting malnutre patients. However, apart from the small number of patients in this study, the young and old groups were evaluated together in the study in which the GNRI was used (27). In our study, CI was insufficient to detect both malnutrition and risky elderly HD patients.

Our study is the first study in the literature evaluating the nutritional status of elderly HD patients with MNA-SF, GNRI and CI. Besides, the study has some limitations. First and foremost, it was based on data from a relatively small group of single centers that limited the generalization of our study results. The second is that it is a cross-sectional study without any intervention in the patients' current condition. Third, our study did not have a control group.

Conclusion

In conclusion, this cross-sectional study reveals that low GNRI is associated with malnutrition in elderly HD patients. In the evaluation of undernourished elderly HD patients, GNRI was as effective as MNA-SF, but CI was insufficient in detecting malnutrition individuals. However, additional studies including evaluations of larger study groups are needed to confirm our findings.

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