Original Article

The geriatric nutritional risk index may predict healthcare costs and health transitions during hemodialysis in China

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Background and Objectives: The aim of the present study was to retrospectively analyze the relationship between the Geriatric Nutritional Risk Index (GNRI) at baseline and healthcare costs of three-month as well as the risk of quality-of-life score at the 6-month follow-up for Chinese hemodialysis patients. **Methods and Study Design:** One hundred patients who had been on maintenance hemodialysis were enrolled in this study. The general characteristics, laboratory test results and GNRI of the patients at baseline were recorded. The healthcare costs and quality-of-life scores were determined at the follow-up examination. **Results:** Patients were divided into two groups according to their median GNRI at baseline: a lower GNRI group (GNRI <86.4) and a higher GNRI group (GNRI >86.4). The patients in the lower GNRI group exhibited reduced hemoglobin (74.7±13.1 g/dL vs 82.3±15.2 g/dL, $p<0.05$) and albumin (27.4±3.3 g/L vs 34.5±4.0 g/L, $p<0.05$) as well as reduced body weight (62.7±9.5 kg vs 68.0±9.2 kg, $p<0.05$) at baseline. The medication cost at follow-up was higher in the lower GNRI group (RMB 3,238±1,534 vs RMB 2,378±1,048, $p<0.05$). And a lower GNRI at baseline was associated with increased future medication costs and worse health in hemodialysis patients. **Conclusions:** The present study suggests that a lower GNRI in hemodialysis patients may be associated with an increased risk of higher future healthcare costs as well as worse health.

Key Words: GNRI, nutrition, healthcare costs, quality-of-life score, hemodialysis

INTRODUCTION

Protein-energy malnutrition (PEM) is common in patients with end-stage renal disease (ESRD). The prevalence of PEM is approximately 18% to 70% among adult dialysis patients, and PEM increases the risk of morbidity and mortality in patients receiving maintenance hemodialysis (MHD) treatment.[1,2] Many nutritional screening tools have been used to evaluate the nutritional status of hemodialysis (HD) patients. The subjective global assessment (SGA) method and the malnutrition–inflammation score (MIS) are commonly used to screen HD patients for nutritional risk, and these scores have been validated as reliable predictors.[3,4] In a study by Kalantar-Zadeh et al, the MIS was shown to be a better nutritional screening tool than the SGA.[4] Moreover, the MIS correlates with morbidity, mortality, various nutritional variables, inflammation,[4,5] and quality of life (QoL) among HD patients.[2] Nonetheless, the SGA is recommended by the Kidney Disease Improving Global Outcomes (KDIGO) guidelines for evaluating the nutritional status of patients every six months. However, both the MIS and SGA require a subjective assessment and well-trained staff and are time consuming.

The Geriatric Nutritional Risk Index (GNRI) has been proposed as a measurement for assessing the risk of malnutrition-related complications and has been used as a predictor of mortality and morbidity in elderly people.[6,7] The GNRI was previously validated as a significant predictor of mortality in dialysis patients,[8-10] with a higher interobserver reproducibility than the MIS.[11] In a previous study, the GNRI was used to predict future healthcare costs and the risk of hospitalization for independent-living older adults.[12] However, it is currently unknown whether the GNRI is associated with healthcare costs and a health transition (HT) in HD patients.

The aim of the present study was to use a retrospective analysis to investigate the relationship between the GNRI and the healthcare costs of three-month, including medication, dialysis and hospitalization costs, and the risk of a HT at follow-up in a single-center cohort of HD patients.

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Manuscript received 11 March 2015. Initial review completed 15 June 2015. Revision accepted 09 November 2015.
doi: 10.6133/apjcn.122015.03

SUBJECTS AND METHODS

Protocol

This was a retrospective study of Chinese HD patients. The clinical data and GNRI were collected at the beginning of HD. Patients were divided into the higher GNRI and lower GNRI groups according to their GNRI score at baseline, and the healthcare costs of three-month and QoL were evaluated at the 6-month follow-up. The relationships between GNRI, healthcare costs and QoL were analyzed.

Subjects

In the present study, 100 patients on stable MHD for more than three months at the First Affiliated Hospital of Zhengzhou University (Zhengzhou, China) were enrolled. All the patients were seen by physicians affiliated with the First Affiliated Hospital of Zhengzhou University and were hospitalized at this location. Patients with an acute illness, significant infection or malignancy were excluded. All the patients underwent MHD sessions thrice weekly using conventional bicarbonate-buffered dialysate containing 100 mg/dL glucose and 30 mEq/L bicarbonate. All the patients provided informed consent before they were enrolled in the study, and the study protocol was approved by the ethics review committee of the hospital (Scientific research-2014-01).

Data collection and GNRI

At the time of enrolment in the study, clinical baseline data for all of the patients, i.e., sex, age, initial date of dialysis, weight and laboratory data, were obtained from each patient's chart. Blood pressure was measured prior to the dialysis session, whereas body weight was measured after the dialysis session.

Geriatric Nutritional Risk Index

The GNRI was developed by modifying the nutritional risk index (NRI) for elderly patients.[6] This index is calculated based on serum albumin and body weight using the following equation:

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

The ideal body weight in this study was calculated using the Lorentz equations:[6] male ideal body weight = measured height–100–[(measured height–150)/4]; female ideal body weight = measured height–100–[(measured height–150)/2.5]. When the patient's body weight exceeded the ideal body weight, the body weight/ideal body weight was set to 1.

Healthcare costs at follow-up

The interview performed at the follow-up examination included the following questions with regard to the number of outpatient consultations:

1. "Have you seen a physician (general practitioner or specialist) in the past three-months?"

If the answer was yes, the patient was asked question 2:

2. "How often did you see a particular physician in the past three-months?"

If the answer was yes, the patient was asked question 3:

3. "Have you been hospitalized at least once in the past three-months?"

If the answer was yes, the hospitalization costs were recorded.

Self-reported information on the number of physician visits and hospitalizations were used to estimate the healthcare costs based on dialysis, medication and hospitalization costs. The medication cost was determined based on what the patient paid for his/her medication and was calculated based on the medication used for every patient and the medication prices at our hospital.

Regarding dialysis costs, the number and type of dialysis sessions were recorded, and the typical price for dialysis was used to calculate the dialysis cost. Hospital records were obtained from our hospital system to establish the hospital costs, and we used the standard cost rates for each unit based on external administrative charges or official statistics to determine the costs. The healthcare costs of three-month were calculated as the sum of dialysis, medication and hospitalization costs.

Quality of life at the time of follow-up

We used the Taiwan Chinese version of the Short-Form-36 (SF36) health survey questionnaire to evaluate the general QoL of the patients. The SF36 uses single-item scales to survey patients for the presence of symptomatic problems associated with their social function, working ability, self-care, health condition, mood and tendency to feel ill. The individual domains of the SF36 include physical function (PF), role-physical (RP), body pain (BP), general health (GH), vitality (VI), social function (SF), role-emotional (RE), mental health (MH), and reported HT. An HT is a change in the health of the patient: if a patient feels much better than last year, the score for that item is 1. If the patient feels much worse than last year, the score is 5. When assessing the results of this test, a low score represents a relatively healthy patient or a good QoL.

Statistical analysis

For variables that did not follow a normal distribution, the data are expressed as the mean±standard deviation (SD) or as the median and inter-quartile range (Q1 to Q3). The patients were divided into two groups according to the GNRI at baseline. An independent *t*-test was used to compare the variables at baseline and follow-up between the two groups. A linear regression model was generated to evaluate the association of the GNRI with future healthcare costs and a reported HT.

RESULTS

One hundred MHD patients were enrolled in this study. The causes of ESRD were diabetes mellitus (19/100), hypertension (12/100), chronic glomerulonephritis (41/100) and others (28/100). The median follow-up was 5.4 months. The baseline demographics and clinical features of the study population are provided in Table 1 (n=100). The patients were divided into two groups according to the median GNRI: a lower GNRI group (GNRI <86.4) and a higher GNRI group (GNRI >86.4). The patients in the higher GNRI group exhibited increased hemoglobin (82.3±15.2 g/dL vs 74.7±13.1 g/dL, $p<0.05$) and albumin (34.5±4.0 g/L vs 27.4±3.3 g/L, $p<0.05$) and a higher body weight (68.0±9.2 kg vs 62.7±9.5 kg,

$p<0.05$), all of which were significant using an independent *t*-test (Table 1). No significant differences were noted in demographics or other clinical features between the two groups, as determined using an independent *t*-test or the chi-square test.

The healthcare costs of three-month and the QoL scores are presented in Table 2. The medication costs were significantly higher in the lower GNRI group (RMB 3,238±1,534 vs RMB 2,378±1,048, $p<0.05$), and a trend toward higher hospitalization costs was noted in this group (RMB 24,620±7,148 vs RMB 23,162±3,891, $p>0.05$). No significant differences in dialysis costs or the patient's QoL scores were noted.

The risks associated with a lower GNRI with regard to healthcare costs and a reported HT were calculated using an adjusted regression model. A lower GNRI at baseline was associated with an increase in future medication costs (medication cost=-48.4×GNRI+7010.3, $p<0.05$) and a worsening of the health condition (health condition= -0.029×GNRI+5.1, $p<0.05$) in HD patients, as determined using the linear regression model, which was adjusted for patient age, hemoglobin, systolic blood pressure (SBP), diastolic blood pressure (DBP), weight, creatinine (Cr) and the neutrophil: lymphocyte ratio (NLR) (Table 3). However, there was no effect of the GNRI on dialysis costs, hospitalization costs, total costs, or other indicators of QoL in the regression model.

DISCUSSION

In this retrospective cohort study of HD outpatients in China, we found that the GNRI was associated with medication costs and health-related QoL. A worsening health-related QoL and a trend toward increased medication costs were associated with a lower GNRI.

A clinically relevant finding of the present study was the association of the GNRI with the SF-36-based reported HT. Indeed, the HD patients with the highest GNRI values had the worst reported HT scores across most of the SF-36 scales and dimensions. This finding is important because a reliable nutritional predictor should be associated with QoL. In the report by Vero et al, the SGA score was a significant predictor of QoL with regard to physical health in chronic kidney disease (CKD) patients.[13] Similarly, markers of poor nutrition, such as

Table 1. Baseline demographics and clinical features of the population

	Lower GNRI group (n=50)	Higher GNRI group (n=50)	*p*-value
Age (years)	47.7±13.1	47.7±19.0	NS
Dialysis vintage (month)	18.7±21.6	20.8±18.5	NS
Men	29	31	NS
Wt (kg)	62.7±9.5	68.0±9.2	<0.05
SBP (mmHg)	155± 22.0	152±22.0	NS
DBP (mmHg)	90.8±14.0	89.3±15.9	NS
Heart rate (bpm)	79.0±9.8	78.6±8.5	NS
Albumin (g/L)	27.4±3.3	34.5±4.0	<0.05
Hb (g/dL)	74.7±13.1	82.3±15.2	<0.05
NLR	2.5 (1.6, 3.8)	2.1 (1.5, 3.3)	NS
BUN (mmol/L)	29.6±8.8	26.7±9.0	NS
Cr (μmol/L)	940±330	826±289	NS
GNRI	80.5±4.4	93.1±5.8	<0.05

Wt: weight; SBP: systolic blood pressure; DBP: diastolic pressure; Hb: hemoglobin; NLR: the ratio of neutrophils to lymphocytes; BUN: blood urea nitrogen; Cr: creatinine; GNRI: the Geriatric Nutritional Risk Index.
NS: non-significant difference; $p<0.05$: significant difference.

Table 2. Healthcare costs of three-month and QoL scores in the two groups separated by the GNRI

	Lower GNRI group (n=50)	Higher GNRI group (n=50)	*p*-value
Dialysis cost (RMB)	19,020±2,227	19,680±3,695	NS
Medication cost (RMB)	3,238±1,534	2,378±1,048	<0.05
Hospitalization cost (RMB)	24,620±7,148	23,162±3,891	NS
Total cost (RMB)	46,878±8,381	45,220±7,549	NS
PF	81.3±8.7	78.1±13.7	NS
RP	50.0 (18.8, 56.3)	25.0 (0, 50)	NS
BP	88.0±20.0	87.6±16.9	NS
GH	56.4±22.2	51.4±18.6	NS
VI	64.2±20.1	60.8±22.2	NS
SF	69.5±23.9	69.6±23.7	NS
RE	70.5±37.3	67.3±43.9	NS
MH	67.1±19.3	65.3±17.7	NS
Reported HT	2.9±1.3	2.5±1.1	NS

QoL: quality of life; GNRI: Geriatric Nutritional Risk Index; PF: physical function; RP: role-physical; BP: body pain; GH: general health; VI: vitality; SF: social function; RE: role-emotional; MH: mental health; HT: health transition.
NS: non-significant difference; $p<0.05$: significant difference.

Table 3. Regression models for the baseline associations of the GNRI with future healthcare costs and a reported HT

Dependent variable	Model	
	β value (95% CI)	*p*-value
Effect on medication cost = β×GNRI+7010.3	-48.4 (-81.0, -15.7)	<0.05
Effect on reported HT = βvGNRI+5.1	-0.029 (-0.056, -0.001)	<0.05

GNRI: the Geriatric Nutritional Risk Index; HT: health transition; SBP: systolic blood pressure; DBP: diastolic pressure; Cr: creatinine; NLR: the ratio of neutrophils to lymphocytes.
The model was adjusted for age, hemoglobin, SBP, DBP, weight, Cr and NLR.

serum albumin and Cr, are associated with decreased physical functioning scores in dialysis patients.[14] Moreover, QoL predicts survival and hospitalization in the CKD population with or without dialysis. In CKD patients not receiving dialysis, a lower QoL score increases the risk of disease progression, such as the initiation of dialysis treatment and the incidence of cardiovascular disease events and all-cause death. These events have also been associated with proteinuria levels at baseline.[15] In the U.S. study by De Oreo et al, lower scores for the physical component of QoL were associated with a greater risk of death and hospitalization in the next two years.[16] In the Dialysis Outcomes and Practice Patterns Study (DOPPS) study, the adjusted relative risk (RR) of death was 93% higher (RR=1.93, $p<0.001$) and the risk of hospitalization was 56% higher (RR=1.56, $p<0.001$) for patients with a low QoL score compared to those with a QoL score in the highest quantile.[17]

The present study found that a lower GNRI at baseline was associated with an increase in future medication costs. The effect of the GNRI on medication costs dictated that the medication cost increased by RMB 48.4 for each 1-increment decrease in the GNRI. Many previous studies have demonstrated that malnutrition increases healthcare costs. In the study by Baumeister et al on adult patients, a lower baseline GNRI predicted increased total follow-up costs, inpatient costs, and pharmaceutical costs, as well as a higher probability of hospitalization.[12] Similarly, in a study performed in the U.S., the mean inpatient cost for 173 patients who had been admitted to the hospital with any disease was 36% higher in the at-risk group than in the not at-risk group ($6,196 vs $4,563, $p<0.05$).[18] Furthermore, a meta-analysis of hospitalized patients found that hypo-albuminemia increased the risk of prolonged intensive care unit and hospital stays.[19] Fuhrman et al also reported that malnutrition influences these costs.[20]

Some limitations associated with our study should be noted. First, as we conducted a single-center cohort study, selection bias may have occurred; thus, a multicenter cohort study is necessary to confirm our findings. Second, the GNRI was assessed only at baseline, not at follow-up. Therefore, we do not know whether the GNRI decreased or increased over time. Third, the study was retrospective in nature.

In conclusion, the present study suggests that a lower GNRI may be associated with increased future healthcare costs and a risk of worsening health in HD patients. The GNRI is a rapid and low-cost tool that can be used to determine whether a patient is malnourished; it requires only measurements of body weight, height and serum albumin. Accordingly, a GNRI assessment of HD patients at risk for malnutrition can be routinely performed and can subsequently be used to plan patient interventions and to decrease costs.

ACKNOWLEDGEMENTS
We wish to thank all of the patients who participated in this study.

AUTHOR DISCLOSURES
The authors declare there is no conflict of interest regarding the publication of this paper. This work was supported by grants from the National Basic Research Program of China 973 Program (No. 2012CB517606), The sub project of the national support program of the Ministry of science and technology (No.2013BAI09B04) and the Youth Funds from the First Affiliated Hospital of Zhengzhou University.

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