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ARTICLE

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Comparison of the efficacy of Nutritional Risk Screening 2002 and Mini Nutritional Assessment Short Form in recognizing sarcopenia and predicting its mortality

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Abstract

Objective This study aimed to examine the efficacy of Nutritional Risk Screening 2002 (NRS2002) and Mini Nutritional Assessment Short Form (MNA-SF) in recognizing sarcopenia and predicting its mortality in Chinese geriatric hospitalized patients.

Methods A prospective analysis was performed in 430 hospitalized geriatric patients. Nutrition status was assessed using the NRS2002 and MNA-SF scales. Anthropometric measures and biochemical parameters were carried out for each patient. Sarcopenia was defined according to the revised consensus definition of the European Working Group on Sarcopenia in Older People (EWGSOP2). Patients were follow-up for up to 26 months.

Results The overall prevalence of sarcopenia was 35.3% in this population. In the sarcopenic patients, 53 (34.9%) were malnutrition/nutritional risk according to NRS2002 assessment and 101 (66.4%) patients were malnutrition/nutritional risk according to MNA-SF assessment. NRS2002 vs MNA-SF showed moderate agreement ($\kappa = 0.460$, $P < 0.001$). Receiver operating characteristic analysis showed that the area under the curve of MNA-SF was larger than NRS2002 in recognizing sarcopenia (0.763 vs 0.649, $P = 0.001$). During a median follow-up time of 20.22 months, 48 (31.6%) sarcopenic patients died. The Kaplan–Meier curve demonstrated that malnutrition/nutritional risk patients according to whether NRS2002 or MNA-SF assessment had a higher risk of death than the normal nutrition patients ($\chi^2 = 15.728$, $P < 0.001$; $\chi^2 = 7.039$, $P = 0.008$, respectively). Age, serum albumin levels, and NRS2002 score were independent factors influencing the mortality.

Conclusion MNA-SF score may be better than the NRS2002 score to recognize sarcopenia in Chinese geriatric population. Both NRS2002 and MNA-SF scores could predict mortality, but NRS2002 score was the independent predict factor.

Introduction

Sarcopenia is a kind of geriatrics syndrome characterized by progressive and generalized loss of skeletal muscle mass and function, increased risk of adverse outcomes such as physical disability, the progression of chronic diseases, poor quality of life, and risk of death in elderly people. It has been recognized as a new code (M62.84) in the international classification of diseases, tenth revision, Clinical Modification (ICD-10CM) [1]. But most studies about sarcopenia were focused on community-dwelling older adults. Among hospitalized patients, sarcopenia appears did not receive much attention.

Malnutrition seems to be one of the more important factors in the cause of sarcopenia. The importance of nutrition in hospitalized old patients has been extensively documented. Malnutrition is more common in geriatric patients due to aging, comorbid diseases, cognitive impairment, polypharmacy, and economical difficulty [2, 3]. The prevalence of malnutrition in inpatient has been reported as 20–60% depending on the screening instruments used for assessment [4, 5]. The presence of malnutrition in geriatric inpatients is associated with increased risk of complications, prolonged hospital stays and readmission rate, increased

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mortality and medical costs [6]. A study from Belgium showed malnutrition could be associated with an approximately fourfold higher risk of developing sarcopenia/severe sarcopenia during a 4-year follow-up [7].

On the other hand, malnutrition and sarcopenia often coexist due to a combination of decreased nutrient intake and decreased bodyweight, along with a decrease in muscle mass, strength, and/or physical function [8]. Thus, it is extremely important to assess nutrition status, furthermore, nutrition assessment should be integrated with sarcopenia screening [9].

Although there are many widely used nutritional screening tools, well-known examples are Short Form of Mini Nutritional Assessment (MNA-SF) [10] and Nutritional Risk Screening 2002 (NRS2002) [11]. MNA-SF only incorporates 6 of the original 18 items and takes ~5 min to perform. MNA-SF has also been validated as a screening tool and shown as high sensitivity and specificity compared with the MNA full test. NRS2002 was developed for inpatients and recommended by the European Society for Clinical Nutrition and Metabolism. NRS2002 was thought to be effective allowing for quicker identification, especially in case of acute illness. A study from Italy reported MNA score is low in noninstitutionalized elderly subjects with sarcopenia, and it is linearly related to muscle mass and muscle strength, indicating that MNA score, when evaluated with muscle mass and strength, may recognize elderly subjects with sarcopenia [12]. How about MNA-SF and NRS2002 efficacy in recognizing sarcopenia? There were few studies focused on this topic.

The present paper attempted to address this gap. The purpose of this study was (1) assessing the efficacy of these two tools in determining sarcopenia among geriatric patients, and (2) assessing the association of these two tools results with the risk of mortality among geriatric patients with sarcopenia.

Material and methods

Study population and design

The study was a prospective longitudinal analysis in patients hospitalized in the Department of Geriatrics at Shanghai Jiaotong University Affiliated Sixth People's Hospital. A total of 430 consecutive patients between July 2017 and April 2018 were recruited in this study. The study inclusion criteria were age ≥65 years, none of the patients had received nutritional therapy at the time of assessment. The exclusion criteria were age <65 years, presence of ending carcinomatous cachexia (referent to the clinical history), inability to communicate, bedridden or wheel-chair status, and edema. The study was approved by the Ethics Committee of the Shanghai Jiaotong University Affiliated Sixth People's Hospital (approval number, 2016-141-(1)). Written informed consent was obtained from all participants and adhered to the tenets of the Declaration of Helsinki.

Data collection

Participants' demographic information, lifestyle variables, and personal disease history were collected using questionnaires and confirmed through examination of medical records. The variables included age, sex, cigarette smoking, alcohol drinking, and personal history of diabetes, hypertension, cerebral infarction, chronic obstructive pulmonary disease (COPD), coronary heart disease (CHD), and neoplasms. Our standard physician assessments define "current smokers or drinkers" if patients recounted a history of active smoking or drinking in the last 6 months. The diagnosis criteria of type 2 diabetes were according to the American Diabetes Association diagnostic criteria 2016. Hypertension was defined as either blood pressure ≥140/90 mmHg or current antihypertension treatment. Dyslipidemia was defined according to the American National Cholesterol Education Program (Adult Treatment Panel III). CHD was defined if the patients had an ischemic history or electrocardiographic signal perturbation that was typical of ischemia. Cerebral infarction was defined as a history of ischemia attack showed by cerebral CT or MRI scan. COPD was diagnosed according to the Chinese Thoracic Society guideline that post-bronchodilator forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) was <0.7 and other airflow limitation diseases should be excluded.

Anthropometric measurements

Anthropometric parameters included height, weight, waist circumference (WC), and calf circumference (CC). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. WC was measured at the middle point between the rib cage and iliac crests. CC was measured with the elderly individual in standing position, at the greatest circumference of the lower right leg, recorded in centimeters (cm). All measurements were performed in duplicate, and the means were calculated for analysis.

Handgrip strength (HGS)

The patient took the seat, bends the knee and bends the hip 90°, and the two feet are naturally placed on the ground; the shoulders remain adducted, the upper arm is flat with the chest, the forearm is neutral, and the elbow is bent to 90°. The maximum grip strength of the dominant hand (WCS-100 electronic vibrometer, China) was measured three

times, and each time after the measurement, the rest was taken for 1 min, and the result was taken as the maximum value of three times.

Sarcopenia diagnosis

The European Working Group on Sarcopenia in Older People revised the consensus definition of sarcopenia recently (EWGSOP2) [13]: Criterion 1: Low muscle strength; Criterion 2: Low muscle quantity or quality; Criterion 3: Low physical performance. Probable sarcopenia is identified by Criterion 1. The diagnosis is confirmed by additional documentation of Criterion 2. If Criterions 1–3 are all met, sarcopenia is considered severe. In this study, the participants did not accept the physical performance test. We only used low muscle strength and low muscle quantity as confirmed sarcopenia. According to EWGSOP2 recommended cutoffs, HGS < 27 kg in men or <16 kg in women were considered as low grip strength. CC lower than 31 cm were considered as low muscle quantity [13].

Nutritional risk assessment

NRS2002 was used to determine malnutrition and nutritional risk. Nutritional status was determined by three variables: recent weight loss, low food intake, and BMI during the week before admission. The diseases were analyzed as an indicator of metabolic stress and increased nutritional requirements. Both categories give 0–3 points. An adjustment factor was used in individuals aged ≥70 years. The total NRS2002 score indicates whether the patient is at risk of malnutrition or already malnutrition (score ≥ 3) or not (normal) (score < 3).

MNA-SF contains six questions selected from MNA. These questions are about BMI, recent weight loss, appetite or eating problems, mobility impairment, acute illness/psychological stress, and dementia or depression. Each question is rated from 0 to 2 or 3 and the total score of MNA-SF is 14. Patients with 12–14 points are at normal nutritional status. And patients with score ≤ 11 are at nutritional risk/malnutrition.

A multidisciplinary nutrition research team evaluated the nutritional status of each patient. All patients underwent nutritional status assessment in the first 24 h of hospital stay. Moreover, the research team members were not aware of the laboratory test results at the time of assessment.

Laboratory measurements

All patients had overnight fasting before the blood samples were collected. Hemoglobin (Hb) level was measured using a standard cyanmethemoglobin method. Total lymphocyte count (TLC) was assayed automatically by a blood cell analyzer (Beckman Coulter LH750). Serum iron (Iron) levels were measured by performing a colorimetric endpoint assay with commercial kits from Roche China (Shanghai, China). The serum albumin (ALB), prealbumin (PAB), retinol-binding protein (RBP), and creatinine (Cr) levels were assessed using turbidimetric immunoassay (Hitachi, Tokyo, Japan). Serum transferrin was detected by nephelometry on Behring BNII automatic specific protein determination system and its supporting reagents (Siemens, Erlangen, Germany). Serum folic acid and vitamin B12 levels were measured using a chemiluminescent immunoassay.

Follow-up for mortality

All the participants accepted follow-up in the geriatric clinic of Shanghai Jiaotong University Affiliated Sixth People's Hospital. The deadline for the follow-up was September 30, 2019. All deaths occurring between study entry and deadline were included. Due to the participants accepting healthcare at Shanghai Jiaotong University Affiliated Sixth People's Hospital, there were no missing follow-ups.

Statistical analysis

For continuous variables, results were presented as mean ± standard deviation or median (25th percentile to 75th percentile), and the differences between groups were evaluated with the Student's t test or Mann–Whitney U test. The differences among the three groups were evaluated with ANOVA test. Categorical variables were presented as frequency percentage, and intergroup comparisons were analyzed using the chi-square test. The association between NRS2002 and MNA-SF scores and other nutritional parameters were evaluated with Pearson or Spearman correlation analysis. The agreement between the two screening tools was compared using the kappa coefficient. Receiver operating characteristic (ROC) analysis was performed to determine the diagnostic performance of NRS2002 and MNA-SF for detecting sarcopenia. Z test was used to compare the area under the ROC curve (AUC). Kaplan–Meier analysis with the log-rank test was used to compare the difference between the normal and malnutrition/nutritional risk groups according to the NRS2002 and MNA-SF assessment. All variables with a $P < 0.05$ in the univariate analysis were included in the multivariate Cox regression analyses. Multivariable Cox regression models with hazard ratios (HR) and 95% CI were conducted to examine the association of NRS2002 and MNA-SF with mortality. All statistical analyses were performed using SPSS 21.0 (SPSS Inc., Chicago, IL). A two-sided P value < 0.05 was considered statistically significant.

Results

A total of 430 individuals met the eligibility criteria and completed nutrition assessment. The average age was 84.5 ± 6.1 years, including 334 men and 96 women. At baseline, 152 (35.3%) patients were diagnosed with sarcopenia. Patients who were classified as sarcopenia had lower BMI, WC, CC, HGS, ALB, PAB, Hb, RBP, and Iron, but higher age, more female percentage, more COPD and CHD prevalence ($P < 0.05$). There was no significant difference between sarcopenia and non-sarcopenia groups in serum levels of Cr, folic acid, vitamin B12, TLC, and transferrin. The percentage of smoking, drinking, CI, diabetes, hypertension, dyslipidemia, and neoplasms were no significant differences in the two groups ($P > 0.05$). MNA-SF scores were lower (9.5 ± 2.9 vs 12.1 ± 1.9, $P < 0.001$) and NRS2002 scores were higher (2.2 ± 1.2 vs 1.6 ± 0.9, $P < 0.001$) in sarcopenia than non-sarcopenia. Distribution of the basic characteristics at baseline between sarcopenia and non-sarcopenia were summarized in Table 1.

Table 2 showed the correlation coefficients of NRS2002 and MNA-SF scores with serum nutrition-related biomarkers and anthropometric parameters. Anthropometric parameters (BMI and WC) and serum nutrition-related biomarkers (ALB, PAB, Hb, RBP, and Iron) correlated positively with malnutrition scores of MNA-SF and correlated inversely with the scores of NRS2002 ($P < 0.05$). CC and HGS correlated positively with the MNA-SF scores ($r = 0.399$, $r = 0.463$, respectively, all $P < 0.001$) and correlated inversely with the NRS2002 scores ($r = -0.269$, $r = -0.281$, respectively, all $P < 0.001$).

Among the sarcopenic patients, 53 (34.9%) were malnutrition/nutritional risk according to NRS2002 assessment. In total, 101 (66.4%) patients were malnutrition or at risk of malnutrition according to MNA-SF assessment. MNA-SF identified more patients who were at malnutrition/nutritional risk than NRS2002. NRS2002 showed a moderately low consistency ($\kappa = 0.426$, $P < 0.001$) with MNA-SF.

Table 1 Clinical and biochemical characteristics of sarcopenia and non-sarcopenia.

Variable	Sarcopenia	Non-sarcopenia	*P*
Cases (*n*)	152	278	
Age (years)	86.7 ± 5.5	83.3 ± 6.0	<0.001
Sex (male%)	70.4	81.7	0.006
Smoking (%)	20.4	16.2	0.290
Drinking (%)	3.9	1.4	0.176
CI (%)	46.7	40.6	0.222
COPD (%)	32.9	21.2	0.010
CHD (%)	69.1	58.6	0.036
Diabetes (%)	31.6	30.2	0.827
Hypertension (%)	84.2	85.3	0.887
Dyslipidemia (%)	23.7	31.7	0.095
Neoplasms (%)	22.4	17.3	0.199
BMI (kg/m^2)	21.5 ± 3.3	24.7 ± 3.1	<0.001
WC (cm)	84.1 ± 9.8	92.9 ± 9.9	<0.001
CC (cm)	27.3 ± 2.40	33.1 ± 2.3	<0.001
HGS (kg)	13.2 (9.1–19.7)	22.3 (17.5–28.9)	<0.001
TLC (cells/m^3)	1.4 (1.1–1.8)	1.3 (0.9–1.7)	0.998
ALB (g/dl)	38.6 ± 4.8	40.6 ± 4.1	<0.001
PAB (mg/L)	186.5 (142.8–229.5)	205.5 (182.0–239.0)	<0.001
Hb (g/dL)	112.0 ± 18.8	124.9 ± 17.5	<0.001
RBP (mg/L)	43.0 ± 10.6	45.5 ± 9.6	0.020
Cr (μmol/L)	83.0 (71.0–99.0)	79.0 (62.5–97.0)	0.564
Iron (μmol/L)	10.4 (7.4–14.4)	14.7 (11.1–17.3)	<0.001
Transferrin (μmol/L)	1.9 ± 0.5	2.0 ± 0.3	0.211
Folic acid (μg/L)	7.5 (5.4–12.1)	6.7 (3.9–11.4)	0.327
Vitamin B12 (ng/L)	642.1 (438.4–969.9)	783.1 (483.8–1045.5)	0.237
NRS2002 (scores)	2.2 ± 1.2	1.6 ± 0.9	<0.001
MNA-SF (scores)	9.5 ± 2.9	12.1 ± 1.9	<0.001

CI cerebral infarction, *COPD* chronic obstructive pulmonary disease, *CHD* coronary heart disease, *BMI* body mass index, *WC* waist circumference, *CC* calf circumference, *HGS* handgrip strength, *TLC* total lymphocyte count, *ALB* albumin, *PAB* prealbumin, *Hb* hemoglobin, *RBP* retinol-binding protein, *Cr* creatine, *Iron* serum iron, *NRS*2002 Nutritional Risk Screening 2002, *MNA-SF* Short Form of Mini Nutritional Assessment.

Table 2 Correlation of anthropometric and biochemical parameters with NRS2002 and MNA-SF scores.

Variable	NRS2002		MNA-SF	
	r	*P*	*r*	*P*
Age	0.085	0.077	−0.176	<0.001
BMI	−0.197	<0.001	0.378	<0.001
WC	−0.174	<0.001	0.244	<0.001
CC	−0.281	<0.001	0.463	<0.001
HGS	−0.269	<0.001	0.399	<0.001
TLC	0.023	0.653	−0.112	0.026
ALB	−0.349	<0.001	0.400	<0.001
PAB	−0.268	<0.001	0.342	<0.001
Hb	−0.276	<0.001	0.355	<0.001
RBP	−0.182	<0.001	0.237	<0.001
Cr	0.060	0.220	−0.073	0.135
Iron	−0.275	<0.001	0.331	<0.001
Transferrin	0.034	0.751	0.151	0.151
Folic acid	−0.008	0.903	−0.004	0.994
Vitamin B12	0.052	0.405	−0.062	0.319

BMI body mass index, *WC* waist circumference, *CC* calf circumference, *HGS* handgrip strength, *TLC* total lymphocyte count, *ALB* albumin, *PAB* prealbumin, *Hb* hemoglobin, *RBP* retinol-binding protein, *Cr* creatine, *Iron* serum iron.

There were 48 patients (inconsistent group) who were classified as malnutrition/nutritional risk in MNA-SF were no risk according to NRS2002 assessment. There were 51 cases (both normal group) that were diagnosed as normal according to both NRS2002 and MNA-SF assessment. There were 53 cases (both malnutrition/nutritional risk group) that were recognized as malnutrition/nutritional risk according to both NRS2002 and MNA-SF assessment. It was found there were significant differences among the three groups in CC values ($P < 0.001$). The CC values of "both normal group" were higher than "inconsistent group" [(28.5 ± 1.9) vs (27.1 ± 2.3), $P = 0.002$] and "both malnutrition/nutritional group" [(28.5 ± 1.9) vs (26.4 ± 2.5), $P < 0.001$]. There was no significant difference between "inconsistent group" and "both malnutrition/nutritional group" in CC values ($P = 0.116$) (Fig. 1). The values of HGS were compared among the three groups too, but no significant differences were found among the three groups or any two groups ($P > 0.05$).

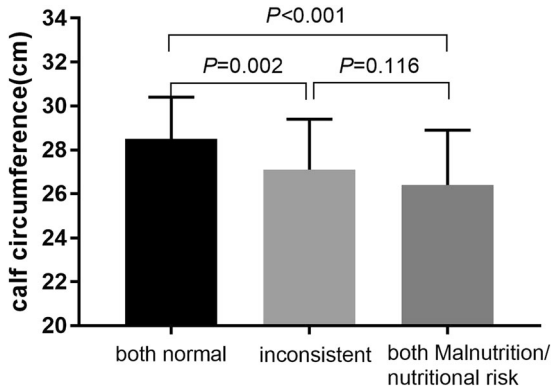

Fig. 1 Comparison of CC levels in three groups. Both normal: patients were recognized as normal nutrition confirmed by both MNA-SF and NRS2002, $n = 51$, CC = 28.5 ± 1.9 cm; inconsistent: patients who were classified as malnutrition/nutritional risk in MNA-SF were no risk according to NRS2002 assessment, $n = 48$, CC = 27.1 ± 2.3 cm; both malnutrition/nutritional risk: patients were recognized as malnutrition/nutritional risk confirmed by both MNA-SF and NRS2002, $n = 53$, CC = 26.4 ± 2.5 cm.

ROC analysis was performed to compare the efficacy of NRS2002 and MNA-SF in recognizing sarcopenia. For the NRS2002, the area under the curve (AUC) was 0.649 (SE = 0.028, 95% CI 0.594–0.705). For MNA-SF, the AUC was 0.763 (SE = 0.025, 95% CI 0.714–0.811). The AUC of MNA-SF was significantly larger than that of NRS2002 ($Z = 3.037$, $P = 0.001$) (Fig. 2).

During a median follow-up time of 20.22 months (range 0–26 months), 48 (31.6%) sarcopenic patients died. There was a significant difference between the sarcopenia and non-sarcopenia in mortality (31.6% vs 12.6%, $P < 0.001$). In the sacopenic patients, the Kaplan–Meier curve demonstrated that malnutrition/nutritional risk patients according to NRS2002 assessment had a higher risk of death than the normal nutrition patients (log-rank test, $\chi^2 = 15.728$, $P < 0.001$). The difference of the survival curve between the malnutrition/nutritional risk and normal groups according to MNA-SF assessment was also statistically significant (log-rank test, $\chi^2 = 7.039$, $P = 0.008$) (Fig. 3).

Mortality was the observational index. A univariate Cox regression analysis indicated that age, CI, COPD, neoplasms, BMI, WC, CC, HGS, Hb, ALB, PAB, Cr, Iron, NRS2002 score, and MNA-SF score were significantly correlated with mortality (Table 3). All significant factors in the univariate Cox analysis were entered into the

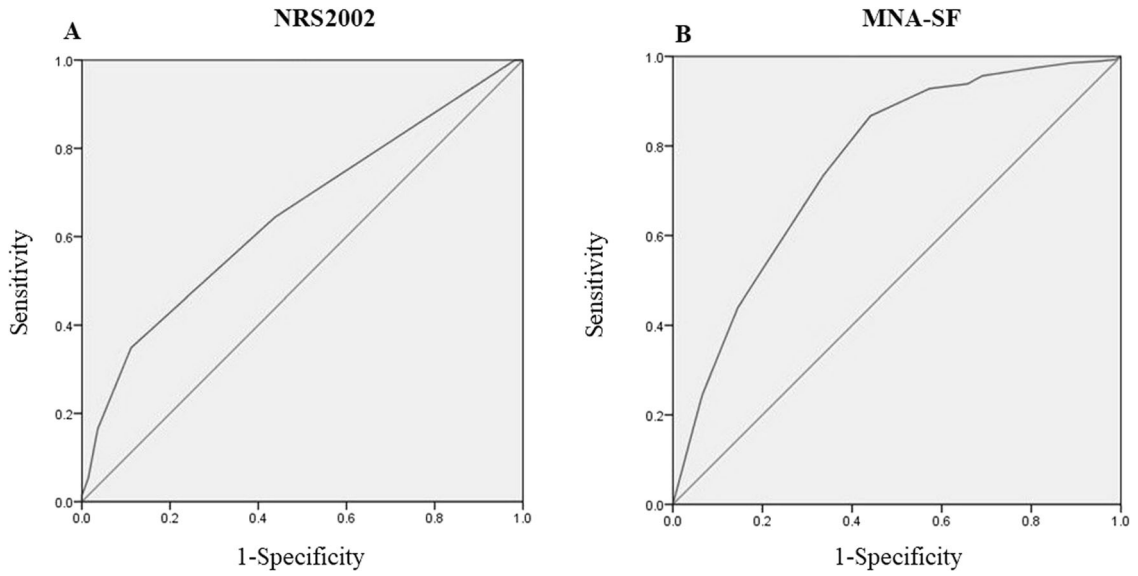

Fig. 2 ROC curve analysis of NRS2002 and MNA-SF for sarcopenia. a NRS2002: AUC = 0.649 (SE = 0.028, 95% CI 0.594–0.705). **b** MNA-SF, AUC = 0.763 (SE = 0.025, 95% CI 0.714–0.811).

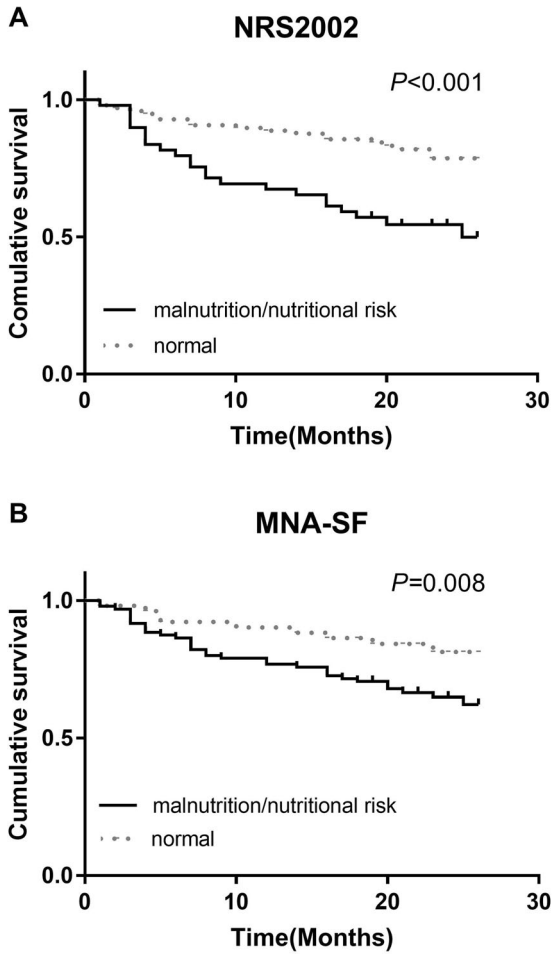

Fig. 3 Kaplan–Meier analysis for sarcopenic patients' mortality. **a** Malnutrition/nutritional risk vs normal according to NRS2002 assessment, log-rank test $\chi^2 = 15.728$, $P < 0.001$. **b** Malnutrition/nutritional risk vs normal according to MNA-SF assessment, log-rank test $\chi^2 = 7.039$, $P = 0.008$.

multivariate regression analysis. From the components of the Cox regression multivariate models, only age, ALB, and NRS2002 score were independent factors influencing the mortality of geriatric hospitalized sarcopenic patients. In the case of the other constant factors, the risk of mortality increased by 1.691-fold when the NRS2002 score increased by 1 point (Table 3).

Discussion

In the present study, the overall prevalence of sarcopenia was 35.3% in Chinese hospitalized geriatric patients. In 152 cases of the sarcopenia population, MNA-SF identified more patients at risk of malnutrition or malnutrition than NRS2002. CC levels were not different between the patients who were underestimated by NRS2002 and malnutrition/nutritional risk patients confirmed by both MNA-SF and NRS2002. ROC analysis showed that the AUC of MNA-SF was larger than NRS2002 in recognizing sarcopenia (0.763 vs 0.649, $P = 0.001$). The Kaplan–Meier curve demonstrated that malnutrition/nutritional risk patients according to NRS2002 or MNA-SF assessment had a higher risk of mortality than normal nutrition patients. From the components of the Cox regression multivariate models, the NRS2002 score was one of the independent factors influencing the mortality, not MNA-SF score.

In this study, we used the EWGSOP2 diagnosis criteria for sarcopenia. Different from other consensus criteria, the EWGSOP2 criteria focus on muscle function rather than muscle mass. It suggested CC measures may be used as a diagnostic proxy for older adults in settings where no other muscle mass diagnostic methods are available, and the cutoff is 31 cm [13]. In our study, we used CC as muscle quantity, HGS as muscle quality. Recently, a study from Brazil showed combing HGS with CC to screen sarcopenia is practical and efficient [14]. CC is an anthropometric parameter that is closely related to whole-body muscle mass [15]. It is highly accessible and easy to measure, and better than BMI in reflecting muscle loss of the lower extremities that occurs with aging or decreased physical activity. This alternative anthropometric measurement makes the assessment more user-friendly, fast, and easy to use in the real world.

The co-occurrence of malnutrition and sarcopenia is of great relevance. Nutritional status is more likely to be addressed to healthy aging for its implications on functional status and ability [16]. Sarcopenic patients had a higher prevalence of COPD and CHD in our study. Those two diseases are associated with nutritional problems [17, 18]. We should pay more attention to these comorbidities in sarcopenic patients. Several studies demonstrated a negative correlation between sarcopenia and anthropometric parameters. In our study, we found sarcopenic patients had lower BMI and WC.

Some studies showed that sarcopenic patients had a poorer nutritional status and increased risk of malnutrition than individuals who did not have sarcopenia [8]. Both malnutrition and sarcopenia share many components, a low-inflammatory state (inflame-aging) being an important one [19]. In our study, the sarcopenic patients had a high prevalence of malnutrition/nutritional risk (34.9% or 66.4%) and worse NRS2002 or MNA-SF scores. Nutrition screening tools do not only use a single parameter to assess nutritional status. Instead, they assess several factors and ask many questions related to weight loss, nutritional intake, and medical diagnoses, etc. They are better than single anthropometric or biochemical parameters.

Our results revealed that only a moderate agreement was found between NRS2002 and MNA-SF, indicating that these nutritional assessments identify different at-risk

Table 3 Cox proportional hazard regression analysis of mortality.

Variables	Univariate		Multivariate	
	HR (95% CI)	*P*	HR (95% CI)	*P*
Age	1.106 (1.06–1.155)	<0.001	1.140 (1.016–1.279)	0.026
Sex	0.624 (0.345–1.128)	0.118		
Smoking	0.66 (0.398–1.092)	0.106		
Drinking	0.563 (0.178–1.784)	0.329		
CI	0.581 (0.371–0.896)	0.014	0.766 (0.258–2.274)	0.631
COPD	0.464 (0.300–0.719)	0.001	0.833 (0.270–2.569)	0.751
CHD	0.717 (0.448–1.145)	0.164		
Diabetes	0.864 (0.548–1.363)	0.530		
Hypertension	0.965 (0.523–1.779)	0.908		
Dyslipidemia	1.282 (0.775–2.120)	0.333		
Neoplasms	0.511 (0.317–0.822)	0.006	0.460 (0.138–1.530)	0.205
BMI	0.896 (0.826–0.972)	0.008	1.042 (0.850–1.277)	0.690
WC	0.976 (0.956–0.997)	0.025	1.021 (0.941–1.108)	0.616
CC	0.824 (0.776–0.875)	<0.001	0.862 (0.692–1.073)	0.184
HGS	0.944 (0.918–0.970)	<0.001	1.024 (0.938–1.118)	0.594
TLC	1.007 (0.969–1.047)	0.730		
ALB	0.862 (0.826–0.898)	<0.001	0.815 (0.688–0.965)	0.018
PAB	0.992 (0.987–0.996)	<0.001	1.009 (0.998–1.021)	0.110
Hb	0.965 (0.955–0.975)	<0.001	1.005 (0.971–1.040)	0.761
RBP	0.977 (0.954–1.001)	0.062		
Cr	1.006 (1.003–1.009)	<0.001	1.007 (0.997–1.017)	0.163
Iron	0.908 (0.846–0.974)	0.007	1.057 (0.947–1.179)	0.326
Transferrin	0.431 (0.068–2.746)	0.730		
Folic acid	0.939 (0.878–1.005)	0.069		
Vitamin B12	1.000 (0.999–1.000)	0.443		
CRP	1.002 (0.994–1.009)	0.669		
NRS2002	1.802 (1.543–2.104)	<0.001	2.691 (1.351–5.358)	0.005
MNA-SF	0.762 (0.715–0.813)	<0.001	0.899 (0.666–1.215)	0.490

CI cerebral infarction, *COPD* chronic obstructive pulmonary disease, *CHD* coronary heart disease, BMI body mass index, WC waist circumference, *CC* calf circumference, *HGS* handgrip strength, *TLC* total lymphocyte count, *ALB* albumin, *PAB* prealbumin, *Hb* hemoglobin, *RBP* retinol-binding protein, *Cr* creatine *Iron* serum iron, *NRS*2002 Nutritional Risk Screening 2002, *MNA-SF* Short Form of Mini Nutritional Assessment.

groups. MNA-SF identified more patients at risk of malnutritional or malnutrition than NRS2002. MNA-SF is the only nutrition screening tool specially designed for the elderly [20–24]. Most importantly, the underestimate by NRS2002 assessment patients had similar CC levels with the malnutrition/nutritional risk patients confirmed by both MNA-SF and RNS2002. Furthermore, ROC analysis showed that the value of MNA-SF for recognizing sarcopenia was better than NRS2002. We thought high sensitivity of MNA-SF can more accurately recognize sarcopenia than NRS2002. Furthermore, compared with NRS2002 which mainly included acute illness, MNA-SF took more account of impaired mobility and neuropsychological and cognitive problems, which are well known to be related to sarcopenia [25–27]. We hope it can cause a high prevalence of nutrition support for sarcopenic patients associated with its use.

Malnutrition is associated with a worsening of the prognosis of the underlying disease and increased the risk of mortality. But most studies just look sarcopenia as a risk factor for geriatric patients' mortality. Few studies investigate the risk factors for sarcopenic patients' mortality. A study from China showed compared with non-sarcopenic subjects with normal nutrition, subjects with the malnutrition-sarcopenia syndrome was more than four times more likely to die (HR, 4.78; 95% CI, 2.09–10.97) [28]. Another study from Japan showed early enteral nutrition was independently associated with reduced in-hospital mortality in sarcopenic patients (OR 0.18, 95% CI 0.05–0.71, $P = 0.014$), but not in non-sarcopenic patients

[29]. Both NRS2002 and MNA-SF assessment could predict mortality well in our study. But only NRS2002 score was an independent predictor for mortality according to Cox analysis. There were a few studies compared the predictive values of NRS2002 and MNA/MNA-SF for mortality in elderly people [4, 30–32]. As far as we know, few studies using screening tools to predict s sarcopenic patients' mortality. It is likely that NRS2002 recognizes comorbid conditions better than MNA-SF. Besides malnutrition, these comorbid conditions are well known to be among the most significant predictors of mortality. The prognostic value of NRS2002 and MNA-SF for mortality in hospitalized geriatric patients still need more study to investigate.

This study had some strengths. First, most of the analyzed correlational studies were performed in community-dwelling older adults, whereas only a few were performed in hospital settings. We did this in hospitalized patients. Second, it is remarkable that we have completed all the patients' follow-up enrolled in this study and the longest follow-up periods was 26 months, thus, the sample it was representative and permitted to analyze the problem in our population. Third, there was seldom study compared the characteristics of disagreement and agreement patients according to NRS2002 and MNA-SF assessment. The results could be a kind of proof to highlight the roles of different screening tools.

This study also had some limitations. First, although the NRS2002 score as an independent predictor can be established in our study, as an observational study, we were unable to establish the causality of the relationship between the NRS2002 score and mortality. Second, the caring teams were not blinded to the nutritional screening results and may have altered their care plans based on assessment results, which might alter the mortality risk. Lastly, it was a single-center study of hospitalized patients in geriatric wards. All study participants were Chinese, so the study results may not be suitable for other ethnic groups.

Conclusion

Sarcopenia and malnutrition are a kind of frequent phenomenon in hospitals and are associated with negative outcomes. Clinicians need to determine which nutrition screening tool is appropriate for use in their institution. Both NRS2002 and MNA-SF are simple, inexpensive, reliable, economical and objective measures for assessing the nutritional status of Chinese elder inpatients. MNA-SF may be more reliable to recognize sarcopenia. But NRS2002 seems to work better than MNA-SF in predicting mortality in this population. More studies are needed to investigate if similar findings also apply to other groups of hospitalized older patients.

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Author contributions The paper was conceived by author XLZ. XLZ, ZZ, YXZ, YYW, YYK, CXR and JX contributed to the implementation of the program and acquisition of the data. YXZ and JT performed the statistical analysis. XLZ and ZZ wrote the paper. XLZ finalized the paper. All authors contributed to the interpretation of data analysis, drafted or reviewed the paper and approved this version for publication.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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