

# Predictive Value of Nutritional Risk for All-Cause Death and Functional Outcomes in Chinese Elderly Patients with Acute Stroke: A 3-Year Follow-Up Study

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**Purpose:** To explore the predictive value of nutritional risk for all-cause death and functional outcomes among elderly acute stroke patients.

**Patients and Methods:** A total of 479 elderly acute stroke patients were enrolled in this study. The nutritional risk of patients was screened by the GNRI and NRS-2002. The primary outcome was all-cause death, and the secondary outcome was poor prognosis defined as a modified Rankin Scale (mRS) score  $\geq 3$ .

**Results:** Based on the NRS-2002, patients with nutritional risk had a higher risk of all-cause death at 3 months (adjusted OR: 3.642, 95% CI 1.046~12.689) and at 3 years (adjusted OR: 2.266, 95% CI 1.259~4.076) and a higher risk of adverse functional outcomes at 3 months (adjusted OR: 2.748, 95% CI 1.518~4.972). Based on the GNRI, compared to those without nutritional risk, patients with mild malnutrition also had a higher risk of all-cause death at 3 months (adjusted OR: 7.186, 95% CI 1.550~33.315) and at 3 years (adjusted OR: 2.255, 95% CI 1.211~4.199) and a higher risk of adverse functional outcomes at 3 months (adjusted OR: 1.947, 95% CI 1.030~3.680), so patients with moderate and severe malnutrition had a higher risk of all-cause death at 3 months (adjusted OR: 6.535, 95% CI 1.380~30.945) and at 3 years (adjusted OR: 2.498, 95% CI 1.301~4.799) and a higher risk of adverse functional outcomes at 3 months (adjusted OR: 2.213, 95% CI 1.144~4.279).

**Conclusion:** Nutritional risk increases the risk of poor short-term and long-term outcomes in elderly patients with acute stroke. For elderly stroke patients, we should pay attention to early nutritional risk screening, and effective intervention should be provided to improve the prognosis of such patients.

**Keywords:** acute stroke, malnutrition, nutritional screening, all-cause death, GNRI, NRS-2002

## Introduction

Stroke is a serious neurological disease with a poor prognosis. Globally, stroke is the second-leading cause of death and the third-leading cause of death and disability combined.<sup>1</sup> Elderly individuals are the main population affected by stroke. Reports indicate that over 80% of ischaemic strokes occur in individuals aged more than 65 years.<sup>2</sup>

Malnutrition is a disease with a high prevalence in elderly stroke patients due to the lack of teeth, the loss of taste, poor mobility and the complications caused by stroke involving dysphagia and cognitive impairments.<sup>3-5</sup> Recent studies have found that malnutrition after stroke may be related to various causes of compromised intake, poor digestion and absorption, and abnormalities in metabolic levels and organ function. The screening of nutritional risk is the key first step in the evaluation of nutritional status.<sup>6</sup> Many studies have shown that malnutritional risk is associated with poor outcomes in stroke patients.<sup>7-9</sup> Early nutritional intervention in patients with nutritional risks improved nutritional status and prognosis. Physical function and neurocognitive function are also improved in stroke patients.<sup>10-12</sup> Previous studies were usually conducted in stroke populations of all ages or focused on acute functional improvement and short-term prognosis. The predictive value of nutritional risk for poor prognosis, particularly long-term prognosis (including mortality), of elderly stroke patients has rarely been reported, warranting further exploration.

Various nutritional tools have been used for screening the risk of malnutrition.<sup>13,14</sup> However, in clinical practice, the measurement of nutritional risk in elderly stroke patients can pose challenges due to the complications of stroke and body composition changes in elderly patients.<sup>15,16</sup> The Nutritional Risk Screening 2002 (NRS-2002) is a nutritional screening tool widely used in clinical applications, and its effectiveness has been confirmed by many clinical studies.<sup>14,17-19</sup> The geriatric nutritional risk index (GNRI), defined in 2005 by Bouillanne, is calculated by the serum albumin level and the ratio of body weight to ideal body weight.<sup>20</sup> Recently, the predictive value of the GNRI for clinical outcomes in patients with heart and renal diseases has been validated in several studies.<sup>21,22</sup> However, there is a scarcity of reports that compare the value of these two screening tools for long-term prognostic prediction in elderly stroke patients.

The purpose of this prospective study was to explore the association between nutritional risk and short-term and long-term prognosis in Chinese elderly stroke patients. Additionally, it aimed to and compare the predictive accuracy of the GNRI with that of the NRS-2002. The results contribute to providing evidence for the study of the correlation between nutritional risk and prognosis of elderly stroke patients, as well as aid in the selection of appropriate nutritional risk screening tools.

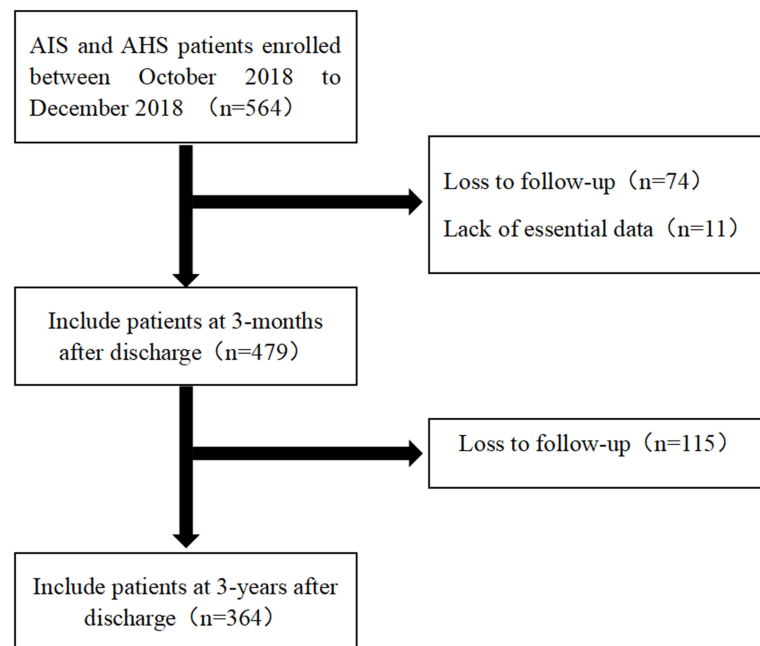
## Method

### Study Population

Five major medical institutions in Wenzhou (the First Affiliated Hospital of Wenzhou Medical University, Yueqing People's Hospital, Ruian People's Hospital, Yongjia People's Hospital, and Pingyang People's Hospital) participated in this multicentre, prospective study. From October 1 to December 31, 2018, patients who were diagnosed with acute stroke (including ischaemic stroke and haemorrhagic stroke) and met the following conditions were enrolled: a) admitted to the hospitals within one week after the sudden onset of stroke; b) with evidence of acute haemorrhagic stroke (AHS) or acute ischaemic stroke (AIS) on brain computed tomography or magnetic resonance imaging scans; and c) aged over 65. Patients whose data were insufficient to calculate the NRS-2002 or GNRI were excluded from the analysis. Ethical approval was obtained from the Ethics Committee of the First Affiliated Hospital of Wenzhou Medical University, and an approval document was signed to allow implementation. All participants provided informed consent before the investigation (Figure 1).

### Clinical Data

Demographic data, clinical data, and laboratory data of patients were all collected. Demographic data (age, sex) and clinical data (medical history, neurological functional assessment, and medical treatment) were extracted from the electronic medical record system used in five hospitals. In addition, we supplemented the information not included in the electronic medical record system with data from the clinical visit. If the patient was unable to cooperate, we asked the patient's relative to assist. Laboratory data were obtained from the first blood sample taken after admission. The severity of stroke was categorized following the National Institute of Health Stroke Scale score (NIHSS).<sup>23</sup> Independence in activities of daily living (ADL) was assessed by the Barthel Index.<sup>24</sup> Body mass index (BMI) was calculated as weight (kg) / height<sup>2</sup> (m<sup>2</sup>).



**Figure 1** Flow chart of the patient inclusion process.

## Malnutrition Screening Tools

The nutritional risk of acute stroke patients was screened by these two scoring systems.

The GNRI is calculated through the following equation:

$$\text{GNRI} = [1.489 \times \text{albumin (g/l)}] + 41.7 \times [\text{body weight (kg)}/\text{ideal body weight(kg)}]$$

$$\text{Ideal body weight (men)} = \text{height (cm)} \times 0.75 - 62.5$$

$$\text{Ideal body weight (women)} = \text{height (cm)} \times 0.60 - 40$$

In our study, patients were categorized in accordance with the following cutoffs: no risk,  $\geq 98$ ; low risk,  $\geq 92\sim 98$ ; moderate/severe risk,  $< 92$ . The score component of the NRS 2002 consists of two parts: impaired nutrition status and the presence of a fatal disease. The impaired nutrition status accounts for weight loss  $> 5\%$  in 3 months, reduced BMI, and the decreased food intake in recent weeks, and there is an additional point added for  $\geq 70$  years. These scores are then added together, and a score of  $\geq 3$  indicates the need for nutrition support.<sup>22,25</sup>

## Outcomes

Evaluation of patient outcomes: The primary outcome measure was all-cause death at 3 months and 3 years after discharge from the hospital, and the secondary outcome measure was functional outcome measured by mRS at 3 months and 3 years. The mRS assesses functional prognosis of patients by rating their ability to live independently and their mobility limitations on a scale from 0 to 6. Patients were defined as having a poor prognosis if their mRS score ranged from 3 to 6.

## Data Collection and Follow-Up

The data collection was conducted by the same investigator within 48 hours after admission, 3 months after discharge, and 3 years after discharge. We followed up with the patients by telephone at the end of 3 months and 3 years after discharge. Patients who could not be contacted by telephone were considered lost to follow-up.

## Statistical Analysis

Categorical variables are expressed as frequencies and percentages. Continuous parameters are expressed as the mean  $\pm$  SD or median (interquartile range) according to the result of the normality test. Normally distributed continuous variables were analysed using independent samples *t*-tests. Continuous variables that were not normally distributed and ordered categorical variables were analysed using the Mann–Whitney *U*-test. Univariate and multivariate logistic regression statistical methods were used to investigate the relationship between nutritional risk and outcomes in elderly acute stroke patients. Collinearity was checked before regression, and a tolerance  $\geq 0.1$  and a variance inflation factor  $< 10$  were considered to indicate the absence of collinearity. A *P* value  $< 0.05$  was considered to indicate statistical significance. Statistical analysis was performed using SPSS.26.0. The discrimination of the prediction models was quantified with the area under the receiver operating characteristic (ROC) curve (AUC), and a 95% CI was calculated for each AUC. ROC curve analysis was performed according to the methodology of DeLong et al with MedCalc ver. 20.0.27.

## Results

### Patient Characteristics

Among the 564 elderly patients with acute stroke who were initially enrolled, 479 were successfully followed for 3 months, and 364 remained in contact for 3 years. The patients included 278 males (58.0%), and the median age was 74 (69–80) years. Of the 479 patients, 381 (79.5%) patients had ischaemic stroke, and 98 (20.5%) had haemorrhagic stroke. The demographic data, clinical data and laboratory features of all patients are shown in [Table 1](#).

### Nutritional Risk and Primary Outcomes

During the postdischarge follow-up, 26 (5.4%) patients died within three months, while 103 (28.3%) patients died within three years.

The individuals at risk of malnutrition at admission screened by the GNRI accounted for 66.4% (mild malnutrition: 36.7%, moderate and severe malnutrition: 29.7%), while the counterparts screened by the NRS-2002 accounted for 66.2%. The univariate regression analysis showed that nutritional risk increased the likelihood of all-cause death at both 3 months and 3 years in elderly stroke patients ([Table 2](#)).

The results of multivariate logistic analysis were as follows. The screening of malnutritional risk with both the NRS2002 and GNRI was independently associated with all-cause death at 3 months and 3 years. ([Table 3](#)) Upon screening with the GNRI at 3 months after discharge, the odds ratio (OR) for the effect of nutritional risk on all-cause death was 7.186 [95% CI, 1.550–33.315, *p* = 0.012] for mild and 6.535 [95% CI, 1.380–30.945, *p* = 0.018] for moderate to severe; when screened with the NRS-2002, the OR was 3.642 [95% CI, 1.046–12.689, *p* = 0.042]. Upon screening with the GNRI at 3 years after discharge, the OR for the effect of nutritional risk on all-cause death was 2.255 [95% CI, 1.211–4.199, *p* = 0.010] for mild and 2.498 [95% CI, 1.301–4.799, *p* = 0.006] for moderate to severe; when screened with the NRS-2002, the OR was 2.266 [95% CI, 1.259–4.076, *p* = 0.006].

### Nutritional Risk and secondary Outcomes

During the postdischarge follow-up, 140 (29.2%) patients had a poor prognosis within three months after discharge, while 172 (47.3%) patients had a poor prognosis within three years after discharge ([Table 4](#)).

At 3 months after discharge, when the GNRI was applied, the ORs of nutritional risks for poor prognosis (*mRS*  $\geq 3$ ) were 1.947 [95% CI, 1.030–3.680, *p* = 0.040] for mild and 2.213 [95% CI, 1.144–4.279, *p* = 0.018] for moderate to severe; when the NRS-2002 was applied, the OR was 2.748 [95% CI, 1.518–4.972, *p* = 0.001]. However, when the follow-up time was 3 years, there were no significant differences in the correlation between malnutritional risk and poor functional outcome as evaluated by either the NRS-2002 (*p* = 0.07) or the GNRI (*p*  $> 0.1$ ). In contrast to all-cause death, nutritional risk was only independently associated with poor prognosis at 3 months ([Table 5](#)).

**Table 1** Baseline Characteristics Stratified by the Mortality

Characteristics	3 Months Post Discharge				3 Years Post Discharge			
	Total (n=479)	Alive (n=453)	Dead (n=26)	P value	Total (n=364)	Alive (n=261)	Dead (n=103)	P value
Age, years, median (IQR)	74 (69 ~ 80)	73 (69 ~ 80)	82 (78 ~ 85)	<0.001	74 (69 ~ 80)	72 (68 ~ 78)	79 (73 ~ 83)	<0.001
Male, n (%)	278 (58.0)	266 (58.7)	12 (48.2)	0.207	216 (59.3)	159 (60.9)	57 (55.3)	0.329
BMI, kg/m <sup>2</sup>	23.4 ± 3.50	23.36 ± 3.44	22.37 ± 4.28	0.047	23.32± 3.51	23.50 ± 3.33	22.86 ±3.90	0.054
Systolic pressure, mmHg	154.52 ± 24.29	154.44 ± 23.01	161.15 ± 30.10	0.283	154.78 ± 24.99	153.14 ± 23.20	158.94 ± 28.76	0.064
Diastolic pressure, mmHg	82.36 ± 14.01	82.00 ± 13.83	88.27 ± 18.41	0.103	82.45± 14.72	82.10 ± 14.07	83.33 ± 16.29	0.548
Hypertension, n (%)	341 (71.2)	320 (70.6)	21 (80.8)	0.267	258 (70.9)	177 (67.8)	81 (78.6)	0.041
Diabetes mellitus, n (%)	151 (31.5)	145 (32.0)	6 (23.1)	0.929	107 (29.4)	70 (26.8)	37 (35.9)	0.086
Hyperlipidemia, n (%)	192 (40.1)	108 (40.2)	10 (38.5)	0.862	147 (40.4)	111 (42.5)	36 (35.0)	0.184
Coronary heart disease, n (%)	31 (6.5)	28 (6.2)	3 (11.5)	0.280	24 (6.6)	14 (5.4)	10 (9.7)	0.132
Atrial fibrillation, n (%)	51 (10.6)	46 (10.2)	5 (19.2)	0.192	41 (11.3)	28 (10.7)	13 (12.6)	0.607
History of smoking, n (%)	147 (30.7)	142 (31.3)	5 (19.2)	0.929	120 (33.0)	84 (32.2)	36 (35.0)	0.613
History of alcohol use, n (%)	146 (30.5)	139 (30.7)	7 (27.0)	0.685	110 (30.2)	83 (31.8)	27 (26.2)	0.296
History of stroke, n (%)	114 (23.8)	108 (23.8)	6 (23.0)	0.929	83 (22.8)	53 (20.3)	30 (29.1)	0.071
Laboratory data								
Erythrocyte, × 10 <sup>12</sup> /l	4.21± 0.56	4.21± 0.56	4.29± 0.69	0.760	4.23± 0.56	4.27± 0.51	4.12± 0.65	0.045
Leukocyte, × 10 <sup>9</sup> /l	7.08± 2.49	6.95± 2.38	9.27± 3.27	<0.001	7.10± 2.60	6.77± 2.26	7.94± 3.18	<0.001
Hemoglobin, g/l	129.04± 17.41	129.3± 16.91	129.15± 79.00	0.543	129.59± 17.46	130.84± 15.28	126.43± 21.80	0.039
Platelet, × 10 <sup>9</sup> /l	212.29± 68.63	212.41± 66.57	210.15± 99.59	0.384	207.23± 63.23	208.17± 58.00	204.85± 74.10	0.277
Albumin, g/l	3.68± 0.36	3.68± 0.46	3.62± 0.26	0.204	3.69± 0.35	3.72± 0.35	3.63± 0.34	0.040
Baseline NIHSS, median (IQR)	3 (1 ~ 7)	3 (1 ~ 6)	10 (4 ~ 16)	<0.001	3 (1 ~ 7)	3 (1 ~ 6)	6 (3 ~ 12)	<0.001
NIHSS >8, n (%)	103 (21.5)	88 (19.4)	15 (57.7)	<0.001	86 (23.6)	43 (16.5)	43 (41.7)	<0.001
The Barthel index of ADL, median (IQR)	60 (35 ~ 85)	65 (35 ~ 85)	15 (5 ~ 40)	<0.001	60 (30 ~ 85)	70 (40 ~ 90)	30 (10 ~ 60)	<0.001
The Barthel index of ADL <60, n (%)	250 (52.2)	225 (49.7)	25 (96.2)	<0.001	197 (54.1)	119 (45.6)	78 (75.7)	<0.001

**Abbreviations:** ADL, activities of daily living; BMI, body mass index; GNRI, Geriatric Nutritional Risk Index; IQR, interquartile range; mRS, The Modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; NRS-2002, Nutritional Risk Screening.

**Table 2** Correlations Between at of Malnutrition Risk (Screened by NRS-2002 and GNRI) and Mortality

NSTs	3-Month				3-year			
	Total	Alive (n=453)	Dead (n=26)	p	Total	Alive (n=261)	Dead (n=103)	p
NRS-2002 score				0.014				0.012
≥ 3	317 (66.2)	294 (64.9)	23 (88.5)		250 (68.7)	166 (63.6)	84 (81.6)	
< 3	162 (33.8)	159 (35.1)	3 (11.5)		114 (31.3)	95 (36.4)	19 (18.4)	
GNRI score				0.016				<0.001
>98	161 (33.6)	159 (35.1)	2 (7.7)		119 (32.7)	97 (37.2)	22 (21.4)	
92 ~ 98	176 (36.7)	163 (36.0)	13 (50.0)		140 (38.5)	96 (36.8)	44 (42.7)	
<92	142 (29.7)	131 (28.9)	11 (42.3)		105 (28.8)	68 (26.0)	37 (35.9)	

**Notes:** P values were calculated from the Chi-square test. Analysis was adjusted for the following covariates: the Barthel Index of ADL <60, baseline NIHSS >8, sex, BMI, systolic pressure, diastolic pressure, hypertension, diabetes mellitus, coronary heart disease, atrial fibrillation, hyperlipidemia, history of stroke, smoking and alcohol use. **Abbreviations:** NST, nutrition screening tool.

**Table 3** Multivariate Logistic Analysis of the Association Between at of Malnutrition Risk (Screened by NRS-2002 and GNRI) and Mortality

NSTs	3-month		3-year	
	OR (95% CI)	P value	OR (95% CI)	P value
NRS-2002 score				
≥ 3	3.642 (1.046 ~ 12.689)	0.042	2.266 (1.259 ~ 4.076)	0.006
GNRI score				
>98	Reference		Reference	
92 ~ 98	7.186 (1.550 ~ 33.315)	0.012	2.255 (1.211 ~ 4.199)	0.010
<92	6.535 (1.380 ~ 30.945)	0.018	2.498 (1.301 ~ 4.799)	0.006

**Notes:** Multivariate analysis: variables entered on backwards stepwise (conditional): NRS-2002 score or GNRI score, The Barthel Index of ADL <60, baseline NIHSS >8, sex, BMI, systolic pressure, diastolic pressure, hypertension, diabetes mellitus, coronary heart disease, atrial fibrillation, hyperlipidaemia, history of stroke, history of smoking, history of alcohol use. **Abbreviations:** CI, Confidence Intervals; OR, Odds Ratio.

**Table 4** Multivariate Logistic Analysis of the Association Between the Poor Prognosis and Nutritional Risk at Admission Screened by the GNRI

GNRI score	Mortality				mRS ≥3			
	3 Months Post Discharge		3 Years Post Discharge		3 Months Post Discharge		3 Years Post Discharge	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
>98	Reference		Reference		Reference		Reference	
92 ~ 98	7.186 (1.550 ~ 33.315)	0.012	2.255 (1.211 ~ 4.199)	0.010	1.947 (1.030 ~ 3.680)	0.040		>0.1
<92	6.535 (1.380 ~ 30.945)	0.018	2.498 (1.301 ~ 4.799)	0.006	2.213 (1.144 ~ 4.279)	0.018		>0.1

**Abbreviations:** GNRI, Geriatric Nutritional Risk Index; mRS, Modified Rankin Scale; NST, nutrition screening tool; NRS-2002, Nutritional Risk Screening. P values were calculated from the Chi-square test.

### Comparison of the Effects of Malnutritional Risk Screened by the GNRI and NRS-2002 on Mortality and Poor Prognosis

In the ROC analysis (Figure 2), based on the area under the curve, the GNRI and NRS-2002 performed similarly in predicting 3-month (0.848 vs 0.827) and 3-year (0.727 vs 0.731) mortality and 3-month functional outcome (0.870 vs 0.876) (p>0.05).

**Table 5** Multivariate Logistic Analysis of the Association Between at of Malnutrition Risk (Screened by NRS-2002 and GNRI) and Prognosis

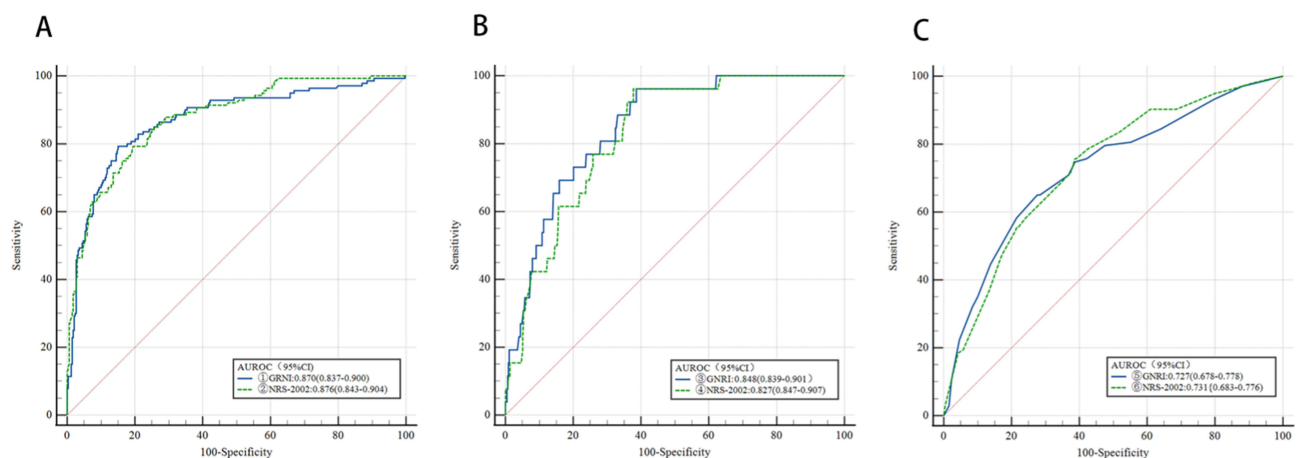
NSTs	3-month		3-year	
	OR (95% CI)	P value	OR (95% CI)	P value
NRS-2002 score ≥ 3	2.748 (1.518 ~ 4.972)	0.001	1.676 (0.957 ~ 2.934)	0.071
GNRI score >98	Reference		Reference	
92 ~ 98	1.947 (1.030 ~ 3.680)	0.040		> 0.1
<92	2.213 (1.144 ~ 4.279)	0.018		> 0.1

**Notes:** Multivariate analysis: variables entered on backwards stepwise (conditional): NRS-2002 score or GNRI score, The Barthel Index of ADL <60, baseline NIHSS >8, sex, BMI, systolic pressure, diastolic pressure, hypertension, diabetes mellitus, coronary heart disease, atrial fibrillation, hyperlipidaemia, history of stroke, history of smoking, history of alcohol use.

## Discussion

To explore the association between malnutritional risk and short-term and long-term outcomes in elderly stroke patients, we conducted this prospective, multicentre study. Attributed to different screening times, ages and stroke subtypes, nutritional risk in patients with acute stroke varies widely.<sup>15,26</sup> Sato et al and Siotto et al reported that the scores of nutritional risk changed after rehabilitation.<sup>27,28</sup> The results of our study demonstrated that nutritional risk was associated with age (GNRI:  $p < 0.010$ , NRS-2002:  $p < 0.010$ ), which deserves clinical attention. In hospitalized AIS patients of all ages, the prevalence of nutritional risk ranged from 35.0–50.0%,<sup>29–31</sup> while the prevalence in patients aged 65 and older ranged from 17.2–53.8%.<sup>8,9,32–34</sup> In our study, the percentages of individuals at risk of malnutrition screened by the GNRI were 66.3% (mild malnutrition: 36.7%, moderate and severe malnutrition: 29.6%), and the percentages screened by the NRS-2002 were basically equal (66.3% vs 66.2%,  $p > 0.05$ ). The prevalence of nutritional risk in the sample population of this study paralleled findings from previous studies.<sup>35</sup>

The main prognostic indicators in this study were all-cause death at 3 months and 3 years. Previous studies focused on the predictive value of malnutritional risk for poor functional outcomes in stroke patients, and the duration of the studies was usually short. In our previous study, the risk of malnutrition was possibly predictive of poor outcomes at 3 months in AIS and acute haemorrhagic stroke (AHS).<sup>36,37</sup> Recent studies have demonstrated that nutritional risk assessed by the NRS-2002 is independently associated with in-hospital mortality in hospitalized patients.<sup>38</sup> The results of a Korean single-centre prospective registry study that enrolled 1906 patients with stroke suggested that severe nutritional risk was associated with poor 3-month outcomes. The results of a large-scale Chinese study involving 15,166 patients with AIS also supported the proposition that patients with moderate to severe nutritional risk were more likely to have adverse 1-year outcomes.<sup>8</sup> However, the association between



**Figure 2** Comparison of the area under the receiver operating characteristic curve (AUROC) of the GNRI and NRS-2002 for the prediction of all-cause mortality (A) and poor functional recovery (B) at three months and all-cause mortality at three years (C).

nutritional risk and long-term all-cause death in elderly stroke patients has been reported on in only a few studies. A previous study illustrated that nutritional risk was associated with four-year mortality in older adults with acute ischaemic stroke.<sup>9</sup> Our study and the results of that study complement each other to further verify that the risk of malnutrition at admission is related to the long-term mortality of elderly patients with stroke.

Our secondary outcome was poor outcomes defined as mRS score  $\geq 3$ . We found that malnutritional risk showed a good predictive value for 3-month functional outcomes, which was consistent with most studies.<sup>8,39,40</sup> However, the association between the risk of malnutrition and poor prognosis diminished at 3 years after discharge. Possible reasons are described below. In our study, an mRS of  $\geq 3$  was considered an indicator of poor outcomes, and a score of 3 denoted “moderate disability”, that is, represented by an individual who prefers some assistance but is able to walk by himself.<sup>41,42</sup> In other words, mRS focuses on the evaluation of walking ability. However, in practice, many stroke patients choose to participate in postdischarge rehabilitation training, which reduces disability after stroke.<sup>43,44</sup> The neuronal plasticity processes may be modified and boosted by rehabilitative training, which results in the spontaneous recovery of patients.<sup>45</sup> Therefore, persistent rehabilitation training after acute stroke may lead to less influence of nutritional risk on long-term prognosis. Thus, the correlation between nutritional risk and the long-term prognosis of elderly stroke patients needs to be confirmed by further studies. Additionally, a cross-sectional comparison to explore the relationship between functional changes and nutritional risk in patients without stroke is warranted.

Two nutritional screening tools were used in our study. The NRS-2002 is an ESPEN-recommended screening tool for hospitalized patients.<sup>46</sup> An NRS-2002 score  $\geq 3$  was linked to stroke-related infections during hospitalization, high requirements for nutritional support and low ADL scores at discharge.<sup>47</sup> The association between NRS-2002 scores and mRS was also confirmed in stroke patients with dysphagia.<sup>40</sup> Although the NRS-2002 is reliable, its use has considerable limitations in clinical neurology, especially in elderly stroke patients. First, many elderly people do not pay attention to their weight changes before the onset of the disease. Second, the aphasia and loss of consciousness of stroke patients makes it difficult to obtain information about weight loss and disease severity.

A large amount of literature has confirmed that the GNRI has a good screening effect on the malnutritional risk of elderly patients.<sup>32,34,48–50</sup> It is calculated by laboratory and physical indicators that can be easily collected. In the modern medical system of information expansion, the GNRI score is much more convenient and constant than NRS 2002. In our study, the comparison of the ROC curves showed that the GNRI and NRS-2002 performed with fair accuracy in all-cause death, both at 3 months (0.848 vs 0.827) and 3 years (0.727 vs 0.731) post discharge. The GNRI and NRS-2002 also performed fairly well in predicting the 3-month functional outcome (0.870 vs 0.876) ( $p > 0.05$ ). Of course, more representative, larger sample long-term studies are warranted to verify the accuracy and predictive performance of the 2 malnutrition scores for predicting poor outcomes in elderly stroke patients.

The strengths of our research are described below. First, our study is both prospective and multicentre. Second, the relatively long duration of this study provided an opportunity for our design of short-term and long-term observation endpoints, which can better reflect the predictive value of malnutritional risk in prognosis. Third, both ischaemic stroke and haemorrhagic stroke patients were enrolled in our study; in contrast, past studies always focused on people with ischaemic strokes only. Fourth, there were multiple indicators of observation. Not only all-cause death but also poor prognostic indicators were observed, reflecting the overall adverse effects of malnutritional risk more comprehensively.

We acknowledge several limitations to our study. First, some patients in the study were lost to follow-up, which may result in follow-up bias. Second, we did not pay attention to nutritional status and rehabilitation training after discharge. If we did, we may have been able to provide a more comprehensive picture of the interaction between nutrition and functional recovery in elderly patients with acute stroke. Third, we investigated the effects of malnutritional risk by screening tools only, and no diagnostic tools were used to further verify the results. Fourth, nutritional intervention was not performed in this study, and further research is needed on the impact of nutritional support on patients with nutritional risk.

## Conclusions

Nutritional risk increases the risk of poor short-term and long-term outcomes in elderly patients with acute stroke. The GNRI may be a more suitable tool to screen nutritional risk in elderly stroke patients based on the convenience of the operation. We recommend initiating complete nutritional screenings to help with individualized nutritional care



management in those with a GNRI score  $\leq 98$  or an NRS-2002 score  $\geq 3$  to improve the overall prognosis of elderly stroke patients.

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## Disclosure

The authors report no conflicts of interest in this work.

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