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Research article

Comparison of different nutritional screening tools in nutritional screening of patients with cirrhosis: A cross-sectional observational study

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ABSTRACT

Aims: The Royal Free Hospital Nutritional Prioritizing Tool (RFH-NPT), the Liver Disease Undernutrition Screening Tool (LDUST) and Nutritional Risk Screening 2002 (NRS2002) were used by nurses to screen, compare, and analyze the nutritional status of patients with liver cirrhosis. The application value of different screening tools was summarized in the nutritional screening of patients with liver cirrhosis.

Methods: In this study, LDUST, RFH-NPT, and NRS2002 were used by nurses to screen the nutritional status of hospitalized patients with liver cirrhosis within 24–48 h after admission. The study calculated validity indicators such as sensitivity, specificity, the area under the receiver operating curve (AUC), and reliability indicators such as the Kappa coefficient. The efficacy of these screening tools in the nutritional screening of patients with liver cirrhosis was compared.

Results: Among the 207 patients, LDUST and NRS2002 identified 72.9 % and 23.7 % as undernourished, respectively. The sensitivity of LDUST and NRS2002 were 92.1 % and 30.0 %, respectively. The Kappa value of LDUST and RFH-NPT was 0.620, and the Kappa value of LDUST compared with NRS2002 was 0.144.

Conclusion: This study shows that the Liver Disease Undernutrition Screening Tool, a special screening tool for patients with liver cirrhosis, has a more reliable screening effect and higher sensitivity than NRS2002. The Liver Disease Undernutrition Screening Tool is recommended for nutritional screening in patients with liver cirrhosis.

Reporting method

The study adheres to the STROBE reporting guidelines.

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1. Introduction

Cirrhosis is a chronic disease caused by inflammation and fibrosis of the liver ，and is the leading cause of liver-related death globally [1]. In 2017, cirrhosis caused more than 1.32 million deaths, accounting for 2.4 % of total deaths globally [2].Patients with cirrhosis are in a hypercatabolic state with increased caloric and protein requirements [3]. About 20 % of compensated and 60 % of decompensated cirrhosis patients exhibit different degrees of malnutrition, and malnutrition can aggravate the patient's condition [4–6]. Malnutrition is associated with the progression of liver dysfunction [7], anorexia, increased energy expenditure, decreased glycogen stores, accelerated hunger response, and protein catabolism [8], and also exposes the patient to complications such as infection, hepatic encephalopathy, and ascites [9]. Furthermore, malnutrition is an independent predictor of poor prognosis in patients with cirrhosis [10], playing a decisive prognostic role [11].

Patients with liver cirrhosis have an elevated risk of deterioration of nutritional status during hospitalization, highlighting the need for special nutritional care in this patient population [12].Several studies have reported the importance of early nutritional interventions in reducing the length of hospital stays and healthcare-related costs, as well as improving quality of life [13,14]. However, nutrition interventions are often delayed due to failure to assess the risk of malnutrition and variations in the accuracy of screening tools [15].It can prolong the length of hospital stay, accelerate decompensation, and increase mortality [3].

The clinical guidelines of the American Society for Parenteral and Enteral Nutrition (ASPEN) indicate that nutritional risk screening, assessment, and supportive treatment are critical for nutritional diagnosis and treatment [16].Experts recommended that nutritional risk screening should be conducted in hospitalized patients [17]. In addition, despite the acknowledged importance of identifying malnutrition in patients with cirrhosis, no universal method has been adopted to detect malnutrition in this population [18].However，early detection and diagnosis are essential for proper treatment [19].The American Society for Parenteral and Enteral Nutrition (ASPEN) also pointed out that many studies have evaluated the sensitivity of tools in detecting malnutrition and predicting complications with long-term nutritional conditions, but the results and interpretations remain controversial [20]. Experts believe that all cirrhosis patients should be screened for the risk of malnutrition, which is challenging due to fluid retention, such as ascites or peripheral edema [21]. Moreover, traditional anthropometric assessment methods do not provide an accurate assessment of the nutritional status of patients with cirrhosis [22].

Several nutritional screening tools have been developed to predict malnutrition in patients, and currently, NRS2002 is commonly used in hospitalized patients. However, NRS2002 is not suitable for some patients who are unable to stand, have blurred consciousness, or have severe fluid load, and some expert studies have suggested that NRS2002 is not suitable for screening malnutrition in patients with cirrhosis [23]. Two additional tools are the nutritional screening tools RFH-NPT and LDUST, developed specifically for liver disease patients. Experts such as Alexandra Georgiou et al. [24] evaluated the use of eight universal screening tools for malnutrition in patients with liver disease and concluded that the two screening tools developed for patients with advanced liver disease, namely RFH-NPT and LDUST, were the most accurate in detecting malnutrition. Studies have shown that the AUC of RFH-NPT in advanced chronic liver disease is greater than that of NRS2002, which confirms that the use of specific tools for liver disease patients is more accurate than NRS2002 [25]. Some expert studies have shown that in patients with cirrhosis, NRS2002 and RFH-NPT are better than LDUST screening, but the sample size is small [26]. At present, screening tools such as LDUST screening tools are rarely used in China, and more studies are needed to prove the specific screening situation.

Therefore, efficient and convenient nutritional risk screening tools should be developed to identify patients at risk of malnutrition in the hospital setting. This study aimed to compare the effectiveness, simplicity, and accuracy of different screening tools for the nutritional screening of patients with liver cirrhosis within 24–48 h of admission.

2. Methods

2.1. Study setting and population

This study was conducted in the Department of Hepatitis of a comprehensive large hospital in China. The hospital was a general hospital with a hepatitis ward containing about 500 beds.The study population was recruited by convenience sampling. Starting in February 2022, three trained nursing researchers screened hospitalized cirrhosis patients for malnutrition using LDUST, NRS2002, and RFH-NPT within 24–48 h of admission, with the patient's consent. The three trained nursing researchers all had over 5 years of work experience and were trained by doctors and nutritionists.

2.2. Inclusion and exclusion criteria

All the patients who met the inclusion criteria and signed the informed consent form were enrolled in this study. In this study, 207 patients with liver cirrhosis admitted to the hepatitis ward of our hospital from February 2022 to August 2022 received nutritional screening. Inclusion criteria: 1. All patients met the diagnostic criteria of liver cirrhosis; 2. Voluntary participation in this study; 3. The patients had the ability to communicate and understand language; 4. Age $\geq$18 years old. Exclusion criteria: 1. Difficulty in communicating with researchers due to language disorder or hearing impairment; 2. Patients with acute exacerbation within the last four weeks; 3. The mentally ill.

2.3. Measurement tools

2.3.1. General information sheet

After admission, the basic information of patients was collected, including demographics (age and gender), occupation, duration of disease, etiology of liver cirrhosis, smoking history, drinking history, anthropometrics (body mass index [BMI], height, weight), complications (ascites, gastrointestinal bleeding), laboratory tests (albumin, total bilirubin, coagulation function). Height and weight were measured using the bathroom scale (RGZ-120-RT), and body mass index [BMI] is kg.body weight [BW]/[height in metre]^2.

2.3.2. Grading of ascites

The diagnosis of ascites is mainly based on physical examination, as indicated by abdominal distension, positive shifting dullness, or quantitative diagnosis of ascites by abdominal CT or abdominal B-ultrasound [27]. The ascites volume was divided into 3 grades: grade 1 represented a small amount of ascites, which was detected by ultrasound as ascites in every space, with a depth of $<$3 cm; grade 2 referred to moderate ascites, with patients exhibiting abdominal distension, positive or negative shifting dullness, and a depth of 3–10 cm; grade 3 referred to massive ascites, with the patient showing obvious abdominal distension, positive shifting dullness, ascites occupying the whole abdomen on imaging, and an average depth of $>$10 cm [28,29].

2.3.3. The Child-Pugh classification of liver cirrhosis

The Child-Pugh classification was first proposed by Child in 1954; it is currently the most widely used classification of liver function worldwide [30]. The classification mainly includes the stage of hepatic encephalopathy, ascites content, prothrombin time, serum albumin level, and total bilirubin level [31]. Each evaluation item is scored from 1 to 3 points, and the total score is calculated by adding the scores of each item. According to the Child-Pugh grading standard, the patients were divided into three groups, namely Child-Pugh A (5–6 points), Child-Pugh B (7–9 points), and Child-Pugh C (10–15 points) [32]. Lower total scores indicate better liver function and prognosis, whereas higher total scores indicate relatively poor liver function and prognosis. Detailed information is presented in the Supplementary Table 1.

2.3.4. Liver disease undernutrition screening tool (LDUST)

LDUST is a simple screening tool developed by Dr. Amy N. Booi [33] of North Las Vegas Medical Center, USA, specifically for cirrhosis patients. LDUST is a rapid and simple screening tool, which is completed by most patients independently, with an average completion time of 4 min and an average completion time of 3 min for outpatients [34].The tool incorporates six factors: nutrient intake, weight loss, subcutaneous fat loss, muscle mass loss, fluid accumulation, and decreased functional status. Our previous research revealed a Cronbach's α coefficient of LDUST of 0.738 and a content validity index (S-CVI) of 0.97, indicating that the tool had good reliability and validity in patients with liver cirrhosis in China (Unpublished data) . The screening tool includes two dimensions and six items; each item is divided into columns A, B, and C for the patient response, indicating "no malnutrition", "mild to moderate malnutrition", and "moderate to severe malnutrition". Finally, five answers in column A indicated no malnutrition, whereas two answers in columns B or C were indicative of malnutrition, suggesting the need for further nutritional screening.Detailed information is presented in the Supplementary Fig. 1.

2.3.5. Nutritional risk screening 2002 (NRS2002)

In NRS2002, Kondrup et al. [35] adopted the scoring method to measure nutritional risk, this method can be performed by bedside inquiry and simple anthropometric measurement, adopting a scoring system in which the total score is calculated by adding the scores of three parts. Patients were scored between 0 and 3 points for disease severity, 0–3 points for nutritional status, and 1 point for age over 70 years old. A total score of $\geq$3 indicates a nutritional risk [36]. NRS2002 is mainly used for malnutrition screening in hospitalized patients and is the most widely used scale in clinical practice. However, screening in liver cirrhosis patients entails some limitations. Yuchao Wu et al. compared this tool with other screening tools, reporting a sensitivity of 52.4 %, and a specificity of 70.0 % [37]. Detailed information is presented in the Supplementary Table 2.

2.3.6. Royal Free Hospital Nutritional Prioritizing Tool (RFH-NPT)

RFH-NPT is a nutritional screening tool developed in the UK for chronic liver disease and is considered suitable for nutritional screening in patients with cirrhosis [38]. The 2019 ESPEN (European Society for Parenteral and Enteral Nutrition) guidelines recommend using the validated RFH-NPT for nutritional screening in patients with liver disease [39].The screening tool accounts for disease causes, fluid retention, weight change, BMI values, and dietary changes. Changes in diet were reported primarily on the basis of patient self-report. Patients scoring 0 are considered at low risk of malnutrition, with a score of 1 indicating medium risk, and scores ranging from 2 to 7 suggesting a high risk of malnutrition. In the study of S.Arora et al. [40], the RFH-NPT demonstrated a sensitivity of 100.0 % and a specificity of 73.0 %.Detailed information is presented in the Supplementary Fig. 2.

2.4. Data collection

Members of the research team collected the basic data and the signed informed consent form of the patients included in the study. Members of the research team (nurses) screened every patient using the three screening tools within 24–48 h of admission. The patients were screened one to one. The screening results were checked after the screening and then recorded. The research team nurses were trained on the steps of using the three screening tools, scoring, and precautions before screening.

2.5. Sample size estimation

A 5 % significance level was considered in the calculation of the sample size, with 90 % power to detect a minimum agreement of 80 % between the different methods. The minimum sample size calculated was 128 cases.

Table 1
Demographic and disease data of patients with liver cirrhosis (N = 207).

Characteristic	Quantity (n/M±SD) (n = 207)	Composition ratio (%)
Age , years	58.2 ± 11.3	
Sex, n		
Male	166	80.2
Female	41	19.8
Education level, n		
Illiterate	16	7.7
Primary school	69	33.3
High school	108	52.2
Bachelor degree or above	14	14
Marital status, n		
Married	199	96.1
Unmarried	3	1.4
Divorce	5	2.4
Smoking history, n		
Yes	68	32.9
No	139	67.1
Drinking history, n		
Yes	57	27.5
No	150	72.5
BMI (kg/m^2) , n		
<18.5	21	7.5
18.5–20	12	5.8
≥20	174	84.1
Career, n		
Farmer	41	15.2
Worker	78	37.7
Enterprise and public institution	40	19.3
Retire/leave	28	13.5
Unemployed	20	20
Years of illness, n	2 (1–8)	
Etiology, n		
Hepatitis B cirrhosis	142	68.6
Nutritional or alcoholic cirrhosis	47	22.7
Autoimmune cirrhosis	2	1.0
Cholestatic cirrhosis	7	3.4
Hepatitis C cirrhosis	4	1.9
Cirrhosis of unknown	12	5.8
CP, n		
CP- A	60	29.0
CP- B	76	36.7
CP- C	71	34.3
Ascites, n		
No	91	44.0
Small	63	30.4
Medium	25	12.1
Mass	28	13.5
Types of comorbidities, n		
Diabetes	34	16.4
Kidney disease	25	12.1
Liver cancer	85	41.1
Gastrointestinal bleeding, n		
Yes	48	23.2
No	159	76.8
Gastroesophageal varices, n		
Yes	91	44.0
No	116	56.0

CP, Child-Pugh classification; Percentages might not add up to 100 % because of rounding; Values are presented as the mean ± SD, or number of patients (%).

2.6. Data analysis

In this study, SPSS 26.0 software was used to analyze the data. The general information of the patients was presented by the mean and standard deviation, and count datas were presented by the frequency and constituent ratio. Categorical variables were expressed by absolute and relative frequencies, continuous normally distributed variables were expressed by means plus or minus standard deviations, and the independent sample *t*-test or Mann-Whitney *U* test was used for comparison. $P < 0.05$(bilateral) was considered statistically significant. The Kappa consistency test was applied to evaluate the consistency of LDUST, RFH-NPT, and NRS2002 in assessing malnutrition in patients with liver cirrhosis. $P < 0.05$ was considered statistically significant. The ROC curve and area under the curve were used to compare the diagnostic value of LDUST and NRS2002 with RFH-NPT screening as the reference line. Finally, the specificity and sensitivity of the two tools were compared.

2.7. Quality control

All measurement indicators were subjected to quality control to ensure correctness and reduce errors. The measurement tools were first calibrated and all measurements were performed using the same tools throughout the study. The research team members have medical and nursing backgrounds and have passed professional training and examinations. Quality control of RFH-NPT, LDUST, and NRS2002: all research team members were trained in LDUST, RFH-NPT, and NRS2002 screening tools. Before formal case collection, all research team members (nurses) independently assessed five patients and qualified for screening.

3. Results

This nursing study included a total of 207 patients with liver cirrhosis. The age of the patients ranged from 30 to 91 years, with an average age of (58.2 ± 11.3) years. The study population consisted of 166 males (80.2 %) and 41 females (19.8 %). The patients mainly included middle-aged and elderly, and more males than females. Among the patients, 16 (7.7 %) were illiterate, 69 (33.3 %) had primary school education, 108 (52.2 %) had secondary school education, and 14 (6.8 %) had a college degree or above. Most of the patients were married (96.1 %), 68 (32.9 %) had a history of smoking, and 57 (27.5 %) had a history of drinking. There were 142 (68.6 %) cases of hepatitis B cirrhosis and 47 (22.7 %) cases of nutritional or alcoholic cirrhosis. Some patients exhibited more than two types of liver cirrhosis. Most patients had a BMI ≥20 kg/m^2 and BMI≤30 kg/m^2(80.2 %), indicating that most had BMI values within the normal range, here we defined BMI ≥30 kg/m2 as obesity. In this study, most of the patients had hepatitis B cirrhosis (68.6 %), which is consistent with the characteristics of liver cirrhosis patients in China, with viral cirrhosis constituting the most common type [41]. A total of 60 patients (29.0 %) were classified as Child-Pugh A, 76 patients (36.7 %) as Child-Pugh B, and 71 patients (34.3 %) as Child-Pugh C. Among the patients with liver cirrhosis, 91 (44.0 %) had no ascites, 63 (30.4 %) had a small amount of ascites, 25 (12.1 %) had a moderate amount of ascites, and 28 (13.5 %) had a large amount of ascites. See Table 1 for details.

According to the screening results, 151 (72.9 %) patients with malnutrition were screened by LDUST, 140 (67.6 %) by RFH-NPT, and 49 (23.7 %) by NRS2002. The malnutrition population screened by LDUST was significantly higher than that by NRS2002 ($\chi^2 = 100.637$, $p < 0.05$), and the malnutrition population screened by RFH-NPT also was significantly higher than that by NRS2002 ($\chi^2 = 80.619$, $p < 0.05$). We also investigated the potential association between age and malnutrition by categorizing individuals into two groups: those aged 70 years or older, and those younger than 70 years. The findings revealed a significant correlation between NRS2002 malnutrition screening results and age ($P < 0.01$), as NRS2002 itself includes an age category. Additionally, although age was not incorporated in other screening tools, we observed a link between age and malnutrition identified by LDUST ($P < 0.05$). See

Table 2
Malnutrition screening by three tools.

Characteristic	Number of people (n = 207)	Age(years) ≥70 (n = 33)	Age(years) <70 (n = 174)	*p*-value
LDUST(Malnutrition)				$P = 0.011$
Yes	151(72.9 %) (n = 207)	30(90.9 %) (n = 33)	121(69.5 %) (n = 174)	
No	56(27.1 %) (n = 207)	3(9.1 %) (n = 33)	53(30.5 %) (n = 174)	
RFH-NPT(Malnutrition)				$P = 0.50$
Yes	140(67.6 %) (n = 207)	24(72.7 %) (n = 33)	116(66.7 %) (n = 174)	
No	67(32.4 %) (n = 207)	9(27.3 %) (n = 33)	58(33.3 %) (n = 174)	
NRS2002(Malnutrition)				$P = 0.001$
Yes	49(23.7 %) (n = 207)	15(45.5 %) (n = 33)	34(19.5 %) (n = 174)	
No	158(76.3 %) (n = 207)	18(54.5 %) (n = 33)	140(80.5 %) (n = 174)	

Note: LDUST, Liver Disease Undernutrition Screening Tool; RFH-NPT, Royal Free Hospital Nutritional Prioritizing Tool; NRS2002, Nutritional Risk Screening 2002.

Table 2 for details.

Table 3 shows the comparison of the three nutrition screening tools under different nutritional statuses. No statistical differences were observed among the three screening tools in terms of age, gender, disease duration, and height. In contrast, statistical differences were found between RFH-NPT and LDUST in terms of ascites and Child classification.

The Kappa value of LDUST and NRS2002 was 0.144, with a statistically significant difference ($p < 0.05$). The Kappa value of LDUST and RFH-NPT was 0.620, showing a significant difference ($p < 0.05$). Comparing the results of NRS2002 and RFH-NPT, the Kappa value of the consistency test was 0.144, demonstrating a statistically significant difference ($p = 0.002$). Using RFH-NPT as a reference, LDUST presented a very good reference value (AUC = 0.797), while NRS2002 had a lower reference value (AUC = 0.598). See Table 4, and Fig. 1 for details.

4. Discussion

However, 56.04 % of the patients with liver cirrhosis included in the study had ascites, and 91 (43.96 %) had no ascites. Therefore, the BMI value does not provide an accurate representation of the nutritional status in most liver cirrhosis patients, and many studies have suggested that "dry weight" is used for estimation [42]. Furthermore, the screening results revealed that patients without ascites were more likely to have no malnutrition. Taking the screening results of LDUST as an example, 56 patients were screened as having no malnutrition, including 51 without ascites.

From the perspective of liver function grading, the number of patients with Child-Pugh A,Child-Pugh B, and Child-Pugh C in this study was similar and relatively average. The number of patients with Child-Pugh B and Child-Pugh C was relatively large. This indicated a relatively poor liver reserve function in the enrolled patients, which may be attributed to the cirrhosis. Moreover, this study indicated a significant relationship between the Child-Pugh classification and the patient's malnutrition, especially for patients with Child-Pugh C. The recognition rate of nutritional risk was higher. Taking LDUST screening as an example, a higher Child-Pugh classification was associated with a higher risk of malnutrition. In addition, the results of LDUST and RFH-NPT were significantly correlated with the Child-Pugh classification ($p < 0.05$) , which indicated that the nutritional risk screened by LDUST and RFH-NPT was related to clinical outcomes. However, no correlation was observed between NRS2002 and the Child-Pugh classification ($p = 0.091$), which may be related to the lack of screening content related to fluid load in NRS2002 screening. Therefore, using NRS2002 alone to screen patients with liver cirrhosis likely leads to biased results.

Malnutrition is one of the most important complications in patients with liver cirrhosis. Early and accurate nutritional screening can promote early nutritional intervention and improve the prognosis of patients. This study included 140 cirrhosis patients who were classified as malnourished by RFH-NPT screening, accounting for 67.6 % of the study population, which was slightly higher than the 52.4 % reported by other studies [25]. The discrepancy in results may be attributed to the high proportion of ascites (56.04 %) in the included samples. At present, NRS2002 is a commonly used screening tool for hospitalized patients in China. In this study, only 49 patients with nutritional risk were screened by NRS2002, accounting for 23.7 %. The screening rate of malnutrition was significantly

Table 3
Comparison of the three screening tools in different nutritional status (N = 207).

	LDUST			RFH-NPT			NRS2002		
	Malnutrition (Yes)(n = 151)	Malnutrition (No)(n = 56)	*P value*	Malnutrition (Yes)(n = 140)	Malnutrition (No)(n = 67)	*P value*	Malnutrition (Yes)(n = 49)	Malnutrition (No)(n = 158)	*P value*
Age[a] (years)	59.0 ± 11.7	56.1 ± 9.7	0.111	58.8 ± 11.3	57.0 ± 11.1	0.282	61.0 ± 14.2	57.3 ± 10.1	0.093
Sex[b]			0.455			0.786			0.596
Male	123(81.5 %)	43 (76.8 %)		113(80.7 %)	53 (79.1 %)		38(77.6 %)	128(81.0 %)	
Female	28(18.5 %)	13 (23.2 %)		27 (19.3 %)	14 (20.9 %)		11 (22.4 %)	30(19.0 %)	
Years of illness (years)	3 (1–8)	1 (1~7.75)	0.148	2.5 (1–8)	3 (1–8)	0.525	3 (1–9)	2 (1–8)	0.221
Height[a] (cm)	166.53 ± 7.73	166.41 ± 8.16	0.923	166.18 ± 7.78	167.16 ± 7.95	0.398	165.63 ± 8.29	166.77 ± 7.68	0.377
BMI[a] (kg/m^2)	23.14 ± 3.55	24.15 ± 3.76	0.075	22.85 ± 3.63	24.59 ± 3.36	0.001	21.83 ± 4.18	23.90 ± 3.31	0.002
Ascites [b]			<0.001			<0.001			0.087
No	40 (26.5 %)	51(91.1 %)		30 (21.4 %)	61 (91.0 %)		16(32.7 %)	75(47.5 %)	
Small	60 (39.7 %)	3 (5.4 %)		59 (42.1 %)	4 (6.0 %)		17 (34.7 %)	46 (29.1 %)	
Medium	23 (15.2 %)	2 (3.6 %)		24 (17.1 %)	1 (1.5 %)		9 (18.4 %)	16(10.1 %)	
Mass	28 (18.5 %)	0 (0.0 %)		27 (19.3 %)	1 (1.5 %)		7(14.3 %)	21(13.3 %)	
CP[b]			<0.001			<0.001			0.091
CP- A	25(16.6 %)	35 (62.5 %)		22 (15.7 %)	38 (56.7 %)		8 (16.3 %)	52(32.9 %)	
CP- B	58(38.4 %)	18 (32.1 %)		56 (40.0 %)	20 (29.9 %)		22(44.9 %)	54(34.2 %)	
CP- C	68 (45.0 %)	3 (5.4 %)		62(44.3 %)	9(13.4 %)		19(38.8 %)	52 (32.9 %)	

Note: CP, Child-Pugh classification; BMI, Body mass index; LDUST, Liver Disease Undernutrition Screening Tool; RFH-NPT, Royal Free Hospital Nutritional Prioritizing Tool; NRS2002, Nutritional Risk Screening 2002; P values were determined by independent sample *t*-test or Mann-Whitney *U* test. a: mean ± standard deviation, b: frequency.

Table 4
Statistical assessment of nutrition screening tools.

Validity Criteria	LDUST	NRS2002
AUC	0.797	0.598
Sensitivity	0.921	0.300
Specificity	0.672	0.896
Significance	<0.001	0.023
Youden index	0.593	0.196
Positive predictive value	0.854	0.857
Negative predictive value	0.804	0.380
Positive likelihood ratio	2.808	2.885
Negative likelihood ratio	0.118	0.781
Kappa coefficient	0.622	0.144

Note: AUC, Area under the receiver operating curve; the Kappa coefficient was calculated from Cohen's Kappa statistic; LDUST, Liver Disease Undernutrition Screening Tool; RFH-NPT, Royal Free Hospital Nutritional Prioritizing Tool; NRS2002, Nutritional Risk Screening 2002.

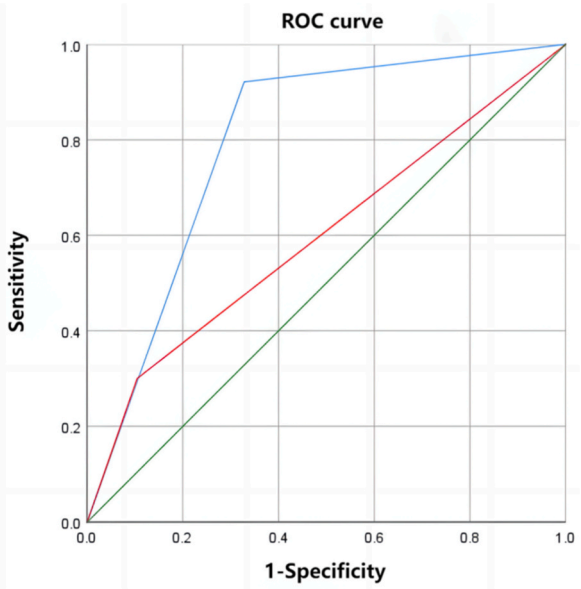

Fig. 1. ROC curves of NRS2002 and LDUST for predicting malnutrition under RFH-NPT criteria. **Note:** Receiver operating characteristic (ROC) curves of the screening tools for the prediction of nutritional risk with the Royal Free Hospital Nutritional Prioritizing Tool (RFH-NPT) as a reference. Diagonal segments are produced by sites. Source of the curve: —, Nutritional Risk Screening 2002; —, Liver Disease Undernutrition Screening Tool (LDUST); —,reference line.

lower than with RFH-NPT. In contrast, LDUST was specially developed for patients with liver disease. In our previous study, the tool was localized for use in China. In this study, the tool screened 151 patients with nutritional risk, accounting for 72.9 %, which was close to the detection rate of nutritional risk in other studies (82 %) [33]. The malnutrition detection rate of this tool was similar to that of RFH-NPT (67.6 %).

In this study, the Kappa values among LDUST, NRS2002, and RFH-NPT were compared to test the consistency of the three tools. A Kappa value of less than 0.4 was indicative of poor consistency between the two tools, and a Kappa value of greater than 0.4 and less than 0.75 indicated good consistency between the two tools [43]. The Kappa value of LDUST compared with RFH-NPT was 0.622, showing a significant difference ($p < 0.05$), which was consistent with the Kappa value of LDUST of 0.630 in the study of foreign experts [44]. The Kappa value of NRS2002 compared with RFH-NPT was 0.144, which was also significantly different ($p < 0.05$), and was close to the Kappa value of NRS2002 of 0.267 reported by Julia Traub et al. [23]. The Kappa value of LDUST compared with NRS2002 was 0.144, demonstrating a significant difference ($p < 0.05$). Hence, LDUST showed good agreement with the RFH-NPT screening tool. Compared with NRS2002, LDUST yielded a better screening effect for malnutrition in patients with liver cirrhosis, providing a more suitable tool for nutritional screening in patients with liver cirrhosis. This may be related to the fact that LDUST and RFH-NPT were developed specifically for patients with liver disease, taking into account their disease characteristics, and also considering the influencing factors likely to lead to malnutrition in such patients.

In this nursing study, RFH-NPT was set as the standard, and the accuracy of the two other screening tools was compared. The area under the curve (AUC), specificity, sensitivity, significance, positive predictive value, and negative predictive value of LDUST and

NRS2002 were compared. An area under the curve (AUC) of <0.5 indicates that the tool has no diagnostic value; an AUC between 0.5 and 0.7 indicates a poor diagnostic value; an AUC between 0.7 and 0.8 indicates moderate diagnostic value; an AUC between 0.8 and 0.9 indicates a good diagnostic value; an AUC between 0.91 and 1 indicates excellent diagnostic value [45]. The area under the curve (AUC) of LDUST was 0.797, which was superior to the AUC of NRS2002 (0.598). Compared with NRS2002, LDUST comprises fewer items and is easier to understand. The sensitivity and specificity of LDUST were 0.921 and 0.672, respectively. The sensitivity and specificity of NRS2002 were 0.300 and 0.896, respectively. These findings indicated that the sensitivity of LDUST was much higher than that of NRS2002. Liver disease patients require prompt and accurate identification of malnutrition, so the selected screening tools should have high sensitivity. In this study, LDUST and NRS2002 showed high specificity (0.672 and 0.896, respectively). The positive predictive value of LDUST was 0.854, and the negative predictive value of LDUST was 0.804. The positive predictive value of LDUST was similar to that of NRS2002 (0.857), while the negative predictive value of LDUST was significantly higher than that of NRS2002 (0.380). In addition, the sensitivity of NRS2002 in other countries was 22.0 % and the Kappa value was 0.267 [23]. Studies have shown that the average screening time of LDUST is 3–4 min, and the operation is simple [34]. Overall, LDUST was found to have better predictive ability than NRS2002. For nursing clinical purposes, LDUST is more suitable for the nutritional screening of liver cirrhosis patients than NRS2002.

5. Limitations

This study was only conducted in a Class III Grade A hospital in China, and the single-center nature of the study may introduce some bias. Future multi-center studies with large sample sizes should be conducted across various regions to improve the accuracy and representativeness of the results. Moreover, this study did not consider the psychological factors of patients, and future research can increase the screening of this aspect.

6. Conclusion

We know that nutritional screening for liver cirrhosis is very important. There are many screening tools at present, but there are great differences. In this study, it can be seen that ascites and the Child-Pugh classification have a great correlation with malnutrition in patients with liver cirrhosis, and how to choose a tool suitable for the characteristics of patients with liver cirrhosis is very important. This study shows that LDUST, a dedicated screening tool for patients with liver cirrhosis, has a more reliable screening effect and better sensitivity. LDUST is recommended for nutritional screening in patients with liver cirrhosis.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. For further data about this research please contact the first author.

Ethics declarations

Informed consent was obtained from all participants/patients (or their proxies/legal guardians) by signing written informed consent.This study was reviewed and approved by the Research Ethics Committee of The First Affiliated Hospital of Zhejiang University, with the approval number (2021) IIT (753). All participants/patients (or their proxies/legal guardians) provided informed consent to participate in the study. All participants/patients (or their proxies/legal guardians) provided informed consent for the publication of their anonymized case details and images.

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CRediT authorship contribution statement

Runzhu Wang: Software, Methodology, Data curation, Conceptualization. **Lihua Huang:** Writing – review & editing, Supervision. **Min Xu:** Resources, Investigation. **Xia Yu:** Software, Formal analysis. **Hao Wang:** Visualization, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e30339.

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