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Network Meta-Analysis of the Applicability of Different Nutritional Screening Tools for Nutritional Screening in Patients with Liver Cirrhosis: A Postprint

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Abstract

Background Malnutrition has become one of the adverse complications in patients with liver cirrhosis. Early nutritional screening and identification in cirrhotic patients can effectively improve clinical outcomes. However, currently, various nutritional screening tools for cirrhotic patients exist without standardization, requiring further research. Objective To systematically evaluate the applicability of four nutritional screening tools for nutritional screening in patients with liver cirrhosis. Methods A computerized search was conducted in CNKI, Wanfang Data Knowledge Service Platform, VIP, PubMed, Embase, Cochrane Library, and Web of Science databases for diagnostic studies on nutritional screening tools for malnutrition in cirrhotic patients from inception to December 2023. Two researchers independently screened literature, extracted data, and assessed the risk of bias in included studies. RevMan 5.4.1, Meta-DiSc, and Stata MP 17.0 software were used for network Meta-analysis. The sensitivity, specificity, positive predictive value, and negative predictive value of different nutritional screening tools were ranked using the surface under the cumulative ranking curve (SUCRA). Results A total of 10 articles were included, comprising 5 Chinese and 5 English articles, with 1299 patients. Four nutritional screening tools were included: Nutritional Risk Screening 2002 (NRS2002), Royal Free Hospital-Nutritional Prioritizing Tool (RFH-NPT), Malnutrition Universal Screening Tool (MUST), and Subjective Global Assessment (SGA). Meta-analysis results showed that the pooled sensitivity of NRS2002, RFH-NPT, and SGA was 0.65 (95%CI=0.56~0.73), 0.93 (95%CI=0.89~0.96), and 0.77 (95%CI=0.72~0.82), respectively; the pooled specificity was 0.87 (95%CI=0.83~0.91), 0.72 (95%CI=0.64~0.79), and 0.81 (95%CI=0.68~0.90), respectively. MUST had only individual studies, with no pooled sensitivity or specificity. Network Meta-analysis results indicated that the sensitivity and

negative predictive value of SGA were lower than those of RFH-NPT (OR=0.03, 95%CI=0~0.55; OR=0.08, 95%CI=0.01~0.81, $P<0.05$); the sensitivity and negative predictive value of RFH-NPT were higher than those of NRS2002 (OR=44.33, 95%CI=3.94~498.52; OR=17.68, 95%CI=2.13~147.05, $P<0.05$). Summary Receiver Operating Characteristic (SROC) curve results showed that the area under the ROC curve (AUC) for NRS2002 in screening malnutrition in cirrhotic patients was 0.86, RFH-NPT was 0.90, and SGA was 0.85. SUCRA ranking results for sensitivity of the four tools from highest to lowest were: RFH-NPT (SUCRA=99.5%) > MUST (SUCRA=43%) > SGA (SUCRA=39%) > NRS2002 (SUCRA=18.5%). SUCRA ranking for specificity from highest to lowest was: MUST (SUCRA=91.4%) > NRS2002 (SUCRA=49.1%) > SGA (SUCRA=39.8%) > RFH-NPT (SUCRA=19.7%). SUCRA ranking for positive predictive value from highest to lowest was: MUST (SUCRA=95.2%) > RFH-NPT (SUCRA=37.4%) > NRS2002 (SUCRA=36.1%) > SGA (SUCRA=31.3%). SUCRA ranking for negative predictive value from highest to lowest was: RFH-NPT (SUCRA=99.1%) > MUST (SUCRA=44.9%) > SGA (SUCRA=39.4%) > NRS2002 (SUCRA=16.7%). Conclusion Current evidence suggests that RFH-NPT and MUST have better applicability for screening malnutrition in liver cirrhosis, but this conclusion requires further validation through large-sample, more rigorous, and multicenter studies.

Full Text

Evidence-Based Medicine: A Network Meta-Analysis of the Suitability of Different Nutritional Screening Tools for Nutritional Screening in Patients with Cirrhosis

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Abstract

Background: Malnutrition has become one of the adverse complications in patients with cirrhosis. Early nutritional screening and identification can effectively improve clinical outcomes; however, the types of nutritional screening tools for patients with cirrhosis are varied and not yet standardized, requiring further research.

Objective: To evaluate the applicability of four nutritional screening tools for patients with cirrhosis.

Methods: CNKI, VIP, Wanfang Data Knowledge Service Platform, PubMed, Embase, Cochrane Library, and Web of Science were searched for diagnostic studies related to nutritional screening tool screens for malnutrition in cirrhotic patients. The search time was limited to December 2023. Two researchers independently read and filtered the literature, extracted data, and assessed the bias risk of the incorporated studies. RevMan 5.4.1, Meta-DiSc, and StataMP 17.0 were used to perform network meta-analysis. The surface under the cumulative ranking curve (SUCRA) was used to rank sensitivity, specificity, positive predictive value, and negative predictive value.

Results: Five Chinese and five English studies were incorporated, totaling 10 studies with 1,299 patients. Four nutritional screening tools were included: the Nutritional Risk Screening 2002 (NRS2002), the Royal Free Hospital-Nutritional Prioritizing Tool (RFH-NPT), the Malnutrition Universal Screening Tool (MUST), and the Subjective Global Assessment (SGA). The findings of meta-analysis revealed that the combined sensitivity of NRS2002, RFH-NPT, and SGA was 0.65 (95%CI=0.56-0.73), 0.93 (95%CI=0.89-0.96), and 0.77 (95%CI=0.72-0.82), respectively. The combined specificity was 0.87 (95%CI=0.83-0.91), 0.72 (95%CI=0.64-0.79), and 0.81 (95%CI=0.68-0.90), respectively. MUST was only evaluated in a single study, so combined sensitivity and specificity could not be calculated. The results of network meta-analysis showed the sensitivity and negative predictive value of SGA were lower than that of RFH-NPT (OR=0.03, 95%CI=0-0.55; OR=0.08, 95%CI=0.01-0.81, $P<0.05$), and the sensitivity and negative predictive value of RFH-NPT were higher than that of NRS2002 (OR=44.33, 95%CI=3.94-498.52; OR=17.68, 95%CI=2.13-147.05, $P<0.05$). The results of the summary receiver operating characteristic (SROC) curve showed that the area under the ROC curve (AUC) for screening for malnutrition in cirrhotic patients was 0.86 for NRS2002, 0.90 for RFH-NPT, and 0.85 for SGA. The SUCRA values of the tools ranked in terms of combined sensitivity from highest to lowest were RFH-NPT (SUCRA=99.5%) > MUST (SUCRA=43%) > SGA (SUCRA=39%) > NRS2002 (SUCRA=18.5%). The SUCRA values of these tools ranked in terms of combined specificity from highest to lowest were MUST (SUCRA=91.4%) > NRS2002 (SUCRA=49.1%) > SGA (SUCRA=39.8%) > RFH-NPT (SUCRA=19.7%). The SUCRA values of these tools ranked in terms of positive predictive value from highest to lowest were MUST (SUCRA=95.2%) > RFH-NPT (SUCRA=37.4%) > NRS2002 (SUCRA=36.1%) > SGA (SUCRA=31.3%). The SUCRA values of these tools ranked in terms of negative predictive value from highest to lowest were RFH-NPT (SUCRA=99.1%) > MUST (SUCRA=44.9%) > SGA (SUCRA=39.4%) > NRS2002 (SUCRA=16.7%).

Conclusion: The current evidence shows that RFH-NPT and MUST are suitable for screening malnutrition in cirrhosis, but this conclusion still needs to be further confirmed by large samples and multiple high-quality studies.

Keywords: Liver cirrhosis; Nutrition; Screening tools; Applicability; Network meta-analysis

1.1 Inclusion and Exclusion Criteria

Inclusion criteria were: (1) study subjects: patients diagnosed with cirrhosis; (2) study design: diagnostic studies; (3) evaluation of the four nutritional screening tools (NRS2002, RFH-NPT, MUST, SGA); (4) availability of true positive, false positive, true negative, and false negative data or other convertible raw data; and (5) publication language: Chinese or English. Exclusion criteria comprised: (1) incomplete data, non-convertible data, or unobtainable full text; (2) duplicate publications; (3) non-Chinese or non-English literature; and (4) review articles or meta-analyses.

1.2 Literature Search

Computerized searches were conducted in CNKI, Wanfang Data Knowledge Service Platform, VIP, PubMed, Embase, Cochrane Library, and Web of Science databases from inception to December 2023. A combination of MeSH terms and free-text keywords was employed. Chinese search terms included: liver cirrhosis, hepatic cirrhosis, NRS2002, Nutritional Risk Screening 2002, RFH-NPT, Royal Free Hospital-Nutritional Prioritizing Tool, MUST, Malnutrition Universal Screening Tool, SGA, Subjective Global Assessment, among others. English search terms included: liver cirrhosis, liver fibrosis, liver hepatic, NRS2002, Nutritional Risk Screening 2002, RFH-NPT, Royal Free Hospital-Nutritional Prioritizing Tool, MUST, Malnutrition Universal Screening Tool, SGA, Subjective Global Assessment, etc. The specific PubMed search strategy was: ("Liver Cirrhosis" [MeSH Terms] OR "hepatic cirrhosis" [Title/Abstract] OR "cirrhosis hepatic" [Title/Abstract] OR "cirrhosis liver" [Title/Abstract] OR "fibrosis liver" [Title/Abstract] OR "liver fibrosis" [Title/Abstract] OR "Cirrhosis" [Title/Abstract] OR "Cirrhotic"[Title/Abstract]) AND ("NRS2002"[Title/Abstract] OR "nrs 2002" [Title/Abstract] OR "nutritional risk screening" [Title/Abstract] OR "RFH-NPT" [Title/Abstract] OR "royal free hospital nutritional prioritizing tool" [Title/Abstract]) OR ("SGA" [Title/Abstract] OR "subjective global assessment" [Title/Abstract]) OR ("MUST" [Title/Abstract] OR "malnutrition universal screening tool" [Title/Abstract]).

1.3 Literature Screening and Data Extraction

Two researchers independently screened literature titles and abstracts according to the inclusion and exclusion criteria. After excluding non-compliant studies, the remaining articles underwent full-text review for final selection. Extracted data included: first author, publication year, country, sample size, age, reference standard, nutritional screening tool, true positives, false positives, false

negatives, and true negatives. Any disagreements were resolved through discussion with a third reviewer.

1.4 Literature Quality Assessment

Literature quality was assessed using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool [10]. This instrument evaluates two domains: risk of bias and clinical applicability. Risk of bias encompasses patient selection, index test, reference standard, and flow and timing. Clinical applicability evaluates patient characteristics, index test, and reference standard. Risk of bias was rated as yes, no, or unclear; if any domain was judged as high risk, the overall study was considered to have high risk of bias.

1.5 Statistical Methods

Meta-DiSc software and RevMan 5.4.1 were used to analyze threshold effects and calculate pooled effect sizes for each nutritional screening tool: combined sensitivity, combined specificity, diagnostic odds ratio (DOR), and area under the curve (AUC), as well as to generate summary receiver operating characteristic (SROC) curves. Heterogeneity was assessed using the I^2 statistic; when $I^2 \leq 50\%$, indicating low or no heterogeneity, a fixed-effects model was applied. For substantial heterogeneity, a random-effects model was used. Meta-regression was employed to investigate the influence of study characteristics on effect sizes in cases of high heterogeneity. StataMP 17.0 software was utilized for network meta-analysis to plot network evidence diagrams, conduct consistency tests, and perform sensitivity analyses. Publication bias was evaluated using funnel plots combined with Egger' s test ($\alpha = 0.10$). The surface under the cumulative ranking curve (SUCRA) was used to rank the performance of different nutritional screening tools in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

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2 Results

2.1 Literature Screening Results

The initial search yielded 9,537 articles. After rigorous screening, 10 studies [11-20] were included, comprising 5 Chinese articles [16-20] and 5 English articles [11-15], with a total of 1,299 patients. The literature screening process is illustrated in Figure 1 [Figure 1: see original paper].

2.2 Basic Characteristics and Quality Assessment of Included Studies

This study included four nutritional screening tools: NRS2002, RFH-NPT, MUST, and SGA. Ten studies [11-20] evaluated RFH-NPT, six studies [11-13,15,17,19] evaluated NRS2002, four studies [14,17-18,20] evaluated SGA, and one study [12] evaluated MUST. The fundamental characteristics of included

studies are presented in Table 1 , and the quality assessment is shown in Figure 2 [Figure 2: see original paper].

2.3 Meta-Analysis Results

Six studies [11-13,15,17,19] used NRS2002 for nutritional screening. The overall threshold effect test showed a Spearman rank correlation coefficient of 0.543 ($P = 0.266$), indicating no threshold effect. However, $I^2 = 63.87\%$ ($P = 0.031$) suggested heterogeneity due to non-threshold effects, warranting a random-effects model for meta-analysis. Ten studies [11-20] used RFH-NPT, with a Spearman coefficient of 0.573 ($P = 0.066$), indicating no threshold effect, but substantial heterogeneity ($I^2 = 96.17\%$, $P < 0.01$) required a random-effects model. Only one study [12] used MUST, precluding heterogeneity testing. Four studies [14,17-18,20] used SGA, showing no threshold effect (Spearman coefficient = 0.40, $P = 0.60$) but significant heterogeneity ($I^2 = 74.6\%$, $P = 0.01$), also analyzed using a random-effects model. The pooled sensitivity, specificity, DOR, and AUC for NRS2002, RFH-NPT, and SGA from traditional meta-analysis are presented in Table 2 .

2.4 Meta-Regression Analysis

Meta-regression was performed on the 10 included studies using study age, region, design, sample size, and quality as covariates, but no sources of heterogeneity were identified (Table 3).

2.5 Network Meta-Analysis Results

2.5.1 Evidence Network Diagram and Consistency Test The evidence network diagram formed a network structure with the four nutritional screening tools as nodes. RFH-NPT had the largest sample size among included studies, while MUST had the smallest. The evidence network diagram is shown in Figure 3 [Figure 3: see original paper]. Consistency and inconsistency tests for all indicators revealed no statistically significant differences between direct and indirect comparisons, suggesting consistency between direct and indirect evidence.

2.5.2 Sensitivity and Specificity Network meta-analysis results for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the four tools are presented in Tables 4 through 7 . Sensitivity analysis revealed that SGA had lower sensitivity than RFH-NPT (OR = 0.03, 95%CI = 0–0.55, $P < 0.05$), while RFH-NPT had higher sensitivity than NRS2002 (OR = 44.33, 95%CI = 3.94–498.52, $P < 0.05$). For NPV, SGA was lower than RFH-NPT (OR = 0.08, 95%CI = 0.01–0.81, $P < 0.05$), and RFH-NPT was higher than NRS2002 (OR = 17.68, 95%CI = 2.13–147.05, $P < 0.05$).

2.5.3 Cumulative Ranking SUCRA rankings for sensitivity from highest to lowest were: RFH-NPT (SUCRA = 99.5%) > MUST (43%) > SGA (39%) > NRS2002 (18.5%). For specificity: MUST (91.4%) > NRS2002 (49.1%) > SGA (39.8%) > RFH-NPT (19.7%). For PPV: MUST (95.2%) > RFH-NPT (37.4%) > NRS2002 (36.1%) > SGA (31.3%). For NPV: RFH-NPT (99.1%) > MUST (44.9%) > SGA (39.4%) > NRS2002 (16.7%).

2.5.4 SROC Curves The SROC curve integrates both sensitivity and specificity, with AUC representing diagnostic accuracy. The AUC was 0.86 for NRS2002, 0.90 for RFH-NPT, and 0.85 for SGA. SROC curves for the different tools are shown in Figures 4 [Figure 4: see original paper], 5 [Figure 5: see original paper], and 6 [Figure 6: see original paper].

2.6 Publication Bias

Funnel plots for sensitivity and specificity showed that study distributions were generally centered around the null line, with more studies distributed to the left of the null line for sensitivity and to the right for specificity. Only a few studies fell outside the funnel plots, suggesting possible publication bias or small-study effects. Egger' s test for sensitivity yielded P = 0.144, indicating no significant publication bias. For specificity, Egger' s test produced P = 0.810, also indicating no significant publication bias. The funnel plots are presented in Figure 7 [Figure 7: see original paper].

2.7 Sensitivity Analysis

Sensitivity analysis was performed by sequentially excluding individual studies and re-running the traditional meta-analysis. The pooled effect sizes for all outcomes remained essentially unchanged, indicating the robustness of our findings.

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3 Discussion

3.1 RFH-NPT Shows Better Sensitivity and Negative Predictive Value, While MUST Demonstrates Better Specificity and Positive Predictive Value

This study included 10 studies evaluating four nutritional screening tools. The findings indicate that RFH-NPT had superior sensitivity and NPV, and both RFH-NPT and MUST demonstrated relatively high sensitivity and specificity, providing an evidence-based foundation for clinical nursing practice. RFH-NPT is a liver disease-specific screening tool considered an independent predictor of survival and liver function deterioration in cirrhosis [21] and has diagnostic value for patients with moderate to severe ascites [22]. Sensitivity reflects the ability to identify malnourished patients; higher sensitivity yields higher NPV, improving

the probability of correctly identifying patients without malnutrition. Wang et al. [23] found that RFH-NPT had lower missed-diagnosis rates than NRS2002 and SGA when screening hospitalized patients with schistosomal cirrhosis, more accurately identifying malnourished patients. Georgiou et al. [12] validated nutritional screening tools and reported that RFH-NPT achieved the highest sensitivity (97.4%) and NPV (99.0%). Since cirrhotic patients frequently present with varying degrees of ascites [24], RFH-NPT' s inclusion of ascites assessment makes it more effective at identifying malnutrition than tools like NRS2002. Therefore, we consider RFH-NPT more applicable for cirrhotic patients.

MUST demonstrated better specificity and PPV, with SUCRA values surpassing the other three tools. Specificity reflects the ability to identify patients without malnutrition; higher specificity yields higher PPV. However, studies using MUST for malnutrition screening in cirrhotic patients remain limited [25], with most applications in inflammatory bowel disease [26]. MUST assesses BMI, weight loss over 3-6 months, and acute disease-related symptoms or eating difficulties. Since ascites can cause weight gain, which MUST does not account for, its screening accuracy in cirrhosis requires further validation.

3.2 Rational Selection of Appropriate Nutritional Screening Tools

Clinical assessment of malnutrition begins with nutritional screening, followed by comprehensive nutritional diagnosis for at-risk patients to confirm malnutrition status. Clinical nurses should be familiar with different screening tools, proficient in their application, and select the most appropriate tool based on patient characteristics. However, it is important to note that SGA is a subjective assessment tool relying heavily on clinician evaluation, which may introduce subjectivity and lack rigor.

3.3 Limitations

This study has several limitations: (1) Some screening tools were evaluated in few studies, with only single-study support for certain tools, potentially introducing bias. (2) High heterogeneity in some outcome measures may be related to variations in included populations and disease stages, but further exploration of underlying differences was not possible; future large-sample, rigorous, multicenter studies are needed for validation. (3) Only Chinese and English language literature was included, which may introduce language selection bias. (4) Despite conducting meta-regression based on study region, age, design, sample size, and quality, sources of heterogeneity remained unidentified, possibly due to statistical methods or other relevant factors.

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4 Conclusion

Different nutritional screening tools exhibit varying sensitivity and specificity. MUST and RFH-NPT demonstrate higher specificity, PPV, sensitivity, and NPV compared to NRS2002, which is currently the most commonly used screening tool in clinical practice. While these findings suggest superior applicability, whether they can replace NRS2002 requires further validation through large-sample, rigorous, and precise comparative studies.

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