Use of Nutrition Risk in Critically Ill (NUTRIC) Scoring System for Nutrition Risk Assessment and Prognosis Prediction in Critically Ill Neurological Patients: A Prospective Observational Study

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Abstract

Background: Critically ill patients who are hospitalized in a neurological intensive care unit (NICU) are largely susceptible to nutrition risk. However, only a limited number of studies have investigated the applicable assessment tool in NICUs.

Methods: This was a prospective observational study conducted at a single-center NICU. A total of 140 adult patients who were hospitalized for >24 hours were enrolled. The Nutritional Risk Screening 2002, Nutrition Risk in the Critically ill (NUTRIC), and modified NUTRIC (mNUTRIC) scores were applied for the assessment of nutrition risk. Analyses of multivariable logistic regression were performed by considering a 28-day mortality as the outcome of interest. Results: Nutrition risk was commonly identified in NICU patients. Multivariate analysis revealed that age ≥ 60 years, hospital infection, mechanical ventilation, and high nutrition risk (mNUTRIC score ≥ 5) independently increased 28-day mortality in NICU patients. For subgroups of patients with a prolonged length of stay, high nutrition risk (mNUTRIC score ≥ 5) has always been an independent risk factor of 28-day mortality. Both NUTRIC and mNUTRIC scores were able to predict 28-day mortality, with area under the receiver operating characteristic curves of 0.857 (95% CI, 0.786–0.928) and 0.856 (95% CI, 0.786–0.927), respectively.

Conclusion: The mNUTRIC scoring system is not only a useful tool for nutrition risk assessment but also, and more importantly, it is independently related to the risk of 28-day mortality in NICU patients. Therefore, mNUTRIC scoring is an appropriate tool for nutrition risk assessment and prognosis prediction of NICU patients. (JPEN J Parenter Enteral Nutr. 2020;0:1–10)

Keywords

28-day mortality; mNUTRIC score; neurological intensive care unit; NUTRIC score; nutrition risk

Clinical Relevancy Statement

Critically ill patients in a neurological intensive care unit (NICU) are more susceptible to nutrition risk, which is directly associated with adverse clinical outcomes. The Nutritional Risk Screening 2002 and the Nutrition Risk in the Critically ill (NUTRIC) are scoring systems typically recommended as assessment tools in the ICU. Yet it has not been verified whether these scoring tools could be applicable in NICUs. Therefore, here we provide a comprehensive...
evaluation of these tools in NICUs for nutrition risk assessment and prognosis prediction. Here we reveal, for the first time, that a modified NUTRIC score could not only serve as a useful tool to assess nutrition risk but also independently associate the risk of 28-day mortality in NICU patients.

**Introduction**

Nutrition risk refers to the risk of adverse effects on patients' clinical outcomes (e.g., mortality, complications, length of stay [LOS]), which are dependent on nutrition factors. For critically ill patients in an intensive care unit (ICU), it has been proven that a high nutrition risk is directly associated with adverse clinical outcomes. Thus, patients with high nutrition risk need to be recognized earlier during hospitalization to potentially avoid delays in nutrition therapy and prevent subsequent complications. Patients with primary or secondary neurological disorders are susceptible to nutrition risk. For instance, the prevalence of malnutrition in patients with acute stroke is reported to be between 8% and 34%. Poor nutrition intake, resulting from swallowing dysfunction, arm and facial weakness, and/or reduced level of consciousness, is a major cause of malnutrition in patients with neurological disorders. Besides, increased catabolism, chronic diseases, and related complications, as well as poststroke depression, can further worsen the nutrition condition of the patient. Critically ill neurological patients admitted to the neurological ICU (NICU) are supposed to be at higher risk, since the disease characteristics and nutrition risk of both ICU and neurological patients can be combined. Typically, the nutrition risk can persist throughout hospitalization in a NICU. The nutrition status of the patient(s) might be one of the decisive factors in disease prognosis. Providing an adequate assessment of their nutrition risk should be a standard procedure for patients in intensive care, since patients at higher nutrition risk could better benefit from nutrition interventions than those at lower risk.

Traditional screening tools, such as the Subjective Global Assessment, Mini Nutritional Assessment, and Malnutrition Universal Screening Tool, are optimal to evaluate general patients but not ICU patients. An appropriate scoring system for nutrition risk in ICUs should include not only classical nutrition variables, such as body mass index (BMI), recent weight loss, and food intake, but also factors that may reflect the metabolic state of the patient. Nutritional Risk Screening 2002 (NRS 2002) and Nutrition Risk in the Critically ill (NUTRIC) scores are screening tools that not only assess the severity of an acute disease but also measure the nutrition status of the patient. Both NRS 2002 and NUTRIC scores contain the Acute Physiology and Chronic Health Evaluation (APACHE) II scoring. Besides, the NUTRIC system also includes the Sequential Organ Failure Assessment (SOFA) scoring. Both APACHE II and SOFA scores have been widely used in ICUs for the assessment of disease severity, as well as to predict mortality.

The NRS 2002 has been recommended by the European Society for Parenteral and Enteral Nutrition (ESPEN) as the preferred tool for nutrition risk screening. As such, it has been frequently used in hospital settings. Originally, NRS 2002 scoring was established from a series of retrospective analyses of controlled clinical trials by using the nutrition characteristics and clinical outcomes in these particular studies. However, these studies were not exclusively based on ICU patient populations. In 2011, Heyland and colleagues introduced the NUTRIC score, the first tool of nutrition risk assessment developed specifically for ICU patients. The NUTRIC score takes into account the following variables: age, APACHE II and SOFA scores, number of comorbidities, days between hospitalization to ICU admission, and interleukin 6 (IL-6) levels. This scoring system helps classify critically ill patients at either high or low nutrition risk, as well as identify ICU patients who may benefit from an aggressive nutrition support. The second version was validated in 2015 after excluding the use of IL-6 as a variable. The newer version, deemed as the modified NUTRIC (mNUTRIC) score, has not shown any direct changes toward the predictive ability of the scoring system. As recently developed tools, both NUTRIC and mNUTRIC scores have not been broadly applied and tested in clinical studies yet.

For the assessment of nutrition risk in ICU patients, no uniform consensus on which assessment tool is optimal has been established. The NRS 2002 score has been recommended by ESPEN, whereas in 2013, the Canadian critical care nutrition guidelines suggested the NUTRIC score. In the “guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient,” raised in 2016 by the American Society for Parenteral and Enteral Nutrition (ASPEN), both NRS 2002 and NUTRIC scores were recommended. In the field of neurocritical care, the NRS 2002 system has been broadly used. However, the application and investigation of the NUTRIC system in this same medical area is still too limited. Moreover, no relevant recommendation on the guidelines for nutrition management in neurocritical care has been developed so far. Therefore, based on these apparent limitations, here we have conducted a single-center, prospective observational study in our NICU, aiming to investigate the value of NRS 2002 and NUTRIC scoring systems for assessing nutrition risk and predicting the prognosis of critically ill neurological patients.
Methods

Study Design

A prospective observational study was conducted in the NICU of Tongji Hospital, affiliated with the Tongji Medical College (Huazhong University of Science and Technology, Hubei, China), between January 2018 and May 2018. This particular NICU is composed of 18 beds and routinely admits critically ill neurological patients. Adult patients (≥18 years of age) who stayed in the NICU for >24 hours were considered for enrollment in this study. Patients who were discharged or died within 24 hours were excluded. The plan of nutrition management was determined by a multidisciplinary team consisting of trained neurologists and dietitians. During hospitalization in the NICU, the daily energy specifications for the critically ill neurological patients were set at 25–30 kcal/kg, with a protein requirement of 1.2–2.0 g/kg/d. Body weight information was fetched on admission by direct measurement or by asking patients’ relatives and/or companions. The use of enteral nutrition (EN) was the preferred route of administration. EN was started within 24 hours of NICU admission for those patients without any contraindications (eg, upper gastrointestinal bleeding). A swallowing test was routinely repeated to help define the EN route. For patients with dysphagia or in coma, a nasogastric (NG) tube was routinely placed. Use of prokinetic agents and placement of a small-bowel feeding tube were considered in patients in whom improper aspiration was a risk. If the energy requirements could not be achieved because of gastrointestinal contraindication and/or EN intolerance, parenteral nutrition (PN) would be applied with the guidance of the clinical team.

This study was approved by the Institutional Review Board of Tongji Hospital (Tongji Medical College, Huazhong University of Science and Technology, Hubei, China) (no. TJ-IRB20180511). Informed consent was properly obtained from all individual participants or their relatives and/or companions.

Data Collection

The following patient data was retrieved from the hospital databases: demographics, height, body weight, main diagnosis, medical complications, nutrition support pattern (EN, PN, or EN+PN), nutrition starting time, administration route, EN volume, EN intolerance, hospital infection, usage of vasoressors, renal replacement therapy, mechanical ventilation, and LOS at the hospital and in the NICU. BMI was calculated, accordingly, based on each patient’s height and body weight upon admission. The nutrition risk for each patient was assessed during admission at the NICU by using NRS 2002, NUTRIC, and mNUTRIC scores. The levels of serum albumin and prealbumin were also examined during admission, and these were reevaluated after 1 and 2 weeks of hospitalization. Both 28-day and NICU mortalities were calculated according to patients’ outcomes at 28-day hospitalization or after NICU discharge, respectively.

The NRS 2002 scoring system consisted of 3 parts: (1) points for impaired nutrition status (0–3 points), (2) points for disease severity (0–3 points), and (3) an age adjustment for patients aged ≥70 years (1 point). So, an NRS 2002 score refers to the total number of points accumulated on these 3 topics (0–7 points). A score of ≥3 would relate to a patient who has nutrition risk and for whom nutrition support should be initiated.14

The NUTRIC score (0–10 points) consisted of 6 variables: (1) age, (2) APACHE II and (3) SOFA scores on admission, (4) number of comorbidities, (5) pre-ICU hospital LOS, and (6) IL-6 levels.8 A score of ≥6 would relate to a patient with high nutrition risk. The mNUTRIC score (0–9 points) was calculated based on the NUTRIC score by eliminating IL-6 values.15 A score of ≥5 would relate to a patient with high nutrition risk.

Sample-Size Calculation

Since a study focusing on NICU population is missing, we estimated the 28-day mortality according to an existing report, which disclosed the 28-day mortality in ICU patients with high nutrition risk was 33.5%, whereas, in the low nutrition risk group, 28-day mortality was 11.9%.9 Sample size was calculated by using PASS 11.0 software, adopting α = .05 and power = 0.8. The ratio of cases between the low and high nutrition risk groups was set to be 2:1. For this, we required 40 patients in the high nutrition risk group, and 80 in the low nutrition risk group.

Statistical Analysis

Statistical analyses were performed by using SPSS version 19.0 software (IBM SPSS Statistics for Windows, version 19.0, Armonk, NY, IBM Corp). Measurement data were expressed as mean ± SD, whereas enumerated data were expressed as percentage. Student t-test was used to examine the measurement data from univariate analysis of potential risk factors. Pearson χ² test, continuity correction, or Fisher exact test was used for the analysis of enumerated data. Variables with a value of P < .05 were then included in the multivariable logistic regression analysis. Repeated measurement data, regarding serum albumin and prealbumin levels, were analyzed by 2-way analysis of variance. Time-point differences between groups, during admission and after 1 or 2 weeks of hospitalization, were compared by using Bonferroni posttest or t-test. Prediction of NRS 2002, NUTRIC, and mNUTRIC scores for the 28-day mortality outcome was evaluated by using the area under the receiver operating characteristic (ROC) curves. Statistical significance was set with P-value <.05.
Table 1. Nutrition Status and Risk of Neurological Intensive Care Unit Patients.

| Index        | Grade                  | Number | Percentage |
|--------------|------------------------|--------|------------|
| BMI          | Underweight (<18.5)    | 0      | 0          |
|              | Normal (18.5–24.0)     | 92     | 65.7%      |
|              | Overweight (24.0–28.0) | 42     | 30.0%      |
|              | Obesity (≥28.0)        | 6      | 4.3%       |
| NRS 2002 score | Without nutrition risk (<3) | 18     | 12.9%      |
|              | With nutrition risk (≥3)| 122    | 87.1%      |
| NUTRIC score | Low nutrition risk (<6) | 118    | 84.3%      |
|              | High nutrition risk (≥6)| 22     | 15.7%      |
| mNUTRIC score | Low nutrition risk (<5) | 100    | 71.4%      |
|              | High nutrition risk (≥5)| 40     | 28.6%      |
| Serum albumin | ≥30 g/L                | 132    | 94.3%      |
|              | <30 g/L                | 8      | 5.7%       |
| Serum Prealbumin | ≥200 mg/L        | 85     | 60.7%      |
|              | <200 mg/L              | 55     | 39.3%      |

BMI is calculated as weight in kilograms divided by height in meters squared.
BMI, body mass index; mNUTRIC, modified Nutrition Risk in the Critically ill; NRS 2002, Nutritional Risk Screening 2002.

Results

Patient Profiling

A total of 140 critically ill neurological patients, including 91 men and 49 women, were included in this study. The mean age of the patient cohort was 55.5 (range, 18–92) years old. The average height of the patients was 167.8 ± 7.0 cm. During admission, their average weight and BMI was 66.3 ± 8.4 kg and 23.5 ± 2.3, respectively. The disease spectrum of the patient cohort included intracerebral hemorrhage (51 cases, 36.4%), acute ischemic stroke (50 cases, 35.7%), intracranial infection (20 cases, 14.3%), myasthenia gravis (5 cases, 3.6%), encephalopathy (4 cases, 2.9%), subarachnoid hemorrhage (4 cases, 2.9%), Guillain-Barre syndrome (2 cases, 1.4%), acute disseminated encephalomyelitis (2 cases, 1.4%), and other (2 cases, 1.4%). The average LOS was 10.7 ± 9.1 days. The average LOS in the NICU was 9.9 ± 8.6 days. Over the course of the study, NICU mortality was 6.4% (9 of 140), whereas the 28-day mortality was 25.0% (35 of 140).

Nutrition Status, Risk, and Support

BMI and serum albumin and prealbumin levels have partially reflected patients’ nutrition status. According to BMI, 65.7% of the patients had a normal weight, whereas 30.0% were overweight and 4.3% were obese. No undernutrition was detected among the patients. In 5.7% of patients, serum albumin level was <30 g/L during admission, whereas in 39.3% of patients, serum prealbumin level was <200 mg/L.

NRS 2002, NUTRIC, and mNUTRIC scores were applied for the assessment of nutrition risk. According to their NRS 2002 scores, 87.1% of NICU patients were at nutrition risk (NRS 2002 score ≥ 3). Using the NUTRIC scoring system, high (NUTRIC score ≥ 6) and low (NUTRIC score < 6) nutrition risk were detected in 15.7% and 84.3% of the patients, respectively. Based on their mNUTRIC scores, a high nutrition risk (mNUTRIC score ≥ 5) was observed in 28.6% of patients, whereas a low nutrition risk (mNUTRIC score < 5) existed in 71.4% of patients. Their nutrition status and respective risks are listed in Table 1.

During their stay in the NICU, the majority of the patients (97.1%) received nutrition support. For 82.1% of these patients, the support pattern was EN with or without PN, whereas the other 15% was only PN. The remaining 2.9% of the patients did not receive any nutrition support because of contraindications. For patients receiving EN, the major route of feeding (78.3% of the cases) was via NG tube, whereas 3.5% was via nasointestinal tube, and 18.3% was oral feeding. For 76.5% of the patients, EN started within 24 hours of NICU admission. The initial time of EN was 24–48 hours for 8.7% of patients, and >48 hours for the remaining 14.8% of the patients. The major factor that could affect the EN starting time was the existence and severity of any acute gastrointestinal injury (AGI) in the patient. EN intolerance has occurred in a small number of patients, including 10.4% with reflux and vomiting, 0.9% with abdominal distension, and 0.9% with diarrhea.

Risk Factors for 28-day Mortality

Patients were divided into the 2 groups (ie, nonsurvivor and survivor) according to the outcome established for the 28-day period. Table 2 shows the results of the univariate and multivariate analyses of related risk factors. The univariate analysis indicated that age ≥60 years, pulmonary infection, hospital infection, organ dysfunction, use of vasopressors, mechanical ventilation, NRS 2002 score ≥ 3, and high
Table 2. Risk Factors for 28-day Mortality.

| Risk factor                  | Nonsurvivor group | Survivor group | Univariate analysis | Multivariate analysis |
|-----------------------------|-------------------|----------------|--------------------|-----------------------|
|                             | n = 35            | n = 105        | OR (95% CI)        | P                     | OR (95% CI)         | P      |
| Male                        | 24 (68.6%)        | 67 (83.8%)     | 1.24 (0.55–2.80)   | .609                  | 3.30 (1.01–10.80)   | .049   |
| Age ≥60 years old           | 20 (57.1%)        | 40 (38.1%)     | 2.17 (1.00–4.71)   | .049³                 | 3.54 (1.04–12.02)   | .043³  |
| Complications               |                   |                |                    |                       |                     |        |
| Pulmonary infection         | 32 (91.4%)        | 73 (69.5%)     | 4.68 (1.33–16.39)  | .010⁵                 | .084              |        |
| Hospital infection          | 27 (77.1%)        | 41 (39.0%)     | 5.27 (2.18–12.71)  | <.001¹                | 3.54 (1.04–12.02)   | .043³  |
| Organ dysfunction           | 12 (34.3%)        | 9 (8.6%)       | 5.57 (2.10–14.78)  | <.001¹                | .311              |        |
| Electrolyte imbalance       | 4 (11.4%)         | 10 (9.5%)      | 1.23 (0.36–4.19)   | 1.000                 |                   |        |
| Gastrointestinal bleeding   | 9 (25.7%)         | 16 (15.2%)     | 1.93 (0.76–4.86)   | .161                  |                   |        |
| Secondary epilepsy          | 1 (2.9%)          | 9 (8.6%)       | 0.31 (0.04–2.57)   | .449                  |                   |        |
| Chronic diseases            |                   |                |                    |                       |                     |        |
| Hypertension                | 19 (54.3%)        | 60 (57.1%)     | 0.89 (0.41–1.92)   | .768                  |                   |        |
| Chronic renal failure       | 1 (2.9%)          | 7 (6.7%)       | 0.41 (0.05–3.47)   | .674                  |                   |        |
| Diabetes                    | 6 (17.1%)         | 15 (14.3%)     | 1.24 (0.44–3.50)   | .682                  |                   |        |
| Chronic hepatitis B         | 3 (8.6%)          | 11 (10.5%)     | 0.80 (0.21–3.05)   | 1.000                 |                   |        |
| Use of vasopressors         | 13 (37.1%)        | 4 (3.8%)       | 14.92 (4.44–50.13) | <.001¹                | 10.88 (3.33–35.57) | <.001³ |
| Renal replacement therapy   | 1 (2.9%)          | 3 (2.9%)       | 1.00 (0.10–9.94)   | 1.000                 |                   |        |
| Mechanical ventilation      | 25 (71.4%)        | 19 (18.1%)     | 11.32 (4.67–27.44) | <.001¹                | 10.88 (3.33–35.57) | <.001³ |
| BMI ≥24                     | 10 (28.6%)        | 38 (36.2%)     | 0.71 (0.31–1.63)   | .411                  |                   |        |
| Serum albumin <30 g/L       | 3 (8.6%)          | 5 (4.8%)       | 1.88 (0.42–8.28)   | .674                  |                   |        |
| Serum prealbumin <200 mg/L  | 17 (48.6%)        | 38 (36.2%)     | 1.67 (0.77–3.61)   | .194                  |                   |        |
| Nutrition risk (NRS 2002 score ≥ 3) | 35 (100%) | 87 (82.9%) | 1.40 (1.25–1.57)   | .020⁶                | .152              |        |
| High nutrition risk (NUTRIC score ≥ 6) | 16 (45.7%) | 6 (5.7%) | 13.90 (4.82–40.06) | <.001³                | 13.95 (4.32–45.01) | <.001³ |
| High nutrition risk (mNUTRIC score ≥ 5) | 25 (71.4%) | 15 (14.3%) | 15.00 (6.01–37.44) | <.001³                | 13.95 (4.32–45.01) | <.001³ |

BMI is calculated as weight in kilograms divided by height in meters squared.
BMI, body mass index; mNUTRIC, modified Nutrition Risk in the Critically ill; NRS 2002, Nutritional Risk Screening 2002; OR, odds ratio.

Nutrition risk (NUTRIC score ≥ 6 and/or mNUTRIC score ≥ 5) significantly increased the rate of 28-day mortality. In addition, our multivariate analysis has revealed that age ≥ 60 years, hospital infection, mechanical ventilation, and high nutrition risk (mNUTRIC score ≥ 5) independently increased the rate of 28-day mortality in the subgroup with LOS ≥ 1 week (Table 3). Multivariate analysis has revealed that mechanical ventilation and high nutrition risk (mNUTRIC score ≥ 5) independently increased the rate of 28-day mortality in the subgroup with LOS ≥ 1 week (Table 3).

For the subgroup with LOS ≥ 2 weeks, univariate analysis has particularly shown that only the use of vasopressors and a high nutrition risk (mNUTRIC score ≥ 5) significantly increased the rate of 28-day mortality (Table 4). Interestingly, multivariate analysis has revealed that only high nutrition risk (mNUTRIC score ≥ 5) was an independent risk factor of 28-day mortality in this particular subgroup (Table 4). Serum albumin and prealbumin levels were measured at different time points (ie, admission and 1 week and 2 weeks after hospitalization), and results were further compared between both groups. As shown in Figure 1, a significant decrease in serum albumin levels and a decreasing trend of serum prealbumin levels were identified during a 2 weeks’ hospital stay. No significant difference in either serum albumin or prealbumin levels was observed when comparing survivors and nonsurvivors at the integral level. However, when taking interactive effects between outcome and LOS
Table 3. Risk Factors for 28-day Mortality in the Subgroup of Patients with a Length of Stay $\geq$ 1 Week.

| Risk factor                      | Nonsurvivor group | Survivor group | Univariate analysis | Multivariate analysis |
|----------------------------------|-------------------|----------------|---------------------|-----------------------|
|                                  | n = 16            | n = 89         | OR (95% CI)         | P                     |
| Male                             | 12 (75.0%)        | 60 (67.4%)     | 1.45 (0.43–4.89)    | .547                  |
| Age $\geq$ 60 years old          | 7 (43.8%)         | 30 (33.7%)     | 1.53 (0.52–4.51)    | .439                  |
| Complications                    |                   |                |                     |                       |
| Pulmonary infection              | 15 (93.8%)        | 66 (74.2%)     | 5.23 (0.65–41.81)   | .163                  |
| Hospital infection               | 13 (81.3%)        | 40 (44.9%)     | 5.31 (1.41–19.93)   | .007*                 |
| Organ dysfunction                | 7 (43.8%)         | 8 (9.0%)       | 7.88 (2.31–26.84)   | .001*                 |
| Electrolyte imbalance            | 1 (6.3%)          | 7 (7.9%)       | 0.78 (0.09–6.82)    | 1.000                 |
| Gastrointestinal bleeding        | 6 (37.5%)         | 15 (16.9%)     | 2.96 (0.93–9.39)    | .118                  |
| Secondary epilepsy               | 0 (0.0%)          | 9 (10.1%)      | 0.83 (0.76–0.91)    | .398                  |
| Chronic diseases                 |                   |                |                     |                       |
| Hypertension                     | 9 (56.3%)         | 51 (57.3%)     | 0.96 (0.33–2.80)    | .938                  |
| Chronic renal failure            | 1 (6.3%)          | 7 (7.9%)       | 0.78 (0.90–6.82)    | 1.000                 |
| Diabetes                         | 2 (12.5%)         | 9 (10.1%)      | 1.27 (0.25–6.51)    | 1.000                 |
| Chronic hepatitis B              | 1 (6.3%)          | 11 (12.4%)     | 0.47 (0.06–3.94)    | .779                  |
| Use of vasopressors              | 7 (43.8%)         | 4 (4.5%)       | 16.53 (4.05–67.53)  | $<.001^*$             |
| Renal replacement therapy        | 1 (6.3%)          | 3 (3.4%)       | 1.91 (0.19–19.62)   | .489                  |
| Mechanical ventilation           | 13 (81.3%)        | 18 (20.2%)     | 17.09 (4.40–66.45)  | $<.001^*$             |
| BMI $\geq$ 24                    | 3 (18.8%)         | 30 (33.7%)     | 0.45 (0.12–1.72)    | .235                  |
| Nutrition risk (NRS score 2002 $\geq$ 3) | 16 (100%)       | 75 (84.3%)     | 1.21 (1.10–1.33)    | .192                  |
| High nutrition risk (mNUTRIC score $\geq$ 6) | 5 (31.3%)       | 6 (6.7%)       | 6.29 (1.64–24.10)   | .012*                 |
| High nutrition risk (mNUTRIC score $\geq$ 5) | 12 (75.0%)       | 14 (15.7%)     | 16.07 (4.53–57.08)  | $<.001^*$             |

BMI is calculated as weight in kilograms divided by height in meters squared.
BMI, body mass index; mNUTRIC, modified Nutrition Risk in the Critically ill; NRS 2002, Nutritional Risk Screening 2002; OR, odds ratio.

$^*P < .05$

Figure 1. Changes of serum albumin and prealbumin levels during 2 weeks of hospitalization.

Comparison Between Nutrition Risk Groups by Using mNUTRIC Scoring System

Analyses of respective risk factor has revealed that high nutrition risk, based on mNUTRIC scoring, was an independent risk factor of 28-day mortality in the whole group and also for each subgroup. Thus, we divided the patient cohort into high and low nutrition risk groups according to the mNUTRIC score, and the respective differences between these 2 groups were annotated. Table 5 shows that the high nutrition risk group (mNUTRIC score $\geq$ 5) exhibited a significantly higher incidence of pulmonary infection, hospital infection, and organ dysfunction, as well as higher use of vasopressors and mechanical ventilation.
Table 4. Risk Factors for 28-day Mortality in the Subgroup of Patients with Length of Stay ≥ 2 Weeks.

| Risk factor                        | Nonsurvivor group | Survivor group | Univariate analysis | Multivariate analysis |
|------------------------------------|-------------------|----------------|---------------------|-----------------------|
| Male                               | n = 5             | n = 46         | OR (95% CI)         | P                     |
| Male                               | 4 (80.0%)         | 32 (69.6%)     | 1.75 (0.18–17.10)   | 1.000                 |
| Age ≥60 years old                  | 2 (40.0%)         | 14 (30.4%)     | 1.52 (0.23–10.15)   | 1.000                 |
| Complications                      |                   |                |                     |                       |
| Pulmonary infection                | 4 (80.0%)         | 39 (84.8%)     | 0.72 (0.07–7.41)    | 1.000                 |
| Hospital infection                 | 4 (80.0%)         | 27 (58.7%)     | 2.82 (0.29–27.21)   | 0.657                 |
| Organ dysfunction                  | 1 (20.0%)         | 4 (8.7%)       | 2.63 (0.23–29.50)   | 0.416                 |
| Electrolyte imbalance              | 0 (0.0%)          | 4 (8.7%)       | 0.89 (0.81–0.99)    | 1.000                 |
| Gastrointestinal bleeding          | 3 (60.0%)         | 11 (23.9%)     | 4.77 (0.71–32.33)   | 0.234                 |
| Secondary epilepsy                 | 0 (0.0%)          | 4 (8.7%)       | 0.89 (0.81–0.99)    | 1.000                 |
| Chronic diseases                   |                   |                |                     |                       |
| Hypertension                       | 3 (60.0%)         | 27 (58.7%)     | 1.06 (0.16–6.94)    | 1.000                 |
| Chronic renal failure              | 0 (0.0%)          | 6 (13.0%)      | 0.89 (0.80–0.99)    | 1.000                 |
| Diabetes                           | 2 (40.0%)         | 4 (8.7%)       | 1.27 (0.25–6.51)    | 0.099                 |
| Chronic hepatitis B                | 1 (20.0%)         | 8 (17.4%)      | 1.19 (0.12–12.09)   | 1.000                 |
| Use of vasopressors                | 2 (40.0%)         | 2 (4.3%)       | 14.67 (1.50–143.73) | .043                  |
| Renal replacement therapy          | 1 (20.0%)         | 2 (4.3%)       | 5.50 (0.41–74.76)   | .271                  |
| Mechanical ventilation             | 4 (80.0%)         | 13 (28.3%)     | 10.15 (1.04–99.61)  | .067                  |
| BMI ≥ 24                           | 1 (20.0%)         | 16 (34.8%)     | 0.47 (0.05–4.55)    | .868                  |
| Nutrition risk (NRS score 2002 ≥ 3)| 5 (100%)          | 42 (91.3%)     | 1.12 (1.01–1.24)    | 1.000                 |
| High nutrition risk (NUTRIC score ≥ 6) | 2 (40.0%)   | 6 (13.0%)      | 4.44 (0.61–32.33)   | .170                  |
| High nutrition risk (mNUTRIC score ≥ 5) | 4 (80.0%)   | 10 (21.7%)     | 14.40 (1.44–143.71) | .025                  |

BMI is calculated as weight in kilograms divided by height in meters squared. BMI, body mass index; mNUTRIC, modified Nutrition Risk in the Critically ill; NRS 2002, Nutritional Risk Screening 2002; OR, odds ratio. *P < .05.

Discussion

In our current single-center, prospective observational study, a large proportion of critically ill neurological patients admitted to the NICU exhibited nutrition risk. During assessment with the NUTRIC and mNUTRIC scores, patients could be distinguished between high and low nutrition risks. In this study, the mNUTRIC score was found to be one of the significant predictors of 28-day mortality. Therefore, our data suggest that the NUTRIC scoring system, especially the mNUTRIC scoring, is of great value for the assessment of nutrition risk and prognosis prediction in critically ill neurological patients.

Patients transferred to the NICU are typically at high nutrition risk because of their characteristic-debilitating conditions. Besides the high proportion of coma, bulbar paralysis, and mental and cognitive disorders, the existence and severity of AGI19 can negatively affect food intake and EN tolerance. Assessing the nutrition risk of debilitating patients is of great importance, since early and adequate energy and protein provisions will benefit patients who are critically ill with neurological injury.5 Until now, no assessment tool for nutrition risk in NICU patient populations has been properly defined. Traditional markers, such as BMI, serum albumin, and serum prealbumin, have limited value in assessing nutrition risk. According to BMI, an undernourished patient was rarely identified. The serum albumin levels in most of the hospitalized patients were within a normal range. Because of its long half-life, serum albumin levels cannot timely reflect changes in nutrition status. In contrast, serum prealbumin levels have a shorter half-life and, compared with serum albumin, its detection may better translate putative nutrition changes. Along with the extension of hospital stay, serum albumin and prealbumin

and, finally, a significant increase in NICU and 28-day mortality rates, when compared with the low nutrition risk group (mNUTRIC score < 5).

**ROC Curves**

The NUTRIC score predicted a 28-day mortality with area under the curve (AUC) of 0.857 (95% CI, 0.786–0.928), whereas mNUTRIC score predicted 28-day mortality with AUC of 0.856 (95% CI, 0.786–0.927). NRS 2002 score predicted 28-day mortality with AUC of 0.607 (95% CI, 0.503–0.711). ROC curves are shown in Figure 2.
Table 5. Comparison Between Nutrition Risk Groups Using mNUTRIC Scoring System.

|                          | High-risk group n = 40 | Low-risk group n = 100 | OR (95% CI)   | P         |
|--------------------------|------------------------|------------------------|----------------|-----------|
| Male                     | 27 (67.5%)             | 64 (64.0%)             | 1.17 (0.54-2.54) | .695      |
| Age ≥60 years old        | 19 (47.5%)             | 41 (41.0%)             | 1.30 (0.62-2.72) | .483      |
| Complications            |                        |                        |                |           |
| Pulmonary infection      | 38 (95.0%)             | 67 (67.0%)             | 9.36 (2.13-41.18) | .001      |
| Hospital infection       | 28 (70.0%)             | 40 (40.0%)             | 3.50 (1.60-7.68) | .001      |
| Organ dysfunction        | 14 (35.0%)             | 7 (7.0%)               | 7.15 (2.62-19.57) | <.001     |
| Electrolyte imbalance    | 5 (12.5%)              | 9 (9.0%)               | 1.44 (0.45-4.61) | .755      |
| Gastrointestinal bleeding| 11 (27.5%)             | 14 (14.0%)             | 2.33 (0.95-5.70) | .060      |
| Secondary epilepsy       | 1 (2.5%)               | 9 (9.0%)               | 0.26 (0.03-2.12) | .324      |
| Chronic diseases         |                        |                        |                |           |
| Hypertension             | 20 (50.0%)             | 59 (59.0%)             | 0.70 (0.33-1.45) | .332      |
| Chronic renal failure    | 2 (5.0%)               | 6 (6.0%)               | 0.83 (0.16-4.27) | 1.000     |
| Diabetes                 | 7 (17.5%)              | 14 (14.0%)             | 1.30 (0.48-3.51) | .600      |
| Chronic hepatitis B      | 4 (10.0%)              | 10 (10.0%)             | 1.00 (0.30-3.40) | 1.000     |
| Use of vasopressors      | 14 (35.0%)             | 3 (3.0%)               | 17.41 (4.65-65.17) | <.001     |
| Renal replacement therapy| 2 (5.0%)               | 2 (2.0%)               | 2.58 (0.35-18.97) | .688      |
| Mechanical ventilation   | 22 (55.0%)             | 22 (22.0%)             | 4.33 (1.98-9.47) | <.001     |
| BMI ≥24                  | 14 (35.0%)             | 34 (34.0%)             | 1.05 (0.48-2.26) | .910      |
| Serum albumin <30 g/L    | 4 (10.0%)              | 4 (4.0%)               | 2.67 (0.63-11.23) | .328      |
| Serum prealbumin <200 mg/L| 21 (52.5%)             | 34 (34.0%)             | 2.15 (1.02-4.52) | .043      |
| NICU mortality           | 7 (17.5%)              | 2 (2.0%)               | 10.39 (2.06-52.53) | .003      |
| 28-day mortality         | 25 (62.5%)             | 10 (10.0%)             | 15.00 (6.01-37.44) | <.001     |

BMI is calculated as weight in kilograms divided by height in meters squared.
BMI, body mass index; mNUTRIC, modified Nutrition Risk in the Critically ill; NICU, neurological intensive care unit; OR, odds ratio.

*P < .05.

Figure 2. Performance of different scoring systems to predict 28-day outcome in neurological intensive care unit patients. mNUTRIC, modified Nutrition Risk in the Critically ill; NRS 2002, Nutritional Risk Screening 2002; ROC, receiver operating characteristic.
levels gradually declined. At 2-week hospitalization, both serum albumin and prealbumin levels in nonsurvivors were significantly lower than those in survivors. Dynamically monitoring changes of serum albumin and prealbumin levels may reflect the nutrition status of the patients to a certain extent.

As recommended assessment tools of nutrition risk in the field of critical care, NRS 2002 and NUTRIC scoring systems are also applicable in the field of neurocritical care. Still, these scoring methods currently lack clinical research evidence. A comparative analysis between these scoring systems is challenging because of the lack of a “gold standard.” However, ASPEN experts tend to consider the NUTRIC/mNUTRIC score to be a more suitable nutrition risk screening tool than the NRS 2002. In this study, 87.1% of NICU patients presented nutrition risk, according to their NRS 2002 scores, which demonstrated their respective susceptibility. However, a high or low nutrition risk could not be further distinguished by using this parameter solely. Both NUTRIC and mNUTRIC scores can help classify critically ill patients as either high or low nutrition risk and then identify which patient(s) might benefit from a more aggressive nutrition therapy. Observational studies in ICU patients have indicated that mNUTRIC score is associated with 28-day mortality, LOS in the ICU, and the duration of mechanical ventilation. In our present study, the NUTRIC and mNUTRIC scores distinguished 15.7% and 28.6% of the NICU patients at high nutrition risk, respectively. Of note, a limited number of NICU patients scored 1 point at the grading of IL-6 in the NUTRIC score. This observation might relate to the low ratio of severe infections in NICU patients, as compared with ICU patients in general. Thus, the NUTRIC score might underestimate the ratio of high nutrition risk patients in the NICU. In this case, the mNUTRIC score might be a more appropriate scoring system.

Based on univariate and multivariate analyses, we have identified that age ≥60 years old, hospital infection, mechanical ventilation, and high nutrition risk (based on mNUTRIC score) were independent risk factors of 28-day mortality in the whole NICU group. For some patients with very short LOS, whose nutrition statuses were mostly consistent, the prognosis may not be significantly affected by nutrition risk. Thus, we have performed some subgroup analyses by excluding patients with short LOS. Mechanical ventilation and high nutrition risk (based on mNUTRIC score) were independent risk factors of 28-day mortality in the subgroup with LOS ≥ 1 week. In the subgroup with LOS ≥ 2 weeks, only high nutrition risk (based on mNUTRIC score) remained significant as an independent risk factor. Based on mNUTRIC score, the patient group with high nutrition risk exhibited significantly higher incidences of pulmonary infection, hospital infection and organ dysfunction, higher ratios of vasopressor use and mechanical ventilation, as well as significantly increased NICU mortality and 28-day mortality, than the low-risk group. ROC curves displayed a superior predictive value of the 28-day outcome by using both NUTRIC and mNUTRIC scores but not for NRS 2002 scoring. Altogether, our data have revealed the significance of the mNUTRIC score in 28-day outcome prediction. Furthermore, the predictive value of the mNUTRIC score has become more meaningful than other factors as an extension of LOS.

The aim of our current study is first to investigate the application of ICU-specific nutrition risk tools in a particular population of critically ill neurological patients. The strength and value of the NUTRIC scoring system as an assessment tool of nutrition risk for ICU patients has been consistently demonstrated. Meanwhile, it has been proven that NUTRIC score ≥ 5 is one of the risk factors for the survival time in ICU. Since IL-6 is not routinely measured in most ICUs, the mNUTRIC score seems to be a more useful version. Several studies have reported the independent prognostic value of mNUTRIC scoring in patients undergoing mechanical ventilation with sepsis and acute gastroesophageal variceal bleeding. In accordance with our studies, another recent report has shown that NUTRIC scoring is superior to NRS 2002 for assessing malnutrition risk in ICU patients. Our current studies have shown that, in fact, a newer version of this scoring system (ie, mNUTRIC) is independently related to the risk of 28-day mortality of critically ill neurological patients in the NICU. This result is possibly related to the low ratio of severe infections and IL-6 grading in critically ill neurological patients, which might be different from general ICU patients. Subgroup analyses have further validated the predictive value of the mNUTRIC scoring in this study.

Still, a few limitations are present in this study and, as such, must be addressed. This study is a single-center observational study, and potential confounding factors of different diseases might have affected the results. In addition, as a NICU, neurosurgical diseases, such as traumatic brain injury and brain tumor, have not been included. Therefore, multiple-center studies using a larger number of patients are further required. Moreover, randomized and controlled studies are still needed to better determine if nutrition interventions, stratified by the mNUTRIC scoring, can indeed improve NICU patient outcomes.

**Conclusion**

We presently investigated, for the first time, the application of ICU-specific nutrition risk tools in a particular population of critically ill neurological patients. A large proportion of NICU patients exhibited nutrition risk. The mNUTRIC scoring is independently related to the risk of 28-day mortality in critically ill neurological patients. Interestingly, upon extending the LOS, the prognosis predictive value of
the mNUTRIC score is apparently more meaningful than other risk factors. Therefore, the mNUTRIC scoring system might be a more appropriate tool to assess nutrition risk and to predict the prognosis of critically ill neurological patients in the NICU.

Acknowledgments

The authors thank all the included patients and their families, as well as all the physicians, nurses, dieticians, and all staff.

Statement of Authorship

P. Zhang and Y. Bian contributed to the conception and design of the research; Z. Tang and F. Wang contributed to the design of the research; P. Zhang and F. Wang contributed to the acquisition of the data; Y. Bian and P. Zhang contributed to the analysis and interpretation of the data; and P. Zhang drafted the manuscript. All authors critically revised the manuscript. All authors critically revised the manuscript, agreed to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

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