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Prediction of mortality in patients admitted to the intensive care unit due to respiratory failure; use of nutritional screening tools mNUTRIC and NRS-2002*

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ABSTRACT

Aims: The objective of this study was to examine the effectiveness of the nutritional screening tools modified nutrition risk in the critically ill (mNUTRIC) and nutrition risk screening-2002 (NRS-2002) in predicting mortality among patients admitted to the intensive care unit (ICU) with acute respiratory failure (ARF) and to determine if their effectiveness varies by respiratory failure (RF) type.

Methods: This prospective, cohort, descriptive study was initiated after ethics committee approval. During a 6-month period, all adult patients (aged ≥18 years) admitted to the tertiary ICUs with acute RF, with type 1 and type 2 RF, who stayed for more than 48 hours were included. Patients were divided into two groups: survivors and non-survivors. Nutritional screening was performed with mNUTRIC and NRS-2002. Scores of 5 points or more on any of the nutritional tools were considered to indicate high nutritional risk. Multiple logistic regression analysis was used to test data predicting 1-month (30-day) and 3-month (90-day) mortality. Relative risk (RR) values of the nutritional tools on mortality were calculated.

Results: Among 525 patients, 35.4% had type 1 RF, and 64.6% had type 2 RF. The mortality rates were 44.2% at one month and 62.5% at three months, with higher mortality observed in type 1 RF in both periods. The mNUTRIC score, the presence of inotropic support, type 1 RF, and admission from the ward were identified as independent variables with a significant association with mortality at 1 and 3 months. The mNUTRIC score emerged as the variable most strongly associated with mortality in both periods. When the mNUTRIC score was evaluated in isolation, the optimal cut-off value was determined to be 6 (1-month mortality AUC: 0.77, 3-month mortality AUC: 0.82). Patients with nutritional risk, as identified by mNUTRIC, exhibited a fourfold elevated risk of mortality within one month (RR=4.2; 95% CI: 2.56–6.95; p<.001) and three months (RR=4.6; 95% CI: 3.04–7.15; p<.001). Combining mNUTRIC and NRS-2002 scores did not significantly enhance predictive accuracy compared to mNUTRIC alone.

Conclusion: In patients with RF, the mNUTRIC score is the most powerful parameter for identifying the high-risk group. The prognosis is worse in patients with type 1 RF compared to type 2. Especially in the group of patients with high mNUTRIC score, in need of inotropic support, type 1 RF findings, and the need for ICU during hospitalization, early intervention and management in terms of nutrition is important to improve the duration of intensive care stay and mortality rates.

Keywords: Acute respiratory failure, intensive care unit, mortality, mNUTRIC, NRS-2002

*Our study was previously presented as an oral presentation at the 24th International Intensive Care Symposium with the first 1-month preliminary data.

INTRODUCTION

Acute respiratory failure (ARF) is the most common reason for intensive care unit (ICU) admission of critically ill patients.[1] The clinical syndrome of ARF can be associated with a variety of acute illnesses, yet there is no universally accepted definition. Consequently, quantifying the true incidence of ARF poses a significant challenge.[2] A substantial proportion of ICU patients, ranging from 40% to 65%, require mechanical ventilation (MV) during their stay in the ICU.[3] The acute disruption of gas exchange between the lungs and blood leads to two possible outcomes: hypercapnia or hypoxia without hypercapnia.[4] Hypoxic respiratory failure (RF) (type 1 RF) is characterized by an arterial partial

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pressure of oxygen (PaO_2) less than 60 mmHg or an arterial blood oxygen saturation (SaO_2) less than 88% in room air at sea level, without hypercapnia. This condition may result from ventilation/perfusion (V/P) mismatch, shunting, hypoventilation, diffusion restriction, or low inspired oxygen pressure.[5] Hypercapnic RF (type 2 RF) is characterized by an arterial partial pressure of carbon dioxide ($PaCO_2$) ≥45 mmHg and a potential hydrogen (pH) of less than 7.35 in room air at sea level. Potential etiologies include alveolar hypoventilation, increased dead space ratio, or increased carbon dioxide production.[5] Given the overlap between the mechanisms causing hypoxemia and hypercapnia, some patients may have both disorders (mixed RF).

Evaluating nutritional status in ICUs presents significant challenges for healthcare professionals due to the diverse range of patient profiles, including variations in diagnoses, ages, comorbidities, and disease severities. Early identification of patients with poor nutritional status and heightened risk of adverse outcomes is crucial during the initial stages of ICU admission.[6] Providing adequate nutrition to critically ill individuals anticipated to remain in the ICU for over 48 hours is a widely recognized standard of care.[7] Among the available tools, the nutrition risk screening-2002 (NRS-2002)[8] and the nutritional risk in critically ill patients (NUTRIC)[9] scores are considered the most suitable for nutritional risk assessment in ICU patients, as they account for the influence of underlying diseases.[9] Nevertheless, no nutritional scoring system has been specifically validated for exclusive use in the ICU setting.[10] The NRS-2002 was not developed with the specific intention of assessing critically ill patients, and the NUTRIC does not incorporate any nutritional parameters.[10]

Although the NRS-2002 includes nutritional parameters such as body-mass index (BMI) below 20.5 kg/m², recent weight loss, and reduced food intake, it was not originally designed for critically ill patients.[9] It also integrates clinical metrics like the severity of illness and the acute physiology and chronic health evaluation II (APACHE II) score.[9] Conversely, the NUTRIC score was explicitly developed to identify ICU patients at nutritional risk who might benefit from intensive nutritional intervention.[9] This tool incorporates variables such as APACHE II and sequential organ failure assessment (SOFA) scores, patient age, comorbidities, hospitalization duration prior to ICU admission, and serum interleukin-6 (IL-6) levels.[9] Given the limited availability of IL-6 in clinical practice, a modified version of the NUTRIC score (modified NUTRIC (mNUTRIC)) excludes this parameter.[11] The mNUTRIC categorizes patients into low-risk (0–4) and high-risk (5–9) groups, with the latter indicating a poorer prognosis.[9,12]

Although both mNUTRIC and NRS-2002 have been proposed, there is no evidence on which scale should be prioritized in the nutritional care protocol of critically ill patients in resource-limited settings. The clinical outcomes of these tools in predicting mortality in the ICU general population have been explored in a limited number of studies, with no existing literature on their use in ICU patients with ARF.[2,12] The present study was designed with the hypothesis that the combined use of NRS-2002 and mNUTRIC scores would outperform the use of these tools alone in predicting mortality in a cohort of ICU patients with ARF. The objective of this study was twofold: first, to evaluate the performance of nutritional screening tools, both as standalone measures and in combination, in predicting 1-month and 3-month mortality in critically ill patients admitted to the ICU with ARF; and second, to assess whether the prognostic performance of these tools varies according to the type of RF.

METHODS

Ethics

This prospective cohort descriptive study was initiated after approval from the Clinical Researches Ethics Committee of Health Sciences University, Ankara Atatürk Sanatorium Training and Research Hospital (Date: 08.02.2023, Decision No: 2012-KAEK-15/2627) and clinicaltrials.gov registration number: NCT06115525. All procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national) and the Declaration of Helsinki revised in 2013. Our hospital is a regional medical facility specializing in the treatment and follow-up of patients with RF.

Study Design and Patients

The study population included all patients over the age of 18 years who were hospitalized with ARF in the tertiary ICUs of the anesthesiology and reanimation department of our hospital between February 15, 2023 and August 15, 2023. Informed consent was obtained from all participants or their first-degree relatives. Patients with a diagnosis of malignancy whose treatment process was terminated due to lack of response to treatment, patients with diagnosed neurodegenerative diseases (Alzheimer's and other dementias, Parkinson's, Prion, Motor neuron, Huntington's, Spinocerebellar ataxia, Spinal muscular atrophy), patients with mixed type (hypoxia and hypercapnia) RF, pregnant women, and those who refused to give written consent by themselves or their first-degree relatives were excluded from the study. Furthermore, patients who remained in the ICU for less than 48 hours and subsequently expired within 48 hours were excluded from the study. In the event of recurrent ICU hospitalizations, patient follow-up was maintained throughout the study period, with data from the patient's initial hospitalization being considered.

Patients who met the inclusion criteria were included in the study after the 48th hour of ICU hospitalization and were followed up through their medical records until discharge from the hospital or death. The data utilized in this study were obtained from physical and electronic records, as well as from the patients themselves, the care team, family members, and/or companions. No changes were made to patients' treatment while in hospital. The study was terminated at the completion of three months (90-day) of follow-up (November 12, 2023), based on the date the last patient was included (August 15, 2023).

The study was developed in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) statement.

Overall Evaluation

The clinical and demographic characteristics of patients admitted with ARF were obtained from the medical records. These characteristics included the patients' age, gender, weight, height, BMI, mode of admission (emergency, ward (clinical service, palliative, second step ICU), outpatient center), presence/absence of comorbidities, and history of malignancy. SOFA scores were calculated at admission, and APACHE II scores were calculated at the 24th hour of hospitalization. These scores were obtained from the medical records. Patients were weighed at admission and discharge from the ICU and recorded in the follow-up file. The following clinical outcome measures were recorded: length of ICU stay, ICU readmission, MV use, inotrope support intake, 1-month mortality, and 3-month mortality. All patients were followed up until they were discharged from the hospital or died, and discharged patients were contacted one month and three months later, and their mortality status was recorded by telephone.

ARF was defined as the presence of respiratory complaints during the patient's ICU hospitalization. Patients with PaO_2 levels below 60 mmHg or SaO_2 levels below 88% in room air during their ICU admission were classified as type 1 RF. Patients with $PaCO_2$ levels of 45 mmHg or higher (50 mmHg or higher in patients with chronic obstructive pulmonary disease (COPD)) and a pH level below 7.35 in room air were classified as type 2 RF. Patients exhibiting both of these RF types were designated as mixed type RF.[5,13]

Nutrition Screening

The nutritional status of patients admitted to our ICUs with RF was assessed by a trained nutritionist (working in the nutritional outpatient clinic of our hospital) using two tools, NRS-2002 and mNUTRIC, within 72 hours after admission to the ICU. These two tools are developed for the evaluation of ICU patients and are scores calculated without the need for patient cooperation. Additionally, both tools can be utilized in intubated patients, and the necessary data can be obtained from the patient's relatives and/or family.[10] The NRS-2002 tool assesses the nutritional risk of patients based on the following five variables: (1) unexplained weight loss in the last three months, (2) appetite, (3) body-mass index, (4) disease stressors (comorbidities), and (5) age greater than 70 years.[14] The mNUTRIC score (without IL-6) employs the following criteria for patient classification: (1) age, (2) APACHE II score, (3) SOFA score, (4) comorbidities, and (5) days of previous hospitalization prior to ICU admission.[8] Patients were defined as being at high nutritional risk when they scored ≥5 points (on one or both of these screening tools).[12]

Outcome

The primary outcome measure of the study was the ability of the NRS-2002 and mNUTRIC screening tools to predict mortality in ICU patients with ARF. The secondary outcome measure was the ability of these two screening tools, when used in combination, to predict mortality in ICU patients with ARF. The study also examined whether the predictive capability of nutritional screening tools differed based on the type of RF.

Statistical Analysis

The data obtained were analyzed with the Statistical Package for the Social Sciences 24.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were expressed as number of cases (n), percentage (%), mean±standard deviation ($\overline{X}$±SD) or median (Q1-Q3), minimum value (min), and maximum value (max). Categorical and demographic data were tabulated as n and %. The Chi-square test was employed to compare two rates. The distribution of the obtained data was evaluated using the Shapiro-Wilk test. Subsequent to the evaluation of the distribution outcomes of the numerical data, a comparison of paired groups was executed through the implementation of the Student-T test and the Mann-Whitney U test. The comparison of categorical data between groups was performed using Pearson Chi-Square test or Fisher exact test. Nutritional risk was assessed by the NRS-2002 and mNUTRIC, and then categorized as dichotomous data as <5 or ≥5 points. Univariate analysis was assessed at 1-month (30-day) and 3-month (90-day) periods, distinguishing between survivors and non-survivors. Multiple logistic regression analysis was used to calculate the relative risk (RR) and the associated 95% confidence intervals (CIs) by type of RF for mortality at 1-month and 3-month periods. Furthermore, a receiver operating characteristic (ROC) curve was constructed to compare the predictive capability of mNUTRIC and NRS-2002 scores, both individually and in combination, for 1-month and 3-month mortality. Statistical significance was set at $p<0.05$.

In the univariate analysis, logistic regression analysis was performed using statistically significant variables in terms of 1-month and 3-month ICU mortality and variables that were not statistically significant but had a p value less than 0.2. For the 1-month mortality outcome, it was determined that 14 variables could potentially be included in the multivariate logistic regression model. To assess the potential for multicollinearity, all variables were evaluated using correlation analysis, variance inflation factors, and tolerance values. However, subsequent to this analysis, it was determined that the duration of ICU stay and MV use were to be excluded from the model, as they exhibited a high correlation with the duration of MV use. SOFA score and APACHE II score were excluded from the model due to their high correlation with mNUTRIC score. The residual and Cook distance values were controlled. No data were excluded from the set. BMI (likelihood ratio (LR) test X^2 values 0.005), presence of comorbidities (LR test X^2 values 0.527) and high nutritional risk (mNUTRIC+NRS-2002) (LR test X^2 values 0.053) were excluded from the model because their contribution was too low. The final model incorporated seven variables: age, sex, mode of admission, mNUTRIC score, type of RF, duration of MV, and inotrope support intake. The overall fit of the model was confirmed by omnibus testing ($p<.001$). The model demonstrated an accuracy power of 50% (Nagelkerke $R^2=0.5058$). The multivariable logistic regression model for 3-month mortality developed with the potential inclusion of fifteen variables. To assess the potential for multicollinearity, all variables were evaluated using correlation analysis, variance inflation factors, and tolerance values. However,

subsequent to the analysis, it was determined that the duration of ICU stay and MV use were to be excluded from the model due to their high correlation with the duration of MV. Furthermore, high nutritional risk, as measured by SOFA score, APACHE II score, and mNUTRIC, was excluded from the model due to its high correlation with mNUTRIC score. Similarly, high nutritional risk as measured by NRS-2002 was excluded from the model due to its high correlation with the NRS-2002 score. Finally, high nutritional risk in terms of mNUTRIC+NRS-2002 was excluded from the model due to high correlation with mNUTRIC and NRS-2002 score. The residual and Cook distance values were controlled. No data were excluded from the set. The LR test X^2 values for age (0.838) and duration of MV (0.797) were found to be minimal contributors to the model, leading to the exclusion of these parameters. The final model incorporated six variables: mode of admission, presence of comorbidity, mNUTRIC score, NRS-2002 score, type of RF, and inotrope support intake. The overall fit of the model was confirmed by omnibus testing (p<.001). The model demonstrated an accuracy power of 55% (Nagelkerke R^2=0.5552).

RESULTS

A total of 525 patients who were hospitalized in the ICU for more than 48 hours with type 1 or type 2 ARF were included in the study. The mean age of the patients was 72±13 years, and the mean BMI was 25.2±5.9 kg/m^2. Of these patients, 327 (62.3%) were male and 463 patients (88.1%) had a chronic comorbidity. 186 (35.4%) had type 1 RF, while 339 (64.6%) had type 2 RF. The mean SOFA score was 6.7±2.2, and the mean APACHE II score was 22.9±6.7. 304 patients (57.9%) were identified as having high nutritional risk according to NRS-2002 screening (NRS-2002 ≥5), and 413 patients (78.6%) were identified as having high nutritional risk according to mNUTRIC screening (mNUTRIC ≥5). Furthermore, 250 patients (47.6%) exhibited high nutritional risk according to both screening tools (NRS-2002 ≥5 and mNUTRIC ≥5). 41.3% of patients were admitted from the emergency department. The mean length of ICU stay was 9±8 days, and the mean length of hospitalization was 20±15 days. During any period of ICU hospitalization, 295 patients (56.2%) received invasive MV support and 187 patients (35.6%) received inotropic support. Tracheostomy was observed in 15 patients (2.8%). 124 patients (23.6%) were readmitted to the ICU. The mortality rate at one-month follow-up was 232 patients (44.2%), and the mortality rate at three-month follow-up was 328 patients (62.5%).

1-Month Mortality

When 1-month mortality was evaluated, demographic and clinical characteristics between survivors and non-survivors are presented in **Table 1**. Demographically, higher mortality rates were observed in the older age group, male gender, those with higher disease severity (APACHE II, SOFA), those with comorbidities, and those hospitalized in the ward (p<0.05). Clinically, a higher mortality rate was observed in patients with high mNUTRIC scores, type 1 RF, invasive MV, and inotrope support (p<0.05). Furthermore, the duration of invasive MV and ICU hospitalization was found to be significantly prolonged in non-survivors (p=0.002).

The findings of the logistic regression analysis for 1-month mortality are delineated in **Table 2**. The multivariate analysis revealed that a high mNUTRIC score, the presence of inotropic support, male gender, type 1 RF, and admission to the ICU were independent variables that were significantly associated with 1-month patient mortality. The LR analysis revealed that the mNUTRIC score contributed the most to the model, with LR test X^2 values of 49.6 and a p-value of <.001. The diagnostic performance of the model was 80.9% sensitivity and 79.6% specificity, with an area under the ROC curve (AUC) of 0.86 (**Figure 1**). When the mNUTRIC score, the most significant contributor to the model, was considered individually, the AUC for 1-month mortality was 0.77; the best cut-off value was 6 (sensitivity and specificity 79% and 62%, respectively) and the youden index was 0.41.

The RR of 1-month mortality in patients with RF according to mNUTRIC, NRS-2002, or both is detailed in **Table 3**. In patients categorized as at high nutritional risk according to mNUTRIC (score ≥5), the 1-month mortality risk was found to be 8 times higher in patients with type 1 RF and 3 times higher in patients with type 2 RF (p<.001). Conversely, in patients assessed to be at high nutritional risk according to NRS-2002 (score ≥5), no statistically significant increase in the risk of death was observed in either type of RF (p values; 0.640, 0.923, respectively). With respect to the complementarity of these tools, the 1-month mortality risk of patients classified as at nutritional risk according to both mNUTRIC and NRS-2002 scores was not statistically significantly increased in the type 1 RF group (p=0.115), but was 1.45 times higher in the type 2 RF group (p=0.010).

3-Month Mortality

Table 4 presents the demographic and clinical characteristics of 3-month survivors and non-survivors. Demographically, higher mortality rates were observed in the older age group, those with higher disease severity (APACHE II, SOFA), those with comorbidities, and those hospitalized in the ward (p<0.05). Clinically, a higher mortality rates were observed in patients with elevated mNUTRIC scores, severe NRS-2002 scores, type 1 RF, invasive MV, and inotrope support (p<0.05). Furthermore, the duration of invasive MV and ICU hospitalization was found to be significantly prolonged in non-survivors (p<.001).

The findings of the logistic regression analysis for 3-month mortality are delineated in **Table 5**. The multivariate analysis revealed that a high mNUTRIC score, the presence of inotropic support, type 1 RF, the presence of comorbidity, and admission to the ICU were independent variables that were significantly associated with 3-month patient mortality. The LR analysis revealed that the mNUTRIC score contributed the most to the model, with LR test X^2 values of 70.1 and a p-value of <.001. The diagnostic performance of the model was 89.2% sensitivity and 74.4% specificity, with an AUC of 0.89 (**Figure 2**). The AUC for 3-month mortality considering the mNUTRIC score alone, the highest contributor to the model, was 0.82; the best cut-off value was 6 (sensitivity and specificity 76% and 76%, respectively), and the youden index was 0.52.

Table 1. Demographic and clinical characteristics of 1-month survivors and non-survivors

		Survivors, (n=293)	Non-survivors, (n=232)	p-value
Age, year, median (Q1-Q3)		72 (64-82)	75 (66-84)	0.019
Gender, n (%)	Female	124 (62.6%)	74 (37.4%)	0.014
	Male	169 (51.7%)	158 (48.3%)	
BMI, kg/m², median (Q1-Q3)		25.9 (21.5-29.1)	24.2 (22-27.6)	0.088
APACHE II score, median (Q1-Q3)		20 (17- 24)	26 (20-31)	**<.001**
SOFA score, median (Q1-Q3)		5 (5-6)	8 (6-9)	**<.001**
Presence of comorbidity	No, n (%)	42 (67.7%)	20 (32.3%)	**0.044**
	Yes, n (%)	251 (54.2%)	212 (45.8%)	
mNUTRIC score, median (Q1-Q3)		5 (4-6)	7 (6-8)	**<.001**
mNUTRIC score	<5, n (%)	98 (87.5%)	14 (12.5%)	**<.001**
	≥5, n (%)	195 (47.2%)	218 (52.8%)	
NRS-2002 score, median (Q1-Q3)		5 (4-5)	5 (4-5)	0.976
NRS-2002 score	<5, n (%)	125 (56.6%)	96 (43.4%)	0.767
	≥5, n (%)	168 (55.3%)	136 (44.7%)	
mNUTRIC+NRS-2002 score	<5, n (%)	175 (63.6%)	100 (36.4%)	**<.001**
	≥5, n (%)	118 (47.2%)	132 (52.8%)	
Mode of admission	Emergency, n (%)	135 (62.2%)	82 (37.8%)	**<.001**
	Ward, n (%)	60 (39.2%)	93 (60.8%)	
	Outpatient center, n (%)	98 (63.2%)	57 (36.8%)	
Respiratory failure	Type 1, n (%)	74 (39.8%)	112 (60.2%)	**<.001**
	Type 2, n (%)	219 (64.6%)	120 (35.4%)	
Invasive MV	No, n (%)	206 (89.6%)	24 (10.4%)	**<.001**
	Yes, n (%)	87 (29.5%)	208 (70.5%)	
Invasive MV duration, day, median (Q1-Q3)		0 (0-3)	3 (1-9.7)	**<.001**
Inotrope support	No, n (%)	242 (71.6%)	96 (28.4%)	**<.001**
	Yes, n (%)	51 (27.3%)	136 (72.7%)	
ICU readmission	No, n (%)	223 (55.6%)	178 (44.4%)	0.869
	Yes, n (%)	70 (56.4%)	54 (43.6%)	
Length of ICU stay, day, median (Q1-Q3)		5 (3-10)	6 (4-14.2)	0.002

Continuous variables are expressed as either the mean±standard deviation (SD) or median (Q1-Q3) and categorical variables are expressed as either frequency (percentage). Continuous variables were compared with Student-t test or Mann-Whitney U test, and categorical variables were compared using Pearson's Chi-square test or Fisher exact test.
APACHE II: Acute physiologic assessment and chronic health evaluation, BMI: Body-mass index, ICU: Intensive care unit, mNUTRIC: Modified nutritional risk in critically ill patients, MV: Mechanical ventilation, NRS-2002: Nutrition risk screening-2002, SD: Standard deviation, SOFA: Sequential organ failure assessment

Table 2. Univariate and multivariate logistic regression modeling for 1-month mortality

Prediction variable	Unadjusted			Adjusted		
	OR	95% CI	p-value	OR	95% CI	p-value
mNUTRIC score	2.28	1.89-2.75	<.001	2.21	1.72-2.82	<.001
Inotropic support, yes	9.89	5.97-16.38	**<.001**	6.75	3.65-12.48	**<.001**
Gender, male	1.79	1.17-2.73	**0.007**	2.55	1.44-4.50	**<.001**
Respiratory failure, type 1	2.59	1.71-3.93	**<.001**	1.98	1.16-3.37	**0.012**
Mode of admission, ward	2.57	1.63-4.07	**<.001**	2	1.12-3.56	**0.018**
Age, year	1.02	1-1.04	**0.002**	0.98	0.96-1	0.108
Invasive MV duration, day	1.05	1.02-1.08	**<.001**	0.98	0.94-1.01	0.251

mNUTRIC: Modified nutritional risk in critically ill patients, MV: Mechanical ventilation, OR: Odds ratio, CI: Confidence interval

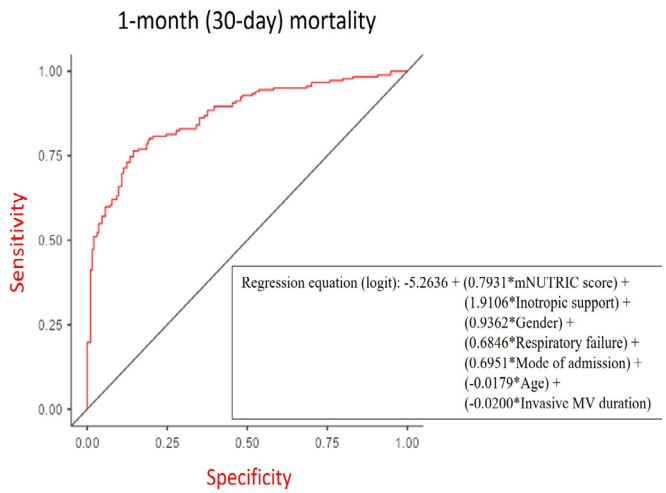

Figure 1. Area under the receiver operating characteristic curve of the model for predicting 1-month mortality in patients hospitalized with respiratory failure in the intensive care unit

Table 3. Relative risk values for 1-month mortality according to types of respiratory failure according to mNUTRIC, NRS-2002 or both

	RR	95% CI	p-value
All			
mNUTRIC ≥5	4.2	2.56-6.95	**<.001**
NRS-2002 ≥5	1.03	0.84-1.25	0.768
mNUTRIC+NRS-2002 ≥5	1.45	1.19-1.76	**<.001**
Type-1 RF			
mNUTRIC ≥5	8.14	2.15-30.84	**0.002**
NRS-2002 ≥5	0.94	0.74-1.20	0.640
mNUTRIC+NRS-2002 ≥5	1.22	0.95-1.57	0.115
Type-2 RF			
mNUTRIC ≥5	3.15	1.83-5.44	**<.001**
NRS-2002 ≥5	0.98	0.73-1.31	0.923
mNUTRIC+NRS-2002 ≥5	1.45	1.09-1.93	**0.010**

mNUTRIC: Modified nutritional risk in critically ill patients, NRS-2002: Nutrition risk screening-2002, RF: Respiratory failure, RR: Relative risk, CI: Confidence interval

The RR of 3-month mortality in patients with RF according to mNUTRIC, NRS-2002, or both is detailed in **Table 6**. In patients categorized as at high nutritional risk according

Table 4. Demographic and clinical characteristics of 3-month survivors and non-survivors

		Survivors, (n=197)	Non-survivors, (n=328)	p-value
Age, year, median (Q1-Q3)		70 (63-80)	76 (65-85)	<.001
Gender, n (%)	Female	78 (39.4%)	120 (60.6%)	0.491
	Male	119 (36.4%)	208 (63.6%)	
BMI, kg/m², median (Q1-Q3)		25.9 (21.3-29.1)	24.5 (22-27.9)	0.350
APACHE II score, median (Q1-Q3)		19 (17-23)	24.5 (19-29)	**<.001**
SOFA score, median (Q1-Q3)		5 (5-6)	7 (6-9)	**<.001**
Presence of comorbidity	No, n (%)	36 (58%)	26 (42%)	**<.001**
	Yes, n (%)	161 (34.8%)	302 (65.2%)	
mNUTRIC score, median (Q1-Q3)		5 (4-5)	6 (6-7)	**<.001**
mNUTRIC score	<5, n (%)	94 (84%)	18 (16%)	**<.001**
	≥5, n (%)	103 (24.9%)	310 (75.1%)	
NRS-2002 score, median (Q1-Q3)		5 (4-5)	5 (4-5)	**0.039**
NRS-2002 score	<5, n (%)	94 (42.5%)	127 (57.5%)	**0.043**
	≥5, n (%)	103 (33.9%)	201 (66.1%)	
mNUTRIC+NRS-2002 score	<5, n (%)	140 (50.9%)	135 (49.1%)	**<.001**
	≥5, n (%)	57 (22.8%)	193 (77.2%)	
Mode of admission	Emergency, n (%)	111 (51.2%)	106 (48.8%)	**<.001**
	Ward, n (%)	33 (21.6%)	120 (78.4%)	
	Outpatient center, n (%)	53 (34.2%)	102 (65.8%)	
Respiratory failure	Type 1, n (%)	40 (21.5%)	146 (78.5%)	**<.001**
	Type 2, n (%)	157 (46.3%)	182 (53.7%)	
Invasive MV	No, n (%)	152 (66.1%)	78 (33.9%)	**<.001**
	Yes, n (%)	45 (15.3%)	250 (84.7%)	
Invasive MV duration, day, median (Q1-Q3)		0 (0-1)	3 (1-8)	**<.001**
Inotrope support	No, n (%)	181 (53.5%)	157 (46.5%)	**<.001**
	Yes, n (%)	16 (8.6%)	171 (91.4%)	
ICU readmission	No, n (%)	158 (39.4%)	243 (60.6%)	0.110
	Yes, n (%)	39 (31.5%)	85 (68.5%)	
Length of ICU stay, day, median (Q1-Q3)		5 (3-8)	6 (4-15)	<.001

Continuous variables are expressed as either the mean±standard deviation (SD) or median (Q1-Q3) and categorical variables are expressed as either frequency (percentage). Continuous variables were compared with Student-t test or Mann-Whitney U test, and categorical variables were compared using Pearson's Chi-square test or Fisher exact test.
APACHE II: Acute physiologic assessment and chronic health evaluation, BMI: Body-mass index, ICU: Intensive care unit, mNUTRIC: Modified nutritional risk in critically ill patients, MV: Mechanical ventilation, NRS-2002: Nutrition risk screening-2002, SD: Standard deviation, SOFA: Sequential organ failure assessment

Table 5. Univariate and multivariate logistic regression modeling for 3-month mortality

Prediction variable	Unadjusted			Adjusted		
	OR	95% CI	p-value	OR	95% CI	p-value
mNUTRIC score	2.80	2.24-3.51	<.001	2.48	1.93-3.19	<.001
Inotropic support, yes	15.96	7.48-34.06	**<.001**	8.63	3.66-20.3	**<.001**
Respiratory failure, type 1	2.95	1.88-4.64	**<.001**	3.1	1.68-5.71	**<.001**
Mode of admission, ward	2.86	1.67-4.89	**<.001**	2.25	1.13-4.46	**0.020**
Presence of comorbidity, yes	2.64	1.01-6.86	**0.046**	4.11	1.06-15.98	**0.041**
NRS-2002 score	1.19	0.92-1.54	0.170	0.68	0.47-1.00	0.055

mNUTRIC: Modified nutritional risk in critically ill patients, NRS-2002: Nutrition risk screening-2002, OR: Odds ratio, CI: Confidence interval

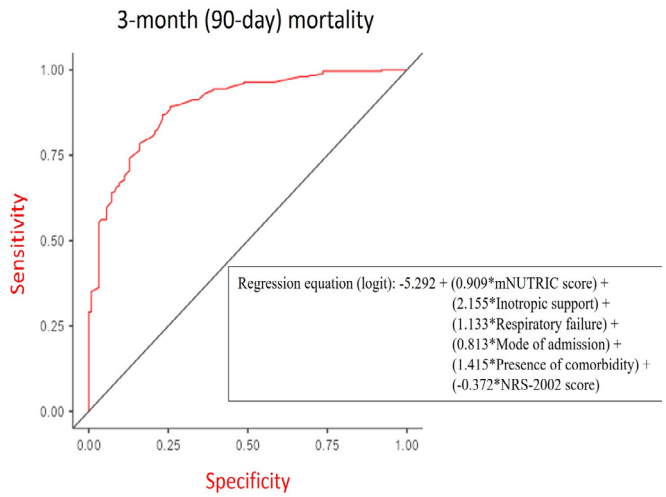

Figure 2. Area under the receiver operating characteristic curve of the model for predicting 3-month mortality in patients hospitalized with respiratory failure in the intensive care unit

Table 6. Relative risk values for 3-month mortality according to types of respiratory failure according to mNUTRIC, NRS-2002 or both

	RR	95% CI	p-value
All			
mNUTRIC ≥5	4.6	3.04-7.15	**<.001**
NRS-2002 ≥5	1.15	1.00-1.32	**0.048**
mNUTRIC+NRS-2002 ≥5	1.57	1.37-1.80	**<.001**
Type-1 RF			
mNUTRIC ≥5	10.66	2.82-40.25	**<.001**
NRS-2002 ≥5	1.00	0.85-1.18	0.929
mNUTRIC+NRS-2002 ≥5	1.31	1.10-1.56	**0.002**
Type-2 RF			
mNUTRIC ≥5	3.63	2.31-5.71	**<.001**
NRS-2002 ≥5	1.17	0.96-1.44	0.115
mNUTRIC+NRS-2002 ≥5	1.63	1.34-1.99	**<.001**

mNUTRIC: Modified nutritional risk in critically ill patients, NRS-2002: Nutrition risk screening-2002, RF: Respiratory failure, RR: Relative risk, CI: Confidence interval

to mNUTRIC (score ≥5), the 3-month mortality risk was found to be 10 times higher in patients with type 1 RF and 3 times higher in patients with type 2 RF (p<.001).

Conversely, in patients assessed to be at high nutritional risk according to NRS-2002 (score ≥5), no statistically significant increase in the risk of death was observed in either type of RF (p values; 0.929, 0.115, respectively). With respect to the complementarity of these tools, the 3-month mortality risk of patients classified as at nutritional risk according to both mNUTRIC and NRS-2002 scores was 1.31 times higher in the type 1 RF group (p=0.002) and 1.63 times higher in the type 2 RF group (p<.001).

DISCUSSION

In the present study, we identified the mNUTRIC score as a robust predictor of 1-month and 3-month mortality in a cohort of patients admitted to a tertiary ICU with type 1 and type 2 RF. Furthermore, the mortality rates were found to be higher in patients with type 1 RF compared to those with type 2 RF, both at one month and three months following admission. Multivariate logistic regression analysis revealed that a high mNUTRIC score, the presence of inotropic support, type 1 RF, and admission to the ward were strongly associated with 1-month and 3-month mortality. Tertiary intensive care beds, defined as those with high occupancy rates resulting from an aging population and advancements in medical technology, are a priority allocation of hospital beds. The ICU length of stay for patients is consistently costly and rising.[15] mNUTRIC and NRS-2002 are the most frequently employed nutritional screening instruments in clinical practice.[12] The utilization of these tools facilitates the early identification of nutritional risk, thereby enabling the timely implementation of specialized and comprehensive nutritional therapy, which is particularly beneficial for patients with severe malnutrition.[9] While our study was conducted in a cohort of patients with RF, the importance of nutrition and its screening in terms of mortality in critically ill patients is clear. The findings of this study indicate that addressing nutritional adequacy may be a crucial measure to reduce mortality in patients with RF.

RF is among the most prevalent etiologies for hospitalization and ICU admissions, with a wide range of underlying causes. Data demonstrate that ARF is present in 32% of patients admitted to the ICU and 24% of patients develop ARF during their ICU stay.[16] The underlying pathophysiology of RF can be multifaceted, involving various mechanisms such as hypoventilation, diffusion impairment, shunting, ventilation-perfusion mismatch, or a combination of these factors.[17] The necessity for ventilatory support is observed in 43-63% of ICU admissions with RF.[2,3,16] Nutritional management of patients with ARF necessitates a multidisciplinary approach.[18] Nutritional status is intricately linked to respiratory function, and a comprehensive understanding of these interrelationships holds therapeutic potential. Malnutrition has been demonstrated to be associated with impaired mechanical function of the lung in both chronic and acute RF.[19] Appropriate and effective patient care and treatment have been shown to reduce complications, shorten ICU and hospital stays, and improve survival rates.[17] The present study examined a cohort of 525 patients, with 186 (35.4%) experiencing type 1 RF and 339 (64.6%) encountering type 2 RF. The necessity for invasive MV support during ICU hospitalization was observed in 56.2% of patients, a finding that aligns with literature data. The mortality rates at one and three months were found to be high in patients with type 1 RF. This underscores the need for enhanced patient care and nutritional interventions to minimize mortality, particularly among patients with type 1 RF who require inotrope and MV support.

The efficacy of early nutritional intervention in critically ill patients is well-documented.[9,20] Recent studies have proposed the use of screening tools and nutritional assessment in conjunction with multiple screening tools for ICU patients.[21] A cross-sectional study of 159 patients compared the predictive power of mNUTRIC and Subjective Global Assessment (SGA), used alone or in combination, to predict the 28-day mortality risk in the ICU. The study revealed that patients classified by mNUTRIC as at nutritional risk (score ≥4) exhibited a 7-fold higher risk of death at the 28-day assessment.[21] Another study of 439 ICU patients evaluated the correlation between mNUTRIC and SGA and showed that the combination of the two has better, significant predictive capacity for in-hospital mortality.[22] The NRS 2002 and NUTRIC scores have been developed to incorporate severity of illness, making them potentially suitable for use in critically ill patients.[20] The NRS 2002 has gained the most traction as a screening instrument to identify hospitalized patients who may benefit from nutritional support.[8] The NRS 2002 is notable for its ease of calculation and the minimal time and data points required for its implementation. The association between the nutritional risk ascertained by the NRS-2002 tool and adverse clinical outcomes, including sepsis and mortality, has been demonstrated.[23,24] The American society for parenteral and enteral nutrition (ASPEN) guidelines have demonstrated the NRS-2002's capacity to differentiate between critically ill patients based on clinical characteristics and outcomes.[24] Furthermore, patients assessed by NRS-2002 to be at high nutritional risk (score ≥3) were reported to have a 2.10-fold increased risk of death in the ICU.[24] Conversely, the NUTRIC score, a tool developed and validated in the intensive care setting, was designed to identify patients who would benefit from aggressive nutritional support, thereby improving adverse clinical outcomes.[9] In a retrospective study, Canales et al.[20] investigated the association of NUTRIC and NRS 2002 scores with macronutrient deficiency in critically ill patients. The study found that NUTRIC scores were associated with macronutrient deficiency in ICU patients, while NRS 2002 scores were not associated with macronutrient deficiency. In their study comparing mNUTRIC and NRS 2002, Machado et al.[12] found a high nutritional risk in 48.4% of NRS-2002 and 54.4% of mNUTRIC in ICU patients. In their 28-day mortality study, they found that the risk of death in the ICU increased 1.41-fold in patients who were assessed to be at high nutritional risk (score ≥5) by NRS-2002, and the risk of death in the ICU increased 3.01-fold in patients who were assessed to be at high nutritional risk (score ≥5) by mNUTRIC.[12] In the present study, which evaluated both 1-month and 3-month mortality in patients admitted to the ICU with RF, the mNUTRIC score emerged as the most robust predictor of mortality. According to the NRS-2002 score, 57.9% of patients exhibited high nutritional risk, while the proportion increased to 78.6% when the mNUTRIC score was considered. This figure exceeded

the rates reported in the extant literature. Furthermore, the prevalence of high nutritional risk (score ≥5) varied according to the specific type of RF. In type 1 RF, the NRS-2002 score identified high nutritional risk in 65.5% of patients, while the mNUTRIC score identified high nutritional risk in 87.1% of patients. In contrast, in type 2 RF, these values were 53.6% according to the NRS-2002 score and 74% according to the mNUTRIC score. These findings underscore the critical importance of nutritional management in patients with RF, particularly in hypoxic patients with type 1 RF, within ICUs. The NRS-2002 score demonstrated no statistical significance in the 1-month mortality assessment. However, a marked increase in mortality was observed, reaching 4.2-fold, in patients evaluated as being at high nutritional risk (score ≥5) by mNUTRIC. In the 3-month mortality assessment, the mortality rate increased 1.15-fold in patients assessed to be at high nutritional risk (score ≥5) by NRS-2002 and 4.6-fold in patients assessed by mNUTRIC. These findings were consistent across different types of RF. The mNUTRIC score emerges as a valuable tool for evaluating patients hospitalized in ICU with RF, applicable to both types of RF. It is noteworthy that the NRS-2002, despite its ease of administration relative to the mNUTRIC, did not demonstrate significant outcomes in ICU patients with RF, particularly in terms of short-term mortality assessment and management.

Limitations

It is imperative to acknowledge the limitations inherent in the present study. Firstly, the study design was observational, single-center, and consequently, the possibility of residual confounding due to unmeasured factors influencing the observed associations cannot be excluded. Furthermore, the inclusion of patients with RF, along with the exclusion of those with mixed-type RF, was a deliberate strategy employed to provide a clear assessment of the outcomes associated with hypoxic and hypercarbic RF. Additionally, the dietary intake of patients was not analyzed in this study. However, the NRS-2002 nutrition screening tool, which includes criteria such as decreased food intake in the last week and recent weight loss, addresses this aspect. It is also important to note that the administration of these screening tools is carried out by a trained nutrition nurse, with direct supervision ensuring the integrity of the process. Therefore, we excluded ICU hospitalizations of less than 48 hours. Furthermore, the present sample included ICU patients with RF, and therefore, the results cannot be generalized to all ICU patients or hospitalized patients. Finally, the study was not designed to conduct a therapeutic analysis, and as such, data regarding treatment management was not available for analysis.

CONCLUSION

The findings of this study indicate that nutritional management is of critical importance in patients hospitalized in the tertiary ICU with RF. In such cases, the utilization of the mNUTRIC nutrition screening tool emerges as a more valuable method for evaluating patients than the NRS-2002 score or both scores in combination. While the NRS-2002 nutrition screening tool is more straightforward to administer, the mNUTRIC tool provides more meaningful results, particularly in the context of short-term mortality assessment and management in ICU patients with type 1 RF. Despite the mNUTRIC score's inclusion of additional parameters, it can be readily derived from the initial data of ICU patients and is the most effective parameter in identifying the high-risk group when the data from our study are considered. In addition to the mNUTRIC score, the presence of inotropic support, type 1 RF, and ward admission are predictors strongly associated with 1-month and 3-month mortality in patients with RF. The prognosis for patients with type 1 RF is worse than for those with type 2, and nutritional management is much more important in this patient group. Especially in patients with high mNUTRIC score, need for inotropic support, and need for ICU while hospitalized with type 1 RF, early intervention and management in terms of nutrition is important to improve the duration of ICU stay and mortality rates.

ETHICAL DECLARATIONS

Ethics Committee Approval

This prospective cohort descriptive study was initiated after approval from the Clinical Researches Ethics Committee of Health Sciences University, Ankara Atatürk Sanatorium Training and Research Hospital (Date: 08.02.2023, Decision No: 2012-KAEK-15/2627).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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