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Clinical Research Study

Use of a Nutritional Risk Assessment Tool to Guide Early Enteral Nutrition among Mechanically Ventilated Trauma Patients ☆

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ABSTRACT

Background: The Modified Nutritional Risk in Critically Ill (mNUTRIC) score has been proposed as a tool to identify hospitalized patients at risk for malnutrition who may benefit from early enteral nutrition (EN) therapy.
Objective: Our goal was to determine if mNUTRIC scores could predict, at time of intensive care unit admission, which mechanically ventilated trauma patients were at risk for malnutrition and might benefit from early EN, as indicated by reduced mortality.
Methods: We conducted a retrospective chart review of all adult trauma patients requiring mechanical ventilation for at least 48 hours between 01/21/2012 and 12/31/2016, reviewing inpatient medical records, demographic data, disease markers, injury severity, and comorbidities. Bivariate statistics and multivariate regression analyses were used to investigate the correlation between time of EN initiation and mortality rates, as well as the relationship of mNUTRIC scores with EN commencement with early EN initiation being ≤48 hours and malnutrition risk mNUTRIC ≥5.
Results: Among 931 patients reviewed, bivariate analysis showed higher mNUTRIC scores correlated with older, sicker patients and higher mortality. However, multivariate analysis revealed no significant association between higher mNUTRIC scores and increased mortality (OR 1.2, 95% CI 0.7-2.1, p=0.52). Although most patients received EN within 48 hours, there was no association between mNUTRIC score and timing of EN initiation after adjusting for demographic variables and illness severity.
Conclusions: Our findings indicate that while the mNUTRIC score can effectively identify malnutrition risk, it does not meaningfully inform early EN initiation timing nor predict mortality in mechanically ventilated trauma patients.

Introduction

Overview + Scope of issue. Achieving and maintaining optimal nutritional balance is an integral part of the treatment plan for hospitalized patients.[1,2] However, the nutritional status of patients admitted to an intensive care unit (ICU) may vary significantly and can be influenced by multiple factors such as acute and chronic starvation, severity of the underlying pathology leading to ICU admission, and an often-pronounced catabolic response to their condition that precipitates rapid loss of lean body mass.[1-6] In fact, an estimated 35% of patients admitted to the hospital are malnourished, many of whom were admitted undernourished to begin with and the majority of which develop malnutrition during their hospitalization.[7-10] The precise definition and criteria of malnourishment has varied in the literature but generally be defined clinically as cachexia or sarcopenia with supporting anthropomorphic measurements such as body mass index less than 20, triceps skin fold thickness and/or mid arm muscle circumference (<15 percentile).[9,10] In critically ill patients, malnutrition is associated with impaired wound healing, muscle wasting, fluid/electrolyte imbalances, and compromised immune function leading to higher rates of nosocomial infection and sepsis, as well

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; EN, enteral nutrition; ICU, intensive care unit; NUTRIC, Nutrition Risk In Critically Ill; mNUTRIC, Modified Nutritional Risk in Critically Ill; SICU, surgical intensive care unit; SOFA, Sequential Organ Failure Assessment.

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as increases in all-cause mortality.[11] The scope of this issue is significant, given the approximately 107,276 ICU beds available in the United States, equating to about 34.7 critical care beds per 100,000 people.[12,13] Even before the COVID-19 pandemic, roughly two-thirds of these beds were typically occupied, a third of which required ventilation and therefore special nutritional support.[14]

Enteral + Parenteral nutrition. Intubated and mechanically ventilated patients have heightened metabolic demands requiring special nutritional support, which can be provided through parenteral and/or enteral routes. When compared to the parenteral route, the more physiologically similar enteral nutrition (EN) has certain advantages, such as preserving intestinal microbial diversity, gut structure, and function, as well as supporting aspects of immune function. This is especially important in critically ill patients where compromising these immunocompetent barriers can contribute to complications like pneumonia, sepsis, and multiple organ dysfunction.[15] Specifically, EN's role in intestinal stimulation helps maintain the mucosal structure of the gastrointestinal system, reducing rates of gastrointestinal hemorrhage and infectious sequelae related to barrier compromise (ie, sepsis onset, organ failure), resulting in shorter hospital length of stay and/or improved patient survival.[16-18] Although some studies have indicated no difference in overall mortality among enteral vs parenteral nutrition, EN has shown strong evidence for reducing infectious complications and total length of ICU stay.[19,20] Regarding timing of initiating EN, there is evidence that early EN in critically ill patients can confer additional mortality benefit and reduction in morbidity parameters like sepsis and pneumonia.[16,17]

Owing to the clinical benefits of early EN, many guidelines now support its initiation within the first 48 hours of ICU admission for patients unable to tolerate oral intake.[1,2,7,21,22] This endorsement stems from both the improved outcomes observed in these patients and the advancements in enteral feeding modalities (ie, nasogastric and nasojejunal tubes), improved enteral formulas, and enteral feeding regimens including use of volume-based feeding protocols to improve formula provision. Thus, EN has emerged as the predominant method for meeting the nutritional needs of these patients, except in cases with contraindications like ileus, obstruction, an inaccessible gut, and high-loss fistulae. However, it is important to note that despite EN potentially being a superior form of nutrition for these patients, it—like any form of medical intervention—is not without its associated risks. Notably, for EN, specific complications can include tube mal-positioning/dislodgment, aspiration, fluid imbalance, mild gastrointestinal intolerance (ie, nausea, vomiting, constipation), as well as increased risk of more severe, although rare, gastrointestinal complications like bowel ischemia and colonic pseudo-obstruction.[22,23] Consequently, a risk-benefit analysis, including the risk for malnutrition, if feeding is withheld, should be made before proceeding with any nutritional intervention, including EN, in order to identify patients who might benefit from aggressive nutritional intervention.[18]

NUTRIC + Modified Nutritional Risk in Critically Ill (mNUTRIC) scores. Algorithms designed to standardize patient selection have been developed to aid assessment and management of patient care, such as the Nutrition Risk in Critically Ill score (NUTRIC) the mNUTRIC score.[1,2,7,12,24] The original NUTRIC score, developed by Heyland and colleagues, aimed to provide an objective measure of malnutrition risk to help determine when aggressive nutritional intervention may be warranted, as not all ICU patients respond equally to such intervention. An additional benefit of the NUTRIC score design is that it accounts for additional mortality risks beyond those captured by traditional severity-of-illness measures, like the Acute Physiology and Chronic Health Evaluation (APACHE II) and baseline Sequential Organ Failure Assessment (SOFA) scoring systems.

The NUTRIC score itself is comprised of age, number of comorbidities, days from hospital to ICU admission, SOFA, APACHE II, and interleukin-6 level (IL-6). It ranges from 0 to 10, with a score of 6 or greater indicating a high nutritional risk (Appendix 1). Higher scores correlate with poorer clinical outcomes, as indicated by increased mortality and extended duration of mechanical ventilation among survivors. Conversely, the mNUTRIC score is a modification of the original NUTRIC score and includes five items: age, APACHE II score, SOFA score, number of comorbidities, and days from hospital to ICU admission. It does not require IL-6 measurement, making it more accessible to facilities without IL-6 lab capability. Despite eliminating IL-6 analysis, there was minimal statistical or clinical impact on its concordance index (0.007).[12,25] The average threshold for mNUTRIC indicating malnutrition is a score of 5 or higher, as compared to 6 or higher for NUTRIC.[25] Overall, both the mNUTRIC and the NUTRIC scores are conceptual models linking starvation, inflammation, nutritional status, and clinical outcomes.[12]

NUTRIC + mNUTRIC score threshold. After their introduction, studies have examined the association of NUTRIC and mNUTRIC scores with specific clinical outcomes in specific populations of critically ill patients. For example, the original NUTRIC score was found to reliably predict 28-day mortality and risk of developing morbidities such as pneumonia, delirium, renal failure in postoperative surgical patients.[26] Similarly certain mNUTRIC scores have been correlated with higher mortality and/or extended length of stay in various patient populations (COVID, postoperative cardiothoracic, septic patients).[27-30]

However, the optimal cut-off scores for relating mNUTRIC ranges with specific clinical endpoints of interest are still being investigated. Some have proposed a range of 0-4 as low risk, 5-9 as high risk, while others used a simple threshold of ≥5 for predicting 28-day mortality.[18,25,26,31,32] In general, the mNUTRIC score indicating malnutrition risk has varied from 4 to 6, depending underlying patient population and the specific clinical endpoints of interest such as mortality, long-term survival, and/or ICU length of stay.[27-30,34]

These findings indicate both NUTRIC and mNUTRIC scores are valid clinic tools for predicting various morbidity and mortality among specific patient populations. However, little is known about whether the mNUTRIC score can reliably predict, at the time of admission ICU, which mechanically ventilated trauma patients are (1) at risk for malnutrition, and (2) who might benefit from early EN. Being able to effectively identify malnutrition risk with mNUTRIC scores in this patient population could meaningfully inform the timing of early EN initiation to potentially reduce mortality. We hypothesize that for new patients with markers of illness such as elevated temperature, abnormal heart rate, increased respiratory rate, or elevated creatinine, the mNUTRIC score could help identify those patients most likely benefit from early EN, as measured/indicated by reduced mortality rates.

Methods

After Institutional Review Board approval, we performed a retrospective chart review of all adult trauma patients admitted to our surgical ICU (SICU) who required mechanical ventilation for more than 48 hours. This review spanned from January 1, 2012, through December 31, 2016. We collected patient-specific demographic data and medical information from inpatient medical record relevant to calculating each patient's mNUTRIC score, including age, APACHE II score, SOFA score, number of comorbidities, and number of days from hospital to ICU admission.

The inclusion criteria stipulated patients must be aged 18 or over, admitted to the Trauma Service, and required mechanical ventilation for more than 48 hours. We excluded patients who were not intubated or were extubated within 48 hours of ICU admission, and those with missing data needed to compute the mNUTRIC score. We also excluded patients with gastrointestinal injuries that may have necessitated prolonged bowel rest or total parenteral nutrition. During the 5-year pe-

Table 1
Demographic Comparisons of Newly Mechanically Ventilated Patients.

	mNUTRIC < 5 (*n* = 785)	mNUTRIC ≥ 5 (*n* = 145)	*P*-Values
Age	42.3 ± 17.2	60.6 ± 16.4	<.001
Sex			.61
Male	584	40	
Female	201	105	
APACHE score	15.2 ± 5.7	24.1 ± 6.5	<.001
SOFA score	4.8 ± 2.4	8.5 ± 3.4	<.001
Hours to EN	37.1 ± 30.4	42.8 ± 34.9	.05
GCS	9.5 ± 4.9	9.1 ± 5.3	.34
ISS	24 ± 12.8	25.1 ± 14.9	.34
Insurance			
Uninsured/Medicaid	157	18	.03
Private/Medicare	626	127	
Mortality			<.001
Lived	667	101	
Died	116	44	

Table 2
Demographic Comparisons of Outcomes of Newly Mechanically Ventilated Patients.

	Lived	Died	*P*-Values
Age	44.4 ± 18	49.4 ± 19.5	.002
Sex			.35
Male	584	114	
Female	197	46	
APACHE score	15.8 ± 6.3	20.1 ± 7.1	<.001
SOFA score	5.1 ± 2.8	6.66 ± 3.4	<.001
Hours to EN	38.3 ± 30.9	38 ± 31.1	.5
GCS	10 ± 4.9	9.5 ± 5	<.001
ISS	23.1 ± 12.8	24.1 ± 13.2	<.001
Insurance			.23
Uninsured/Medicaid	153	25	
Private/Medicare	628	136	
mNUTRIC score	2.2 ± 1.8	3.3 ± 2	<.001

riod, we identified 956 potential subjects, of whom with an average age of 42.3 years. See Appendix 2 for patient flow chart.

We obtained a patient list from the Trauma Registry, followed by a second query using patient's names and other Protected Health Information to review the patients' SICU course. The data collected from the EPIC Electronic Medical Record (EMR) system included medical record numbers, age, gender, race, hospital admission date, ICU admission date, admission diagnosis, and the date of EN initiation. We also gathered specific data required to calculate individual mNUTRIC scores noted above (age, APACHE II score, SOFA score, number of comorbidities, and number of dates of hospital to ICU admission). Based on previous studies, we designated a mNUTRIC score of 5 or greater as indicative of high malnutrition risk.[25,27-33]

We performed descriptive statistical analyses and made comparisons using Student's *t*-test or Pearson's Chi-squared test, as appropriate. Multivariable linear and logistic regression analysis were performed to determine independent predictors of time to EN and mortality, respectively.

Results

Sample characteristics. Over the 5-year study period, at total of 930 patients were included. Among these, 785 subjects (584 male, 201 female) had mNUTRIC scores below 5, and the remaining 145 subjects (40 male, 105 female) had mNUTRIC scores of 5 or above. The average age for the group with mNUTRIC scores <5 was 42.3 ± 17.2, while the group with mNUTRIC scores of ≥5, it was 60.6 ± 16.4 (Table 1).

Bivariate analysis. Generally, the group with the elevated mNUTRIC scores of 5 or more were older (60.6 vs 42.3, $P < .002$) and more clinically ill, as indicated by their higher mean APACHE scores (24.1 ± 6.5 vs 15.2 ± 5.7, $P < .001$) and SOFA scores (8.5 ± 3.4 vs 4.8 ± 2.4, $P < .001$). However, both groups had similar Glasgow Coma Scores (9.5 ± 4.9 for mNUTRIC <5 vs 9.1 ± 5.3 for mNUTRIC ≥5, $P = .34$) and Injury Severity Scores (24 ± 12.8 for mNUTRIC <5 vs 25.1 ± 14.9 for mNUTRIC ≥5, $P = .34$). Time to EN initiation was slightly longer in the group with the higher mNUTRIC scores (42.8 ± 34.9 hours vs 37.1 ± 30.4, $P = .05$). The group with higher mNUTRIC scores also had a higher mortality rate (30.3%, or 44 out of 145 patients), compared to the group with lower scores (14.7%, or 116 out of 786 patients). Of note, we did examine time to EN initiation (<48 vs >72 hours) but found no significant difference across all variables (Appendix 3).

Multivariate analysis. Although the average time to EN initiation was short, less than 48 hours for most patients, the mNUTRIC score was not associated with a longer time to EN after adjusting for age and severity of illness through multivariable linear regression analysis. However, the abdominal injury score was significantly higher in patients with a delay in EN initiation ($P = .005$). While the mNUTRIC score was associated with mortality in bivariate analysis, along with other severity markers (Table 2), it was not associated with mortality in a multivariate analysis (OR 1.2, 95% CI 0.7-2.1, $P = .52$). Ultimately, the predictors of mortality in the multivariable logistic regression model were the Injury

Severity Scores, Glasgow Coma Scores, APACHE and/or SOFA scores, and age, although the associations were weak.

Discussion

Nutritional therapy can play a crucial role in minimizing mortality and morbidity among critically ill patients. Given that EN, including early EN, carries its own risks, it is crucial to identify patients for whom the benefits of early EN outweigh those risks. This is an important decision that the critical care team must make and ideally should be augmented by clinical decision tools/algorithms when possible. To that end, the purpose of this study was to use the mNUTRIC score to predict those mechanically ventilated trauma patients who were at high risk for malnutrition, with the aim of (1) identifying shared characteristics and risk factors between high and low mNUTRIC scores and, (2) determining the ultimate impact of a high mNUTRIC score on the timing of EN initiation and mortality. We hypothesized that for new patients with markers of illness such as elevated temperature, abnormal heart rate, increased respiratory rate, or elevated creatinine, the mNUTRIC score could help identify those patients most likely benefit from early EN, as measured/indicated by reduced mortality rates.

In our retrospective study, the mNUTRIC score ultimately did not significantly correlate with the time to early EN initiation, demonstrating a negligible difference of 5 hours, with a mean time for both being under 48 hours. This is likely not a clinically significant gap of time for EN initiation that translates to differences in clinical outcomes, and we surprisingly found no meaningful difference when comparing <48 and >72 hours cohorts. As for mortality, although the mNUTRIC score did show a positive correlation with other markers of illness severity, it did not predict mortality by our multivariate analysis. Additionally, our analysis did not support the hypothesis that delays in early EN in intubated and mechanically ventilated trauma patients admitted to our SICU led to a higher mortality rate that could be predicted independently by the mNUTRIC score. However, these findings should not be considered evidence that this algorithm is not useful or effective for identifying those ICU patients at greatest risk for malnutrition who might benefit from more aggressive nutritional intervention, such as early EN to certain critically ill patients. Rather, future research should employ more detailed prospective studies, particularly those addressing barriers to early EN and/or obstacles to achieving nutritional goals and determining appropriate mNUTRIC score thresholds for specific patient population subsets (ie, trauma patients, COVID patients). Additional directions of study should examine if a lower mNUTRIC threshold (ie, 4 rather than 5) could increase the algorithm's sensitivity while maintaining a reasonable specificity that could still be generalizable to a heterogenous ICU population.

The limitations of this study include its retrospective nature and the potential impact of inclusion and exclusion of data, as well as the age of the data. Although the data in our study are not recent, their relevance should not be disregarded because it can continue to be useful tool for future comparison and trending analyses across time, which is especially important for informing and directing subsequent research about this inherently complex and nuanced topic.

Declaration of competing interest

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

CRediT authorship contribution statement

Julia Heizmann: Writing – review & editing, Writing – original draft. **Christopher Gross:** Writing – review & editing, Writing – original draft. **Chelsea Yap:** Writing – review & editing, Writing – original draft. **Mary Anne Walling:** Writing – review & editing. **Moya Reid:** Writing – review & editing. **Albert Hsu:** Writing – review & editing, Investigation, Data curation. **Marie Crandall:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation. **Jin Ra:** Writing – review & editing, Methodology, Data curation, Conceptualization.

Data Availability

Data described in the manuscript, code book, and analytic code will be made available upon request pending application and approval.

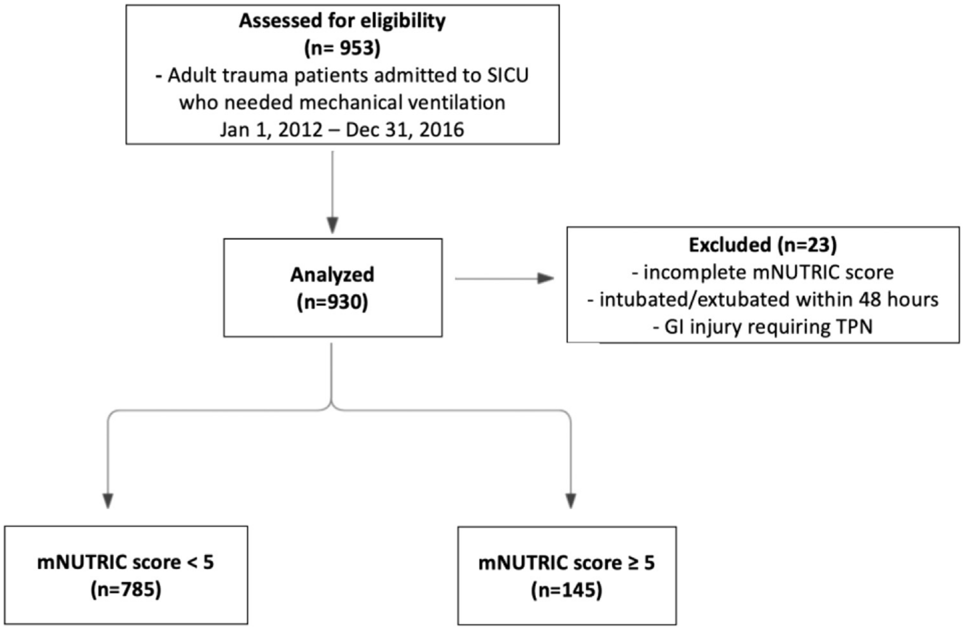
Acknowledgments

JR designed the research; MC, JR, and AH conducted the research; JR provided essential materials and constructs; MC analyzed the data; all authors helped write the paper; MC, JR, and CG had primary responsibility for final content. All content was written by participants listed above, however, artificial intelligence proofreading software was used to proofread for grammar, syntax, and punctuation errors. All authors read and approved the final manuscript.

Appendix 1. Nutrition Risk in the Critically Ill Score

Age/Year	<50	0
	50-74	+1
	≥75	+2
APACHE II	<15	0
	15-19	+1
	20-27	+2
	≥28	+3
SOFA score	<6	0
	6-9	+1
	≥10	+2
Number of comorbidities	0-1	0
	≥2	+1
Days in hospital to ICU	0	0
	≥1	+1
IL-6 u/mL	0-399	0
	≥400	+1
Maximum score	10	
Modified NUTRIC score eliminates IL-6		
Maximum score-9		

Appendix 2. Patient Flow Diagram



Appendix 3. Timing of Enteral Nutrition Comparison

	<48 Hours (n = 115)	>72 Hours (n = 18)	P-value
mNUTRIC	2.2 +/− 1.7	2.4 +/− 1.3	.75
# of comorbidities	2.4 +/− 3.1	2.8 +/− 2.5	.6
SOFA	4.8 +/− 2.8	4.7 +/− 3	.89
APACHE	15.1 +/− 6.7	14.2 +/− 5.9	.59
Age	47.2 +/− 19	52.6 +/− 17.7	.26
Sex			.94
Male	84	13	
Female	31	5	

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