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Triagem de risco nutricional em paciente crítico: análise comparativa de diferentes ferramentas e desenvolvimento de uma nova proposta mais factível ao ambiente de terapia intensiva

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Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Ciências da Nutrição da Universidade Federal de Ciências da Saúde de Porto Alegre, como requisito parcial para obtenção do título de Mestre em Ciências da Nutrição.

Orientadora: Profª Dra. Flávia Moraes Silva

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DEDICATÓRIA

À minha família e amigos.

A todos os pesquisadores e profissionais da área da saúde envolvidos no cuidado dos pacientes hospitalizados.

À minha orientadora que não mediu esforços para a conclusão deste trabalho.

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SUMÁRIO

FORMATO DA DISSERTAÇÃO

Esta dissertação foi desenvolvida com base na *Normativa de instrução para trabalho final* do Programa de Pós-graduação em Ciências da Nutrição da Universidade Federal de Ciências da Saúde de Porto Alegre, a qual pode ser consultada no site institucional (https://www.ufcspa.edu.br/index.php/stricto-sensu/ciencias-da-nutricao/arquivos).

Os produtos desta dissertação compreendem dois artigos científicos originais, conforme detalhado abaixo:

- *Concurrent and predictive validity of nutritional risk screening tools in critically ill patients: a longitudinal study,* submetido ao peródico *Journal of the Academy of Nutrition and Dietetics – J Acad Nutr Diet* (ISSN: 2212-2672; fator de impacto 4,91 - qualis A1), cujas diretrizes podem ser consultadas em https://www.jandonline.org/content/authorinfo.

- *Screening of Nutritional Risk In Intensive Care (SCREENIC score): A New Proposal for a Nutritional Screening Tool in Critically Ill Patients*, será submetido ao periódico *Clinical Nutrition* (ISSN: 0261-5614; fator de impacto: 7,643- qualis A1), cujas diretrizes podem ser consultadas em https://www.elsevier.com/journals/clinical-nutrition/0261-5614/guide-for-authors.

LISTA DE ABREVIATURAS

AMIB	Associação de Medicina Intensiva Brasileira
AND	Academia de Nutrição e Dietética / Academy of Nutrition and Dietetics
APACHE II	Acute Physiology and Chronic Health Evaluation
APMT	Adductor pollicis muscle thickness
ASBRAN	Associação Brasileira de Nutrição
ASG	Avaliação Subjetiva Global
ASPEN	American Society for Parenteral and Enteral Nutrition
AUC	Area under the curve
BMI	Body Mass index
BRASPEN	Sociedade Brasileira de Nutrição Parenteral e Enteral
CC	Calf circumference
CI	Confidence interval
CRP	C-reactive Protein
DM	Diabetes Mellitus
ESPEN	European Society for Clinical Nutrition and Metabolism
GLIM	Global Leadership Initiative on Malnutrition
GLIM	Global Leadership Initiative on Malnutrition
HAS	Hipertensão Arterial Sistêmica
HD	Hemodialysis
HR	Hazar ratio
ICU	Intensive care unit
IFN-γ	Interferon gama
IL-1	Interleucina-1
IL-10	Interleucina-10
IL-2	Interleucina-2
IL-6	Interleucina-6
IMC	Índice de Massa Corporal
LOS	Length of stay
MAC	Mid-arm circumference
MAG-BAPEN	Malnutrition Advisory Group of the British Association for Parenteral and Enteral Nutrition
MM	Muscle mass

mNUTRIC	Modified Nutrition Risk in Critically Ill
MST	Malnutrition Screening Tool
MUST	Malnutrition Universal Screening Tool
MV	Mechanical ventilation
NCP	Nutrition care process
NCP	Nutrition care process
NPV	Negative predictive value
NUTRIC	Nutrition Risk in Critically Ill
NR	Nutritional risk
NRE-2017	Nutritional Risk in Emergency
NRS-2002	Nutritional Risk Screening
NST	Nutritional screening tool
OR	Odds ratio
PPV	Positive predictive value
ROC	Característica de Operação do Receptor / Receiver operating characteristic
SAPS-3	Simplified Acute Physiology Score III
SCREENIC	Screening of Nutritional Risk in Intensive Care
SGA	Subjective Global Assessment
SOFA	Sequential Organ Failure Assessment
TNF-α	Fator de necrose tumoral al
TRN	Triagem de risco nutricional
UTI	Unidade de Terapia Intensiva
UWL	Unintentional weight loss
VM	Ventilação mecânica

RESUMO

Introdução: A triagem de risco nutricional (TRN) é o primeiro passo da sistematização do cuidado de nutrição e deve ser realizada a partir de ferramenta com validação prévia, ser destinada à população em que será aplicada, de baixo custo, rápida aplicabilidade, composta por questionamento simples e com plano de ação que possa ser facilmente aplicado e adaptado. Dentre as ferramentas existentes, apenas o *Malnutrition Universal Screening Tool* (MUST), *Nutritional Risk Screening* (NRS-2002) e *Modified Nutrition Risk in Critically Ill* (mNUTRIC) já foram previamente estudadas em pacientes críticos. As ferramentas *Malnutrition Screening Tool* (MST) e *Nutritional Risk in Emergency* (NRE-2017) parecem ser mais fáceis e acessíveis por não considerarem peso e altura aferidos, porém a validade das mesmas em unidade de terapia intensiva não foi investigada. De acordo com as diretrizes nacionais e internacionais para paciente crítico, recomenda-se utilizar as ferramentas NUTRIC ou NRS-2002 para TRN, no entanto, ambas as ferramentas apresentam limitações. Sendo assim, essa etapa do cuidado nutricional do paciente crítico requer maior investigação. **Objetivos:** Avaliar a validade de critério de cinco diferentes ferramentas de triagem de risco nutricional em pacientes críticos adultos e desenvolver uma nova ferramenta com maior factibilidade para identificação de risco nutricional no ambiente de terapia intensiva. **Métodos:** Realizamos um estudo de coorte com coleta de dados prospectiva de pacientes adultos e idosos, admitidos em seis Unidades de Terapia Intensiva (UTIs) de um complexo hospitalar do Sul do Brasil, no período de Julho/2019 e Maio/2022. As ferramentas de triagem de risco nutricional aplicadas foram o mNUTRIC, NRS-2002, MST, MUST e NRE-2017. Para realizar a análise concorrente das ferramentas utilizamos o mNUTRIC e a NRS-2002 como métodos de referência. A curva Característica de Operação do Receptor (ROC) e o coeficiente κ avaliaram a acurácia e concordância das ferramentas. A regressão logística verificou a associação entre risco nutricional e tempo de internação na UTI prolongada, e a regressão de Cox foi utilizada para verificar a associação entre risco nutricional e mortalidade na UTI, ambas com ajuste para os confundidores. Realizamos também uma análise secundária para o desenvolvimento de uma nova ferramenta de TRN para pacientes críticos, o escore SCREENIC (*Screening of Nutritional Risk In Intensive Care*). Foram realizadas quatro etapas para o desenvolvimento da ferramenta, e as variáveis de diferentes ferramentas de TRN e diagnóstico de desnutrição [mNUTRIC, NRS-2002, MST, MUST e NRE-2017, Avaliação Subjetiva Global (ASG) e critérios do *Global Leadership Initiative on Malnutrition* (GLIM)] foram consideradas para nortear a construção. O ponto de corte para classificação do risco nutricional foi definido através da construção da curva ROC, utilizando o mNUTRIC como referência. Foi calculada a sensibilidade, especificidade, valor preditivo positivo e negativo. A validade preditiva foi avaliada por regressão logística para tempo de internação na UTI e no hospital, readmissão na UTI e desfechos pós-alta. A regressão de COX foi utilizada para avaliar a associação entre risco nutricional pelo SCREENIC e

mortalidade na UTI e no hospital. **Resultados:** Foram avaliados 450 pacientes (64 [AIQ: 54-71] anos, 52,2% homens), e o risco nutricional variou de 36,4% (NRS-2002 ≥ 5) a 50,2% (NRS-2002 ≥ 3). A NRS-2002 ≥ 5 apresentou a melhor acurácia [0,63 (IC95% 0,58–0,69]) com mNUTRIC, e o MST com NRS-2002 ≥ 5 [0,76 (IC95% 0,71–0,80]), embora para nenhuma ferramenta essa métrica foi satisfatória. Todas as ferramentas apresentaram concordância fraca com o mNUTRIC (k=0,019–0,268) e concordância moderada com o NRS-2002 ≥ 5 (k=0,474–0,503). O MUST (HR=2,26 (IC95% 1,40–3,63]) e o MST (HR=1,69 (IC95% 1,09–2,60]) foram preditores de óbito na UTI, e o NRS-2002 ≥ 5 [OR=1,56 (IC95% 1,02– 2,40)] e o mNUTRIC (OR=1,86 (IC95% 1,26–2,76)] de permanência prolongada na UTI. Para a construção do SCREENIC a partir de 14 variáveis pré-selecionadas, seis questões com possibilidade de respostas sim/não foram incluídas na ferramenta por estarem associadas com o alto mNUTRIC escore (idade ≥ 65 anos, dias pré-UTI ≥ 1, número de comorbidades ≥ 2, sepse, perda moderada ou grave de massa muscular no exame físico, ventilação mecânica (VM) na admissão). O ponto de corte para classificação de risco nutricional foi de 4,0 pontos, definido a partir do equilíbrio entre maior sensibilidade (88,5%) e especificidade (68,8%). O escore SCREENIC identificou 57,6% pacientes com alto risco nutricional e apresentou concordância moderada (k=0,564) e acurácia alta [0,896 (IC95% 0,867 - 0,925] com o mNUTRIC. O escore SCREENIC foi preditor independente de internação prolongada na UTI [OR=1,81 (IC95% 1,14 - 2,85)] e no hospital [OR=2,15 (IC95% 1,37 - 3,38)]. **Conclusão:** Nenhuma ferramenta de TRN apresentou validade concorrente satisfatória com o mNUTRIC ou com o NRS-2002 e apenas o MUST e MST foram preditoras de óbito na UTI e NRS-2002 ≥ 5 e mNUTRIC associados independentemente à internação prolongada na UTI. Com isso, foi desenvolvido o escore SCREENIC para TRN para pacientes críticos, composta por seis questões com respostas sim ou não, com variáveis que não necessitam de anamnese e podem ser obtidas em prontuário e a partir do exame físico realizado à beira leito. A nova ferramenta apresentou concordância moderada e alta sensibilidade com o mNUTRIC e foi preditora independente de permanência prolongada na UTI e no hospital. A aplicabilidade, reprodutibilidade e validade preditiva do escore SCREENIC em identificar pacientes que se beneficiarão de terapia nutricional precoce e plena deve ser avaliada em estudos futuros.

Palavras-chaves: risco nutricional; triagem de risco nutricional; paciente crítico, unidade de terapia intensiva; métricas de acurácia.

ABSTRACT

Introduction: The nutritional risk screening (NR) is the first step in the nutrition care process (NCP) and must be performed using a tool with prior validation, intended for the population in which it will be applied, low cost, fast to apply, consisting of simple questioning and with an action plan that can be easily applied and adapted. Among the existing tools, only the Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening (NRS-2002) and Modified Nutrition Risk in Critically Ill (mNUTRIC) have been previously studied in critically ill patients. The Malnutrition Screening Tool (MST) and Nutritional Risk in Emergency (NRE-2017) tools seem to be easier and more accessible because they do not consider measured weight and height, but their validity in the intensive care unit (ICU) has not been investigated. According to national and international guidelines for critically ill patients, it is recommended to use the NUTRIC or NRS-2002 tools for NR screening, however, both tools have limitations. Therefore, this stage of nutritional care for critically ill patients requires further investigation. **Objectives:** To evaluate the criterion validity of five different nutritional screening tools (NSTs) in critically ill patients and to develop a new tool with greater feasibility for identifying nutritional risk in the ICU setting. **Methods:** We performed a cohort study with prospective data collection of adult and elderly patients admitted to six ICUs of a hospital complex in southern Brazil, between July/2019 and May/2022. The NSTs applied were mNUTRIC, NRS-2002, MST, MUST and NRE-2017. To perform the concurrent analysis of the tools, we used mNUTRIC and NRS-2002 as reference methods. The Receiver Operating Characteristic Curve (ROC) and the κ coefficient evaluated the accuracy and agreement of the tools. Logistic regression verified the association between NR and prolonged ICU stay, and Cox regression was used to verify the association between NR and ICU mortality, both with adjustment for confounders. We also performed a secondary analysis for the development of a new NST for critically ill patients, the SCREENIC (Screening of Nutritional Risk in Intensive Care) score. Four stages were carried out for the development of the tool, and the variables of different NSTs and malnutrition diagnosis tools [mNUTRIC, NRS-2002, MST, MUST and NRE-2017, Global Subjective Assessment (ASG) and Global Leadership Initiative on Malnutrition (GLIM)] were considered to guide the construction. The cutoff point to classify NR was defined through the construction of the ROC curve, using the mNUTRIC as a reference. Sensitivity, specificity, positive and negative predictive value were calculated. Predictive validity was assessed by logistic regression for length of ICU and hospital stay, ICU readmission, and post-discharge outcomes. COX regression was used to assess the association between NR by SCREENIC score and ICU and hospital mortality. **Results:** We evaluated 450 patients (64 [54-71] years, 52.2% men), and the NR ranged from 36.4% (NRS-2002 $\geq$ 5) to 50.2% (NRS-2002 $\geq$ 3). NRS-2002 $\geq$ 5 showed the best accuracy [0.63 (95%CI 0.58–0.69]) with mNUTRIC, and MST with NRS-2002 $\geq$ 5 [0.76 (95%CI 0.71–0 .80]), although for no tool this metric was

satisfactory. All tools showed weak agreement with the mNUTRIC (k=0.019–0.268) and moderate agreement with the NRS-2002 ≥ 5 (k=0.474–0.503). MUST (HR=2.26 (95%CI 1.40–3.63]) and MST (HR=1.69 (95%CI 1.09–2.60]) were predictors of death in the ICU, and NRS-2002 ≥ 5 [OR=1.56 (95%CI 1.02–2.40)] and mNUTRIC (OR=1.86 (95%CI 1.26–2.76)] for prolonged ICU stay. For the construction of the SCREENIC score we used 14 pre-selected variables, and six questions with the possibility of yes/no answers were included in the score because they were associated with a high mNUTRIC score (age > 65 years, pre-ICU days > 1, number of comorbidities > 2, sepsis, moderate or severe loss of muscle mass on physical examination, mechanical ventilation (MV) on admission.) The cutoff point for nutritional risk classification was 4.0 points, defined from the balance between greater sensitivity (88.5%) and specificity (68.8%). The SCREENIC score identified 57.6% of patients with high NR and showed moderate agreement (k=0.564) and high accuracy [0.896 (95%CI 0.867 - 0.925] with the mNUTRIC. SCREENIC score was an independent predictor of prolonged ICU [OR=1 .81 (95%CI 1.14 - 2.85)] and hospital [OR=2.15 (95%CI 1.37 - 3.38)] stay. **Conclusion:** No NST tool showed satisfactory concurrent validity with mNUTRIC or NRS-2002. Only MUST and MST were predictors of ICU death and NRS-2002 ≥ 5 and mNUTRIC independently associated with prolonged ICU stay. As a result, the SCREENIC score for NST for critically ill patients was developed, consisting of six questions with yes or no answers, with variables that do not require anamnesis and can be obtained from electronic records and from the physical examination performed at the bedside. The new tool showed moderate agreement and high sensitivity with the mNUTRIC and was an independent predictor of prolonged ICU and hospital stays. The applicability, reproducibility, and predictive validity of the SCREENIC score in identifying patients who will benefit from early and full nutritional therapy should be evaluated in future studies.

Keywords: nutritional risk; nutritional risk screening; critically ill patient, intensive care unit; accuracy metrics.

1 REFERENCIAL TEÓRICO

1.1 Contexto e epidemiologia da doença crítica

De acordo com a Portaria nº 466 de 1998, as Unidades de Terapia Intensiva (UTIs) são unidades destinadas para o atendimento de pacientes graves e de risco que exigem assistência médica e de enfermagem ininterruptas, além de equipamentos e recursos humanos especializados. Os serviços de terapia intensiva devem funcionar atendendo a um parâmetro de qualidade que assegure a cada paciente o direito à sobrevida, assim como a garantia da manutenção da estabilidade de seus parâmetros vitais. Além disso, devem prestar uma assistência humanizada, com exposição mínima aos riscos decorrentes dos métodos propedêuticos e do próprio tratamento em relação aos benefícios obtidos e garantir o monitoramento permanente da evolução do tratamento, assim como de seus efeitos adversos[1].

Em dezembro de 2019, um mês antes da pandemia de COVID-19, o Brasil possuía cerca de 46 mil leitos de UTI e em julho de 2022 houve um aumento para 60,5 mil, de acordo com dados do DATASUS[2]. Pesquisa realizada pela Associação de Medicina Intensiva Brasileira (AMIB) em parceria com a *Epimed Solutions* demonstrou que os pacientes internados nas UTIs de todo Brasil apresentam mediana de idade de 65 anos, sendo as comorbidades mais frequentes a Hipertensão Arterial Sistêmica (HAS) e Diabetes Mellitus (DM) e diagnóstico clínico mais prevalente de infecção/sepse (32,1%) e doença cardiovascular (26,42%) na admissão. Além disso, os homens apresentam maior prevalência (51,27%) de internação na UTI quando comparados às mulheres. Em relação aos desfechos clínicos, os pacientes críticos apresentam uma média de internação de 5,7 dias e uma taxa de mortalidade na UTI de 12,78%. No Rio Grande do Sul a taxa de mortalidade encontrada entre os pacientes críticos foi maior que a taxa nacional, sendo de 19,19% na UTI e de 26,68% no hospital[3].

A UTI é uma unidade com elevado custo hospitalar, devido à necessidade de espaço específico, profissionais especializados e tecnologias para o cuidado. Diversos pacientes necessitam de ventilação mecânica (VM) invasiva e por tempo prolongado, gerando, consequentemente, um custo ainda mais elevado à instituição. Desse modo, o trabalho da equipe multidisciplinar e os processos de cuidados intensivos precisam ser adequados e otimizados financeiramente por meio do aumento das habilidades humanas e dos recursos técnicos de forma mais econômica. O manejo de pacientes gravemente doentes representa um desafio significativo para os sistemas de saúde, uma vez que se deve buscar a melhor relação entre a qualidade do serviço prestado e menor uso não planejado dos recursos, primando pela segurança nos processos de trabalho e atendimento de qualidade.

1.2 Fisiopatologia e resposta orgânica ao estresse no paciente crítico

Embora a doença crítica seja frequentemente associada à infecção ou sepse, outras condições como trauma grave, o estado pós-cirúrgico, pancreatite, queimadura, hemorragia, e a isquemia podem produzir os mesmos achados clínicos que a invasão microbiana, mesmo na ausência de um organismo infeccioso, portanto, essas condições também podem se enquadrar na categoria de doença crítica[4]. As diferentes fases da doença crítica podem ser descritas como aguda, crônica e pós crônica[5]. A primeira fase inicia imediatamente após o agravo e é caracterizada por instabilidade hemodinâmica devido ao choque hipovolêmico, com redução do débito cardíaco e consumo de oxigênio, baixa temperatura corporal central e níveis elevados de glucagon, catecolaminas e ácidos graxos livres. Nesta fase há a produção de mediadores de processo inflamatório, principalmente das citocinas pró-inflamatórias Interleucina-1 (IL1), Interleucina-6 (IL6) e Fator de necrose tumoral alfa (TNF-α), que possuem papel crucial na resposta ao estresse, promovendo alterações no metabolismo de macronutrientes. A duração desta fase pode ser variável dependendo do tipo de trauma, início das medidas de ressuscitação e tratamentos específicos para controlar o processo patológico primário. A fase subsequente é mais prolongada e é caracterizada por um aumento no consumo total de oxigênio corporal, na taxa metabólica, no débito cardíaco e na oxidação de fontes de combustível (carboidratos, aminoácidos e gorduras)[6,7].

O aumento do gasto de energia correlaciona-se com a gravidade da lesão, sendo mínimo em lesões leves e podendo ser duplicado em queimaduras graves. Esta fase necessita de suporte agressivo na UTI e estratégias de manejo adaptadas à etiologia da doença[6]. Essa resposta pró-inflamatória sistêmica à infecção e dano tecidual é o mecanismo do corpo para lutar contra a infecção e fornecer substratos para a cura. No entanto, quando essa resposta pró-inflamatória é grave e avassaladora, pode ser prejudicial ao paciente, assim, há uma resposta anti-inflamatória que contrabalança a resposta pró-inflamatória. Durante esta fase de resposta anti-inflamatória, as citocinas anti-inflamatórias (Interleucina-4 e Interleucina-10) podem predominar em relação às citocinas pró-inflamatórias (TNF-α, IL-2 e interferon gama (IFN-γ)) e quando o equilíbrio muda desproporcionalmente para um estado anti-inflamatório, o sistema imunológico enfraquecido é incapaz de erradicar patógenos e iniciar processos reparadores à medida que o hospedeiro se torna cada vez mais imunocomprometido. Assim, há um tênue equilíbrio entre as fases pró-inflamatória e anti-inflamatória para facilitar a recuperação do hospedeiro e ter um desfecho favorável[8,9].

1.3 Risco nutricional e valor prognóstico em unidade de terapia intensiva

As alterações metabólicas do paciente crítico levam a um catabolismo acelerado no tecido muscular associado a uma redução da eficiência no uso de proteínas pelos miócitos, que respondem por uma degradação muscular acentuada e por função e contratilidade muscular reduzidas. A resposta metabólica aliada ao balanço energético e proteico negativo,

normalmente observado nesses pacientes, gera importante perda de gordura subcutânea e de massa muscular, contribuindo para o comprometimento do estado nutricional desses pacientes e desenvolvimento de desnutrição[10]. Revisão sistemática com sete estudos, envolvendo cerca de 300 pacientes que tiveram avaliação de massa muscular por ultrassonografia demonstrou que a perda de massa muscular variou entre -6%/dia a -1,6%/dia durante a internação na UTI. Em seis estudos, alterações na arquitetura muscular foram evidenciadas e associadas com o tempo de internação na UTI[11]. De fato, desnutrição é uma condição bastante frequente em UTI, podendo atingir até 82% dos pacientes, conforme evidenciado em revisão sistemática com 20 estudos observacionais. Nessa revisão os autores também apontam que pacientes críticos desnutridos apresentam maior mortalidade, maior tempo de internação hospitalar e maior tempo de internação na UTI quando comparados aos pacientes sem comprometimento do estado nutricional[12].

De acordo com as novas propostas para diagnóstico de desnutrição, deve-se ponderar na avaliação dos pacientes hospitalizados o risco nutricional e a presença e gravidade da inflamação, sendo os pacientes críticos susceptíveis ao desenvolvimento de desnutrição relacionada à doença aguda, condição em que inflamação acentuada encontra-se presente e contribui para um maior catabolismo proteico e um processo mais acelerado de comprometimento do estado nutricional, que dificilmente é revertido com terapia nutricional[13]. Diante disso, a avaliação precoce do risco nutricional dos pacientes admitidos em UTI é crucial, devendo ser realizada nas primeiras 24 horas após a admissão, conforme recomendações das entidades nacionais e internacionais[14,15].

1.3.1. Definição de risco nutricional no paciente não crítico e crítico

A triagem de risco nutricional (TRN) no paciente hospitalizado foi definida pela *American Society for Parenteral and Enteral Nutrition* (ASPEN) como “um processo para identificar um indivíduo que está desnutrido ou que está em risco de desnutrição e determinar se uma avaliação nutricional detalhada é indicada"[16]. De acordo com a *European Society for Clinical Nutrition and Metabolism* (ESPEN), o objetivo da triagem nutricional é avaliar a capacidade dos fatores nutricionais em predizer desfechos clínicos, considerando a demanda metabólica[17].

A TRN é o primeiro passo da sistematização do cuidado de nutrição proposto pela Associação Brasileira de Nutrição (ASBRAN)[18] e, conforme Kondrup e colaboradores, a ferramenta de TRN deve ter validação prévia, deve ser destinada à população em que será aplicada, de baixo custo, rápida aplicabilidade, composta por questionamento simples e com plano de ação que possa ser facilmente aplicado e adaptado. Neste sentido, o autor sugere que uma ferramenta deve conter quatro princípios principais: 1) Qual a condição clínica atual do paciente? (Peso corporal, estatura e Índice de Massa Corporal (IMC); 2) Essa condição é estável? (Perda de peso não intencional recente); 3) Essa condição vai piorar? (Redução do

consumo alimentar); 4) O processo de doença pode acelerar a deterioração nutricional? (Efeito do estresse metabólico da doença)[19].

Apesar do reconhecimento universal da necessidade de rastreamento do risco nutricional, um estudo demonstrou que a triagem nutricional é realizada como parte da rotina diária em 52% dos hospitais avaliados. Este estudo concluiu que o estabelecimento de protocolos de TRN é um ponto de partida importante para melhorar o atendimento nutricional nesses hospitais, pois não existe consenso quanto ao método de referência para identificação de pacientes em risco nutricional, sendo encontradas inúmeras ferramentas de triagem nutricional na literatura[20].

Existem diversas ferramentas para a triagem nutricional do paciente hospitalizado, elas utilizam geralmente os parâmetros determinantes da deterioração do estado nutricional, no entanto, considerando que o estado inflamatório e hiper catabólico dos doentes críticos acelera o processo de desnutrição, a gravidade da doença deve ser interpretada com destaque, uma vez que o risco nutricional do paciente crítico não depende apenas do estado nutricional, mas também de fatores que alteram o tempo de internação, dias de ventilação mecânica e mortalidade[22].

Nos pacientes críticos, Heyland e colaboradores propuseram que o risco nutricional não deve ser visto como o risco de desnutrição, haja vista que a resposta inflamatória ao estresse e o consequente catabolismo proteico incidem em risco de desnutrição em todos os pacientes críticos. Os autores sugerem, portanto, que risco nutricional no paciente crítico seja avaliado como o risco de o paciente apresentar complicações ou desfechos adversos que poderiam ser prevenidos com terapia nutricional adequada[23].

1.3.2. Como avaliar risco nutricional no paciente crítico

A partir do conceito publicado por Heyland e colaboradores, o autor desenvolveu o escore NUTRIC para avaliação do risco nutricional de pacientes críticos, o qual considera idade, *Acute Physiology And Chronic Health Evaluation* (APACHE II), S*equential Organ Failure Assessment* (SOFA), número de comorbidades, número de dias de hospitalização antes da admissão na UTI e níveis séricos de interleucina-6. No estudo de validação da ferramenta, os autores demonstraram associação significativa e linear entre o escore NUTRIC e a taxa de mortalidade e o tempo de ventilação mecânica. Ademais, os autores demonstraram que dentre os pacientes em risco nutricional pelo NUTRIC, aqueles que receberam terapia nutricional adequada (>70% do alvo nutricional) morreram significativamente menos do que aqueles que receberam terapia nutricional inadequada. Por outro lado, nos pacientes sem risco nutricional a terapia nutricional não apresentou influência nas taxas de mortalidade[23]. Posteriormente, Rahman e colaboradores validaram a ferramenta sem a dosagem de interleucina-6 e demonstraram que o NUTRIC modificado (mNUTRIC) apresentou desempenho similar em predizer desfechos clínicos e em demonstrar o impacto benéfico da

terapia nutricional adequada sobre tais desfechos naqueles pacientes classificados como tendo risco nutricional. O mNUTRIC classifica pacientes com risco nutricional quando apresentam uma pontuação maior ou igual a 5 pontos[24]. Considerando-se que atualmente o escore APACHE está em desuso no ambiente de terapia intensiva e que o escore *Simplified Acute Physiology Score III* (SAPS-3) é utilizado para avaliar o prognóstico desses pacientes, Toledo e colaboradores propuseram uma versão modificada do mNUTRIC, o NUTRIC-S, com a substituição do APACHE pelo SAPS-3, a qual apresentou foi preditora de mortalidade[25].

A ESPEN recomenda que todos os pacientes que permanecerem na UTI por mais de 48 horas devem ser considerados em risco nutricional, partindo do conceito de risco nutricional como o risco de desnutrição e considerando a intensa resposta catabólica evidenciada em pacientes críticos[5]. A ASPEN[26] e a Sociedade Brasileira de Nutrição Parenteral e Enteral (BRASPEN)[14] recomendam o uso do mNUTRIC ou da *Nutritional Risk Screening* (NRS-2002) para a TRN no paciente crítico. A NRS-2002 é constituída por dois componentes: comprometimento do estado nutricional e severidade da doença. A avaliação do estado nutricional é composta por indicadores presentes na maioria das ferramentas de triagem nutricional: IMC, percentual de perda de peso e redução na ingestão alimentar. A avaliação da severidade da doença considera o estresse metabólico a ela associado, atentando para o fato de que a gravidade da doença pode promover aumento das necessidades nutricionais e, consequentemente, influenciar o estado nutricional do paciente. Para cada componente da NRS-2002 (comprometimento do estado nutricional e estresse metabólico da doença), o paciente pode ser identificado em uma das quatro categorias disponíveis (ausente, leve, moderado, grave), para a qual pontuação específica é atribuída. De acordo com a ferramenta, pacientes com escore APACHE maior ou igual a 10 apresentam doença severa. A idade superior a 70 anos é considerada fator de risco adicional para ajuste na classificação do risco nutricional. Pacientes com escore total maior ou igual a três são considerados em risco nutricional e pacientes críticos com escore maior ou igual a cinco são classificados como alto risco nutricional, sendo recomendado o início de terapia nutricional[17].

No cenário da terapia intensiva, ambas as ferramentas indicadas para TRN no paciente crítico possuem limitações. A NRS-2002 possui informações difíceis de serem coletadas no ambiente de terapia intensiva, como avaliação quantitativa do consumo alimentar e percentual de perda de peso e IMC, além disso, classifica todo paciente com pontuação de APACHE maior de 10 como tendo risco nutricional, o que é comumente observado na grande maioria dos pacientes críticos. Por outro lado, o mNUTRIC não apresenta variáveis nutricionais, desta forma poderia ser mais adequado como escore prognóstico e não de risco nutricional.

1.3.3 Validade das ferramentas de triagem de risco nutricional na UTI

Diversas ferramentas foram desenvolvidas e validadas para avaliar o risco nutricional em pacientes não críticos, como o *Malnutrition Universal Screening Tool* (MUST)[27], o *Malnutrition Screening Tool* (MST)[28] e o *Nutritional Risk Emergency-2017* (NRE-2017)[29], as variáveis que compões as ferramentas estão apresentadas na **Tabela 1**.

Tabela 1 - Ferramentas de triagem de risco nutricional – critérios, pontuação e classificação

Variáveis	**NRE-2017**	**NRS-2002**	**MST**	**MUST**	**mNUTRIC**
APACHE					x
SOFA					x
Idade	x	x			x
Número de comorbidades					x
Número de dias de hospitalização antes da UTI					x
Consumo alimentar x requerimento energético		x			
Inanição >5 dias				x	
Apetite reduzido	x		x		
Alteração da consistência da dieta	x				
IMC		x		x	
Perda de peso	x	x	x	x	
Estresse metabólico	x	x			
Perda de massa muscular	x				
Pontuação e classificação					
Sem risco nutricional	< 1.5	< 3	<2	0	≤ 4
Com risco nutricional	≥ 1.5	≥ 3	≥ 2	≥	≥ 5

NRE-2017, *Nutritional Risk in Emergency 2017*; NRS-2002, *Nutritional Risk Screening 2002*; MST, *Malnutrition Screening Tool*; MUST, *Malnutrition Universal Screening Tool*; mNUTRIC, *modified Nutrition Risk in Critically ill*; APACHE II, *Acute Physiology and Chronic Health Evaluation*; SOFA, *Sequential Organ Failure Assessment*; UTI, Unidade de Terapia Intensiva; IMC, Índice de Massa Corporal

A triagem nutricional MUST foi desenvolvida por um grupo multidisciplinar do Reino Unido, o MAG-BAPEN (*Malnutrition Advisory Group of the British Association for parenteral and Enteral Nutrition*), podendo ser aplicada por diferentes profissionais para identificação de risco nutricional em diferentes pacientes adultos, sendo recomendada para a área clínica e de saúde pública. O propósito dessa ferramenta é detectar desnutrição com base no conhecimento acerca da associação entre estado nutricional prejudicado e funcionalidade

prejudicada, tendo sido desenvolvida primeiramente para uso em comunidades e posteriormente validada para o ambiente hospitalar. A MUST considera três itens: 1) Perda ponderal não intencional nos últimos 3-6 meses; 2) IMC; e 3) Efeito agudo da doença sob a ingestão alimentar. O paciente é classificado como tendo médio risco nutricional quando apresentarem pontuação igual a 1 ponto e como tendo alto risco nutricional quando a pontuação é $\geq$ 2 pontos[27].Essa ferramenta pode ser aplicada em pacientes cuja aferição do peso corporal e da estatura esteja impossibilitada, já que medidas antropométricas (antebraço, altura do joelho, hemi-envergadura e circunferência do braço) e critérios subjetivos alternativos podem ser utilizados. No ambiente hospitalar a MUST prediz tempo de internação e mortalidade[30], enquanto na comunidade é preditora de taxa de admissão hospitalar e necessidade de visitas domiciliares da equipe de saúde, além de demonstrar que intervenção nutricional apropriada melhora desfechos em geral[31]. Até onde sabemos, apenas um estudo avaliou a validade preditiva da MUST em pacientes críticos, que foi realizado com 475 pacientes holandeses, e demonstrou que o MUST não foi preditor de óbito e ventilação mecânica prolongada[32].

A ferramenta de triagem nutricional MST foi desenvolvida para identificar pacientes com doenças agudas em risco nutricional no momento da admissão hospitalar. Três questões compõem a ferramenta de triagem nutricional MST: 1) “Você perdeu peso recentemente de forma não-intencional?”; 2) “Caso você tenha perdido peso, quanto você perdeu?”; 3) “Você está se alimentando menos por perda de apetite?”. Pontuação específica é atribuída para cada resposta e o escore final igual ou superior a dois classifica o paciente como “em risco nutricional”. A validade da MST foi determinada a partir da comparação com medidas antropométricas e parâmetros bioquímicos e considerou o tempo de permanência hospitalar. A confiabilidade da ferramenta foi avaliada em uma amostra de 32 pacientes a partir da aplicação da MST por dois nutricionistas de forma independente, com concordância de 96% entre elas. A MST apresenta sensibilidade e especificidade igual a 93%, sendo uma ferramenta de triagem nutricional simples, de rápida aplicação, validada e confiável para pacientes hospitalizados[28]. De acordo com pesquisa realizada na literatura, a ferramenta MST não foi estudada quanto a sua validade em pacientes críticos até o presente momento, embora seja recomendada pela Academia de Nutrição e Dietética (AND) como a ferramenta a ser escolhida para triagem nutricional de pacientes, independente independentemente de sua idade, histórico médico ou ambiente, incluindo UTI[33].

A ferramenta NRE-2017 foi desenvolvida pelo nosso grupo de pesquisa para pacientes admitidos na emergência, a qual foi construída a partir de uma análise de regressão logística, sendo composta em sua versão final por seis questionamentos simples com respostas "sim" ou "não": 1) Perda ponderal nos últimos seis meses; 2) Idade $\geq$ 65 anos; 3) Sinais de perda de massa muscular no exame físico; 4) Mudança na consistência da dieta nas últimas duas semanas; 5) Apetite reduzido nas últimas duas semanas; 6) Doença com estresse metabólico elevado. A pontuação maior ou igual a 1,5 classifica o paciente com risco

nutricional. A ferramenta NRE-2017 apresentou satisfatória validade concorrente quando comparada com outras ferramentas de TRN. Ainda, pacientes em risco nutricional de acordo com a ferramenta NRE-2017 apresentaram maior risco de óbito e chance de internação hospitalar prolongada[29]. Até onde sabemos, nenhum estudo aplicou a ferramenta NRE-2017 em pacientes críticos.

1.3.4 Valor prognóstico do risco nutricional no paciente crítico

Nos últimos anos, diversos estudos avaliaram a acurácia do NUTRIC em diferentes grupos de pacientes críticos. Jeong e colaboradores compararam a acurácia do NUTRIC original e modificado em predizer mortalidade após 28 dias em 482 pacientes com sepse e não demonstraram diferença entre as ferramentas[34]. Outro estudo observacional prospectivo envolvendo pacientes críticos comparou o NUTRIC modificado com o MUST quanto ao seu desempenho prognóstico, o qual foi significativamente superior com o NUTRIC modificado quando avaliado o tempo de ventilação mecânica e a mortalidade como desfechos clínicos[32]. Em outro estudo observacional, quase metade dos pacientes foi identificado como tendo risco nutricional, o qual foi associado positivamente com mortalidade e tempo de internação na UTI[35]. Tais achados também foram evidenciados em estudo conduzido em uma UTI asiática[36].

O desempenho satisfatório do NUTRIC em predizer mortalidade, tempo de internação na UTI e tempo de ventilação mecânica é previsível, haja vista que ele considera dois indicadores de gravidade no paciente crítico, os quais predizem mortalidade e desfechos clínicos: APACHE II[37] e SOFA[38]. Embora saiba-se que risco de desnutrição é intrínseco à resposta metabólica que o paciente crítico apresenta, questiona-se a aplicabilidade do NUTRIC em avaliar o comprometimento nutricional desses pacientes[22].

Um estudo de coorte prospectivo realizado com 100 pacientes críticos demonstrou que o NRS-2002 foi um preditor de permanência prolongada na UTI, mas não foi um preditor de óbito, porém, não foi realizada análise multivariada[39]. Outro estudo de coorte prospectivo brasileiro com 384 pacientes críticos também relatou que os pacientes identificados com alto risco nutricional pela NRS-2002 ≥ 5 não tiveram aumento estatisticamente significativo no risco de morte[40]. Em contraste, um estudo com 413 pacientes críticos mostrou que um aumento de 1 unidade no escore NRS-2002 foi associado ao risco de mortalidade aumentar em 1,23 vezes, após ajuste para sexo, idade, comorbidade e IMC[41]. A validade preditiva da NRS-2002 é questionável, pois há um número limitado de estudos em que foi realizada análise multivariada, e os estudos adotaram diferentes pontos de corte para a classificação do risco nutricional.

Como citado anteriormente, não foram identificados estudos que avaliaram a valor prognóstico do MST e do NRE-2017 em pacientes críticos, enquanto a validade preditiva do MUST foi explorada por um estudo e não foi confirmada[32].

1.3.5 Interação entre risco nutricional, aporte calórico e desfechos clínicos em pacientes críticos;

A TRN no paciente crítico permite identificar indivíduos que se beneficiarão de terapia nutricional mais precoce e individualizada[14]. De acordo com Heyland e colaboradores, em pacientes com alto risco nutricional, a terapia nutricional adequada pode reduzir as chances de desfechos desfavoráveis[23]. Portanto, identificar os pacientes em risco nutricional nas primeiras 24 horas após a admissão na UTI é um passo importante no processo do cuidado nutricional.

A interação entre terapia nutricional, risco nutricional e desfechos clínicos em pacientes críticos não é evidenciada em todos os estudos que buscam investigá-la e parece ser dependente da ferramenta de TRN empregada. Estudo realizado por Canales e colaboradores com 312 pacientes críticos demonstrou que a presença de alto risco nutricional pelo NUTRIC foi associado ao déficit proteico e calórico, enquanto essa associação não foi evidenciada quando o risco nutricional foi identificado a partir da NRS-2002[36].

Diversos estudos na literatura buscaram avaliar a interação entre o balanço energético e proteico, risco nutricional avaliado pelo mNUTRIC e desfechos clínicos em pacientes críticos, porém os resultados são conflitantes. Estudo conduzido por Heyland e colaboradores com 597 pacientes demonstrou que no subgrupo de pacientes que permaneceram na UTI mais de três dias, os pacientes com alto risco nutricional pelo NUTRIC se beneficiaram mais com terapia nutricional agressiva[23]. Outro estudo realizado por Jeong e colaboradores com 248 pacientes demonstrou que nos pacientes com alto risco nutricional a mortalidade em 28 dias reduziu de acordo com o aumento da ingestão de energia ou proteína[42]. Em contrapartida, estudo realizado com 154 pacientes críticos demonstrou que entre os pacientes com alto risco nutricional não foi encontrada diferença na mortalidade entre aqueles com terapia nutricional agressiva ou não[43].

1.4 Aplicabilidade de outras ferramentas - perspectivas

Pelo que identificamos na literatura, dentre as ferramentas de TRN validadas para pacientes hospitalizados, apenas o MUST, NRS-2002 e NUTRIC tem sua aplicabilidade estudada em pacientes críticos. O NRE-2017 foi desenvolvido e validado por nosso grupo de pesquisa e apresentou validade de critério satisfatória em serviços de emergência. As ferramentas MST e NRE-2017 parecem ser mais fáceis e acessíveis para pacientes graves, pois não consideram peso e altura aferidos, portanto, seria interessante avaliar a sua validade em ambientes de UTI.

Conforme citado anteriormente, a TRN é o primeiro passo no processo de cuidado nutricional e requer uma ferramenta que deve ter validade, confiabilidade, sensibilidade,

especificidade e valor preditivo positivo e negativo adequados para detectar pacientes com alto risco nutricional. Kondrup e colaboradores sugerem que quatro princípios devem ser considerados em uma ferramenta desenvolvida e validada para TRN, no entanto estes princípios envolvem questões sobre dados antropométricos e sobre ingestão alimentar[19], dados que geralmente são difíceis de serem obtidos na UTI.

Recentemente, Marian e colaboradores publicaram uma revisão narrativa acerca de novos insights sobre TRN e trouxeram uma discussão sobre a necessidade de identificar risco nutricional a partir de fatores de risco para desnutrição ao invés de sintomas precoces de desnutrição. Os autores fazem uma crítica à maioria das ferramentas disponíveis por considerarem perda ponderal, IMC reduzido, consumo alimentar reduzido e estresse metabólico, os quais representam sintomas precoces de desnutrição. Ainda, discutem que os fatores de risco para desnutrição, tais como disfagia, dor, falta de apetite, imobilidade, etilismo, dependência e acesso aos alimentos, não estão contemplados nas ferramentas comumente utilizadas para TRN[44]. No entanto, acreditamos que essa discussão acerca das ferramentas de TRN não se aplique ao paciente crítico, por entendermos que o risco nutricional no paciente crítico não deve ser definido como o risco de o paciente vir a apresentar desnutrição, mas sim como o risco de o paciente vir a apresentar piores desfechos clínicos se terapia nutricional apropriada não for instituída precocemente. Conforme descrito por Kondrup, um escore de risco nutricional em UTI não é dependente de indicadores nutricionais tradicionais, mas sim da condição clínica e do tempo de internação previsto na UTI, incluindo variáveis que possam refletir a duração do estresse metabólico[22].

No nosso entendimento, a definição da ferramenta de TRN a ser aplicada em UTI deve também ponderar a sua viabilidade já que é necessário que as informações a serem coletadas possam ser obtidas de forma acurada. Embora os estudos não descrevam a factibilidade do NRS-2002 em UTI, já discutimos previamente que a coleta de dados antropométricos e de consumo alimentar pode ser uma limitação naqueles pacientes em VM e sedados. Portanto, uma ferramenta mais fácil e viável poderia ser desenvolvida, e deveria incluir dados clínicos e nutricionais que pudessem ser avaliados sem a necessidade de realizar a anamnese com o paciente ou familiar. Destaca-se que o desenvolvimento de uma ferramenta deve ser baseado em métodos previamente validados, dentre os quais pode-se citar a construção de modelos de regressão que definem quais as variáveis estão significativamente associadas com o risco nutricional ou com algum desfecho clínico de interesse, sendo estas as variáveis incluídas no escore final e a elas atribuídas uma pontuação dependente da magnitude da associação com a variável dependente. Essa metodologia foi empregada para a construção das ferramentas SNAQ[45], NRE-2017[29], e do NUTRIC[23]. Revisão da literatura acerca da metodologia para construção de ferramentas de TRN concluiu que dentre as 44 ferramentas analisadas, a maioria apresenta uma descrição incompleta do seu processo de desenvolvimento[46].

2 JUSTIFICATIVA

O paciente crítico apresenta resposta metabólica que acelera o metabolismo, gerando um catabolismo acentuado e, consequentemente, degradação muscular. Essa resposta metabólica associada ao balanço energético e proteico negativo, normalmente observado nesses pacientes, gera importante perda de gordura subcutânea e de massa muscular, contribuindo para o comprometimento do estado nutricional desses pacientes e desenvolvimento de desnutrição.

O primeiro passo da sistematização do cuidado nutricional do paciente é a TRN. Atualmente existem diversas ferramentas validadas para os pacientes hospitalizados, no entanto a aplicabilidade delas no ambiente de terapia intensiva é limitada e pouco explorada. Embora as diretrizes nacionais e internacionais recomendem o uso da NRS-2002 e do NUTRIC nos pacientes críticos, ambas possuem limitações na aplicação. A NRS-2002 possui informações difíceis de serem coletadas, como avaliação quantitativa do consumo alimentar e percentual de perda de peso e IMC, além disso, classifica todo paciente com pontuação de APACHE maior de 10 como tendo risco nutricional, o que é comumente observado na grande maioria dos pacientes críticos. Por outro lado, o mNUTRIC não apresenta variáveis nutricionais, desta forma poderia ser mais adequado como escore prognóstico e não de risco nutricional.

Considerando as lacunas na literatura sobre as ferramentas de TRN no cenário da UTI, torna-se necessário avaliar a validade concorrente e preditiva de diferentes ferramentas de TRN existentes, bem como a viabilidade de sua aplicação em pacientes críticos, a fim de explorar a necessidade de desenvolvimento de uma ferramenta mais fácil e viável na prática.

3 OBJETIVOS

3.1 Objetivo Geral

Avaliar a validade de critério de cinco diferentes ferramentas de triagem de risco nutricional, bem como a viabilidade de aplicação das mesmas em pacientes adultos críticos e construir uma nova ferramenta com maior factibilidade para identificação de risco nutricional no ambiente de terapia intensiva.

3.2 Objetivos Específicos

1) Avaliar a validade concorrente e preditiva de cinco diferentes ferramentas de triagem de risco nutricional, bem como a viabilidade de aplicação das mesmas em pacientes adultos críticos
2) Desenvolver e avaliar a validade preditiva de uma nova ferramenta com maior factibilidade para identificação de risco nutricional em pacientes críticos adultos.

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5 ARTIGO CIENTÍFICO I

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Concurrent and predictive validity of nutritional risk screening tools in critically ill patients: a longitudinal study

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ABSTRACT

Background: Nutritional risk (NR) is frequent in intensive care units (ICUs) and is associated with a poor prognosis. Several nutritional screening tools (NSTs) have been validated for hospitalized patients; however, their applicability in critically ill patients has been explored scarcely. **Objective:** This study evaluated the concurrent and predictive validity of five NSTs in the ICU. **Design:** Prospective cohort study. **Participants/setting:** Data were collected between July/2019 and May/2022 from critically ill patients, and NR was evaluated using the Modified Nutrition Risk in Critically Ill (mNUTRIC), Nutritional Risk Screening (NRS-2002), Malnutrition Screening Tool (MST), Malnutrition Universal Screening Tool (MUST), and Nutritional Risk in Emergency (NRE-2017). **Statistical analyses:** The receiver operating characteristic (ROC) curve and κ coefficient assessed the accuracy and agreement of the tools. Logistic regression verified the association between NR and prolonged ICU stay, and Cox regression was used to verify the association between NR and mortality in the ICU, both with adjustment for confounders. **Results:** 450 patients (64 [54-71] years, 52.2% men) were included, and NR ranged from 36.4% (NRS-2002 $\geq$ 5) to 50.2% (NRS-2002 $\geq$ 3). NRS-2002 $\geq$ 5 showed the best accuracy [0.63 (CI95% 0.58–0.69]) with mNUTRIC, and the MST with NRS-2002 $\geq$ 5 [0.76 (CI95% 0.71–0.80]). All tools had poor agreement with mNUTRIC (k=0.019–0.268) and moderate agreement with NRS-2002 $\geq$ 5 (k=0.474–0.503). MUST (HR=2.26 (CI95% 1.40–3.63]) and MST (HR=1.69 (CI95% 1.09–2.60]) were predictors of ICU-death, and the NRS-2002 $\geq$ 5 [OR=1.56 (CI95% 1.02–2.40)] and mNUTRIC (OR=1.86 (CI95% 1.26–2.76)] of prolonged ICU stay. **Conclusion:** None NST demonstrated satisfactory concurrent validity; only MUST and MST were predictors of ICU death and NRS-2002 $\geq$ 5 and mNUTRIC of prolonged ICU stay.

Keywords: nutritional risk; screening; critically ill patients; intensive care; accuracy metrics.

Introduction

Critically ill patients present a stress response characterized by marked inflammation and, consequently, intense protein catabolism. A reduction in the efficiency of protein utilization has also been observed, with muscle degradation associated with the loss of muscle function and contractility.[1] Marked protein catabolism, muscle wasting, and unintentional weight loss (UWL) are consequences of critical illness that predispose patients to a high risk of malnutrition. During the intensive care unit (ICU) stay, most patients have reduced energy-protein "reserves," compounding the restricted food intake during ICU and hospital stay, prolonged fasting, and frequent interruptions in feeding.[2] Thus, identifying critically ill patients who would benefit from earlier and more aggressive initiation of nutrition therapy is a challenge because the traditional methods of assessing the nutritional status of hospitalized patients are frequently not feasible in the ICU setting.[3]

As recommended by the main national and international societies,[4–6] the first step in the nutrition care process (NCP) requires a validated nutritional screening tool (NST), which should have adequate validity, reliability, sensitivity, specificity, and positive predictive value (PPV) for detecting patients at high nutritional risk (NR).[7] Heyland et al. proposed that the NR of critically ill patients should not be considered a risk factor for malnutrition, given that the inflammatory response to stress and the consequent protein catabolism affect all critically ill patients. The authors suggest that it be evaluated as the risk of the patient presenting complications or worse outcomes that could be prevented with adequate nutritional therapy.[8]

Based on this concept, Heyland et al.[8] developed the Nutrition Risk in Critically Ill (NUTRIC) score to assess the NR of critically ill patients. Subsequently, Rahman et al. validated the tool without interleukin-6 (IL-6) measurement. They demonstrated that the modified NUTRIC (mNUTRIC) tool performed similarly in predicting clinical outcomes and demonstrating the beneficial impact of adequate nutritional therapy on such outcomes in patients classified as NR.[9] The American Society for Parenteral and Enteral Nutrition (ASPEN)[4] and the Brazilian Society of Parenteral and Enteral Nutrition (BRASPEN)[5] recommend the use of NUTRIC[8] or Nutritional Risk Screening (NRS-2002)[10] as NST in the ICU. However, both methods have limitations in this setting. NRS-2002[10] contains information that is usually difficult to collect, such as a quantitative assessment of food consumption and information on the percentage of UWL, in addition to classifying patients with an Acute Physiology and Chronic Health Evaluation (APACHE II)[11] score greater than 10 as having NR, which is commonly observed in most critically ill patients. However, the NUTRIC[8] score has no nutritional parameters in the tool, which may be more useful for evaluating the clinical prognosis. Furthermore, the agreement between these two tools is poor according to a unique study found in the literature.[12]

Several other tools have been developed and validated to assess NR in non-critically ill patients, such as the Malnutrition Universal Screening Tool (MUST),[13] Malnutrition Screening Tool (MST),[14] and Nutrition Risk at Emergency (NRE-2017).[15] Few studies have

explored the association between NR by MUST and worse clinical outcomes in ICU settings.[16,17] To the best of our knowledge, no study has applied the other two tools to critically ill patients. Despite this, according to the latest position of the Academy of Nutrition and Dietetics (AND), MST should be used to screen adults for malnutrition regardless of their age, medical history, or setting, including the ICU.[18] NRE-2017 was developed and validated by our research group and presented satisfactory criterion validity in emergency services.[15] The MST[14] and NRE-2017[15] tools appear to be easier and more accessible to critically ill patients because they do not consider actual weight and height. Therefore, their validity in the ICU settings needs to be explored. Considering the gaps in the literature on NST in the ICU setting, this study aimed to evaluate the concurrent and predictive validity of different NSTs, as well as the feasibility of their application in critically ill patients.

Methods

Design and sample

We conducted a cohort study of critically ill adult patients admitted to six ICUs from a hospital complex in Porto Alegre (Rio Grande do Sul, Brazil). All patients aged ≥ 18 years who were able to respond to simplified nutritional anamnesis or whose relatives were able to respond were included. The study excluded patients expected to stay in the ICU for fewer than 24 hours, pregnant and lactating women (nine months postpartum), patients without arterial blood gas analysis and/or blood count at admission, patients in anasarca with an inability to perform a physical examination, and those with medical contraindications for mobilization to perform anthropometry.

The sample size was estimated at 393 patients based on the difference in the NUTRIC score of survivors [5 (3–6)] and non-survivors [6 (5–7)] identified in the study conducted by Vries et al., considering 80% power and 5% significance level and a ratio of 0.25[17] survivors to non-survivors. Indeed, a 20% additional for potential losses to follow-up and adjustments in a multivariate model were adopted, and the final estimated sample size was 472 patients.

Ethics

The project was approved by the Santa Casa Research Ethics Committee (opinion number 2.598.103), and data collection was performed after the patients, family members, and/or guardians of the participants signed the written informed consent. The research protocol was conducted in accordance with the ethical assumptions of Brazilian resolution 466/12.

Data collection

We collected data prospectively from electronic medical records, such as age, sex, the reason for hospital and ICU admission, number of comorbidities, number of days of hospital stay before admission to the ICU, medications, and undergoing mechanical ventilation (MV) or hemodialysis (HD) in the ICU, as well as the duration of these therapies. The severity scores applied in the initial assessment of the patient were APACHE II[11] and Sequential Organ Failure Assessment (SOFA).[19]

Nutritional assessment was performed within 24 hours of the patient's admission to the ICU by a team of four trained registered dietitians through an interview with patients, or their relatives when they were not able to answer it (with sedative prescription and/or MV). Anamnesis was performed with relatives face-to-face or by phone. It comprised the assessment of food consumption in the last two weeks regarding quantity and consistency, change in appetite and WL (if intentional or not, magnitude, and period), as well as self-reported usual, current weight, and height. Body mass index (BMI) was calculated from the ratio between weight/height^2 and the percentage UWL from the equation (%UWL = usual weight − current weight/usual weight × 100). Indeed, a physical examination was performed to evaluate the presence of muscle mass loss in the face (temporal and masseter), deltoid (clavicle, shoulders, scapula), intercostal, and calf muscles and classified as normal, mild, moderate, or severe muscle mass loss.[20]

NR screening was performed using five tools: mNUTRIC,[9] NRS-2002,[10] MUST,[13] MST,[14] and NRE-2017.[15] **Table 1** summarizes the variables from each tool and their respective scores for NR classification. We categorized NR using all tools into two categories (with or without NR), aiming to standardize the comparisons. Therefore, for screening tools with more than two risk categories (MUST), we grouped the patients classified as medium and high-risk into the category "with NR". The NRS-2002 was evaluated with two different cutoff points ($\geq$ 3 and $\geq$ 5), considering its recommendations in previous publications.[4,5]

The study followed the patients using electronic records until hospital discharge to collect the primary outcomes of interest: death in the ICU and length of stay (LOS) in the ICU categorized according to the median of our sample upon data analysis since we did not identify any standard for prolonged ICU stay in the literature.

Statistical analysis

Descriptive statistics were calculated for sample characterization: mean and standard deviation for parametric quantitative variables, median and interquartile range for non-parametric quantitative variables, and absolute and relative frequencies for categorical variables. The Kolmogorov-Smirnov test assessed the normality of the variables.

The concurrent validity of the MUST, MST, NRE-2017, and NRS-2002 was tested by κ coefficient calculation and by the construction of a receiver operating characteristic (ROC) curve with a 95% confidence interval (CI) using the mNUTRIC as the reference method. For κ interpretation, the reference values considered were the following: < 0.20 as poor, 0.21–

0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, 0.81–0.99 as almost perfect, and 1.00 as perfect.[21] The sensitivity, specificity, PPV, and negative predictive value (NPV) were calculated and classified according to the following cutoffs: 90–100% as high, 80–89% as moderate, and ≤ 79% as low.[18] The same accuracy metrics were calculated for MUST, MST, and NRE-2017 using NRS-2002 ≥ 5 as the reference. The comparison of AUCs from the NSTs used the DeLong test in MedCalc Statistical Software.[22]

The predictive validity of all NSTs applied in the present study was evaluated using logistic regression to verify the association between NR and prolonged ICU stay (median was considered as the cutoff since we did not identify a universal duration accepted as prolonged ICU stay), adjusting for potential confounders (SOFA score, age, and surgical procedures). Cox regression analysis was performed to verify the association between NR and mortality in the ICU with adjustment for potential confounders. When considering the NR by the mNUTRIC, only the surgical variable was considered in the adjusted model, considering that age and SOFA score is one of its variables. We defined the confounders based on clinical relevance and a P value <0.20 in the bivariate analysis.

Statistical analysis was performed using SPSS version 22.0 (IBM Corporation, SPSS, Inc., Chicago, IL, USA), and p-values <0.05 were considered significant.

Results

General characteristics of the sample

Data collection started in July 2019 and was interrupted in March 2020 due to the COVID-19 pandemic. The collection was resumed in April 2021 and was completed in May 2022. We compared the patients included in the study in the first and second periods of data collection regarding general features, frequency of NR, and outcomes, and no difference was observed between them (data not shown).

A total of 472 patients were initially screened as eligible for the current study, but 22 patients were excluded because they died before the nutritional analysis was performed (**Supplementary Figure 1**). Thus, 450 patients were included in the study, with a mean age of 64 [54-71] years, of which 52.2% were men and 64.7% underwent surgical procedures before ICU admission. Most patients were from the ward (49.9%), with a median length of hospital stay of 1 (0–7) days prior to admission to the ICU. The main reasons for ICU admission were pulmonary disorders (29.3%) and oncological disorders (28.2 %).

At ICU admission, approximately half of the patients (51.3%) had a prescription of antibiotics, 47.1% of sedatives, 80% of analgesics, and 59.3% of vasoactive drugs. Approximately one-fourth of the sample (22.3%) had sepsis and 53.3% required ventilator support, with a median duration of two (1–8) days. Only 8% of the patients underwent HD. The median SOFA score was 6 (3–10) points, and the mean APACHE was 18.07±8.59 points. The median length of stay was 5 days (range, 3–9 days), and 20% of the patients died in the ICU.

Nutritional anamnesis was performed with patients in approximately half of the sample (51.3%). Weight and BMI were 72.24 ±17.12 kg and 25.9 ±5.26 kg/m , respectively. The details of the general features of the sample are presented in **Supplementary Table 1**.

Nutritional risk screening tools

The relative frequency of patients at NR varied among the NSTs: 46.9% of patients were at NR by the mNUTRIC, 40% by the MUST, 43.3% by the MST, 41.8% by the NRE 2017, 50.2% by the NRS-2002 (≥ 3 points), and 36.4% at high NR by the NRS-2002 (≥ 5 points). The mean mNUTRIC was 4.41 ±2.12 points. The MUST score was 0 (0–2) points, MST was 1 (0–3) point, NRE-2017 was 1 (0.5–2.0) point, and NRS-2002 was 4 (3–5) points.

Regarding the feasibility of the tools, it was not possible to apply the MUST in 8.7%, MST in 0.4%, NRE-2017 in 0.4%, and NRS-2002 in 0.5% of the patients. The frequency of each component for all the NSTs is shown in **Table 2**. The most frequent component in the NRS-2002 was the severity of disease classified as severe (77.9%), in the mNUTRIC was the age between 50 and 75 years (63.7%), and the days from hospital admission to ICU admission (64.8%); in the MUST and MST, UWL was 37.9% and 68.6%, respectively, and in the NRE-2017, in addition to disease severity (100%), the most frequent component was UWL (51%).

Concurrent validity

Table 3 shows the concurrent validity of the NSTs used to identify NR, using mNUTRIC as the reference method. All NSTs presented unsatisfactory accuracy, although NRS-2002 ≥ 3 had a sensitivity of 100% and specificity of 24.5%. The NRS-2002 ≥ 5 points showed the best accuracy among the tools, but it presented a fair agreement with mNUTRIC, while for the other tools, this agreement was poor (κ coefficient between 0.019–0.139).

The comparisons between the AUC of the ROC showed no significant difference between the AUC of MST and MUST ($p = 0.286$), between MST and NRE-2017 ($p = 0.151$), or between NRS-2002 with different cut-off points (> 3 and ≥5 points) ($p = 0.849$). On the other hand, the comparison between the AUC of MST and MUST with the NRS-2002 with different cut-off points (≥ 3 and ≥5 points) demonstrated a significant difference ($p < 0.001$), as well as between the AUC of NRE-2017 and the NRS-2002 with different cut-off points (NRS-2002 ≥ 3 points ($p = 0.015$) and NRS-2002 ≥ 5 points ($p = 0.003$]) (**Table 3** and **Supplementary Figure 2**).

The concurrent validity was also calculated using NRS-2002 ≥ 5 points as a reference method. All NR screening tools had better accuracy than mNUTRIC as a reference method. The MST showed the best agreement with NRS-2002 ≥ 5 points and moderate agreement (κ coefficient between 0.474 and 0.503) with MUST and NRE-2017 was found. In the comparisons between the AUC of the ROC curves, there was no significant difference between the areas (**Table 3** and **Supplementary Figure 2**).

Predictive validity

An analysis based on outcomes of interest was performed to compare general characteristics and NR, as shown in **Table 4**. Non-survivors were older and presented higher APACHE II and SOFA scores, ICU LOS scores, and more pre-ICU days than survivors. Indeed, the frequency of MV and HD on ICU admission was higher in non-survivors, while survivors underwent more frequent surgical procedures. A significantly higher frequency of patients at NR was observed in non-survivors than in survivors, regardless of the NST applied, except for MUST. Patients with prolonged ICU stay (≥ 5 days) presented higher APACHE II, SOFA, and frequency of MV and HD on ICU admission, whereas patients with ICU stay ≤ 5 days underwent more frequent surgical procedures. More patients at NR regardless of the NSTs applied were identified among those with prolonged ICU stay in comparison to their pairs, but the difference reached statistical significance only for mNUTRIC and NRS-2002.

The crude and adjusted multivariate analyses to evaluate the validity of the NSTs in predicting death and length of ICU stay are shown in **Table 5**. The MUST, NRE-2017, and MST tools were predictors of death in the ICU in the crude analysis; however, in the adjusted analysis, only the MUST and MST remained statistically significant. Patients at NR by the MUST and MST presented an increase of 2.26 and 1.69 times, respectively, in the risk of death in the ICU in comparison with patients at no NR.

In the unadjusted analysis, NRS-2002 (both cutoff points) and mNUTRIC were predictors of prolonged ICU stay (≥ 5 days); however, only NRS-2002 ≥ 5 points and mNUTRIC remained statistically significant after adjusting for confounders. The NRS-2002 ≥ 5 points and mNUTRIC presented an increase of 1.56 and 1.86 times, respectively, in the odds of prolonged ICU stay (≥ 5 days) in comparison with the patients at no NR.

Discussion

This study evaluated the concurrent and predictive validity of different NSTs in critically ill patients, using mNUTRIC and NRS-2002 (≥ 5 points) as reference methods. By conducting anamnesis with patients or their families, the application of NSTs was feasible in almost all samples. The prevalence of NR varied from 36.4% to 50.2%, and the concurrent validity of all tools (mNUTRIC as a reference method) was unsatisfactory, with a sensitivity of < 80%, except for NRS-2002 ≥ 3, with a sensitivity of 100% but low specificity. Similarly, when using NRS-2002 ≥5 points as a reference method, no tools showed a sensitivity of > 80%. In multivariate analysis for predictive validity, MUST and MST were predictors of death in the ICU, and NRS-2002 ≥ 5 and mNUTRIC were predictors of prolonged ICU stay (≥ 5 days).

In our study, the prevalence of NR ranged from 36.4 to 50.2%, depending on the screening tool applied; the lowest prevalence was in the NRS-2002 ≥ 5 and the highest prevalence was in the NRS-2002 ≥ 3, while the mNUTRIC showed a prevalence of 46.9% in

patients with NR. A previous systematic review[23] reported a mean prevalence of NR in critically ill patients of 55.9% (16.0% to 99.5%), and NUTRIC and NRS-2002 were the most used tools. When they considered the NR identified by NRS-2002, the prevalence ranged from 39.4% to 99.5% and using any version of NUTRIC the prevalence ranged from 16.0% to 91.1%. Among studies published in recent years using the NRS-2002 $\geq$ 5 to identify patients at NR, the prevalence ranged from 20.9% to 54.4%.[24–27] To the best of our knowledge, fewer than five studies have applied the MUST to identify critically ill patients at NR and showed a prevalence of 35.7 to 47.7%,[17,28,29] while we did not find any study reporting the NR by MST and NRE-2017 in the ICU. These differences in the prevalence of NR in critically ill patients can be explained by the heterogeneity of the patients in the studies, such as age and disease severity, in addition to the different methods of collecting data. Many studies[30,31] with the NRS-2002 consider all patients with a score of 3 in the severity of the disease; however, our study used the APACHE cutoff of 10 to classify the severity of the disease according to the tool's recommended criteria, which may justify our findings of lower prevalence when compared to the literature. In addition, the differences in APACHE and SOFA scores can explain the range of prevalence according to NUTRIC identified among the studies.[17,32–34]

In the current study, none NST presented satisfactory accuracy with mNUTRIC because the sensitivity was lower than 80% (except NRS-2002 $\geq$ 3), the overall accuracy was lower than 65%, and the κ agreement was lower than 0.30. We did not identify any studies that evaluated these accuracy metrics in the ICU setting. A Brazilian study[11] conducted with 208 patients demonstrated low agreement between mNUTRIC and NRS-2002 $\geq$ 5 ($\kappa = 0.39$). Another study[35], involving 120 critically ill patients, compared the NRS-2002 and mNUTRIC to the Subjective Global Assessment (SGA) and showed a sensitivity of 79% and 58%, respectively. However, SGA is a diagnostic nutritional tool and should not be used as a reference method for testing the accuracy of NSTs.[36] Hiller et al[37] assessed the accuracy of NRS-2002 $\geq$ 3, MUST, and mNUTRIC in identifying the need for nutritional intervention in critically ill patients and demonstrated a higher accuracy for MUST (79.3%) compared to the other tools (NRS-2002: 56%, mNUTRIC: 73.3%).

As recommended in the literature,[38] the best way to validate a tool is to analyze the criterion validity, comprising both concurrent and predictive validity, which is determined by comparing a test tool to a "gold standard." The recommended statistical metrics for concurrent validity are the calculation of sensitivity, specificity, and positive and negative predictive values, as well as the κ coefficient to determine the agreement among the tools. In our study, we compared different NSTs using mNUTRIC and NRS-2002 $\geq$ 5 as the reference methods, considering that ASPEN[4] and BRASPEN[5] recommend these NSTs for critically ill patients. However, when we compared MUST, MST, and NRE-2017 with NRS-2002 $\geq$ 5, the accuracy was not satisfactory. This may be explained by the fragility of NRS-2002 as a reference method, since it was originally proposed for nutritional risk screening of non-

critically ill patients[10] and, to the best of our knowledge, the cutoff of ≥ 5 (that is proposed by ASPEN)[4] is based on expert opinion. Considering this, a specific NST for critically ill patients should be developed since the major criticism regarding the mNUTRIC is that it is a prognostic score, not an NR score, and the NRS-2002 requires information that is often difficult to obtain in the ICU, such as body weight, weight loss, and food intake.

The present study demonstrated that MUST and MST were predictors of death in the ICU, and NRS-2002 ≥ 5 and mNUTRIC score were predictors of prolonged ICU stay (> 5 days). To our knowledge, only one study[17] has evaluated the predictive validity of MUST in critically ill patients, which was conducted with 475 Dutch patients, and showed that MUST was not a predictor of death and prolonged MV. Similar to our findings, a prospective cohort study[39] conducted with 100 critically ill patients showed that NRS-2002 was a predictor of prolonged ICU stay, but not of death; however, multivariate analysis was not performed. A Brazilian prospective cohort study[40] with 384 critically ill patients also reported that patients identified as a high nutritional risk by the NRS-2002 ≥ 5 did not have a statistically significant increase in the risk of death. In contrast, a study[30] with 413 critically ill patients showed that a 1-unit increase in NRS-2002 score was associated with the risk of mortality increasing it by 1.23 times, after adjusting for sex, age, comorbidity, and BMI. The NRS-2002 predictive validity is questionable because there are a limited number of studies in which a multivariate analysis was performed, and these studies adopted different cutoff points for the NR classification.

The AND[18] position recommends that the MST be used as a NST, regardless of the setting, due to its higher overall validity, agreement, reliability, and generalizability, as evidenced through a systematic review comparing different screening tools.[41] However, we did not find any study with the MST conducted in critically ill patients; therefore, our study is the first to assess the concurrent and predictive validity of this tool in the ICU, and they were not satisfactory. NRE-2017 was constructed by our research group, aiming to have a simple screening tool without anthropometric parameters for nutritional risk screening in emergency services. It was validated by a study involving 748 patients that demonstrated satisfactory accuracy in comparison to NRS-2002 (sensitivity: 81.2%; specificity: 79.4%; overall accuracy: 80.2%) and significant association with very long hospital stay (OR=2.10 [CI 95% 1.65–2.69]) and hospital death (OR=2.78 [CI 95% 1.03–7.49]).[15] We hypothesized that this tool would be accurate in the ICU setting, but this was not confirmed. We speculate that NRE-2017 was not accurate because it does not include a discriminatory indicator of severity, which is probably crucial in the identification of NR in ICU settings. On the other hand, it fits the criteria for an ideal NST proposed recently by Marian et al. better than the other tools applied in the current study, since NRE-2017 combines criteria addressing malnutrition risk factors.[42]

As demonstrated in the results of our study, the data were collected mostly from patients (51.3%), whereas reminders were collected from family members, and only a small

sample was collected from medical records (0.9%). Critically ill patients are usually on MV and are unaccompanied by a family member during their stay in the ICU, which makes existing NST not completely feasible or viable, since we could not find the necessary information in the electronic medical records. Detailed information regarding who responded to nutritional anamnesis has not always been reported. Narayan et al. suggested that an ideal NST for ICU settings might assess dietary, physical, anthropometric, psychological, social, and clinical factors, and each assessed variable should be justified with an evidence-based risk factor or outcome.[43] As seen in the current study, none evaluated NST has been able to predict a wide variety of worse outcomes in critically ill patients, although most fulfill the majority of these criteria. Considering our results and the challenge of accessing the food intake and body weight/height of critically ill patients, as well as the relevance of the severity of the disease in their prognosis, a new tool should be developed combining an easy and simple nutritional indicator and disease severity markers for identification of critically ill patients at NR.

The greatest strength of our study is its originality since the concurrent and predictive validity of different NSTs in the ICU has scarcely been explored until now. Furthermore, our study evaluated a sample with adequate power to test the hypothesis, with a heterogeneous group of critically ill patients, conducted by a trained group of nutritionists, which made the data collection more reliable and supported the internal validity of our study. One limitation of this study is that it considered the reported weight, not the measured weight, in the MUST and in the NRS-2002 tools; however, our study was pragmatic since we were not able to measure weight and height data in the ICU because of the severity of these patients. In addition, we could not evaluate the validity of the NSTs in predicting which patients might respond to nutritional therapy since a small subsample was receiving enteral or parenteral support, and there was no accurate control of delivered and prescribed energy in the hospitals where the study was conducted. This gap should be investigated in future studies.

Conclusion

The prevalence of nutritional risk varied depending on the NST applied, and none of them demonstrated satisfactory concurrent validity using mNUTRIC and NRS-2002 $\geq$ 5 as reference methods. Only MUST and MST were predictors of death in the ICU, and NRS-2002 $\geq$ 5 and mNUTRIC were predictors of prolonged ICU stay ($\geq$ 5 days). Anamnesis with patients' families was necessary for more than 45% of the patients to make nutritional risk screening feasible in the ICU setting.

Author contributions:

FMS contributed to the conception of the study. DSJM, ELR, JL and FMS contributed to data acquisition. ELR and FMS analyzed the data. ELR, FMS, DSJM and JL contributed to the interpretation of data. ELR and FMS drafted the manuscript. All authors reviewed and commented on subsequent drafts of the manuscript.

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Conflict of interest

The authors declare no conflicts of interest.

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Table 1: Nutritional risk screening tools criteria, points, and classification

Variables	NRE-2017	NRS-2002	MST	MUST	mNUTRIC
APACHE					x
SOFA					x
Age	x	x			x
Number of comorbidities					x
Number of days of hospitalization prior to ICU					x
Food consumption x energy requirement		x			
No nutritional intake for >5 days				x	
Reduced appetite	x		x		
Change in diet consistency	x				
Body mass index		x		x	
Weight loss	x	x	x	x	
Disease stress	x	x			
Muscle mass loss	x				
Points and classification					
No nutritional risk	< 1.5	< 3	<2	0	≤ 4
Nutritional risk	≥ 1.5	≥ 3	≥ 2	≥	≥ 5

Abbreviations: NRE-2017, Nutritional Risk in Emergency 2017; NRS-2002, Nutritional Risk Screening 2002; MST, Malnutrition Screening Tool; MUST, Malnutrition Universal Screening Tool; mNUTRIC, modified Nutrition Risk in Critically ill; APACHE II, Acute Physiology and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; ICU, Intensive Care Unit

Table 2. Relative frequency of components of nutritional risk screening tools

Variables	%
NRE-2017	
1. Is the patient's age above 65 years old?	48.1
2. Does the patient have a high-stress disease?	100.0
3. Has the patient reported decreased appetite in the last 2 weeks?	40.5
4. Has the patient reported changing of food consistency in the last 2 weeks?	13.1
5. Has the patient had unintentional weight loss in the last 6 months?	51.0
6. Does the patient have signs of muscle mass loss according to the physical exam?	43.9
NRS-2002	
Impaired nutritional status	
Absent	46.9
Mild	17.5
Moderate	18.6
Severe	16.6
Severity of disease	
Absent	2.7
Mild	10.9
Moderate	8.5
Severe	77.9
Age ≥70 years	
Yes	28.3
MST	
Have you recently lost weight without trying?	
No	47.2
Unsure	6.0
If yes, how much weight have you lost (Kg)?	
1-5	19.2
6-10	21.8
11-15	7.1
>15	4.7
Unsure	15.8
Have you been eating poorly because of a decreased appetite?	
Yes	41.9
MUST	
Body mass Index (kg/m^2)	
> 20 (>30 obese)	87.4
18,5 – 20	6.7
<18,5	5.9
Unintentional weight loss (%)	
<5	62.1

5-10	17.9
>10	20.0
No nutritional intake > 5 days	2.2
mNUTRIC	
Age (years)	
<50	20.0
50-75	63.7
≥75	16.3
APACHE II (points)	
<15	37.0
15-20	20.7
20-28	27.6
≥28	14.7
SOFA (points)	
<6	43.0
6- <10	28.7
≥10	28.3
Number of comorbidities	
0-1	25.8
≥2	73.9
Days from hospital to ICU admission	
0-<1	35.2
≥1	64.8

Abbreviations: NRE-2017, Nutritional Risk in Emergency 2017; NRS-2002, Nutritional Risk Screening 2002; MST, Malnutrition Screening Tool; MUST, Malnutrition Universal Screening Tool; mNUTRIC, modified Nutrition Risk in Critically ill; APACHE II, Acute Physiology and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; ICU, Intensive Care Unit

Table 3: Concurrent validity of nutritional risk screening tools

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Kappa (p-value)	AUC ROC curve
mNUTRIC						
NRS-2002 ≥ 3	100	24.5	54	100	0.233 (p<0.001)	0.63 (0.58 - 0.68) [a]
NRS-2002 ≥ 5	50.5	75.9	65	63.4	0.268 (p<0.001)	0.63 (0.58 - 0.69) [a]
MUST	44.8	57.1	48	53.9	0.019 (p=0.694)	0.51 (0.45 - 0.57) [b d]
MST	46.7	59.3	50.5	55.6	0.060 (p=0.203)	0.53 (0.47 - 0.59) [b c]
NRE-2017	49.5	64.3	54.8	59.3	0.139 (p=0.003)	0.56 (0.51 - 0.62) [c]
NRS-2002 ≥5						
MUST	77.5	73.4	59.8	86.5	0.475 (p<0.001)	0.76 (0.71 - 0.80) [e]
MST	76.7	75.6	64.4	84.9	0.503 (p<0.001)	0.76 (0.71 - 0.80) [e]
NRE-2017	73.0	75.9	63.6	82.9	0.474 (p<0.001)	0.75 (0.69 - 0.81) [e]

De Long Test. Equal superscript letters indicate the absence of statistical significance difference between areas (p>0.05). Different superscript letters indicate significant differences between areas (p<0.05)

Abbreviations: mNUTRI, modified Nutrition Risk in Critically ill; PPV, Positive Predictive Value; NPV, Negative Predictive Value; AUC ROC, area under the receiver operating characteristic curve; NRS-2002, Nutritional Risk Screening 2002; MUST, Malnutrition Universal Screening Tool; MST, Malnutrition Screening Tool; NRE-2017, Nutritional Risk in Emergency 2017;
[e] = MUST compared to MST, p = 0.905; MUST compared to NRE-2017, p = 0.653; NRE-2017 compared to MST, p= 0.586

Table 4: Predictive Validity - Association between clinical outcomes and general features and nutritional risk

	Death in the ICU			Length of stay in the ICU		
	Survivors (n=360)	Non Survivors (n=90)	p	≥ 5 days (n=229)	< 5 days (n=221)	p
General features						
Age	60.5 ± 14.63	65.9 ± 12.89	0.001 [a]	60.5 ± 15,0	62.6 ± 13.8	0.120[a]
Males	50.8%	57.8%	0.288 [b]	50.2%	54.1%	0.467[b]
APACHE II	16.84 ± 7.92	23.01 ± 9.38	<0.001 [a]	20.3 ± 8.7	15.7 ± 7.9	<0.001[a]
SOFA	6 (3 - 10)	8 (5 - 11.3)	<0.001 [c]	8 (4 - 11)	5 (2 - 8)	<0.001[c]
Surgical	73.1%	31.1%	<0.001 [b]	53.3%	76.8%	<0.001[b]
Pre ICU days	1 (0 - 7)	3 (1 - 9)	0,008 [c]	2 (0 - 9)	1 (0 - 6)	0,155 [c]
ICU length of stay	4 (2 - 7)	8 (5 - 21.3)	<0.001 [c]	-	-	-
MV on admission	50.6%	64.4%	0.025 [b]	69.4%	36.8%	<0.001 [b]
HD on admission	5.6%	17.8%	<0.001 [b]	10.5%	5.0%	0.048 [b]
Nutritional risk						
mNUTRIC	41.3%	68.9%	<0.001[b]	56.1%	37%	<0.001 [b]
NRS-2002 ≥ 3	84.3%	97.8%	<0.001[b]	93.4%	80.4%	<0.001 [b]
NRS-2002 ≥ 5	33.3%	48.9%	0.009 [b]	43.6%	29.2%	0.002 [b]
MUST	41.3%	53%	0.072 [b]	46.1%	41.5%	0.400 [b]
MST	40.8%	53.9%	0.034 [b]	45.4%	41.6%	0.473 [b]
NRE-2017	38.3%	57.3%	0.002 [b]	45.4%	38.8%	0.191 [b]

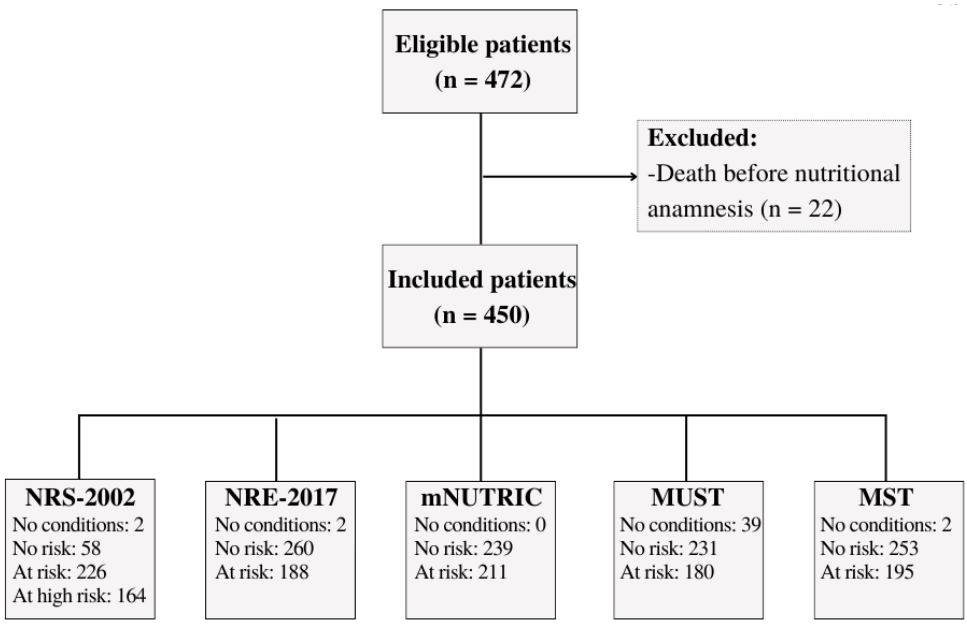
[a] Student t test, [b] Qui-square test, [c] Mann-Whitney test.

Abbreviations: APACHE II, Acute Physiology and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; ICU, Intensive Care Unit, MV, Mechanical ventilation; HD, Hemodialysis; mNUTRIC, modified Nutrition Risk in Critically ill; NRS-2002, Nutritional Risk Screening 2002; MUST, Malnutrition Universal Screening Tool; MST, Malnutrition Screening Tool; NRE-2017, Nutritional Risk in Emergency 2017;

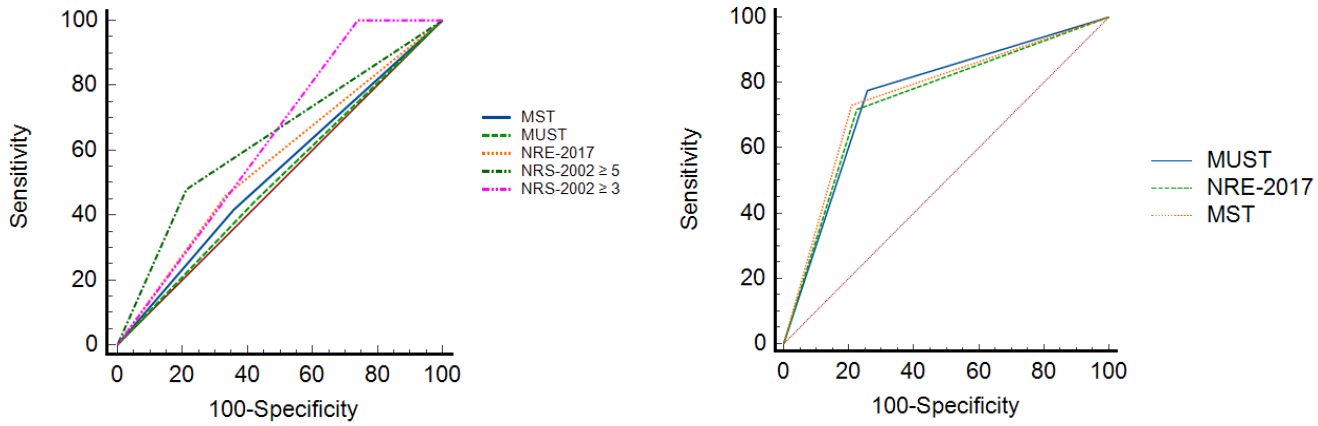
Table 5: Predictive Validity - Association between clinical outcomes and nutritional risk - Multivariate analysis

	Death in the ICU[a]				**Length of stay in the ICU ≥ 5 days** [b]			
	Unadjusted analysis HR (CI 95%)	p	Adjusted analysis HR (CI 95%)	p	Unadjusted analysis HR (CI 95%)	p	Adjusted analysis HR (CI 95%)	p
NRS-2002 ≥ 5	1.48 (0.97 – 2.25)	0.066	1.35 (0.89 – 2.07)	0.161	1.87 (1.27 - 2.77)	0.002	1.56 (1.02 - 2.40)	0.042
NRS-2002 ≥ 3	2.16 (0.53 – 8.85)	0.287	1.79 (0.42 – 7.67)	0.435	3.45 (1.86 - 6.42)	<0.001	1.96 (0.99 - 3.88)	0.055
MUST	1.94 (1.23 – 3.05)	0.004	2.26 (1.40 – 3.63)	0.001	1.22 (0.82 - 1.80)	0.325	1.18 (0.78 - 1.79)	0.429
NRE-2017	1.65 (1.08 – 2.51)	0.021	1.48 (0.97 – 2.30)	0.071	1.32 (0.91 - 1.93)	0.149	1.39 (0.91 - 2.13)	0.133
MST	1.68 (1.10 – 2.57)	0.016	1.69 (1.09 – 2.60)	0.018	1.18 (0.81 - 1.71)	0.392	1.20 (0.80 - 1.79)	0.385
mNUTRIC	1.52 (0.96 – 2.40)	0.072	1.43 (0.90 – 2.26)	0.130	2.18 (1.49 - 3.19)	<0.001	1.86 (1.26 - 2.76)	0.002

[a] Cox regression, [b] Logistic Regression. **Abbreviations:** NRS-2002, Nutritional Risk Screening 2002; MUST, Malnutrition Universal Screening Tool; MST, Malnutrition Screening Tool; NRE-2017, Nutritional Risk in Emergency 2017; mNUTRIC, modified Nutrition Risk in Critically ill



Supplementary Figure 1. Flowchart of study participants



Supplementary Figure 2. Comparisons between the AUC of the ROC of different nutritional screening tools for identifying nutritional risk considering mNUTRIC as the reference.

***Supplementary Table 1*:** Clinical and nutritional characteristics of 450 critically ill patients

Characteristics	Descriptive Statistics
Clinical	
ICU admission type	
Pulmonology/Respiratory System	132 (29.3%)
Oncology	127 (28.2%)
Gastrology/hepatology	73 (16.2%)
Infectology	47 (10.4%)
Cardiology	35 (7.8%)
Endocrinology	3 (0.7%)
Neurology	15 (3.3%)
Nephrology	15 (3.3%)
PO complications	2 (0.4%)
Maxillofacial Oral	1 (0.2%)
CRP (mg/L)	143.11 ± 109.37
Nutritional	
Current weight (kg)	72.24 ± 17.12
Usual weight (kg)	75.97 ± 18.15
Weight loss (%)	10.20 ± 6.6
Adductor pollicis muscle thickness (mm)	22.25 ± 4.94
Arm circumference (cm)	29.79 ± 4.52

Data are presented as absolute (relative) frequencies and mean ± standard deviation
Abbreviations: CRP, C-reactive Protein

6 ARTIGO CIENTÍFICO II

Será submetido ao Clinical Nutrition.

Screening of Nutritional Risk in Intensive Care (SCREENIC score): A New Proposal for a Nutritional Screening Tool in Critically Ill Patients

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ABSTRACT

Background & aims: Nutritional risk (NR) screening is the first step in the nutrition care process and must be performed using a validated nutritional screening tool (NST). For critically ill patients its recommended to use The Nutrition Risk in Critically Ill (NUTRIC) or the Nutritional Risk Screening 2002 (NRS-2002), however, both have limitations and only the NUTRIC was validated in the intensive care unit (ICU). This study aimed to develop a new NST for critically ill patients and test its predictive validity. It was named the Screening of Nutritional Risk in Intensive Care (SCREENIC score).

Methods: We conducted a secondary analysis of a cohort study for the development of the SCREENIC score. Four stages were fulfilled for the development, and the variables of different NST and malnutrition diagnosis tools [mNUTRIC, NRS-2002, Malnutrition Screening Tool (MST), Malnutrition Universal Screening Tool (MUST), Nutritional Risk in Emergency-2017 (NRE-2017), Subjective Global Assessment (SGA) and Global Leadership Initiative on Malnutrition (GLIM)] criteria were considered to guide the construction and selected to compose the final score by logistic regression analysis. The cut-off point for the classification of high NR was defined with the construction of the receiver operating characteristic (ROC) curve, using the mNUTRIC as a reference. Sensitivity, specificity, and positive and negative predictive values were calculated. Predictive validity was assessed by logistic regression for the length of ICU and hospital stay, ICU readmission, and post-discharge outcomes, and Cox regression was used for ICU and hospital mortality.

Results: A total of 450 patients (64 [54-71] years, 52.2% men) were included. From 14 pre-selected variables, six questions with the possibility of yes/no answers were included in the score because they were associated with a high mNUTRIC score. The cutoff point for a high NR classification was 4.0 points. The SCREENIC score showed moderate agreement (k=0.564), high accuracy [0.896 (95%CI 0.867-0.925] and sensitivity (88.5%) with the mNUTRIC. The SCREENIC score was an independent predictor of prolonged ICU [OR=1.81 (95%CI 1.14-2 .85)] and hospital [OR=2.15 (95%CI 1.37 - 3.38)] stays.

Conclusion: The SCREENIC score consists of six questions with variables that do not require anamnesis and can be obtained from electronic records and from the physical examination performed at the bedside. The SCREENIC showed moderate agreement and high sensitivity with the mNUTRIC and was an independent predictor of prolonged ICU and hospital stays. The applicability, reproducibility, and predictive validity of the SCREENIC score in guiding nutrition therapy should be evaluated in future studies.

Keywords: nutritional risk, critical care, critically ill, screening tool, tool development.

Introduction

Critical illness involves a hypercatabolic state and systemic inflammatory response syndrome, which contribute to the impairment of nutritional status[1]. It is related to worse outcomes in critically ill patients such as the increased risk of death, prolonged intensive care unit (ICU) and hospital stay, as well as increased hospital costs[2]. It is suggested that adequate nutrition therapy can reduce the odds of unfavorable outcomes in patients at nutritional risk (NR)[3]. So, identifying patients at NR in the first 24 hours after the ICU admission is an important step in the nutrition care process (NCP) in this setting[4]. It is supported by the significant association between NR and mortality, ICU length of stay (LOS), and mechanical ventilation (MV) duration demonstrated in several studies involving critically ill patients[5].

According to the American Society of Parenteral and Enteral Nutrition (ASPEN)[6] and Brazilian Society of Parenteral and Enteral Nutrition (BRASPEN)[7] two nutritional screening tools (NSTs) can be adopted in the ICU setting: The Nutrition Risk in Critically Ill (NUTRIC)[8] or the Nutritional Risk Screening 2002 (NRS-2002)[9]. For the first NST, the original version or its modified version without interleukin-6 is recommended. Patients with a mNUTRIC score equal to or higher than 5 are considered at high NR[10]. For the second NST, patients are classified at NR and high NR whether NRS-2002 $\geq$3 points and NRS-2002 $\geq$5 points, respectively. NUTRIC score was validated for critically ill patients while NRS-2002 was validated for non-critically ill patients and the proposal of a new cutoff point for the identification of patients at high NR (NRS-2002 $\geq$5) recommended by ASPEN and BRASPEN is based on expert opinion and its validity has been scarcely explored until now[6,7]. It makes sense since patients with Acute Physiology and Chronic Health Evaluation (APACHE II)[11] score higher than 10 points receive 3 points in the NRS-2002 and are classified as "at NR"[9], reducing the discriminatory performance of the NST in the ICU setting since most patients had high severity score. On the other hand, according to the European Society for Clinical Nutrition and Metabolism (ESPEN), all patients spending more than 48 hours in the ICU should be considered at risk for malnutrition[12]. However, this approach does not help the ICU team make decisions related to the nutrition therapy prescription and focuses on the risk of patients developing malnutrition during the ICU stay, not on the interaction between NR, outcomes, and nutrition therapy.

These divergences in the recommendations on NR screening of critically ill patients show that it remains a challenge in the ICU setting. We speculate that it can be partially attributed to the lack of an easy, fast, and sensible NST to identify NR in critically ill patients that involves factors and signs of NR that are feasible in the ICU. In this setting, nutritional anamnesis and anthropometry can not be performed on several patients. NRS-2002 involves the investigation of food consumption and weight loss, which are difficult in patients with reduced sensory function due to the use of sedatives. Measuring weight and height to calculate body mass index is also a challenge in this scenario[13]. On the other hand, the mNUTRIC score does not include any nutritional parameter, and it is better described as a

prognostic tool than a NST[14]. Indeed, the severity scores APACHE II is not usually applied in several ICUs, and other scores have been adopted to evaluate the severity of critically ill patients by medical staff, such as SAPS III due to its higher prognostic value[15,16].

There are other tools validated for NR screening in non-critically ill patients, such as the Malnutrition Universal Risk Tool (MUST)[17], Malnutrition Screening Tool (MST)[18], and Nutritional Risk in Emergency (NRE-2017)[19], but their feasibility and applicability in the ICU setting were poorly explored until now. In a previous study conducted by our research group, involving 450 critically ill patients, none of these NSTs (NRS-2002, MUST, MST, NRE-2017) demonstrated satisfactory concurrent validity in comparison to mNUTRIC as the reference method. Indeed, only MUST and MST were predictors of ICU death, while NRS-2002 $\geq$ 5 and mNUTRIC were predictors of prolonged ICU stay (data not published yet). These three tools also require nutritional anamnesis and could be applied in our study since patients were able to answer an interview in more than 50% of cases, and in the remaining cases it was possible due to an interview with their relatives (efforts were made for the research).

NR can be found in 55.9% (16.0% to 99.5%) of patients admitted to an ICU, as demonstrated in a systematic review of 36 studies, and it is an independent predictor of worse outcomes[5]. There is no doubt that it is essential to conduct a NR screening in ICU settings. However, we understand that a more feasible tool should be developed, and it should combine clinical data with nutritional data that could be obtained without patients' or their families' collaboration in providing the information. So, this study aimed to develop a new tool for NR screening of critically ill patients and test its predictive validity. It was named the Screening of Nutritional Risk in Intensive Care (SCREENIC score).

Methods

Design and study setting

A secondary analysis of a cohort study with prospective data collection was performed. The primary study was conducted with patients admitted to the six ICUs from a hospital complex in Porto Alegre (Rio Grande do Sul, Brazil) aiming to test the validity of different NSTs (using mNUTRIC as a reference method) and of Global Leadership Initiative on Malnutrition (GLIM)[20] criteria for malnutrition diagnosis (using Subjective Global Assessment (SGA)[21] as reference method).

The Ethics Committee of the Hospital approved the protocol (number 4.735.356) and it was conducted according to the 466/12 Resolution of the National Ethics Committee[22]. All patients or their relatives gave their written informed consent before data collection.

Sample size and eligibility criteria

Considering that this study is a secondary analysis of a longitudinal study, the sample size was not calculated, and we included all patients selected for the primary study with

available data of mNUTRIC (n=448). The inclusion criteria were patients of both sexes, aged ≥ 18 years, who were able to respond to a simplified nutritional anamnesis or whose relatives were available to do this. We did not include pregnant and lactating women; patients expected to stay less than 24 hours in the ICU; patients without blood count and/or arterial blood gas analysis at admission; patients who were unable to perform the physical examination and anthropometric measures due to anasarca or medical contraindication for mobilization.

Data collection

Three trained registered dietitians and three Nutrition undergraduate students collected data prospectively between November 2019 and March 2020 and between April 2021 and May 2022, with a suspension period due to the COVID-19 pandemic since ICU access was limited to professionals in the field. Clinical, sociodemographic, and nutritional data were collected within 24 hours after the patient's ICU admission.

a. *General and clinical data:* We collected from electronic records or nursing sign sheets the following information: age, sex, vital signs, hospital and ICU admission dates, the reason for ICU admission, morbid history, number of comorbidities, and number of days at the hospital before ICU admission. We also checked if patients underwent surgical procedures before ICU admission and if the diagnosis of sepsis was established by the medical staff and registered in the electronic records. In the ICU setting, it is diagnosed as recommended by Evans et al[23]. Vasopressors used at ICU admission, prescription of mechanical ventilation and hemodialysis, and laboratories from the first 24 hours were also collected. From these data, we calculated the disease severity scores APACHE II[11] and Sequential Organ Failure Assessment (SOFA)[24]. Considering SOFA, APACHE II, age, number of comorbidities, and number of hospital stay days before ICU admission, we calculated the mNUTRIC score and classified patients at low NR if it was lower than 4 points and at high NR if it was ≥ 5 points. Based on the physiopathology of diseases, the severity of stress was considered high for all patients. Also, the inflammation was defined by C-Reactive Protein (CRP) plasma levels >5mg/dL (according to the cutoff point of the hospital laboratory).

b. *Nutritional data:* We conducted a detailed nutritional assessment of patients for NR screening and malnutrition diagnosis based on different tools previously defined: GLIM, SGA, NRE-2017, NRS-2002, MUST, and MST. The anamnesis was performed with the patients whenever possible (not in MV or sedatives prescription) or with their relatives at the hospital visit time or by telephone call. The nutritional assessment comprised questions about food consumption in the last two weeks

concerning consistency and quantity (auto referred compared to usual intake, expressed in 100%, 75%, 50%, 25%, or 0%), changes in appetite, the presence of gastrointestinal symptoms (anorexia, nausea, vomiting, and diarrhea) in the last 2 weeks, and recently functional capacity changes. The anthropometric assessment consisted of self-reported current body weight and height, as well as usual weight and unintentional weight loss (UWL) (period and magnitude), calculated with the equation (%UWL = usual weight − current weight/usual weight × 100). The body mass index (BMI) was calculated with the current self-reported weight and height with the equation (weight/[height*height]) and expressed in kg/m^2. The calf circumference (CC) was measured on the largest circumference in the perpendicular plane to the longitudinal line of the calf and was classified as reduced when CC $\leq$ 33cm for women and $\leq$34 cm for men[25]. The adductor pollicis muscle thickness (APMT) was performed using a LANGE® adipometer, pinching the vertex of the imaginary triangle formed by the extension of the thumb and forefinger; the measurement was performed 3 times and the mean was calculated for classification according to the cutoff point established for the Brazilian population by gender and age[25]. The CC and APMT measures were not assessed in patients with contraindications, like edema and/or venous return boots use. The mid-arm circumference (MAC) was measured using an inelastic tape at the midpoint between the olecranon process and the acromion. The equation calculated the MAC adequacy: %MAC=[(measured MAC/50th percentile MAC)*100], using the 50th percentile according to age and sex, and classified as reduced MAC when the adequacy was <90%[26]. The physical examination was performed, and the muscle mass (MM) was evaluated in the face (temporal and masseter), deltoid (clavicle, shoulders, scapula), intercostal, and calf muscles. The subcutaneous fat was assessed in the orbital, triceps, and overlying ribs. Both were classified as mild, moderate, or severe depletion. Edema (generalized or localized fluid accumulation in the extremities) and ascites were also inspected and classified as absent, mild, moderate, or severe[27].

c. *Development of SCREENIC score:* For the construction of a new tool for NR screening in critically ill patients that could be feasible for patients noncommunicable, fast, and easy to be applied we considered some assumptions in the variables' selection: 1) it should not be collected from patients or their relatives by a detailed and complete anamnesis; 2) it should not include anthropometric parameters more difficult to be obtained, such as body weight, height, UWL (%), and BMI; 3) it should be possible to provide simple answers categorized as ‘yes’ or ‘no’. So, we listed the variables of SGA, GLIM criteria, MUST, MST, NRS-2002, NRE-2017, and mNUTRIC and selected these variables that fulfilled our predefined criteria. Indeed, we would not intend to include severity scores since it is not simple and fast to be

obtained in clinical practice by dietitians. So, we investigated if other clinical characteristics could be an alternative for them since the disease severity is a recognized factor for NR in critically ill patients[14.] It was investigated by a comparison of clinical features of patients with low and high mNUTRIC scores. Considering these predefined assumptions, a list of 14 variables was created to investigate which of them were associated with a high mNUTRIC score and should be combined to construct the SCREENIC score (**Table 1**). All questions were transformed into bicategory answers to be quicker and easier in the ICU setting.

c. *Outcomes of interest:* The primary outcomes of interest were prolonged ICU LOS and death in the ICU and as the secondary outcomes we included prolonged hospital LOS death in the hospital and ICU readmission. All outcomes were obtained from the medical records of each participant and were collected to test the predictive validity of the new proposal NST. Indeed, as exploratory outcomes we evaluated the hospital readmission and mortality 3-months after discharge by call phone to survivors.

Statistical Analysis

Four phases were performed to investigate the questions that could be applied to the early identification of patients at risk of malnutrition and develop the SCREENIC score: 1) a bivariate analysis through the Chi-squared test was conducted to compare the 14 predefined variables between patients classified at low NR and high NR evaluated by mNUTRIC; 2) variables associated with mNUTRIC score in this bivariate analysis (all variables with $P < 0.20$) were considered as an independent variable in a univariate regression model with NR as the dependent variable; 3) variables significantly associated with mNUTRIC score in the previous phase were taken to multivariate logistics with the backward stepwise procedure; 4) for the variables remaining in the model due to its significant association with mNUTRIC score, the beta coefficient was multiplied by a constant 0.67, which was obtained by the ratio of the 6 questions selected in the third phase and by the 9 questions selected in the second phase (6/9) to weigh the points assigned to each question for the final score. The cutoff point for the scores belonging to "at high NR" was determined by the receiver operating characteristic (ROC) curve, using mNUTRIC as the reference method. The Yodeen Index was calculated to define the best cutoff point for the SCREENIC score, considering the greatest balance between sensitivity and specificity.

After that, the concurrent validity of the SCREENIC score was determined by calculating the κ coefficient between the SCREENIC score and mNUTRIC. The value of κ varies from 0 to 1; a value of <0.2 indicates poor, 0.2–0.4 indicates fair, 0.4–0.6 moderate, 0.6–0.8 substantial, and >0.8 indicates almost perfect concordance[28]. The discriminatory power of the SCREENIC score to identify patients at high NR was determined by the area under the ROC curve, considering as a reference the mNUTRIC tool. Sensitivity, specificity,

positive predictive value (PPV) and negative predictive value (NPV), and likelihood ratio were also obtained[29]. The predictive validity was assessed by Logistic regression with the ICU and hospital LOS (categorized by the median of the sample), ICU readmission, hospital readmission and death 3 months after discharge as dependent variables. Cox Regression was performed to evaluate the association between NR by the SCREENIC score and mortality in ICU and hospital. Crude and adjusted models were constructed, and confounders were variables with $p < 0.20$ in the bivariate analysis and those with recognized clinical relevance.

Descriptive statistics calculated are presented as mean and standard deviation for parametric quantitative variables, median and interquartile range for nonparametric quantitative variables, and absolute and relative frequencies for categorical variables. The normality of quantitative variables was evaluated by the Kolmogorov-Smirnov test. Data analyses were performed with SPSS 20.0 and P values < 0.05 were considered statistically significant.

Results

General features of the sample

A total of 448 patients were included in the current study and their features are presented in **Table 2.** The median age of the sample was 64.0 (54.0 - 71.0) years, of which 52.2% were men and the main ICU admission reasons were pulmonary disorders (29.3%) and oncological disorders (28.2 %). More than half of the sample (53.3%) underwent MV at ICU admission, and 22.2% had sepsis, while 64.7% underwent surgical procedures before ICU admission. Considering that 130 patients died during the hospital stay and we did not get call contact with 77 patients, hospital readmission and mortality 3-months after discharge could be evaluated in 243 patients and occurred in 24.7% and 4.5%, respectively.

Two patients were excluded from the analysis for the SCREENIC development due to the lack of mNUTRIC score. Patients at high NR by the mNUTRIC (46.9%) were older [67.0 (59.0 - 74.0 years]), had more sepsis diagnosis (34.9%), and required more frequent ventilator support (81.9%) in ICU admission in comparison to those at low NR. Also, they presented higher scores of APACHE II [24.0 (20.0 - 29.0) points] and SOFA [10.0 (7.0 - 11.0) points], and more frequent reduced CC (51.4%) and MM in physical examination (52.2%) comparing with patients with no NR. In contrast, patients with no NR underwent more surgical procedures before ICU admission (74.4%), as shown in **Table 2**. In this table, we also described the comparison of other general clinical, nutritional, and outcomes between patients grouped by mNUTRIC score.

Development of SCREENIC score

As demonstrated in **Table 3**, from 14 variables predefined as potential components of SCREENIC score, three were not associated with NR by mNUTRIC: the frequency of patients with UWL in the last six months of patients reporting changes in food consistency in

the last 2 weeks, and of patients with CRP > 143 mg/dL. They did not differ between those with low and high NR (p >0.20). So, 11 variables were tested by logistic regression to investigate their association with high mNUTRIC. In this analysis, two of them were not associated with NR: impaired nutrient assimilation and reduced MAC. Then, nine variables were included in a multivariate model to define which variables should be combined to identify high mNUTRIC, and six variables were significantly associated with NR, as shown in **Table 4**: have 2 or more comorbidities (OR = 7.5), LOS higher than 1 day previous ICU admission (OR = 3.6), sepsis diagnosis at ICU admission (OR = 4.3), MV at ICU admission (OR = 57.7), age higher than 65 years (OR = 5.9), signs of MM loss in the physical examination (OR =2.6).

Table 4 presents the score calculated for each one of the six variables of the SCREENIC score. The final SCREENIC score was composed of six questions with two possible answers: yes or no. Each positive answer received a specific score, as follows: 1. Does the patient have $\geq$ 2 comorbidities? (1.3 points); 2. Does the patient hospitalize for 2 days or more before the ICU admission? (0.9 points); 3. Does the patient have sepsis? (1.0 points); 4. Was the patient on MV on admission? (1.2 points); 5. Is the patient's age above 65 years old? (1.2 points); 6. Does the patient have signs of MM loss according to the physical exam? (0.6 points). The final score of SCREENIC ranges from 0 to 7.7 points.

The cutoff point to identify patients at high NR by SCREENIC was established through the ROC curve construction using the mNUTRIC as the reference method. Considering the greatest balance between sensitivity (88.5%) and specificity (68.8%), a SCREENIC score of 4.0 was discriminatory to identify critically ill patients at high NR. The AUC of the ROC curve was 0.896 (CI95% 0.867 - 0.925), and the PPV and NPV were equal to 71.3% and 87.2%, respectively. The concordance between the SCREENIC score and mNUTRIC was moderate (kappa coefficient = 0.564). The mean SCREENIC score was 4.05 $\pm$ 1.86 and 57.8% of patients presented SCREENIC $\geq$ 4 and were classified as "at high NR".

Predictive validity of SCREENIC score

Prolonged hospital and ICU LOS, hospital and ICU death were more frequent in patients at high NR according to SCREENIC score in comparison to those with low NR The frequency of readmission was also higher in patients at high NR, but the difference did not reach statistical significance. The incidence of hospital readmission and death 3 months after discharge did not differ between groups (**Table 5**). In multivariate analyses, adjusted for confounders, patients at high NR according to SCREENIC score presented an increase of 1.8 and 2.2 times in the odds of prolonged ICU and hospital stay, respectively.

Discussion

We aimed to develop a new tool to screen NR in critically ill patients considering variables available in validated NSTs and tools for malnutrition diagnosis and named it the

SCREENIC score. We considered eligible variables that would not need anamnesis with patients or their relatives and could be easily obtained by the dietitians. After that, we tested by logistic regression which variables should compose the SCREENIC score. The final score was composed of six questions and the cutoff point for high NR identification was 4.0. It presented a moderate concordance and high sensitivity with mNUTRIC and was an independent predictor of prolonged ICU and hospital LOS.

According to Kondrup et al, a NST should predict the odds of outcomes (such as reduced number or severity of diseases, as well as hospital LOS due to nutritional indicators and if nutritional therapy will modify this[30]. For a tool to be relevant, its content must be based on information known or believed to be associated with NR[31]. Jones evaluated the methodology for the construction of 44 NSTs and demonstrated that just for 9.1% of them the authors described their refined selection to achieve a subset with a strong association with NR[31]. Indeed, just four studies constructed the NST based on the results of multivariate analyses or the use of algorithms. It should be noted that NR in the critical care context refers to the risk of developing complications or adverse outcomes that could have been avoided by timely and appropriate nutrition therapy. It is not the risk of malnutrition. So, the optimal NR score system in the ICU is not dependent on common nutritional indicators and depends on the clinical condition to be a proxy for the severity of stress metabolism and its duration[14]. Regardless of the NR concept, NR scores for ICU settings should also be developed based on data related to NR or clinical outcomes.

The NUTRIC score was validated based on the construction of a multivariate model with mortality as an outcome as it is recommended for the construction of a new tool, however, NUTRIC does not include any nutritional parameter. So, it could be more interesting as a prognostic score since there are several studies in the literature demonstrating its association with worse clinical outcomes[32-34]. Also, in the original study, its validity in predicting whom patients should benefit from adequate nutritional therapy was confirmed[8]. The SCREENIC score was developed as recommended by Kondrup et al.[30] and considered the high NR assessed by the mNUTRIC as the outcome since it is a unique score validated based on the definition that NR in critically ill patients is not the risk of malnutrition. In addition, we selected by logistic regression the variables that were associated with the mNUTRIC to construct the final score and tested the predictive validity of the SCREENIC score, showing that it was a predictor of clinically relevant outcomes, such as ICU and hospital LOS.

The SCREENIC score was composed of questions related to age, comorbidities, days of hospitalization prior to the ICU, sepsis, MV, and physical examination, and these variables can be easily scored by the dietitian in the patient's ICU admission. Among the variables reflecting the clinical conditions pre-selected, underwent a surgical procedure previous ICU admission, and CRP levels were not included in the final model, while comorbidities, days of hospitalization prior to the ICU, sepsis, MV were associated with high NR and were selected

to compose the SCREENIC score. Sepsis and MV at admission are always registered on electronic records and are easier to be obtained than severity scores. Indeed, they can reflect the clinical condition and the expected duration of ICU stay, which is mandatory for an optimal nutritional-risk scoring system in the ICU setting[14]. Among the variables reflecting nutritional status, only reduced MM identified by the physical exam was associated with high mNUTRIC in the final regression model and included in the SCREENIC score. It is a fast and simple nutritional indicator that can be obtained for all critically ill patients since it does not depend on high technologies but depends on the dietitian's training for the correct classification. The evaluation of the physical examination makes it possible to identify the loss of MM in several body compartments, such as in the face (temporal and masseter muscle), deltoid (clavicle, shoulders, scapula), intercostal, and calf muscles. Aiming to avoid or reduce misclassification, moderate or severe MM loss was scored in the SCREENIC, which is easier to identify in critically ill patients.

We established the cutoff point $\geq$ 4.0 to define high NR by the SCREENIC score considering the best balance between sensitivity and specificity. So, the SCREENIC score showed moderate agreement (k=0.564), high accuracy (89.6%), and sensitivity (88.5%) with the mNUTRIC. The prevalence of patients at high NR by SCREENIC score (57.6%) was a bit higher than mNUTRIC (46.9%), which probably can be explained by the low specificity (68.8%) that results in higher values of false positives. It is important to highlight that in the nutrition screening process a high sensitivity is mandatory[30] since the greater the sensitivity of a NST, the smaller the number of patients at NR that will not be identified. It is essential to consider that NR identification will direct nutrition therapy prescription. Moreover, identifying more false positives due to a low specificity will not be a big problem, since these patients will receive early therapy nutrition and it is not related to worse outcomes[35]. According to the Academy of Nutrition and Dietetic (AND)[29], a NST must have sensitivity >80% and it was filled by SCREENIC score.

A high NR by the SCREENIC score was an independent predictor of prolonged hospital and ICU LOS, however, it was not a predictor of death. The prognostic value of NR in predicting these outcomes in critically ill patients has already been demonstrated previously[36-39]. According to Kondrup the ideal NR scoring system in ICU settings is dependent on clinical features and expected LOS, including the duration of MV and the ICU stay as a proxy for the severity and duration of the disease stress[14]. So, it is important that a new proposal NST for ICU be an independent prediction of hospital and ICU LOS. The association between NR and mortality in critically ill patients is controversial in the literature, regardless of the NST applied. High NR evaluated by NRS-2002 was not an independent predictor of death in two studies [37,40] involving critically ill patients. On the other hand, a study involving 413 critically ill patients showed a significant association between the NRS-2002 score with the risk of mortality, increasing it by 1.23 times[41]. As far as we know, only one study evaluated the association between death and the NR evaluated by the MUST and

did not show a significant result[33]. High NR by mNUTRIC was not an independent predictor of death in a Brazilian study (n= 281) that proposed to replace APACHE II with SAPS 3 in the score and demonstrated that NUTRIC-S increased the risk of death 1.76 times (CI95% 1.16 - 2.66)[16]. Also, a study involving a total of 285 patients with COVID-19 from an observational multicentric study in 12 ICUs showed no association between mNUTRIC $\geq$ 5 and mortality, while NRS-2002 $\geq$3 and SGA B or C increased 2.25 (CI95% 1.01 - 5.01) and 2.13 (CI95% 1.11 - 4.06) times the odds for death, respectively[42]. Indeed, in the multivariate analysis, Rattanachaiwong et al demonstrated that mNUTRIC $\geq$ 5 was not an independent predictor of death in a sample of 120 patients[43].

The greatest strength of our study is its originality since we developed a new proposal for a NST for critically ill patients. The SCREENIC score is a fast, not expensive, and simple NST composed of six dichotomic questions which can be quickly checked by any professional in the ICU setting since its trained to perform the physical examination. Indeed, it precludes the anamnesis with the patient or their relatives, which is the main limitation in applying most NST in the ICU setting. Five of the six variables can be obtained by electronic records and one variable can be obtained at the bedside, making it feasible for all patients in ICU settings. In addition, our study was conducted with a large and heterogeneous sample. The power calculated for 3-months after discharge outcomes was lower than 50% while for in-hospital outcomes it was higher than 80%, except for ICU readmission (data not shown). Furthermore, the process for developing the SCREENIC score was robust and based on four steps including univariate and multivariate analysis as well as a weighted score for each variable based on the magnitude of association of the dependent variable (high mNUTRIC score). This methodology has already been followed in the development of other NSTs such as mNUTRIC, NRE-2017, and Short Nutritional Assessment Questionnaire (SNAQ)[44].

We also need to cite some limitations of our study and highlight some potential research questions for future studies to better explore the validity of the new proposed NST, as follows: 1) we did not assess intermediate outcomes such as functionality, quality of life, and ICU-acquired weakness. Future studies should assess the validity of the SCREENIC score for these outcomes as they greatly impact the patient's rehabilitation after ICU discharge[45-47]; 2) we did not assess the interaction between NR and outcomes and nutrition therapy adequacy as performed in the validation study of the NUTRIC[8]. However, future studies should evaluate the performance of SCREENIC score in predicting the effect of nutrition therapy on outcomes by a randomized controlled trial in which patients with high SCREENIC scores are allocated to different nutrition therapy groups to investigate if it can improve the clinical outcomes. It is important because of its limited content validity regarding the common nutritional indicators[14]; 3) we did not evaluate the reproducibility of the SCREENIC score, so it needs to be explored in future studies. It should consider if the different stakeholders of ICU staff with an acceptable precision could apply the SCREENIC score.

Conclusion

The SCREENIC score was developed to screen the NR of critically ill patients. It consists of six questions with a score from 0 to 7.7, and the cutoff point of 4.0 classified the patients as "at high NR". The SCREENIC score showed moderate concordance and high sensitivity with mNUTRIC and was an independent predictor of prolonged hospital and ICU LOS.

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Conflict of interest

The authors declare no conflicts of interest.

Authorship

FMS contributed to the conception of the study. DSJM, ELR and JL contributed to the data acquisition. FMS and ELR analyzed the data and developed the SCREENIC. FMS and ELR contributed to the interpretation of data. FMS and ELR drafted the manuscript. All authors critically revised the manuscript, provided their final approval, and agreed to be accountable for all aspects of the work ensuring its integrity and accuracy.

Data sharing

All data can be shared if required with the corresponding author.

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Table 1. Variables included in nutritional risk screening and malnutrition diagnosis tools

Variables	SGA	GLIM	mNUTRIC	NRE 2017	NRS 2002	MST	MUST
Age			x	x			
APACHE II			x				
SOFA			x				
Comorbidities			x				
Previous ICU days			x				
Weight Loss	x	x		x	x	x	x
BMI		x			x		x
Muscle mass							
- *Physical exam*	x	x		x			
- *Anthropometry*		x					
- *Image exam*		x					
Fat mass	x						
Functional capacity	x						
Food intake/assimilation	x	x			x		
Inflammation							
- *Objective parameter (CRP)*		x					
- *Disease understanding*		x					
Metabolic stress	x			x	x		
Appetite	x			x		x	
Food consistency	x			x			
Starvation > 5 days							x

Abbreviations: mNUTRIC, modified Nutrition Risk in Critically ill; GLIM, Global Leadership Initiative on Malnutrition; NRE-2017, Nutritional Risk in Emergency 2017; NRS-2002, Nutritional Risk Screening 2002; MST, Malnutrition Screening Tool; MUST, Malnutrition Universal Screening Tool; APACHE II, Acute Physiology And Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; ICU, Intensive Care Unit; BMI, Body Mass Index; CRP, C-reactive Protein;

Table 2. Features of critically ill patients grouped according to the mNUTRIC categories.

Variables	Total sample *(n= 448)*	Low mNUTRIC *(n=238)*	High mNUTRIC *(n=210)*	P - value
Clinical Features				
Age (years)	64.0 (54.0 - 71.0)	61.0 (47.0 - 68.0)	67.0 (59.0 - 74.0)	<0.001[a]
SOFA score	6.0 (3.0 - 10.0)	4.0 (2.0 - 6.0)	10.0 (7.0 - 11.0)	<0.001[a]
APACHE II	18.1 (11.0 - 24.0)	12.0 (8.0 - 16.0)	24.0 (20.0 - 29.0)	<0.001[a]
Pre ICU days	1.0 (0.0 - 7.0)	1.0 (0.0 - 6.0)	2.0 (0.0 - 9.0)	0.058 [a]
Sepse diagnosis	22.2	11.3	34.9	<0.001[b]
Surgical procedures	64.7	74.4	53.8	<0.001[b]
MV at admission	53.3	28.6	81.9	<0.001[b]
CRP (mg/dL) (n= 313)	125.0 (47.2 - 216.3)	127.2 (42.0 - 201.2)	114.7 (51.7 - 227)	0.590 [a]
Nutritional Features				
Current Weight (Kg)	72.2 $\pm$ 17.1	73.6 $\pm$ 18.1	70.9 $\pm$ 15.8	0.106 [d]
Usual Weight (Kg)	75.0 (63.2 - 85.0)	75.0 (63.0 - 89.5)	74.5 (64.0 - 83.0)	0.313 [a]
%WL (n= 209) - UWL present	8.6 (5.2 - 14.2) 51.2	7.7 (4.3 - 12.3) 52.1	10.1 (6.2 - 16.2) 50.2	0.009 [a] 0.767 [b]
BMI (kg/m) - <20(<70y)/ <22($\geq$70y) or <18.5	25.9 $\pm$ 5.3	26.2 $\pm$ 5.3	25.6 $\pm$ 5.3	0.507 [d]

(<70y)/ <20(≥70y)	14.4	15.7	12.9	0.507 [b]
CC (cm) (n= 345) - Reduced CC	34.6 ± 4.6 40.8	35.4 ± 4.3 32.8	33.5± 4.8 51.4	<0.001[d] 0.001[b]
APMT(mm)(n= 333) - Reduced AMPT	22.3 (18.6 - 25.0) 18.0	22.6 (19.2 - 25.7) 17.6	21.9 (18.6 - 24.7) 18.3	0.271[a] 0.976 [b]
MAC (n=425) - %MAC < 90%	95.4 ± 15.3 34.9	97.1 ± 15.4 31.5	93.4 ± 14.9 38.3	0.011 [d] 0.167 [b]
Reduced muscle mass in physical exam	43.9	36.6	52.2	0.001 [b]
- Food intake ≤50% (>1 week) / any reduction >2 weeks - Food assimilation - Anorexia - Change in food consistency	39.6 12.6 40.5 13.1	33.6 10.2 34.0 12.6	46.7 15.3 48.3 13.9	0.007 [b] 0.141 [b] 0.003 [b] 0.798 [b]
Outcomes				
Prolonged ICU LOS (>5 days)	50.9	44.5	56.0	0.020 [b]
Prolonged Hospital LOS (>20 days)	50.1	42.0	61.2	<0.001 [b]
ICU readmission	11.8	10.1	13.3	0.356 [b]
Hospital death	28.9	17.2	42.4	<0.001 [b]
ICU death	20.0	11.8	29.5	<0.001 [b]
3m after discharge readmission*	24.7	21.3	29.9	0.181 [b]

3m after discharge death *	4.5	2.6	8.0	0.059 [b]

Abbreviations: mNUTRIC, modified Nutrition Risk in Critically ill; SOFA, Sequential Organ Failure Assessment; APACHE II, Acute Physiology And Chronic Health Evaluation; ICU, Intensive Care Unit; MV, mechanical ventilation; HD, hemodialysis; CRP, C-Reactive Protein; WL, weight loss; UWL, unintentional weight loss; BMI, body mass index; CC, calf circumference; APMT, aductor pollicis; MAC, mid-arm circumference; LOS, length of stay;

[a] Mann Whitney test. [b] Chi-Square test. [c] Fisher test. [d] Student T test.

* High NR (n = 87) and Low NR (n = 156).

Table 3. First Phase of SCREENIC construction: selection of pre-defined questions by comparison of patients grouped according to mNUTRIC score.

Questions	Low mNUTRIC (n=238)	High mNUTRIC (n=210)	P-value [a]
1. Does the patient have ≥ 2 comorbidities?	63.7%	86.2%	<0.001
2. Does the patient hospitalize for 2 days or more before the ICU admission?	58.8%	71.4%	0.007
3. Does the patient have sepsis?	11.3%	34.9%	<0.001
4. Is the patient on mechanical ventilation on admission?	28.6%	81.9%	<0.001
5. Does the patient have food assimilation or absorption alteration? - GLIM	10.2%	15.3%	0.141
6. Has the patient reported decreased appetite in the last 2 weeks?	34.0%	48.3%	0.003
7. Has the patient reported changes in food consistency in the last 2 weeks?	12.6%	13.9%	0.798
8. Has the patient had unintentional weight loss in the last 6 months?	52.1%	52.2%	0.767
9. Is the patient's age above 65 years old?	37.0%	61.2%	<0.001
10. Does the patient have signs of muscle mass loss according to the physical exam?	36.6%	52.2%	0.001
11. Does the patient have reduced mild arm circumference?	31.5%	38.3%	0.167
12. Does the patient have reduced calf circumference?	32.8%	51.4%	0.001
13. Is the patient inflamed in admission (CRP >143mg/dL)	42.5%	41.9%	1.000
14. Was the patient submitted a surgical procedure before ICU admission?	74.4%	53.8%	<0.001

[a] Chi- square test.

Abbreviations: ICU, Intensive Care Unit; GLIM, Global Leadership Initiative on Malnutrition; CRP, C-Reactive Protein.

Table 4. Phases 2 and 3 of SCREENIC score construction: logistic regression models.

Question	Phase 2 RR (95% CI)	Phase 3 RR (95% CI)	ß	Score
1. Does the patient have ≥ 2 comorbidities?	3.56 (2.22–5.71)	7.52 (2.78–20.36)	2.017	1.3
2. Does the patient hospitalize for 2 days or more before the ICU admission?	1.75 (1.18–2.60)	3.60 (1.66–7.80)	1.280	0.9
3. Does the patient have sepsis?	4.20 (2.57–6.86)	4.30 (1.66–11.12)	1.456	1.0
4. Is the patient on mechanical ventilation on admission?	11.32 (7.22–17.75)	57.73 (21.22–157.10)	4.056	2.7
5. Does the patient have food assimilation or absorption alteration? - GLIM	1.59 (0.90–2.80)	–	–	–
6. Has the patient reported decreased appetite in the last 2 weeks?	1.81 (1.24–2.65)	–	–	–
7. Is the patient's age above 65 years old?	2.69 (1.84–3.95)	5.87 (2.51–13.74)	1.770	1.2
8. Does the patient have signs of muscle mass loss according to the physical exam?	1.89 (1.30–2.76)	2.57 (1.22–5.44)	0.944	0.6
9. Does the patient have reduced arm circumference?	1.35 (0.91–2.02)	–	–	–
10. Does the patient have reduced calf circumference?	2.16 (1.39–3.36)	–	–	–
11. Is the patient inflamed in admission (CRP> 143mg/dL)	2.49 (1.67–3.71)	–	–	–

Abbreviations: ICU, Intensive Care Unit; GLIM, Global Leadership Initiative on Malnutrition; CRP, C-Reactive Protein;

Table 5. Association between clinical outcomes and nutritional risk by SCREENIC score

Outcomes	Low SCREENIC (n=190)	High SCREENIC (n=258)	p-value[a]	Unadjusted analysis OR/HR (CI 95%) p-value	Adjusted analysis OR/ HR (CI 95%) p-value
Prolonged hospital LOS	37.8	58.4	<0.001	2.31 (1.57 - 3.40) <0.001[b]	2.15 (1.37 - 3.38) 0.001[b]
Prolonged ICU LOS	35.6	61.9	<0.001	2.93 (1.98 - 4.33) <0.001[b]	1.81 (1.14 - 2.85) p=0.011[b]
Death in ICU	12.2	24.8	0.001	0.91 (0.56 - 1.49) 0.715[c]	-
Death in hospital	15.4	38.0	<0.001	1.62 (1.07 - 2.46) 0.024[c]	1.17 (0.75 - 1.84) p=0.487[c]
Readmission in ICU	9.0	14.0	0.151	1.63 (0.89 - 3.03) 0.116[b]	-
Readmission in 3 months *	22.5	27.2	0.483	1.29 (0.72 - 2.31) 0.396[b]	-
Death in 3 months*	2.3	7.0	0.120	3.17 (0.82 - 12.25) 0.094[b]	-

Abbreviations: ICU, Intensive Care Unit. LOS, length of stay.

[a] Chi-square, [b] Logistic Regression (Hosmer & Lemeshow test for adjustment of model's quality, p>0.05 for all analysis), [c] Cox regression.

[*] High SCREENIC (n = 114) and Low SCREENIC (n = 129).

7 CONSIDERAÇÕES FINAIS

Tendo em vista que o risco nutricional é uma condição frequente no ambiente da terapia intensiva e que está associado com pior prognóstico clínico, sua identificação precoce deve fazer parte dos protocolos assistenciais que compõem a sistematização do cuidado nutricional de pacientes críticos. Como já destacado em diferentes seções deste trabalho, as ferramentas de TRN existentes para paciente hospitalizado apresentam limitações de aplicação nos pacientes críticos. Poucas ferramentas foram exploradas quanto à sua aplicabilidade e acurácia na UTI. Além disso, nos pacientes críticos, o risco nutricional não deve ser visto como o risco de desnutrição, haja vista que a resposta inflamatória ao estresse e o consequente catabolismo proteico incidem em risco de desnutrição em todos os pacientes críticos, desta forma o risco nutricional no paciente crítico deve ser avaliado como o risco de o paciente apresentar complicações ou desfechos adversos que poderiam ser prevenidos com terapia nutricional adequada.

O presente trabalho de Mestrado teve como objetivo avaliar a validade de critério de cinco diferentes ferramentas de triagem de risco nutricional, bem como a viabilidade de aplicação delas em pacientes críticos e construir uma nova ferramenta com maior factibilidade para identificação de risco nutricional no ambiente de terapia intensiva. Para responder a esses objetivos, foram conduzidos dois estudos que demonstraram os seguintes achados: 1) Dentre as cinco ferramentas estudadas, nenhuma apresentou validade concorrente satisfatória com o mNUTRIC ou com o NRS-2002 e apenas o MUST e MST foram preditoras de óbito na UTI e NRS-2002 $\geq$ 5 e mNUTRIC associados independentemente à internação prolongada na UTI. 2) A nova proposta de ferramenta de TRN para paciente crítico, o SCREENIC escore, é composta por seis questões com respostas sim ou não, com variáveis que não necessitam de anamnese e podem ser obtidas em prontuário e a partir do exame físico realizado à beira leito. A nova ferramenta apresentou concordância moderada e alta sensibilidade com o mNUTRIC e foi preditora independente de permanência prolongada na UTI e no hospital.

Conduzimos um estudo longitudinal com tamanho amostral expressivo, comparamos diferentes ferramentas de triagem de risco nutricional em pacientes críticos, dentre as quais ferramentas até então não testadas por estudos prévios em ambiente de terapia intensiva e propusemos uma nova ferramenta visando a viabilidade de triagem de risco nutricional em todos os pacientes críticos. Foram elaborados dois artigos originais. Contudo, por fragilidades intrínsecas ao controle de dieta prescrita e infundida do Complexo Hospitalar em que nossa coleta de dados foi realizada, a avaliação da interação entre risco nutricional e terapia

nutricional na predição de desfechos não pode ser avaliada. Além disso, quando o presente projeto foi idealizado não era factível avaliação de funcionalidade e qualidade de vida, entre outros desfechos intermediários por questões logísticas e de equipe reduzida.

Considerando-se que na prática clínica a aplicabilidade do mNUTRIC é limitada e que existe a crítica acerca do fato de o mesmo não apresentar nenhum indicador direto de comprometimento nutricional, os resultados dessa dissertação sugerem que a recomendação da ESPEN parece ser a mais pertinente a ser adotada na primeira etapa do cuidado nutricional do paciente crítico: todo paciente que permanecer na UTI por mais de 48 horas deve ser considerado como tendo risco nutricional. Isso pois, ferramentas validadas para triagem de risco nutricional em pacientes não críticos não apresentaram validade concorrente satisfatória com o mNUTRIC ou com o NRS-2002 $\geq$5. Ademais, a validade preditiva foi limitada para todas as ferramentas. Além disso, por dependerem de dados coletados com o paciente, podem ser impraticáveis em cerca de metade deles e depender de anamnese com familiares, como ocorreu no presente estudo.

Destaca-se que, embora o SCREENIC escore não tenha as limitações apresentadas pelas demais ferramentas atreladas à anamnese nutricional e considere indicadores nutricionais diretos e os resultados por nós demonstrados possam ser considerados promissores para os pacientes críticos, a sua aplicabilidade, reprodutibilidade e validade preditiva em identificar pacientes que se beneficiarão de terapia nutricional precoce e plena deve ser avaliada em estudos futuros. Isso é relevante já que direcionar a terapia nutricional com base no resultado da triagem de risco nutricional parece impactar na incidência de desfechos. Possivelmente essa interação entre risco nutricional, terapia nutricional e desfechos associados possa ser melhor evidenciada se os estudos futuros avaliarem desfechos intermediários, dentre os quais cabe destacar funcionalidade e qualidade de vida.

8 ANEXO

Termo de Consentimento Livre e Esclarecido

Você está sendo convidado para participar do projeto de pesquisa "Validade concorrente e preditiva do NRE-2017 em pacientes críticos: estudo observacional" que tem por objetivo avaliar o risco nutricional de pacientes hospitalizados em unidade de terapia intensiva (UTI) a partir de um questionário com seis perguntas simples para verificar se esse questionário é válido para identificar pacientes em risco nutricional e com maior chance de permanecer na UTI por mais tempo, de permanecer mais tempo em ventilação mecânica ou de vir a falecer. Já sabemos que pacientes críticos com risco nutricional ou desnutrição apresentam uma pior condição clínica e menor chance de melhora, mas ainda existem poucas formas confiáveis para identificar quais pacientes apresentam risco nutricional. Por isso, esse estudo está sendo proposto e você está sendo convidado a participar.

Esse projeto de pesquisa será realizado nas UTIs do Complexo Hospitalar Santa Casa. Caso você concorde em participar do estudo, será convidado a responder algumas perguntas sobre sua história nutricional, seu consumo alimentar e peso corporal. Faremos a estimativa do seu peso e da sua altura a partir da medida da circunferência do seu braço e da medida da altura do seu joelho. Além disso, iremos entrar em contato com você após três e seis meses da sua alta hospitalar para sabermos como está a sua saúde e se você precisou reinternar neste período e por qual motivo - para isso precisaremos que você nos informe um contato telefônico. Nós acessaremos o seu prontuário médico para acompanhar a sua evolução clínica até a sua alta hospitalar.

Esse estudo poderá contribuir com a validação de novos métodos de triagem de risco nutricional na UTI. Você não é obrigado a concordar em participar do estudo e pode retirar o seu consentimento em qualquer momento caso desista da participação. Se você não quiser participar do estudo o seu atendimento no hospital não terá nenhuma alteração. O risco associado à participação nesse estudo é mínimo, já que as perguntas relacionadas ao risco nutricional já são feitas pela nutricionista na rotina assistencial.

Eu,....., fui informado dos objetivos especificados acima e da justificativa desta pesquisa de forma clara e detalhada. Recebi informações específicas sobre cada procedimento no qual o participante estará envolvido, dos desconfortos ou riscos previstos tanto quanto dos benefícios esperados. Todas as minhas dúvidas foram respondidas com clareza e sei que poderei solicitar novos esclarecimentos a qualquer momento. Além disto, sei que novas informações obtidas durante o estudo me serão fornecidas e que terei liberdade de retirar meu consentimento de participação na pesquisa face a estas informações.

O profissional Dr/Dra. ..... certificou-me de que as informações coletadas terão caráter confidencial. Fui informado que não haverá nenhum gasto com a participação nessa pesquisa. Os dados coletados serão utilizados apenas para a realização desse estudo e o nome dos participantes não será divulgado em nenhum momento.

Os dados obtidos serão utilizados somente para este estudo, sendo os mesmos armazenados pela pesquisadora principal durante 5 (cinco) anos e após totalmente destruídos (conforme preconiza a Resolução 466/12). Todos os documentos relacionados ao estudo e o

processamento computadorizado dos dados (informações e resultados) serão tratados de forma confidencial e somente números e iniciais identificarão você, garantindo o sigilo dos dados.

EU_____, recebi as informações sobre os objetivos e a importância desta pesquisa de forma clara e concordo em participar do estudo. Declaro que também fui informado:

- Da garantia de receber resposta a qualquer pergunta ou esclarecimento acerca dos assuntos relacionados a esta pesquisa.
- De que minha participação é voluntária e terei a liberdade de retirar o meu consentimento, a qualquer momento e deixar de participar do estudo, sem que isto traga prejuízo para a minha vida pessoal e nem para o atendimento prestado a mim.
- Da garantia que não serei identificado quando da divulgação dos resultados e que as informações serão utilizadas somente para fins científicos do presente projeto de pesquisa.
- Sobre o projeto de pesquisa e a forma como será conduzido e que em caso de dúvida ou novas perguntas poderei entrar em contato com a pesquisadora responsável pela pesquisa: Flávia Moraes Silva, pelo telefone 995752778 ou na Universidade - Rua Sarmento Leite, 245, prédio I, sala 401-b.
- Também que, se houverem dúvidas quanto a questões éticas, poderei entrar em contato com Comitê de Ética em Pesquisa da Irmandade Santa Casa de Misericórdia de Porto Alegre – telefone 3214.8571 , Endereço: Av. Independência, 155 – 6º andar- Hospital Dom Vicente Scherer - POA/RS, caso esteja internado em algum dos hospitais do Complexo Hospitalar Santa Casa durante a participação no estudo.

Assinatura do paciente: .....
Assinatura do investigador: .....

Pesquisador responsável: Flávia Moraes Silva