Original Article

Nutritional status dynamics in neurocritical patients during ICU hospitalization: a retrospective observational study in intensive care units in the interior of Ceará

Dinâmica do estado nutricional em pacientes neurocríticos durante internação em UTI: estudo observacional retrospectivo em unidades de terapia intensiva no interior do Ceará

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ABSTRACT
Introduction: The main challenge of nutritional therapy (NT) in neurocritical patients is to prevent complications secondary to brain injury. Following acute neurological insult, a hypermetabolic and hypercatabolic state develops, with high nutritional demands. Adequate NT is essential to stabilize or restore nutritional status (NS). We aimed to analyze the association between NT and NS in the clinical evolution of neurocritical patients in an intensive care unit. **Methods:** This was a retrospective observational quantitative study. Anthropometric, demographic and nutritional therapy data were collected from electronic medical records and the nutrition department database of neurocritical patients admitted to intensive care units (ICU) I–V of Hospital Regional do Cariri (HRC), Ceará, Brazil, throughout 2022. Reporting followed the STROBE statement. **Results:** Thirty-nine patients were analyzed, predominantly male (87.2%), with a mean age of 45.8 years (95%CI=39.4–52.2). At admission, 51.3% were eutrophic, 38.5% overweight, 5.1% obese and 5.1% had mild malnutrition. At discharge, mild malnutrition rose to 15.4%. Enteral NT predominated (94.9%), hyperproteic (97.3%) and hypercaloric (70.3%). Anthropometric means decreased significantly between admission and discharge: weight (67.36 vs. 62.79 kg), BMI (24.69 vs. 23.08 kg/m²) and arm circumference (29.46 vs. 28.19 cm), all with $p<0.001$. Patients with obesity at admission had a longer mean ICU stay (23 days). **Conclusion:** NT was associated with NS modulation in neurocritical patients, although significant anthropometric depletion was observed during ICU stay. Early characterization, systematic monitoring and adequate caloric-protein delivery of NT were associated with more favorable clinical outcomes, although the observational design does not allow causal inference.

Keywords:
Neurocritical patients. Nutritional status. Nutritional therapy. Intensive care unit.

Unitermos:
Pacientes neurocríticos. Estado nutricional. Terapia nutricional. Unidade de terapia intensiva.

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RESUMO
Introdução: O principal desafio da terapia nutricional (TN) do paciente neurocrítico é evitar complicações secundárias à lesão cerebral. Após o agravo neurológico agudo, instala-se estado hipermetabólico e hipercatabólico, exigindo TN adequada para estabilizar ou recuperar o estado nutricional (EN). O objetivo do estudo foi analisar a associação entre TN e EN na evolução clínica de pacientes neurocríticos em unidade de terapia intensiva. **Método:** Esse foi um estudo observacional retrospectivo, quantitativo e alinhado à diretriz STROBE. Foram coletados dados antropométricos, demográficos e da TN dos pacientes neurocríticos atendidos nas unidades de terapia intensiva (UTI) I–V do Hospital Regional do Cariri (HRC), Ceará, Brasil, ao longo de 2022. **Resultados:** Foram analisados 39 pacientes, predominantemente do sexo masculino (87,2%), com idade média de 45,8 anos (IC95%=39,4–52,2). Na admissão, 51,3% estavam eutróficos, 38,5% com sobrepeso, 5,1% obesos e 5,1% com desnutrição leve. À saída, a desnutrição leve elevou-se a 15,4%. A TN enteral predominou (94,9%), hiperproteica (97,3%) e hipercalórica (70,3%). As médias antropométricas reduziram-se significativamente entre admissão e saída: peso (67,36 vs. 62,79 kg), IMC (24,69 vs. 23,08 kg/m²) e circunferência do braço (29,46 vs. 28,19 cm), todas com $p<0,001$. Pacientes com obesidade apresentaram maior tempo médio de internação (23 dias). **Conclusão:** A TN esteve associada à modulação do EN em pacientes neurocríticos, embora a depleção antropométrica tenha sido significativa durante a internação. A caracterização precoce, a monitorização sistemática e a adequação calórico-proteica da TN mostraram-se associadas a desfecho clínico mais favorável, ainda que o desenho observacional não permita inferir causalidade.

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INTRODUCTION

Patients presenting with failure in one or more organ systems, accompanied by neurological impairment, are classified as neurocritical patients. After acute neurological injury, these patients develop a hypermetabolic and hypercatabolic state with high nutritional demands[1]. Energy expenditure may increase by up to 200%, with a negative nitrogen balance lasting up to four weeks, water and sodium retention, poor glycemic control and immune dysfunction immediately after traumatic brain injury[2].

These patients require continuous monitoring of their clinical status and, fundamentally, of their nutritional status (NS), by the entire multidisciplinary nutritional therapy team (MNTT)[3]. Defining the neurocritical patient establishes objective criteria for clinical improvement and guides the nutritional and broader multidisciplinary care[4]. In this context, early therapeutic nutritional support is essential to attenuate exacerbated catabolism and the inflammatory cascade, aiming at reducing morbidity and mortality[5].

Disease severity, combined with deteriorated nutritional status, produces an additive effect, increasing the risk of complications and prolonging recovery, with cumulative nutritional risk greater than that associated with disease alone[6]. This hypercatabolic scenario reinforces the importance of early recognition of malnutrition signs and timely initiation of nutritional therapy (NT). NS monitoring begins at admission, using screening tools within 48 hours to enable timely intervention, improving treatment response, supporting recovery and reducing complications and hospital costs[7].

Among nutritional screening tools, the Nutrition Risk Screening (NRS 2002) stands out, being applicable by any member of the MNTT. When appropriately performed, it is accurate and reliable. In this scenario, early NT is the most effective treatment to stabilize or reverse NS alterations in hospitalized patients[8].

The main challenge in neurocritical care is preventing secondary complications of brain injury, such as increased resting energy expenditure (REE) and metabolic processes including glycogenolysis and gluconeogenesis, which lead to hyperglycemia and high skeletal protein catabolism. Under inadequate nutritional intake, this catabolism may result in negative nitrogen balance, reflecting loss of total body protein and progressive clinical deterioration[9].

Given these high demands, admission of neurocritical patients to an intensive care unit (ICU) is essential. The ICU is dedicated to patients with clinical instability requiring complex care and continuous monitoring; the use of appropriate technological equipment enables better management of risk situations, with faster decisions and interventions in critical scenarios[10].

Despite the pathophysiological consistency of NT in the neurocritical patient, observational studies systematically describing the association between the profile of NT delivered, NS evolution and ICU length of stay remain scarce in Brazil, particularly in public hospitals located in the interior of the Brazilian Northeast. Given this gap, the following research question arises: what is the association between the NT delivered, NS and ICU length of stay among neurocritical patients admitted to a regional reference hospital?

The present study aimed to analyze the association between NT and NS in the clinical evolution of neurocritical patients in ICUs, by classifying nutritional status at admission and discharge, characterizing the NT delivered, and assessing the relationship between NS and length of hospitalization.

METHODS

This was a retrospective observational study with a quantitative approach, conducted in accordance with the STROBE statement (Strengthening the reporting of observational studies in epidemiology). Data were collected during the first and second semesters of 2023 from electronic patient records of Hospital Regional do Cariri (HRC), located in Juazeiro do Norte, the first state public hospital established in the interior of Ceará, Brazil. The sample comprised neurocritical patients admitted to ICUs I, II, III, IV and V of HRC throughout 2022, aged ≥18 years and with complete and accessible electronic medical records.

Inclusion criteria were: patients whose weight and height (or respective estimates) had been assessed and recorded by the HRC nutrition team and who had at least seven days of ICU admission. This minimum threshold was adopted because patients with less than seven days of ICU stay lacked anthropometric reassessment, preventing analysis of NS trajectory through BMI and percentage of weight change, which directly influences clinical evolution.

Exclusion criteria were: (i) patients who died during ICU stay within the study period; (ii) patients without detailed description of the nutritional strategy in the nutrition department database; and (iii) patients with bilateral upper- or lower-limb amputation. Exclusion of patients who died is justified by the primary outcome of the study, which

required paired anthropometric reassessment (admission vs. discharge) to track NS trajectory under NT; including these patients would introduce bias from incomplete paired data, restricting the analysis of the association between NT and NS over time. We acknowledge, however, that this choice limits generalization to the subgroup of survivors, as discussed in the limitations of the study.

A research request was submitted to the teaching and research center of HRC, including: research request registration form, institutional consent letter, request for waiver of informed consent, awareness statement on scientific research at the hospital unit, data use commitment form, custodian agreement, and researcher/advisor awareness statement. Following favorable authorization and signing of the respective documents, the project was forwarded to the Research Ethics Committee of the Institute of Health and Hospital Management (CEP/ISGH) and concurrently to the CEP of Centro Universitário Maurício Nassau de Juazeiro do Norte, via Plataforma Brasil. Once approved, data collection began.

As the research involved previously completed documents and there was no means of contacting the patients whose data were collected, the waiver of the informed consent form (ICF) was justified.

Data were collected from each patient's exclusive electronic medical record (ARS VITAE platform) and from the nutrition department's evaluation database hosted on an institutional Google Drive environment. The reason for admission was analyzed, applying the inclusion and exclusion criteria. When database information was insufficient to make a decision, the electronic medical record was reviewed for additional information. Access to the medical record was obtained through the institutional login of the auxiliary researcher, an intern in the HRC nutrition department at that time, with direct institutional affiliation.

The following demographic data were collected: race (white/black), gender (female/male), date of birth (dd/mm/yyyy) and date of ICU admission (dd/mm/yyyy). Anthropometric parameters included weight (kg), height (m) and BMI (kg/m^2) at admission and at discharge, with their respective estimates when applicable, arm circumference AC (cm) at admission and at discharge, and knee height KH (cm). Duration of NT monitoring (days), ICU length of stay (days) and number of evaluations during admission were also registered. Regarding NT, the route was recorded (enteral/parenteral/oral) and, for the enteral route, caloric density and protein delivery. NS at admission and at discharge was categorized as malnutrition (severe, moderate or mild), eutrophy, overweight and obesity.

When possible, weight and height were measured directly using scales and a non-stretchable measuring tape (1.5 m, 0.01 m increments), according to patient mobility; otherwise, the estimates described in Charts 1 and 2 were used.

Chart 1 – Body weight estimation formulas.

Estimated weight (men) = (0.98 × CC) + (1.16 × KH) + (1.73 × AC) + (0.37 × TSF) – 81.69
Estimated weight (women) = (1.27 × CC) + (0.87 × KH) + (0.98 × AC) + (0.40 × TSF) – 62.35

Source: Chumlea et al., 1994[11].

Chart 2 – Height estimation formulas.

Estimated height (men) = 64.19 – (0.04 × age) + (2.02 × KH)
Estimated height (women) = 84.88 – (0.24 × age) + (1.83 × KH)

Source: Chumlea et al., 1985[12].

NT was categorized according to caloric density into hypocaloric (<20 kcal/kg/d), normocaloric (20–25 kcal/kg/d) and hypercaloric (>25 kcal/kg/d), and according to protein delivery into hypoproteic (<1.2 g/kg/d), normoproteic (1.2–1.5 g/kg/d) and hyperproteic (>1.5 g/kg/d), following the BRASPEN Guideline for Nutritional Therapy in the Critically Ill Patients[15].

BMI was calculated using the Quetelet formula: BMI (kg/m^2) = weight (kg)/height (m^2). Classification followed the World Health Organization (WHO) cut-offs: malnutrition = BMI$<$18.5 kg/m^2; eutrophy = 18.5$\leq$BMI$\leq$24.9 kg/m^2; overweight = 25.0$\leq$BMI$\leq$29.9 kg/m^2; and obesity BMI$\geq$30.0 kg/m^2.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 20.0 for Windows. A descriptive analysis of the studied population was initially conducted, with exploratory correction of inconsistencies. Continuous variables weight (kg), height (m), BMI (kg/m^2) and their estimates AC (cm), KH (cm), age (years), duration of NT monitoring (days), ICU length of stay (days), and number of evaluations were described by measures of central tendency (mean, median) and dispersion (standard deviation, 95% confidence interval). Nominal variables sex, race, diet route, caloric profile, protein profile, and NS were described by absolute and relative frequency. Normality of continuous variables was assessed using the Kolmogorov-Smirnov test and histogram inspection. Anthropometric

means at admission and discharge were compared using the paired Student's t-test (normal distribution) or the Wilcoxon test (otherwise). Associations between nominal variables were tested using Pearson's chi-square, with Fisher's exact test when >20% of cells had expected frequency <5. Mean length of stay across admission NS categories was compared using one-way ANOVA or the Kruskal-Wallis test, according to the distribution. A significance level of $p<0.05$ was adopted.

The project was approved by the CEP/ISGH and by the CEP of Centro Universitário Maurício Nassau de Juazeiro do Norte/UNINASSAU JUAZEIRO DO NORTE, in compliance with Resolution No. 466/12 of the National Health Council, ensuring participant anonymity.

Risks were considered minimal, restricted to potential loss or corruption of documentary data. Security, coding and anonymization measures were adopted, preserving privacy and integrity of information. As a benefit, the study characterizes the association between NS, NT and clinical evolution of neurocritical patients in ICUs, with potential contribution to regional clinical practice.

RESULTS

The sample comprised 39 neurocritical patients, predominantly male (87.2%) and White (76.9%). Mean age was 45.8 years (95%CI=39.4–52.2). Mean height was 1.65 m (95%CI=1.63–1.67), and mean knee height was 50.91 cm (95%CI=49.9–51.9).

Table 1 summarizes the nutritional status profile at ICU admission and discharge, as well as the characteristics of the nutritional therapy delivered to neurocritical patients. A redistribution of nutritional status was observed between ICU admission and discharge, with an increase in the prevalence of mild malnutrition (5.1%→15.4%) and a reduction in excess weight (overweight: 38.5%→20.5%; obesity: 5.1%→2.6%). The proportion of eutrophic patients increased (51.3%→61.5%), influenced by the transition of patients initially classified as overweight or obese to lower BMI categories.

Regarding the nutritional therapy delivered, the enteral route predominated (94.9%), with a hyperproteic profile in 97.3% of cases and a hypercaloric profile in 70.3%. These data are consistent with current recommendations for critically ill patients, in which adequate protein delivery (≥1.2 g/kg/d) is considered a priority.

The trajectory of nutritional status redistribution was associated with ICU length of stay, with greater depletion observed in patients with longer hospitalizations.

Table 1 – Nutritional status and nutritional therapy profile of neurocritical patients (n=39).

Variables	n	%
Nutritional status		
At admission		
Mild malnutrition	2	5.1
Eutrophic	20	51.3
Overweight	15	38.5
Obesity	2	5.1
Nutritional status		
At discharge		
Mild malnutrition	6	15.4
Eutrophic	24	61.5
Overweight	8	20.5
Obesity	1	2.6
Route of NT		
Enteral	37	94.9
Oral	2	5.1
Caloric profile of NT		
Hypocaloric	1	2.7
Normocaloric	10	27
Hypercaloric	26	70.3
Protein profile of NT		
Normoproteic	1	2.7
Hyperproteic	36	97.3

n = sample size; NT = nutritional therapy.

Figure 1 illustrates the relationship between nutritional status at admission and mean ICU length of stay. Patients with obesity had a longer mean length of stay (23 days) compared to the other categories.

Table 2 presents the comparison of anthropometric means of neurocritical patients between ICU admission and discharge. Anthropometric means differed significantly between these time points ($p<0.001$).

Mean body weight decreased from 67.36 to 62.79 kg, BMI from 24.69 to 23.08 kg/m^2, and arm circumference from 29.46 to 28.19 cm.

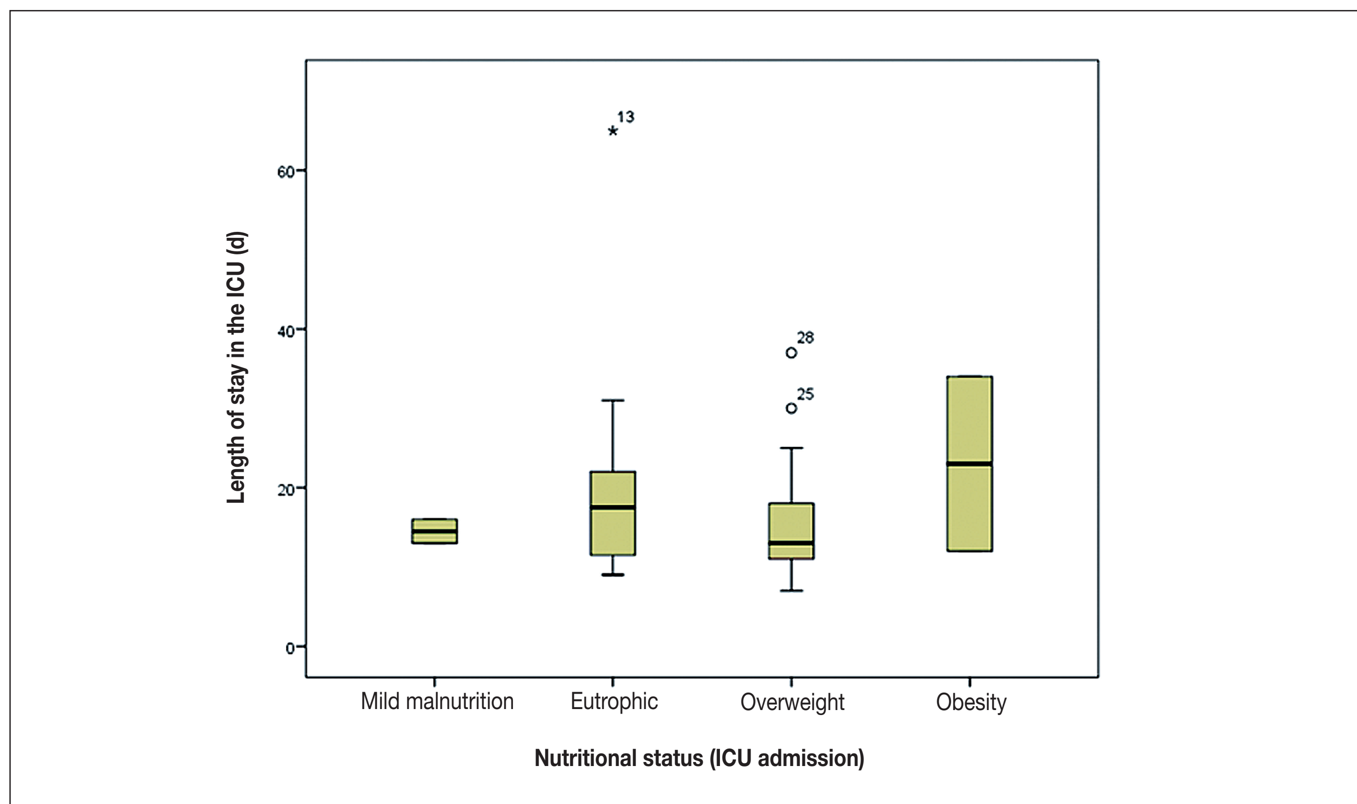

Figure 1 - *Relationship between nutritional status at admission and mean intensive care unit (ICU) length of stay.*

Table 2 – Comparison of anthropometric measurements of neurocritic patients between admission and discharge from the ICU (n=39).

Variables	Mean	SD	SEM	95% CI lower	95% CI upper	t	p
Weight (kg) — admission	67.36	9.88	1.58	64.16	70.56	—	—
Weight (kg) — discharge	62.79	8.33	1.33	60.09	65.49	—	—
Weight difference	**4.57**	**5.59**	**0.90**	**2.76**	**6.38**	**5.11**	**<0.001**
BMI (kg/m²) — admission	24.69	3.44	0.55	23.58	25.81	—	—
BMI (kg/m²) — discharge	23.08	3.22	0.52	22.03	24.12	—	—
BMI difference	**1.61**	**1.95**	**0.31**	**0.98**	**2.25**	**5.16**	**<0.001**
AC (cm) — admission	29.46	3.05	0.49	28.47	30.45	—	—
AC (cm) — discharge	28.19	2.43	0.39	27.40	28.98	—	—
AC difference	**1.27**	**1.93**	**0.31**	**0.64**	**1.89**	**4.11**	**<0.001**

n = sample size; SD = standard deviation; SEM = standard error of the mean; 95%CI = 95% confidence interval; BMI = body mass index; AC = arm circumference. Paired Student's t-test for dependent samples.

DISCUSSION

Although the findings presented here are expressive regarding the depletion of nutritional status, this could have been even more pronounced in the absence of adequate nutritional therapy, considering the intense inflammatory and hypercatabolic state characteristic of neurocritical patients. The interpretation that follows, however, must respect the observational design of the study, in which

associations are described without the possibility of causal inference.

The first step in the management of neurocritical patients is their identification and characterization, which allows the establishment of objective criteria for clinical improvement and guides the provision of appropriate nutritional therapy[4]. Regarding gender, a predominance of males was observed. This was consistent with Arruda et al.[4], who reported 68.7% male patients and a mean age of 42.9 years, a profile similar to that of the present investigation. These data are compatible with the higher incidence of trauma and vascular events in males and with the relatively worse clinical outcomes described in the literature for this subgroup.

Regarding anthropometric parameters, Santos et al.[13] reported similar findings, with a high prevalence of eutrophy at admission (54.8%) and an increase in malnutrition at discharge (11.7%). When nutritional diagnosis was based on arm circumference, the prevalence of malnourished patients reached 44%, indicating greater sensitivity of this parameter in identifying malnutrition in critically ill patients. These findings reinforce the importance of using multiple methods for nutritional status assessment, considering the limitations of each isolated parameter in the ICU context.

This context justifies the application of standardized screening tools, such as the Nutrition Risk in Critically Ill (NUTRIC) score and the NRS-2002, which are considered the most appropriate for assessing disease severity in critically ill patients. The NUTRIC score stands out for integrating prognostic indices such as the Acute Physiology and Chronic Health Evaluation II (APACHE II) and the Sepsis-Related Organ Failure Assessment (SOFA)[15], allowing better adjustment of nutritional therapy to individual clinical conditions.

Brazilian studies show that the prevalence of high nutritional risk among critically ill patients varies according to the admission condition (clinical, surgical, traumatic), ranging from 36.5% to 67.9%. In these patients, mortality among those at high nutritional risk ranges from 54.7% to 73.7%[14]. These data consistently associate nutritional status with clinical outcomes, supporting the need for standardized and routine screening.

The effectiveness of nutritional therapy is associated with caloric and protein delivery adjusted to the patient's clinical condition, capable of minimizing morbidity and mortality related to malnutrition[13]. Another relevant factor is the early achievement of nutritional targets, between the fifth and seventh day, according to current guidelines[7], since prolonged fasting tends to be associated with greater depletion of nutritional status and intensification of the inflammatory response[14].

In the present study, the provision of hyperproteic nutritional therapy was consistent with recent literature, which has prioritized protein targets over caloric targets to support metabolic demand, wound healing, and immune function in critically ill patients. Although neurocritical patients should receive hyperproteic diets (≥1.2 g/kg/d), achieving this recommendation remains a clinical challenge. Nevertheless, the data suggest that the strategy adopted at HRC is aligned with current recommendations[13].

Regarding length of stay, Moock et al.[16] reported a longer hospital stay in obese survivors compared to eutrophic patients, a finding similar to that of the present investigation. This pattern may be related to the high nutritional risk of this subgroup, often underestimated, as well as to the metabolic characteristics of adipose tissue, which is associated with chronic inflammation, insulin resistance, and greater clinical complexity[15].

Obese patients present greater proteolysis and consumption of lean mass, with a risk of sarcopenic obesity, in addition to increased susceptibility to complications associated with overfeeding. In this context, hypocaloric strategies combined with hyperproteic intake aim to minimize such complications and preserve lean mass[15].

The interpretation of these findings should also consider the limited availability of studies specifically focused on neurocritical patients, which makes it difficult to define optimal parameters for the delivery and monitoring of nutritional therapy in this group. These patients often present a hypermetabolic and hypercatabolic state, resulting from systemic inflammatory response and neuroendocrine alterations associated with acute neurological injury, substantially increasing their energy and protein demands.

In this context, the anthropometric depletion observed throughout hospitalization should be interpreted as an expression of the metabolic complexity inherent to this clinical profile. Although the nutritional therapy provided in this study was aligned with current recommendations, with a predominance of hyperproteic strategies and appropriate administration routes, the evolution of nutritional status in neurocritical patients is influenced by multiple clinical determinants, including disease severity, length of stay, and the intensity of the systemic inflammatory response.

Thus, the findings do not suggest inadequacy of nutritional therapy but rather reinforce the need for continuous monitoring and individualized strategies, considering that in scenarios of high catabolism, preservation of nutritional

status may not be fully achieved even with appropriate management. The absence of specific consensus for this population highlights the need for further scientific production to support more precise clinical practices.

Additionally, it is noteworthy that this study was conducted in a public referral hospital located in the interior of Northeast Brazil, demonstrating the feasibility of producing high-quality scientific research outside major urban centers. The systematization and critical analysis of clinical data represent essential tools not only for improving clinical practice but also for expanding knowledge in still underexplored areas, such as nutritional therapy in neurocritical patients.

This study has limitations that should be considered when interpreting the findings. It is a single-center, retrospective study based on secondary data, which may introduce information bias and limit the generalizability of the results. The small sample size restricts statistical power for more robust analyses, and the exclusion of patients who died during hospitalization limits interpretation to the subgroup of survivors.

Furthermore, the use of body mass index as the main anthropometric marker does not fully capture changes in body composition in the context of a hypercatabolic state. Future studies may benefit from incorporating functional and body composition markers, as well as the systematic application of validated nutritional screening tools.

Despite these limitations, the study's strength lies in the systematic analysis of clinical data in a regional public referral hospital, contributing to the understanding of nutritional status dynamics in neurocritical patients a population still underrepresented in the literature, especially in contexts outside major centers.

CONCLUSION

The present investigation showed that, in neurocritical patients admitted to the ICUs of HRC, nutritional therapy, predominantly enteral, hyperproteic, and hypercaloric, was associated with modulation of nutritional status, although significant anthropometric depletion was observed throughout hospitalization. Patients with obesity at admission had a longer mean ICU length of stay.

The findings suggest that early characterization of the neurocritical patient, systematic monitoring of nutritional status, and adequate caloric-protein delivery of nutritional therapy are associated with the observed clinical evolution, without allowing the establishment of a direct causal relationship, given the observational design of the study.

In this sense, the results should be interpreted as hypothesis-generating, reinforcing the need for prospective, multicenter studies with greater analytical power, particularly focused on neurocritical populations and healthcare settings outside major urban centers.

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Study location: Hospital Regional do Cariri, Juazeiro do Norte, CE, Brazil.

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