Early mobilization and ventilatory, functional and clinical outcomes of neurocritical patients

Mobilização precoce e desfechos ventilatórios, funcionais e clínicos de pacientes neurocríticos

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Abstract

Introduction: Neurocritical patients may suffer functional limitations due to various factors, ranging from primary brain injury to cultural and structural barriers. **Objective:** To compare the functional mobility of adult neurocritical patients on invasive mechanical ventilation (IMV) undergoing an early mobilization protocol between intensive care unit (ICU) admission and discharge and to evaluate ventilatory and clinical outcomes. **Methods:** A retrospective study conducted in the neurological ICU of a teaching hospital from January to December 2022. Data were collected from electronic medical records, including sex, age,diagnosis, comorbidities, length of IMV and ICU stay, discharge or death outcomes, and functionality scores from the ICU Mobility Scale and the Johns Hopkins Scale. **Results:** Seventy-five patients were included in the study, with a mean age of 52.1 ± 19.5 years, predominantly female (52%). The most prevalent diagnosis and comorbidity were traumatic brain injury (24%) and hypertension (40%). The mean duration of IMV was 4.7 ± 3.3 days, with an average ICU stay of 11.9 ± 6.9 days. The study showed an 85% success rate in IMV weaning and 95% of ICU discharge rate. There was a significant improvement in functionality ($p < 0.0001$) from admission to discharge, with a notable reduction ($p < 0.0001$) in the total restriction score and a significant increase ($p < 0.0001$) in the moderate and mild reduction in mobility scores. **Conclusion:** The functional mobility of neurocritical patients improved from total complete bed restriction to the ability to perform orthostatic activities, transfer out of bed, and walk with assistance between ICU admission and discharge. Among the outcomes analyzed, there were high rates of ventilatory weaning and ICU discharges.

Keywords: Physiotherapy. Early mobilization. Mobility limitation. Intensive care units.

Resumo

Introdução: *Pacientes neurocríticos podem sofrer limitações de funcionalidade por diversos motivos, desde lesão cerebral primária até barreiras culturais e estruturais.* ***Objetivo:*** *Comparar a mobilidade funcional de pacientes neurocríticos adultos em ventilação mecânica invasiva (VMI) submetidos a um protocolo de mobilização precoce entre a admissão e a alta da unidade de terapia intensiva (UTI) e avaliar desfechos ventilatórios e clínicos.* ***Métodos:*** *Estudo retrospectivo, realizado na UTI neurológica de um hospital-escola entre janeiro e dezembro de 2022. Foram coletados dos prontuários eletrônicos: sexo, idade, diagnóstico, comorbidades, tempo de permanência em VMI e de internação na UTI, desfechos (alta ou óbito) e escores de funcionalidade da escala de mobilidade em UTI e da Johns Hopkins.* ***Resultados:*** *Foram incluídos no estudo 75 pacientes, com idade média de 52,1 ± 19,5 anos, com predomínio do sexo feminino (52%). O diagnóstico e a comorbidade mais prevalentes foram traumatismo cranioencefálico (24%) e hiper-tensão arterial (40%). A média de permanência em VMI foi de 4,7 ± 3,3 dias e 11,9 ± 6,9 dias de internação na UTI; 85% de sucesso no desmame da VMI e 95% de altas da UTI. Houve melhora significativa da funcionalidade (p < 0,0001) da admissão até a alta, com redução significativa (p < 0,0001) do escore de restrição total e incremento significativo (p < 0,0001) dos escores de moderada e ligeira redução da mobilidade.* ***Conclusão:*** *A mobilidade funcional dos pacientes neurocríticos melhorou da restrição total deitado no leito para atividades de ortostatismo, transferência para fora do leito e deambulação com auxílio, entre a admissão e a alta da UTI. Entre os desfechos analisados, houve altas taxas de desmame ventilatório e altas da UTI.*

Palavras-chave: *Fisioterapia. Mobilização precoce. Limitação de mobilidade. Unidades de terapia intensiva.*

Introduction

Neurocritical patients are individuals with severe primary brain injuries who are at high risk of secondary brain impairment, necessitating intensive care unit (ICU) admission for specialized management and continuous monitoring.[1–3] The most common causes of severe acute brain injury include traumatic brain injury (TBI), acute ischemic stroke, intracranial hemorrhage, and subarachnoid hemorrhage.[1,2]

These patients often face functional limitations due to a variety of factors. The primary brain injury may require the use of sedatives, neuromuscular blockers, vasoactive drugs, and invasive mechanical ventilation (IMV). Additionally, the use of invasive devices — such as vascular catheters, drains, and feeding tubes — combined with altered consciousness, delirium, and even cultural barriers within the healthcare team, may contribute to functional decline.[4,5] These factors heighten the risk of severe functional impairment in neurocritical patients, leading to prolonged IMV dependence, extended ICU and hospital stays, an increased risk of infec-tions, and higher morbidity and mortality rates.[6–9]

Early mobilization has emerged as a viable and safe intervention to reduce the incidence of myopathy and polyneuropathy, shortening IMV duration, decreasing ICU and hospital stay, and enhancing functional outcomes in neurocritical patients.[10–12] However, current evidence remains of low quality due to methodological restrictions, heterogeneous protocols, insufficient description of early mobilization strategies, early mobilization protocols used, and clinical and statistical variability, resulting in weak recommendations for routine implementation.[13]

Further research is necessary to address these knowledge gaps and better understand the true impact of early and progressive mobilization strategies in patients with severe acute brain injuries. Therefore, this study aimed to compare the functional mobility of mechanically ventilated adult neurocritical patients who underwent an early mobilization protocol from ICU admission to discharge, while also evaluating ventilatory and clinical outcomes.

Methods

This retrospective observational study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[14] Data were collected from electronic patient records within the MVPEP® system for patients admitted to the adult neurological ICU of the Hospital de Base, in São José do Rio Preto, Brazil, from January to December 2022.

The inclusion criteria were patients of both sexes, over 18 years of age, who required IMV for more than 24 hours, regardless of underlying pathology.

The exclusion criteria were patients on spontaneous breathing and those with incomplete electronic clinical records or lacking data in the Google Drive® spreadsheets maintained by the ICU physiotherapy service.

Data collection

Data was collected from the electronic clinical records included sex, age, diagnosis, comorbidities, IMV duration, ICU stay, Simplified Acute Physiology Score (SAPS III),[15] and outcomes (discharge or death). Functional mobility was assessed at ICU admission and discharge using the ICU mobility scale (IMS)[16] and the Johns Hopkins Highest Level of Mobility (JH-HLM)[17] scale. These scores were obtained from the Google Drive® spreadsheets maintained by the physiotherapy service of the neurological ICU.

SAPS III is a clinical score composed of 20 parameters evaluated on ICU admission, reflecting disease severity and pre-hospital health status and indicating the patient's premorbid condition. The score ranges from 16 to 217 points, with each parameter assigned a weighted value based on physiological derangement. The assessed parameters include temperature; systolic blood pressure; heart and respiratory rates; oxygenation; arterial pH; sodium, potassium, creatinine, bilirubin, and hematocrit level; leukocyte and platelet count; and Glasgow coma scale score.[15]

The IMS is a 10-point scale that quantifies functional mobility, where zero represents complete immobility (passive in-bed exercises only) and 10 represents fully independent ambulation.[16] Mobility levels were categorized as follows: 0 = total restriction; 1 to 3 = severe functional reduction; 4 to 6 = moderate functional reduction; 7 to 9 = mild functional reduction; and 10 = fully functional.[17]

The JH-HLM scale measures mobility by analyzing patients' current condition rather than their potential capabilities. It records a patient's highest level of mobility since the last recorded assessment.[18] The JH-HLM scale is an eight-point observational tool. It ranges from one point for patients in bed rest to eight points for patients ambulating more than 75 meters.[18]

Outcomes

The primary clinical outcome was functional mobility level. Secondary clinical outcomes included IMV duration, ventilatory weaning success or failure, ICU stay, and ICU outcome (discharge or mortality).

Intervention

The early mobilization protocol used in the neurological ICU was initiated upon ICU admission or once clinical and hemodynamic stability was achieved. It included three progressive phases,[19] following the FITT-VP (frequency, intensity, type, time, volume, progression) exercise prescription framework[20,21] presented in Table 1.

The early mobilization session was discontinued, and the patient was returned to bed upon presenting any of the following conditions: respiratory alterations with peripheral oxygen saturation (SpO_2) < 88%, respiratory rate exceeding baseline by > 20 breaths per minute, Borg scale rating of perceived exertion (RPE) ≥ 5, use of accessory respiratory muscles, and/or paradoxical breathing; hemodynamic instability with pallor, profuse sweating, heart rate exceeding the upper normal limit, arrhythmias, or precordial pain; other conditions including patient request or occurrence of falls.[22]

Ethical considerations

The project received approval by the Research Ethics Committee of the School of Medicine of São José do Rio Preto (FAMERP) under protocol no. 5,557,881. As a retrospective study analyzing secondary data from medical records, an exemption from informed consent was requested and granted.

Data analysis

Descriptive statistics were conducted, with results presented as percentages, absolute numbers, means ± standard deviations, and medians with interquartile ranges. The normality of data distribution was measured using the Kolmogorov Smirnov test. Inferential statistical analysis included the Wilcoxon test for comparing discrete parameters and the Fisher's exact test for comparing categorical parameters related to functionality between ICU admission and discharge. Statistical analyses were conducted using the GraphPad Instat® software, with a significance threshold set at $p \leq 0.05$.

Table 1 - Early mobilization protocol and FITT-VP (frequency, intensity, type, time, volume, progression) exercise prescription framework for neurocritical patients

Phase	Phase I	Phase II	Phase III
Description	Functional positioning; passive mobilization of upper and lower limbs; passive sitting at the bedside	Active-assisted or active exercises for the upper and lower limbs in bed; passive sitting out of bed; passive or active-assisted standing	Active standing, assisted ambulation, and active ambulation
Frequency	3 times/day	2 times/day	2 times/day
Intensity	Not applicable	Borg scale 3 – 4	Borg scale 3 – 4
Type	Passive mobilization	Active-assisted mobilization or active mobilization	Active mobilization
Duration	10 minutes/session	10 - 20 minutes/session	10 - 30 minutes/session
Volume	3 series, 10 repetitions	3 series, 10 repetitions	1 series, at least 5 meters
Progression	Phase I to Phase II	Phase II to phase III	10 – 100 meters

Results

During the study period, 460 patients were admit ted to the neurological ICU, of whom 75 neurocritical patients required IMV. In terms of sociodemographic and clinical characteristics, the patients had a mean age of 52.1 ± 19.5 years, with a predominance of females (52%). The most common primary diagnosis was TBI (24%), while systemic arterial hypertension (40%) was the most prevalent comorbidity (Table 2).

Regarding ventilatory outcomes, neurocritical patients had a mean duration of IMV of 4.7 ± 3.3 days, with successful ventilatory weaning in 85% of cases. In terms of clinical outcomes, the mean ICU stay was 11.9 ± 6.9 days, and the discharge rate was 95% (Table 3).

A significant improvement ($p < 0.0001$) in functionality and mobility scores was observed between ICU admission and discharge (Table 4).

Stratification of the ICU Mobility Scale (IMS) into functional impairment categories revealed a significant reduction ($p < 0.0001$) in the total restriction category and significant increases ($p < 0.0001$) in the moderate and mild reduction categories between ICU admission and discharge (Table 5).

Table 2 - Sociodemographic and clinical characteristics of neurocritical patients

Parameter	Mean ± standard deviation
Age (years)	52.1 ± 19.5
Male, n (%)	36 (48)
Female, n (%)	39 (52)
Simplified Acute Physiology Score (SAPS III)	57.6 ± 18.7
Admission diagnoses, n (%)	
Traumatic brain injury	18 (24)
Stroke	12 (16)
Brain tumor resection	11 (15)
Postoperative drainage of cerebral hematomas	8 (11)
Subarachnoid hemorrhage	6 (8)
Spinal arthrodesis	6 (8)
Others	14 (19)
Comorbidities, n (%)	
Systemic arterial hypertension	30 (40)
Diabetes mellitus	17 (23)
Dyslipidemia	4 (5)
Obesity	3 (4)

Table 3 - Ventilatory and clinical outcomes of neurocritical patients on invasive mechanical ventilation (IMV)

Outcomes	Mean ± standard deviation
Ventilatory	52.1 ± 19.5
Days on IMV	4.7 ± 3.3
Weaning success, n (%)	64 (85)
Weaning failure, n (%)	11 (15)
Intensive care unit stay (days)	11.9 ± 6.9
Intensive care unit discharge, n (%)	71 (95)
Intensive care unit deaths, n (%)	4 (5)

Table 4 - Comparison of functionality and mobility scores between intensive care unit (ICU) admission and discharge of neurocritical patients on invasive mechanical ventilation

Tool	ICU admission	ICU discharge	p-value
IMS	0 [0–4]	5 [1–10]	< 0.0001*
JH-HLM	1 [1–4]	5 [2–8]	< 0.0001*

Note: IMS = Intensive Care Unit Mobility Scale; JH-HLM = Johns Hopkins Highest Level of Mobility. *Wilcoxon test, p < 0.05.

Table 5 - Comparison of functionality levels by the Intensive Care Unit Mobility Scale (IMS) between intensive care unit admission and discharge of neurocritical patients

IMS	Admission, n (%)	Discharge, n (%)	p-value*
0 - Total restriction	59 (79)	0 (0)	**< 0.0001**
1–3 - Severe functional reduction	15 (20)	14 (20)	1.0000
4–6 - Moderate functional reduction	1 (1)	27 (38)	**< 0.0001**
7–9 - Mild functional reduction	0 (0)	28 (39)	**< 0.0001**
10 - Fully functional	0 (0)	2 (3)	0.2400

Note: *Fisher's exact test. Bold values indicate p < 0.05.

Discussion

Our analysis revealed significant functional improvement from ICU admission to discharge. This progress was evidenced by a substantial decrease in the total restriction score and a significant elevation in the moderate functional reduction score, which includes activities such as standing, bed-to-chair transfers, and stationary ambulation. Furthermore, an increase was observed in the mild functional reduction score, which includes assisted ambulation facilitated by one or more caregivers or supported by a walking aid. Secondary outcomes highlighted a mean duration of IMV of four days, an 85% success rate in IMV weaning, a mean ICU stay of 11 days, and a 95% discharge rate from the ICU.

A recent study investigated the effects of aerobic training with a cycle ergometer on lower limb muscle strength and functional mobility using the IMS in 20 patients with acute stroke, divided into an intervention group (receiving conventional physiotherapy plus cycle ergometer training twice a day) and a control group (receiving conventional physiotherapy alone).[23] The authors reported significant lower limb muscle strength in the intervention group, and significant functionality enhancement in both groups. Notably, the intervention led to a six-point increase in the IMS score.[23] These findings align with our results, which exhibited a five-point increase in the IMS score at ICU discharge. However, unlike the aforementioned study, our mobilization protocol did not include a cycle ergometer, suggesting that this additional intervention may further enhance functional outcomes.

Souza et al.[24] compared an early mobilization protocol with 48 hours of bed rest in 208 neurocritical patients and found that early mobilization was associated with fewer medical complications, such as infections, seizures, and thrombosis, as well as improved functionality scores. While these outcomes are similar to ours, their study differs as their control group remained on bed rest for 48h, whereas our protocol initiated early mobilization within the first 24 hours of ICU admission.

A recent randomized clinical trial comparing an early rehabilitation protocol with and without the inclusion of virtual reality training in 143 patients with acute ischemic

stroke reported that virtual reality improved limb muscle strength and reduced anxiety and depression. However, no significant differences were observed between groups in functionality scores measured by the Functional Status Score for the ICU (FSS-ICU),[25] translated and validated in Brazil by Silva et al.[26] This contrasts with our findings, which were measured using the IMS. The divergence may stem from differences in assessment tools, as the FSS-ICU evaluates five mobility tasks, including rolling, supine-to-sitting transfer, sitting-to-standing transfer, bedside sitting, and walking. These mobility tasks may be more impacted by hemiparesis or hemiplegia in the acute phase of stroke, which may justify similar functionality scores.

Rocca et al.[27] conducted a prospective randomized study evaluating changes in sympathetic activity and blood pressure during gradual postural transitions using a verticalization robot and LL ergometer training in 30 patients with severe brain injuries. Their findings revealed that early mobilization did not significantly increase catecholamine production or blood pressure, reinforcing the safety and feasibility of early mobilization in neurocritical patients.[27] While not directly comparable to our study, their results exhibit that early mobilization has no effect on hemodynamic physiological parameters and support its broader applicability in critically ill patients.

Most of the cited studies confirmed the benefits of early mobilization for functional mobility in neurocritical patients. However, a recent pilot study assessing functional mobility using the IMS in neurocritical patients found a statistically significant increase ($p < 0.0001$) in scores between ICU admission and discharge,[28] but questioned the clinical relevance of this improvement. This underscores the necessity for further research to establish the minimal clinically important difference, which refers to the smallest change in a score considered beneficial for a patient.[28-30]

Regarding secondary outcomes, our study found a mean IMV duration of four days and an 85% success rate in ventilatory weaning. A narrative review[31] emphasized that ventilatory weaning in neurocritical patients aims to gradually reduce ventilatory support to achieve sustained extubation for more than 48 hours. However, extubation failure rates in neurological patients reach up to 38% in the literature.[32] The higher weaning success rate achieved in the present study may be attributed to the lower severity of the sample, as reflected by an average SAPS III score of 57 points.

Other secondary outcomes included an average ICU stay of 11 days and a 95% ICU discharge rate. A study comparing clinical outcomes in mechanically ventilated neurosurgical ICU patients reported a median ICU stay of nine days and a 90% ICU discharge rate among successfully weaned patients.[33] Another study analyzing neurological patients with and without prolonged IMV reported a median ICU stay of eight days in the group without prolonged IMV and an 85% ICU discharge rate in both groups.[34] These results are consistent with ours and suggest a potential role of early mobilization in improving these clinical outcomes, though studies analyzing this association remain limited in the literature.

The only study[19] examining the relationship between ICU length of stay and functionality at discharge within a heterogeneous cohort of critically ill patients, categorized by medical specialty, identified a significant inverse correlation among neurology and pulmonology patients. This finding suggests that extended ICU stays were associated with reduced functionality at discharge. However, the study did not include specific statistical analyses to discern whether the functional decline was attributable to an inadequate mobilization protocol or other contributing factors.

The restrictions of this study encompass its retrospective, single-center design, which restricts causal inferences, as well as a small sample size. Furthermore, the study lacks post-ICU and post-hospital follow-up, along with respiratory and peripheral muscle strength assessments. Other limitations are the absence of data on neuromuscular blockers, vasoactive drugs and sedative dosages, and the lack of documented adverse events associated with early mobilization protocol sessions.

Despite these restrictions, this study is the first to stratify the IMS scale into categories of functional impairment to better characterize neurocritical patients' functional limitations at admission and their improvement at discharge. Future randomized clinical trials using this stratification and assessing minimal clinically important difference and the effects of early mobilization in neurocritical patients are necessary.

Conclusion

The functional mobility of neurocritical patients on IMV who underwent an early mobilization protocol

improved from total restriction (lying in bed) to the ability to perform standing activities, transfer out of bed, and ambulate with assistance between ICU admission and discharge. Additionally, clinical outcomes reflected high success rates in ventilator weaning and ICU discharge, underscoring the effectiveness of the intervention.

Authors' contributions

LLF and ACL were responsible for project conception and design. LLF was also responsible for analyses and manuscript writing, and ACL for reviewing and improving manuscript writing. MCN was responsible for material preparation and data collection. All authors approved the final version of the manuscript.

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