DOI: 10.1590/1809-2950/e24006024en

ORIGINAL RESEARCH

The impact of an early, viable, and low-cost mobilization protocol in critically ill patients: comparison with conventional physical therapy

O impacto de um protocolo de mobilização precoce, viável e de baixo custo em pacientes críticos: comparação com a fisioterapia convencional

El impacto de un protocolo de movilización precoz, viable y de bajo costo en pacientes críticos: una comparación con la fisioterapia convencional

Rodrigo César Maia Moreira[1], Rodrigo Marques Tonella[2], Lucinara Martins Silva Tallarico[3], Taís Mendes de Camargo[4], Liliane Patrícia Souza Mendes[5], Mariana Hoffman Barbosa[6], Maria Clara Xavier Salles[7], Marcelo Velloso[8]

ABSTRACT | This study aims to analyze the outcomes of applying an early mobilization protocol, using low-cost interventions with the minimum necessary equipment in an intensive care unit. A clinical trial, controlled and randomized, conducted in collaboration with the Laboratory for Assessment and Research in Cardiorespiratory Performance of the Department of Physical Therapy at the Federal University of Minas Gerais and the Intensive Care Unit of Risoleta Tolentino Neves Hospital in Belo Horizonte, Brazil, over a period of 5 months. Patients were randomized into two groups (treatment n=67 and control n=67). The primary outcome was days of discharge from bed. Secondary outcomes included ICU length of stay, hospital length of stay, hospitalization costs, time on mechanical ventilation, ICU mortality, and hospital mortality. The group characteristics were similar in the initial assessment. It was found that 61 patients (97%) in the treatment group were discharged from bed compared to only two patients (3%) in the control group. The proposed mobilization protocol reduced hospitalization costs by 30.27%, an approximate difference of R$7,000.00 per patient. The mean ICU stay time for the treatment group was less than the control group. There were no statistically significant differences in ICU hours, hospital length of stay, or mechanical ventilation time. The results of this study demonstrated that the application of a low-cost and minimally equipped early mobilization protocol was safe and effective for patients, promoting early discharge from bed.

Keywords | Early Mobilization; Cost; Physical Therapy; Low-Cost Technology; Intensive Care Unit.

RESUMO | Neste estudo foi analisado o resultado da aplicação de um protocolo de mobilização precoce, fazendo uso de intervenções de baixo custo, com o mínimo de equipamentos necessários em uma unidade de terapia intensiva. Trata-se de um ensaio clínico, controlado e randomizado, realizado em parceria com o Laboratório de Avaliação e Pesquisa do Desempenho Cardiorrespiratório do Departamento de Fisioterapia da Universidade Federal de Minas Gerais e com a Unidade de Terapia Intensiva (UTI)

[1]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. E-mail: rodfisiomaia@gmail.com. Orcid: 0009-0002-6758-9203
[2]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. E-mail: digomato@ufmg.br. Orcid: 0000-0001-5363-0717
[3]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. Email: lucinara1@yahoo.com.br.. Orcid: 0009-0008-9593-7379
[4]University of São Francisco – Bragança Paulista (SP), Brazil. Email: taismendesdecamargo@gmail.com. Orcid: 0000-0002-3804-280X
[5]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. Email: lilicev@yahoo.com.br. Orcid: 0000-0002-2602-xxxx
[6]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. Email: mariana.hoffman1@monash.edu. Orcid: 0000-0002-8818-2958
[7]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. Email: mariacxsalles@gmail.com. Orcid: 0009-0008-2844-7652
[8]Federal University of Minas Gerais (UFMG) – Belo Horizonte (MG), Brazil. Email: marcello.vel@gmail.com. Orcid: 0000-0002-2352-8954

Correspondence: Rodrigo Marques Tonella – Avenida Presidente Antônio Carlos 6,627, Campus Pampulha, Belo Horizonte (MG), Brazil. Zip Code: 31270-901. Funding source: nothing to declare – Conflict of interests: nothing to declare – Presentation: Mar. 21st, 2024 – Accepted for publication: Jan. 02nd, 2025 – Approved by Ethics Committee: Protocol No. 598.0.203.000-10

do Hospital Risoleta Tolentino Neves, em Belo Horizonte, Brasil, no período de cinco meses. Os pacientes foram distribuídos de forma aleatória em dois grupos (tratamento [GT] n=67 e controle [CG] n=67). O desfecho primário foram os dias de saída do leito, enquanto os desfechos secundários foram: tempo de internação na UTI, tempo de internação hospitalar, custos de internação, tempo em Ventilação Mecânica Invasiva (VMI), mortalidade na UTI e mortalidade hospitalar. As características dos grupos foram similares na avaliação inicial. Verificou-se que 61 pacientes (97%) do GT foram retirados do leito, em comparação com apenas dois pacientes (3%) do GC. O protocolo de mobilização proposto reduziu os custos de internação em 30,27%, diferença aproximada de R$7 mil por paciente. A média de tempo de estadia na UTI do GT foi menor do que a do GC. Não houve diferença estatisticamente significativa quanto às horas de permanência em UTI, tempo de permanência hospitalar e tempo de VMI. A aplicação do protocolo de mobilização precoce de baixo custo e com o mínimo de equipamentos foi segura e eficaz para os pacientes, promovendo a saída precoce do leito.

Descritores | Mobilização Precoce; Custo; Fisioterapia; Tecnologia de Baixo Custo; Unidade de Terapia Intensiva.

RESUMEN | Este estudio analizó el resultado de la aplicación de un protocolo de movilización precoz, que utiliza intervenciones de bajo costo y con el mínimo de equipamiento requerido en una unidad de cuidados intensivos. Se trata de un ensayo clínico controlado y aleatorizado, realizado en colaboración con el Laboratorio de Evaluación e Investigación del Rendimiento Cardiorrespiratorio en el Departamento de Fisioterapia de la Universidad Federal de Minas Gerais y con la Unidad de Cuidados Intensivos (UCI) del Hospital Risoleta Tolentino Neves, en Belo Horizonte, Brasil, durante un período de cinco meses. Los pacientes se sometieron aleatoriamente a dos grupos (tratamiento [GT] n=67 y control [GC] n=67). El resultado primario fueron los días de retiro de la cama, mientras que los resultados secundarios fueron: duración de la estancia en la UCI, duración de la hospitalización, costos de hospitalización, tiempo en ventilación mecánica invasiva (VMI), mortalidad en la UCI y mortalidad hospitalaria. Las características de los grupos fueron similares en la evaluación inicial del estudio. Se encontró que 61 pacientes (97%) del GT fueron retirados de la cama en comparación con solo dos pacientes (3%) del GC. El protocolo de movilización propuesto redujo los costos de hospitalización en un 30,27%, una diferencia aproximada de R$ 7.000 por paciente. La duración media de la estancia en la UCI del GT fue más breve que la del GC. No hubo diferencias estadísticamente significativas con respecto a la estancia en la UCI, a la duración de la estancia hospitalaria y a la duración en VMI. La aplicación del protocolo de movilización precoz de bajo costo y con equipo mínimo fue segura y eficaz para los pacientes al promover un retiro temprano de la cama.

Palabras clave | Movilización Precoz; Costo; Fisioterapia; Tecnología de Bajo Costo; Unidad de Cuidados Intensivos.

INTRODUCTION

Patients hospitalized in the Intensive Care Unit (ICU), especially those who remain for an extended period, have been known to present functional limitations, which can be observed after hospital discharge. They may face long-term physical impairment, recurrent limitations to exercise, and decreased perception of health-related quality of life[1]. Additionally, there is a high rate of hospital readmission, especially in the first year after discharge[2], and a low rate of return to work, with 31% of critically ill patients not returning to their occupations after ICU admission[3].

Early rehabilitation in the ICU aims to minimize complications due to an extended hospitalization and promote greater functional independence after discharge[4-7]. However, randomized, multicenter studies have shown that long-term interventions still do not impact the clinical outcomes, such as the hospital length of stay and patient survival, in addition to being associated with the incidence of adverse events[8,9].

Many studies sought to evaluate the application of advanced technologies, such as automatic cycle ergometers and neuromuscular electrical stimulation (NMES) in appendicular muscles, or the combination of both[10-12], aiming to reduce mortality and the readmission rate. These protocols foresaw excessive costs, not universally available in most intensive care units, especially in Brazil. Zayed et al.[12] conducted a systematic review that encompassed six randomized studies on the NMES effect in critically ill patients, involving 718 participants. They concluded there was no difference in the values measured by the Medical Research Council (MRC) scale in the mortality rate, hospital length of stay, and duration of mechanical ventilation (MV) of the population undergoing NMES.

Investment in early mobilization can also generate savings in hospital resources, which directly impacts the costs

of the health system. The implementation of institutional programs reduces the net costs of hospitalization, thus optimizing health resources, their best use and investment[13].

Therefore, this study analyzed and compared hospital costs, effects, and risks of applying an early mobilization protocol, using low-cost intervention, regarding the institutional protocol of an ICU.

METHODOLOGY

This is a randomized controlled clinical trial, conducted in partnership with the Cardiorespiratory Performance Assessment and Research Laboratory (LabCare) of the Department of Physical Therapy of the School of Physical Education, Physical Therapy and Occupational Therapy (EEFFTO) of the Federal University of Minas Gerais (UFMG) and with the ICU of the Risoleta Tolentino Neves Hospital (HRTN), Belo Horizonte, Minas Gerais, Brazil. This study was approved by the Human Research Ethics Committee of UFMG (COEP)/UFMG under No. 598.0.203.000-10 and registered in the Brazilian Registry of Clinical Trials (ReBEC) RBR-92j6qf.

The sample consisted of patients admitted to the ICU of the HRTN and the time of the research application was five months. Patients were include if they were over 18 years of age, regardless of gender; remained 24 hours after ICU admission, with or without sedation or Invasive Mechanical Ventilation (IMV); were hemodynamically stable (absence of hypotension or need for vasoactive drugs or at low doses) (less than 1mcg/hour/kg of noradrenaline); absence of previous neuromuscular diseases, such as Duchenne muscular dystrophy, Guillian-Barré syndrome, myasthenia gravis, multiple sclerosis or amyotrophic lateral sclerosis; absence of previous diagnosis of advanced cancer or immunosuppressive therapy (prednisone dose greater than 20mg/d), absence of stroke as a reason for hospitalization; absence of amputation of one or more limbs; absence of fractures in the hip or lower extremities, as well as unstable fractures in the spine; no recent surgery on the lumbar spine, pelvis, or lower limbs; absence of congenital anomalies in the lower limbs; absence of functional impairment related to ambulation (except in cases of need for support for ambulation); absence of cardiopulmonary resuscitation on admission or during ICU stay; informed consent form signed either by a family member or guardian when the patient did not have sufficient state of consciousness to decide or by the patient themselves. Patients were excluded from the study if they had a previous hospitalization period of less than 30 days from the date of admission to the ICU; were transferred from other hospitals; conscious patient who refused to participate in either of the two groups after the randomization process; refused to participate in the study after regaining consciousness; and patients who presented alteration from the initial diagnosis to stroke as the cause of the current hospitalization.

Procedures

After recruitment (Figure 1), the patients were randomly distributed into two groups—Treatment Group (TG) and Control Group (CG)—according to the order of admission to the ICU, via a list generated by the Excel software (Microsoft Home and Student 2010, version 14), and were later identified in the study, according to the allocation group, entry position, and number of hospitalizations in the institution, for an eventual electronic consultation. Access to information (which group each selected research subject belonged to) was exclusive to the main researcher.

Initial clinical data, such as: age, gender, Acute Physiology and Chronic Health Evaluation II (APACHE II), diagnosis of hospitalization, C-reactive protein (CRP), and lactate were collected on an ICU form, as well as clinical data regarding the patients' comorbidities.

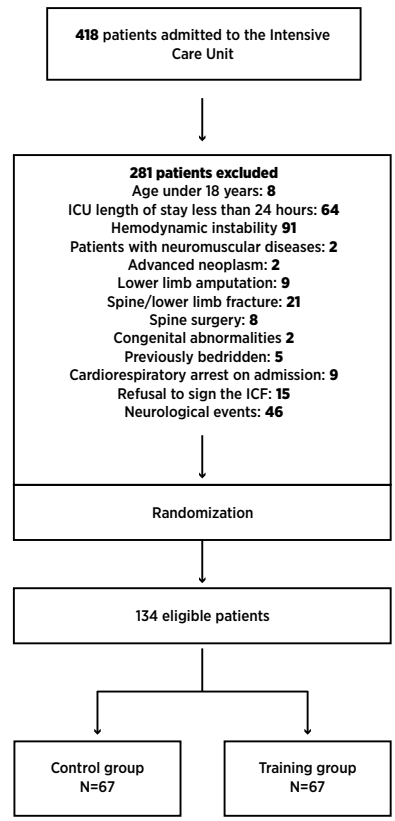

Figure 1. Study flowchart

The usual care provided by the HRTN physical therapy team to the CG patients consisted of physical therapy admission, evaluation, fixation of the artificial airway, adjustments of ventilatory parameters on the mechanical ventilator, observation of the appropriate positioning of the patient in bed, application of secretion mobilization techniques such as manual hyperinflation, followed by aspiration of tracheal secretion, when indicated. Among the usual precautions, no specific muscle and/or functional evaluation instruments were used at the time of admission or during the patient's stay in the ICU. The only resource routinely used was bedside and/or armchair sedation, when enabled by the patient's clinical condition.

The patients in the TG received the scheduled physical therapy interventions 24 hours after admission to the ICU, aiming at the patient's clinical stability. At the beginning of each session, the patients were evaluated for hemodynamic stability (mean arterial pressure between 60 and 110 mmHg in the absence of vasopressor drugs or a dose lower than 1μg/kg/hour, approximately up to the limit of continuous infusion of 15ml/h; presence of low doses of vasoactive drugs, such as noradrenaline and/or dobutamine; heart rate lower than 140bpm or higher than 50bpm in the absence of specific drugs (nitroprusside, nitroglycerin, amiodarone, etc.), respiratory rate ≤35 breaths/minute, and pulse oximetry ≥88%.

After determining the usual care for the CG and the clinical stability criteria for the TG, an early mobilization protocol was conducted, applied by a trained and specific team to perform the mobilization. This team was composed of five physical therapists who were not part of the HRTN staff. The proposed mobilization protocol was based on the foundations of the study by Morris et al.[14].

Stage 1: Initial evaluation based on the Glasgow Coma Scale (GCS), grading less than or equal to eight, and/or Richmond Agitation-Sedation Scale (RASS), grading between −4 and −5. Patients under these conditions underwent passive mobilization of the upper limbs (ULs) (shoulders, elbows, and wrists) in the frontal and sagittal planes of movements involving flexion/extension, abduction/adduction, pronation/supination; in the lower limbs (LLs) (hips, knees, and ankles) the same movement plans were performed frequently and once a day, with five repetitions for each performed movement.

Stage 2: Initial evaluation: patients with CCS greater than or equal to nine, RASS between −3 and zero, and without sufficient muscle strength in upper limb to overcome the force of gravity in the proximal joints (shoulders) underwent active-assisted mobilization sessions in the same planes and joints described in Stage 1, with the minimum assistance necessary to perform the required task, bed transfer training for change of decubitus, hip bridge exercises with the minimum necessary help from the physical therapist.

Stage 3: Initial evaluation: patients with ECG≥9, RASS between −1 and zero and active shoulder movement, capable of overcoming the force of gravity, were submitted to hip bridge exercises in bed, decubitus transfer training, transfer to the acquisition of anti-gravity postures, such as going from lying down to sitting in bed with legs hanging down, trunk balance training, functional training and muscle strength gain, in addition to assisted transfer to the armchair.

Stage 4: Initial evaluation: patient showing the same conditions as in Stage 3, but with the ability to move the hips against the force of gravity. The patients underwent bed transfer training for the acquisition of antigravity postures, transfer to orthostatism, pre-gait activities—weight bearing in the lower limbs stationary gait, balance training in standing and transfer to the armchair.

At the beginning of each session, the physical therapist evaluated the patients to determine the stage of the protocol in which they fit that day. However, if the patient was not able to perform the proposed stage, he returned to the previous one and the reasons were duly recorded.

During the time of hospitalization and protocol application, the follow-up of the patients' evolution in the study was conducted by recording in a clinical evolution form, noting infectious criteria (fever, leukocytosis, pneumonia, infiltrate in the thoracic region, septic syndrome), events such as acute respiratory distress syndrome, poly neuromyopathy of the critically ill patient and organ failure.

The sessions were conducted between 7 and 10 p.m., respecting the rest periods and the circadian cycle of the patients individually. The patients in the TG were submitted to the early mobilization protocol until the moment of the ICU discharge, and all were monitored until the moment of hospital discharge or another achieved outcome.

The costs related to ICU admission were collected from the financial sector of the HRTN, as a patient/day value, and converted into a value/hour of hospitalization, to establish the relation with the length of stay in the

ICU (hours). The cost informed by the financial sector defines the total cost of hospitalization in the sector, including all services provided, such as: employees from various areas and direct health care (physical therapists, nurses, physicians, nursing technicians, hygiene and cleaning assistants, etc.), complementary procedures and exams, infrastructure (electricity, water, telephone, elevator, equipment maintenance, etc.) and values related to pharmacy/medication costs.

To analyze the data, the following variables of interest were defined as follows: time of discharge from bed, time of mechanical ventilation, ICU and hospital length of stay, ICU and hospital mortality, and total costs of ICU admission.

STATISTICAL ANALYSIS

Data normality was evaluated using the Kolmogorov-Smirnov test. For variables with normal distribution, the t-Student test was used and, for continuous variables, the Mann-Whitney U test for data with non-normal distribution. For categorical/dichotomic variables, the Chi-square test was used.

The sample size was calculated for the primary outcome (days of discharge from bed), using the Gpower software (25), which indicated the need for 116 patients to achieve a statistically significant difference. Considering the possible losses, 15% was increased to this amount, totaling 134 patients, divided into two groups.

All data were analyzed using the Statistical Package for Social Sciences (SPSS 17.0, Chicago, United States). Descriptive analyses included means and standard deviations for continuous variables. The significance level of the tests was set at 5% ($p<0.05$).

RESULTS

The study was conducted for a period of five consecutive months, with 415 patients admitted to the ICU of the HRTN. Of the total number of patients hospitalized in the period, 281 were not eligible for the study (Figure 1). Thus, 134 patients were eligible, of whom 87 required IMV at some point during hospitalization, of which 40 were allocated to the TG and 47 allocated to the CG.

There was a sample loss of 14 patients who died, in both groups. The deaths were related to the worsening of the clinical condition, and there was no influence of the early mobilization protocol on such events.

Table 1 describes the characteristics of the sample. There was no statistically significant difference between the groups in baseline characteristics (age, gender, APACHE II, CRP, lactate, duration of IMV, and clinical diagnosis) and between the TG and CG regarding the time (number of days) of continuous and intermittent sedation (p=0.837), insulin therapy (p=0.068), and use of corticosteroids (p=0.779).

Table 1. Population characteristics

Characteristic	TG (n=67)	CG (n=67)	p value
Mean age in years (95%CI)	58.51 (54.00-63.02)	55.34 (50.07-60.62)	0.364
Male sex n (%)	37 (55.2)	41 (61.2)	0.484
APACHE II mean (95%CI)	19.89 (18.34-21.44)	21.07 (18.97-23.17)	0.369
Lactate mean (95%CI)	2.1259 (1.67-2.43)	5.827 (0.37-12.03)	0.101
CRP mean (95%CI)	156.45 (135.18-177.73)	160.866 (129.80-191.93)	0.947
Diagnosis n (%)			0.455
Cardiovascular	10 (14.9)	10 (14.9)	
AMI	2	5	
ACS	5	3	
DHF	3	2	
Respiratory	22 (32.8)	14 (20.90)	
Asthma	2	1	
COPD	3	3	
ARpF	9	7	
PNM	8	3	
Neurological	6 (9)	6 (9)	
Trauma	5 (7.5)	12 (17.9)	
Postoperative	8 (11.9)	8 (11.9)	
Other	16 (23.9)	17 (25.4)	

APACHE: Acute Physiology and Chronic Health Evaluation II; CRP: C-reactive protein; AMI: Acute myocardial infarction; ACS: Acute coronary syndrome; DHF: Decompensated heart failure; COPD: Chronic obstructive pulmonary disease; ARpF: Acute respiratory failure; PNM: Pneumonia; N: absolute number; %: N percentage: CI: confidence interval.

Regarding adverse events, there were only two related to loss of peripheral venous access and loss of nasoenteric tube. There were no reports of hemodynamic complications in the TG, and the most frequent adverse event in this group was postural hypotension (45 events), which was observed in the acquisition of antigravity postures that were promptly reversed when the patient returned to the previous posture, in the sedentary or supine position. The most frequent reasons for the session interruption were requests from the patients or presence of muscle fatigue perceived and/or reported during the exercises.

It was found that 61 patients (97%) in the TG were removed from bed, compared to only two patients (3%) in the CG (p=0.0001) (Table 2).

Table 2. Comparison of the proportion of patients who left bed during intensive care unit admission

		Leaving the bed		Total	
		Treatment	Control		p
Leaving the bed	Yes	61	2	63	0.0001
	No	6	65	71	
Total		67	67	134	

There was no statistically significant difference in the hours of ICU stay between the groups (p=0.122). The mean ICU length of stay of the TG was 264.76 hours (95%CI: 197.41–332.07) and the mean for CG was 379.71 hours (95%CI: 272.97–486.45). The mean cost recorded by the HRTN during the study period, per patient admitted to the ICU, was R$55.70/hour. There was no statistically significant difference between the groups regarding hospitalization costs (p=0.122). Considering the average hours of ICU stay in each group, the TG required R$14,746.28 mean/patient, while the CG required R$21,148.62 mean/patient in the ICU.

There was no statistically significant difference between the groups in relation to the hospital length of stay, with the mean TG being 28.60 days (95%CI: 21.37–35.83) and the 36.08-day CG (95%CI: –28.04–44.13) (p=0.159).

No statistical difference was seen in the total duration of IMV during ICU stay, with the mean number of days of use in the TG being 5.36 days (95%CI: –3.32–7.40) and 7.66 days in the CG (95%CI: –5.09–10.22) (p=0.094).

Regarding hospital mortality, 25 patients (18.7%) died, 14 in the TG and 11 in the CG, and no statistically significant difference was observed between the groups during the ICU stay (p=0.506). Regarding overall hospital mortality, 35 patients (26.1%) died during the hospitalization period, 17 patients in the TG and 18 in the CG, with no statistically significant difference between the groups (p=0.844) (Table 3).

Table 3. Secondary outcomes. Intensive care unit and hospital length of stay, hospitalization costs, mechanical ventilation time, intensive care unit and hospital mortality

	TG (n=67)	CG (n=67)	p value
ICU length of stay (hours) [a]	264.74 (197.41-332.07)	379.71 (272.97-486.45)	0.122
Length of hospital stay (days) [a]	28.60 (21.37-35.83)	36.08 (28.04-44.13)	0.159
Hospitalization costs (R$) [c]	14,746.28	21,148.62	0.122
MV Time (days) [a]	5.36 (3.32-7.40)	7.66 (5.09-10.22)	0.094
Mortality in the ICU [b]	14 (20.9)	11 (16.4)	0.506
Hospital mortality [b]	17 (25.4)	18 (26.9)	0.844

a. data showed as means and 95% confidence intervals.
b. data shown in absolute values and percentage – n (%).
c. ICU hospitalization costs – calculated from the mean patient/day value and, subsequently, converted into mean hours/patient, therefore, the converted value having been calculated based on the length of stay in the ICU.

DISCUSSION

The application of the early mobilization protocol promoted the removal of the patient from the bed in 97% of the TG participants, whereas in the CG the withdrawal was only 3%. The adverse effects observed were postural hypotension (45 events) and loss of a peripheral venous catheter and a nasoenteric tube, which were of minor severity. No statistically significant differences were identified in the parameters of ICU and hospital length of stay between the groups, hospital costs, duration of mechanical ventilation, and mortality rate.

Evaluating the impact of mobilization programs on various organ systems, whether musculoskeletal, cardiorespiratory, or functional status, appears to be essential and may provide a better understanding of the real benefits of these programs in ICUs[15].

The population of this study was heterogeneous regarding the reasons for the ICU admission, a factor predicted by the researchers, since this is the reality of this sector of the hospital, in addition to being in line with studies previously conducted with different populations, in which the aim was not to evaluate the mobilization program in specific diseases, but the impact of the program

on the functional condition of the hospitalized patient[14-19]. Levine et al.[20] evaluated 14 organ donor patients submitted to IMV, in a period of 18 to 69 hours. Diaphragm biopsy revealed both fast and slow loss of the cross-section of the fibers. This corroborates the methodology proposed in this study, in which the early mobilization protocol was initiated just 24 hours after ICU admission.

The application of the early mobilization protocol, proposed in this study, certainly increased the proportion of patients who left the bed during hospitalization (61 in the TG versus 2 in the CG), an issue of extreme importance to be considered, since the current literature points to the negative repercussions and unfavorable evolutions of the clinical condition when there is a prolonged stay in bed during hospitalization, causing loss of overall muscle strength, joint contractures, physical deconditioning[21-23], and difficulty weaning from IMV[24], in addition to increasing the length of stay in the ICU and in the hospital[25].

The adverse effects seen in the sample of this study were of minor severity (loss of peripheral venous access and loss of nasoenteric tube), in addition to 45 events of postural hypotension in the TG, which were promptly reversed and did not determine the interruption of therapy. Schujmann et al.[15] described in a randomized sample the impact of a progressive mobilization program, which did not have adverse events related to the inadvertent loss of devices, such as venous accesses, during therapy, in addition to no adverse effects during the protocol. By contrast, in the TEAM study[8], adverse events (desaturation and arrhythmias in 3.5% and 2.2%, respectively) were reported with statistical relevance when comparing the two study groups.

The body of evidence is enough to ensure the applicability of early mobilization in the ICU in a safe and effective way, favoring the functional recovery of critically ill patients[26-28]. However, attention should be focused on the definition of a safe and effective protocol to be followed, considering the different dysfunctions presented by patients, as well as the conditions of performance of physiotherapists in different countries[14]. The time of initiation of the protocol presented in this study demonstrated that the application, 24 hours after admission, was beneficial and safe, since the patients did not have any adverse event that would prevent its applicability, and all of them had hemodynamic and ventilatory stability within the limits that are considered safe.

The application of the early mobilization protocol proved to be decisive to reduce the IMV time, as the TG showed a reduction of eight days in this therapeutic modality in relation to the CG. Although there was no statistically significant difference, this time variation between the groups is considered clinically relevant[29], due to the complications inherent to this therapy. In the same sense, Hsieh et al.[22] and Moraes et al.[30] observed in their studies that the implementation of the *Bundles* ABCDE and ABCDEF, in which early mobilization is inserted, may be important for the management of these critically ill patients, since it results in a lower incidence of *Delirium*, reduction in MV time and ICU stay, decrease in ICU and hospital mortality compared to patients who receive only usual care.

The mobilization protocol proposed in this study showed a 30.27% reduction in hospitalization costs , which represented a difference of approximately R$7 thousand per patient. These findings are consistent with those found by Morris et al.[14], which already showed the same proportion regarding expenses between the TG and CG, indicating that the TG had a lower proportion of expenses during their hospitalization time, which was also later found by Hsieh et al.[22].

In addition to the reduction in the length of stay in the ICU, the application of the proposed protocol was also responsible for the reduction in the total length of stay of patients, according to the literature[29]. However, mortality was similar between the groups during ICU discharge. All recorded deaths were associated with clinical worsening of the patients, and there was no relation with the mobilization protocol proposed in the case of the TG, and these results were similar to those found by Schweickert et al.[31] and Tipping et al.[21] in relation to ICU mortality rates linked to active mobilization.

This study has limitations: the lack of blinding of the intensive care professionals of the team regarding the allocation of patients in the groups and the fact that the protocol was applied in a single research center, which makes it difficult to extrapolate the results.

CONCLUSION

In summary, the results demonstrated that the application of a low-cost early mobilization protocol with minimal equipment, instituted after 24 hours of ICU admission, was safe and effective for patients, promoting early exit from bed.

ACKNOWLEDGMENTS

We would like to thank the Risoleta Tolentino Neves Hospital for providing the ICU to conduct the research and for the institutional support of access to the hospital's financial data.

REFERENCES

1. McIlroy PA, King RS, Garrouste-Orgeas M, Tabah A, Ramanan M. The effect of ICU diaries on psychological outcomes and quality of life of survivors of critical illness and their relatives: a systematic review and meta-analysis. Crit Care Med. 2019;47(2):273-9. doi: 10.1097/CCM.0000000000003547
2. Hiser S, Fatima A, Ali M, Needham DM. Post-intensive care syndrome (PICS): recent updates. J Intens Care. 202323;11(1). doi: 10.1186/s40560-023-00670-7
3. Kamdar BB, Sepulveda KA, Chong A, Lord RK, Dinglas VD, et al. Return to work and lost earnings after acute respiratory distress syndrome: a 5-year prospective, longitudinal study of long-term survivors. Thorax. 201716;73(2):125-33. doi: 10.1136/thoraxjnl-2017-210217
4. Yende S, Austin S, Rhodes A, Finfer S, Opal S, et al. Long-term quality of life among survivors of severe sepsis. Crit Care Med. 2016;44(8):1461-7. doi: 10.1097/CCM.0000000000001658
5. Dinglas VD, Aronson Friedman L, Colantuoni E, Mendez-Tellez PA, Shanholtz CB, et al. Muscle weakness and 5-year survival in acute respiratory distress syndrome survivors. Crit Care Med. 2017;45(3):446-53. doi: 10.1097/CCM.0000000000002208
6. Voiriot G, Oualha M, Pierre A, Salmon-Gandonnière C, Gaudet A, et al. Chronic critical illness and post-intensive care syndrome: from pathophysiology to clinical challenges. Ann Intens Care. 2022;12(1). doi: 10.1186/s13613-022-01038-0
7. Poulsen JB, Møller K, Kehlet H, Perner A. Long-term physical outcome in patients with septic shock. Acta Anaesthesiol Scan. 2009;53(6):724-30. doi: 10.1111/j.1399-6576.2009.01921.x
8. The TEAM Study Investigators and the ANZICS Clinical Trials Group. Early active mobilization during mechanical ventilation in the ICU. N Eng J Med. 2022; 387(19):1747-58. doi: 10.1056/NEJMoa2209083
9. Wang DS, Moitra VK, Flynn BC. Early mobilization in the intensive care unit: to rest or to test? J Cardiothor Vasc Anesth. 20231;37(6):854-6. doi: 10.1053/j.jvca.2023.02.004
10. Parry SM, Berney S, Warrillow S, El-Ansary D, Bryant AL, et al. Functional electrical stimulation with cycling in the critically ill: A pilot case-matched control study. J Crit Care. 2014;29(4):695.e1-7. doi: 10.1016/j.jcrc.2014.03.017
11. Segers J, Hermans G, Bruyninckx F, Meyfroidt G, Langer D, et al. Feasibility of neuromuscular electrical stimulation in critically ill patients. J Crit Care. 2014;29(6):1082-8. doi: 10.1016/j.jcrc.2014.06.024
12. Zayed Y, Kheiri B, Barbarawi M, Chahine A, Rashdan L, et al. Effects of neuromuscular electrical stimulation in critically ill patients: A systematic review and meta-analysis of randomised controlled trials. Aust Crit Care. 2020;33(2):203-10. doi: 10.1016/j.aucc.2019.04.003
13. Lord RK, Mayhew CR, Korupolu R, Mantheiy EC, Friedman MA, et al. ICU early physical rehabilitation programs: financial modeling of cost savings. Crit Care Med. 2013;41(3):717-24. doi: 10.1097/CCM.0b013e3182711de2
14. Morris PE, Goad A, Thompson C, Taylor K, Harry B, et al. Early intensive care unit mobility therapy in the treatment of acute respiratory failure. Crit Care Med. 2008;36(8):2238-43. doi: 10.1097/CCM.0b013e318180b90e
15. Schujmann DS, Teixeira Gomes T, Lunardi AC, Zoccoler Lamano M, Fragoso A, et al. Impact of a progressive mobility program on the functional status, respiratory, and muscular systems of ICU patients. Crit Care Med. 2020;48(4):491-7. doi: 10.1097/CCM.0000000000004181
16. Martínez-Velilla N, Casas-Herrero A, Zambom-Ferraresi F, Sáez de Asteasu ML, et al. Effect of exercise intervention on functional decline in very elderly patients during acute hospitalization. JAMA Int Med. 2019;179(1):28. doi: 10.1001/jamainternmed.2018.4869
17. Burtin C, Clerckx B, Robbeets C, Ferdinande P, Langer D, et al. Early exercise in critically ill patients enhances short-term functional recovery*. Crit Care Med. 2009;37(9):2499-505. doi: 10.1097/CCM.0b013e3181a38937
18. Denehy L, Skinner EH, Edbrooke L, Haines K, Warrillow S, et al. Exercise rehabilitation for patients with critical illness: a randomized controlled trial with 12 months of follow-up. Crit Care. 2013;17(4):R156. doi:10.1186/cc12835
19. Schujmann DS, Lunardi AC, Fu C. Progressive mobility program and technology to increase the level of physical activity and its benefits in respiratory, muscular system, and functionality of ICU patients: study protocol for a randomized controlled trial. Trials. 2018;19(1). doi: 10.1186/s13063-018-2641-4
20. Levine S, Nguyen T, Taylor N, Friscia ME, Budak MT, et al. Rapid disuse atrophy of diaphragm fibers in mechanically ventilated humans. N Engl J Med. 2008;358(13):1327-35. doi: 10.1056/NEJMoa070447
21. Tipping CJ, Harrold M, Holland A, Romero L, Nisbet T, et al. The effects of active mobilisation and rehabilitation in ICU on mortality and function: a systematic review. Int Care Med. 2017;43(2):171-83. doi: 10.1007/s00134-016-4612-0
22. Hsieh SJ, Otusanya O, Gershengorn HB, Hope AA, Dayton Cet al. Staged implementation of awakening and breathing, coordination, delirium monitoring and management, and early mobilization bundle improves patient outcomes and reduces hospital costs. Crit Care Med. 2019;47(7):885-93. doi: 10.1097/CCM.0000000000003765
23. Zhang L, Hu W, Cai Z, Liu J, Wu J, et al. Early mobilization of critically ill patients in the intensive care unit: a systematic review and meta-analysis. Plos ONE. 2019;14(10):e0223185. doi: 10.1371/journal.pone.0223185
24. Thille AW, Boissier F, Muller M, Levrat A, Bourdin G, et al. Role of ICU-acquired weakness on extubation outcome among patients at high risk of reintubation. Crit Care. 2020;24(1). doi: 10.1186/s13054-020-2807-9
25. Nazwar TA, Triangto I, Pringga GA, Bal'afif F, Wardana DW. Mobilization phases in traumatic brain injury. Acute Crit Care. 2023;38(3):261-70. doi: 10.4266/acc.2023.00640

26. Alaparthi GK, Gatty A, Samuel SR, Amaravadi SK. Effectiveness, safety, and barriers to early mobilization in the Intensive Care Unit. Crit Care Res Pract. 2020;2020(7840743):1-14. doi: 10.1155/2020/7840743

27. Zhang L, Hu W, Cai Z, Liu J, Wu J, et al. Early mobilization of critically ill patients in the intensive care unit: A systematic review and meta-analysis. Plos One. 2019;14(10):e0223185. doi: 10.1371/journal.pone.0223185

28. Yang X, Zhang T, Cao L, Ye L, Song W. Early Mobilization for critically ill patients. Resp Care. 2023;68(6):respcare.10481. doi:10.4187/respcare.10481

29. Grosu HB, Lee YI, Lee J, Eden E, Eikermann M, et al. Diaphragm muscle thinning in patients who are mechanically ventilated. Chest. 2012;142(6):1455-60. doi: 10.1378/chest.11-1638

30. Moraes FS, Marengo LL, Moura MDG, Bergamaschi CC, Sá Del Fiol F, et al. ABCDE and ABCDEF care bundles: a systematic review of the implementation process in intensive care units. Medicine. 2022;101(25):e29499 doi: 10.1097/MD.0000000000029499

31. Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. Lancet. 2009;373(9678):1874-82. doi: 10.1016/S0140-6736(09)60658-9