Hemodynamic, respiratory conditions and their safety when performing exercises in an intensive care unit

Daniella Andrade Tavares da Rocha, Katia de Miranda Avena, Helder Brito Duarte, Kristine Menezes Barberino Mendes, Luciana Ferreira Feijó

ABSTRACT

Introduction: The prolonged stay in the Intensive Care Unit (ICU) compromises the functionality and quality of life of patients. Physical exercise can contribute to improving functional status and accelerating return to activities. **Objective:** to assess the safety of patient mobilization in the ICU, describing the hemodynamic and respiratory conditions and the occurrence of adverse effects. **Methods:** This is an uncontrolled, "before and after" study, carried out with 42 patients hospitalized in the ICU, submitted to mobilization through passive kinesiotherapy, active kinesiotherapy, seating and walking. In addition to epidemiological and clinical data, the adverse effects of mobilization were evaluated. Hemodynamic and respiratory variables were measured at the bedside, at three times: before, during and immediately after mobilization. **Results:** Elderly patients (65.8±13.7 years), predominantly women (59.5%), with a clinical admission diagnosis (64.3%) were studied. Patients on mechanical ventilation predominantly performed passive kinesiotherapy (57.1%) and those on spontaneous ventilation predominantly performed seating (28.6%) and walking (28.6%). Among the adverse effects, there was an unsatisfactory ventilatory muscle pattern (7.1%), peripheral oxygen saturation less than 90% (4.8%), and changes in blood pressure (7.1%). There was no record of changes in heart rate, accidental extubation or loss of venous access during mobilizations, as well as changes in hemodynamic, respiratory and oxygenation behavior before, during and after mobilization were not observed. **Conclusion:** physical exercises proved to be safe, viable in any clinical environment, respecting safety limits, and may bring potential benefits to patients admitted to the ICU.

Keywords: Patient safety, Exercise, Intensive care unit, Physical therapy, Mobilization.

INTRODUCTION

The survival of critically ill patients after recovering from a serious illness has been extended in recent times. However, after hospitalization, the biggest challenges for these patients are the quality and functionality in which they perform their tasks in the environment in which they live[1].

In this context, within the hospital setting, Physiotherapy has been strongly contributing to the maintenance and rehabilitation of these patients, obtaining positive results regarding the duration of mechanical ventilation, length of hospital stay, acquired muscular weakness in the Intensive Care Unit (ICU), and post-discharge functionality [2,3].

To initiate patient mobilization, the level of consciousness, muscle strength, and functionality must be evaluated. In addition, it is necessary to establish the Kinetic-Functional Diagnosis (KFD) properly, through precise assessment tools, allowing the choice of the best intervention for the patient at that moment, aiming at short-, medium-, and long-term results[4]. Among the existing assessment tools, Medical Research Council (MRC), Functional Status Scale (FSS), and ICU Mobility Score (IMS) are widely used to diagnose weaknesses and functional deficiencies[5–7].

Regarding exercise prescription, there is a framework of techniques that can be used, such as neuromuscular electrostimulation (NMES); functional electrical stimulation (FES); kinesiotherapy (passive, active-assisted, or active); stretching; functional training (transfer training, sit-to-stand training); mechanical therapy (leg press, orthostatic board, ambulation elevator); ambulation and its variations. The prescription of exercise intensity and duration has been heavily debated in recent years, however, there is still no consensus regarding patients hospitalized in the ICU [8,9].

Hospital da Cidade, Salvador, (BA), Brasil.

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In this context, studies suggest that early mobilization associated with maintenance through an exercise program can be considered safe even with the use of vasopressor drugs, and should be encouraged in all ICUs, especially when well-designed protocols allow achieving functional goals earlier [10–13].

Therefore, the present study aims to evaluate the safety of mobilization for critically ill patients in the ICU, describing hemodynamic and respiratory conditions and the occurrence of adverse effects associated with mobilization.

METHODS

This is a non-controlled, descriptive, and analytical before-and-after study conducted in an adult general ICU of a private hospital in Salvador, Bahia, Brazil. The study included both male and female patients who were admitted to the ICU of the aforementioned hospital between January and March 2010 and who provided informed consent or had their legal guardian provide it. Patients with neurological diseases that caused alterations in the respiratory center, with orthopedic and/or neurological contraindications for mobilization, with electrocardiogram abnormalities suggesting ischemia, recent myocardial infarction (within 2 days), or other cardiac events such as unstable angina or uncontrolled arrhythmia causing hemodynamic instability, and those with important clinical alterations such as symptomatic severe aortic stenosis, uncontrolled symptomatic heart failure, acute pulmonary embolism or infarction, acute myocarditis or pericarditis, suspected or known dissecting aneurysm, and acute infections with uncontrolled fever above 38°C[14] were excluded from the study.

Regarding the exercises, the following events were considered: passive kinesiotherapy, active kinesiotherapy, sitting up, and ambulation. Passive and active kinesiotherapy were defined as exercises performed on the shoulders, elbows, wrists, hips, knees, and ankles, with three sets of 10 repetitions. Sitting up consisted of positioning the patient in the bed with the lower limbs supported on a step and the trunk leaning on bed (with dorsal support) or on a chair, actively or passively with the help of a mobile crane, and this positioning was maintained for up to one hour. Ambulation consisted of walking a maximum of 50 meters, with the use of mobility aids such as walking frame, armpit crutches, or unilateral/bilateral assistance from the physiotherapist.

Adverse effects of mobilization were considered Respiratory Rate (RR) greater than 35 breaths per minute, Saturation Peripheral Oxygen (SpO2) lower than 90%, a 20% change in Blood Pressure (BP) or Heart Rate (HR), and loss of devices due to accidental extubation or loss of venous access. Thus, if cardiovascular and respiratory adverse events were observed, the physiotherapy session could be temporarily interrupted for the patient's recovery. In the opposite situation and/or in the occurrence of loss of devices, physical activity would be terminated, and appropriate support for the patient's needs would be provided[8,10].

Data collection was performed at the bedside. The interventions were performed by a trained physiotherapist. Hemodynamic and respiratory parameters were collected at three different times: before, during, and immediately after the interventions. The information was recorded by two other duly trained and blinded physiotherapists, contributing to the reliability of the data obtained.

Clinical and epidemiological variables of interest included: age, sex, neurological state assessed using the Richmond Agitation Sedation Scale (RASS), diagnosis, length of stay in the ICU, comorbidities, ventilatory support at the time of mobilization, airway used, need for Mechanical Ventilation (MV), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Blood Pressure (MBP) medication use, mortality rate, and estimated mortality through the Acute Physiology and Chronic Health Disease Classification System II (APACHE II).

Statistical analysis was performed using IBM SPSS software, version 26.0. Categorical data were presented as absolute frequencies (n) and relative frequencies (%), while continuous variables were defined using the arithmetic mean (AM) with standard deviation (SD) or median (MD) with interquartile range (IQR, 25%-75%) using the Kolmogorov-Smirnov and Shapiro-Wilk tests for normality. Numeric variables with normal distribution were presented as AM and SD. One-way repeated measures ANOVA was used for parametric data, and Kruskal-Wallis was used for non-parametric data. Friedman's test was used for paired variables. Values were considered statistically significant if $p<0.05$.

The research project was approved by the Research Ethics Committee of the Bahia State School of Public Health (CEP-EESP), protocol number 009/2010, in accordance with Resolutions 466/12 and 510/16 of the National Health Council. Data collection began after the patient or their legal representative signed the Informed Consent Form.

RESULTS

The study included 42 patients with a mean age of 65.8 ± 13.7 years, predominantly female (59.5%), mostly alert (59.5%), without the use of sedatives (85.7%), analgesics (64.3%), or vasoactive drugs (71.4%), and who stayed in the ICU for a median of 7.0 (5.0-12.0) days. Regarding the admission diagnosis, most patients were clinical (64.3%), subdivided among neuropathic, pneumopathic, cardiac, oncologic, and nephropathic patients. At the time of mobilization, most patients were using a physiological airway (66.6%) and oxygen support (54.8%). Furthermore, only 33.3% of patients were on mechanical ventilation, and of these, 85.7% used an orotracheal tube. The overall mortality rate was 17% (Table 1).

Regarding the mobilization performed, passive kinesiotherapy (31.0%) and sitting upright in bed (31.0%) were the most frequently applied. When analyzing patient characteristics according to the mobilization performed (Table 2), it was observed that none of the patients on mechanical ventilation were able to ambulation. Among patients on mechanical ventilation, the majority underwent passive kinesiotherapy (57.1%). Among those who were spontaneously ventilating, the most common mobilizations were sitting upright in bed (28.6%) and walking (28.6%).

Table 1
Sociodemographic and clinical profile of patients undergoing physical exercises in the Intensive Care Unit.

Variables	Sample (n=42)
Age, in years (mean ± SD)	65.8 ± 13.7
Sex, n (%)	
Female	25 (59.5)
Male	17 (40.5)
RASS Scale, n (%)	
+1	3 (7.2)
0 to -1	25 (59.5)
-2	4 (9.5)
-3 a -5	10 (23.8)
HBP, n (%)	30 (71.4)
DM, n (%)	16 (38.1)
COPD, n (%)	2 (4.8)
Obesity, n (%)	3 (7.1)
Cardiopathy, n (%)	11 (26.2)
Neuropathies, n (%)	3 (7.1)
Diagnosis, n (%)	
Valve Replacement Surgery	8 (19.0)
Sepsis	7 (16.7)
CPB Surgery	4 (9.5)
Gastric Bypass Postoperative	3 (7.1)
Hemorrhagic Stroke	3 (7.1)
Pulmonary Embolism	2 (4.8)
Abdominal Pain + Fever	2 (4.8)
Myocardial Infarction	2 (4.8)
Other Clinical Diagnoses	11 (26.2)
Length of stay in the ICU, in days, MD (IQR, 25%-75%)	7.0 (5.0-12.0)
Airway, n (%)	
Physiological	28 (66.6)
Tracheostomy	12 (28.6)
Endotracheal Tube	2 (4.8)
Mechanical Ventilation, n (%)	14 (33.3)
Oxygen Support, n (%)	
Mechanical Ventilation	14 (33.3)
Low Flow	8 (19.0)
Venturi	1 (2.5)
No Oxygen	19 (45.2)
APACHE II, n (%)	
5-13	5 (11.9)
13-21	24 (57.2)
21-29	8 (19.0)
>29	5 (11.9)
Medication in use, n (%)	
Analgesics	15 (35.7)
Vasoactive Drugs	12 (28.6)
Sedatives	6 (14.3)
Mortality, n (%)	7 (16.7)

MA: Arithmetic Mean; SD: Standard Deviation; n: Absolute frequency of categories; %: Relative frequency of categories, in percentage; MD: Median; IQR: Interquartile Range; RASS: Richmond Agitation Sedation Scale; HBP: High Blood Pressure; DM: Diabetes Mellitus; COPD: Chronic Obstructive Pulmonary Disease; PO: Postoperative; CPB: Cardiopulmonary Bypass; APACHE II: Acute Physiology and Chronic Health Disease Classification System II.

Table 2
Profile of patients considering mobilization performed in the Intensive Care Unit.

Variables	Performed Mobilization			
	Passive Kinetic Therapy (n=13)	**Active Kinetic Therapy (n=8)**	**Sitting Position (n=13)**	**Ambulation (n=8)**
Ventilation, n (%)				
SV	5 (17.8)	7 (25.0)	8 (28.6)	8 (28.6)
MV	8 (57.1)	1 (7.1)	5 (35.8)	0
Medication in use, n (%)¥				
Analgesics	7 (50.0)	1 (7.1)	6 (42.9)	0
Vasoactive drugs	7 (58.3)	0	5 (41.7)	0
Sedatives	5 (83.3)	0	1 (16.7)	0
ICU LOS, days, MD (IQR, 25%-75%)*	10.0 (7.0-22.0)	6.0 (3.75-7.25)	9.0 (5.0-12.0)	5.0 (2.0-6.0)
APACHE II, n (%)				
5-13	0	1 (20.0)	3 (60.0)	1 (20.0)
13-21	7 (29.2)	4 (16.6)	7 (29.2)	6 (25.0)
21-29	2 (25.0)	2 (25.0)	2 (25.0)	2 (25.0)
>29	4 (80.0)	1 (20.0)	0	0

n: absolute frequency of categories; %: relative frequency of categories, in percentage; SV: Spontaneous Ventilation; MV: Mechanical Ventilation; ICU: Intensive Care Unit; LOS: Length of Stay; MD: median; IQR: interquartile range; APACHE II: Acute Physiology and Chronic Health Disease Classification System II; * Kruskal-Wallis test Walking versus passive kinesiotherapy; ¥Percentage calculated considering the total number of patients using the medication.

Passive kinesiotherapy was the most frequently performed mobilization for patients using analgesics (50.0%), vasoactive drugs (58.3%), and sedatives (83.3%). In addition, considering the length of hospitalization and the mobilization performed, it was observed that patients who walked had a shorter length of stay in the ICU (p=0.0147).

Considering the prognosis calculated by APACHE II, it was observed that patients with lower clinical severity more frequently underwent active kinesiotherapy (60.0%), and those with higher severity underwent passive kinesiotherapy (80.0%).

When analyzing the occurrence of adverse effects during mobilization (Table 3), it was observed that only 7.1% of patients had episodes of tachypnea, only 4.8% had SpO2 below 90%, but none of the values reached below 80%. Furthermore, only 7.1% of patients had changes in blood pressure, but both systolic and diastolic blood pressure remained within normal values. There were no records of changes in heart rate, accidental extubation, or loss of venous access during mobilizations.

Table 3
Adverse effects occurring during mobilization performed in the Intensive Care Unit.

Adverse Effects, n (%)	Sample (n=42)
Increase in RR > 35 bpm	3 (7.1)
Decrease in SpO2 < 90%	2 (4.8)
Change in BP > 20%	3 (7.1)
Change in HR > 20%	0
Accidental Extubation	0
Loss of Venous Access	0

n: absolute frequency of categories; %: relative frequency of categories, in percentage; RR: Respiratory Rate; SpO2: Saturation of Peripheral Oxygen; BP: Blood Pressure; HR: Heart Rate.

When analyzing the hemodynamic, respiratory, and oxygenation behavior before, during, and after mobilization (Table 4), no statistically significant changes were observed in HR, SBP, DBP, MBP, RR, and SpO2.

Table 4
Hemodynamic, respiratory, and oxygenation behavior before, during, and after mobilization.

Variables	MOBILIZATION			*p-valor*
	BEFORE	DURING	AFTER	
$SpO_2$$	93.0 (14.9)	93.0 (14.8)	93.0 (14.9)	0.99*
RR$	20.0 (5.2)	21.0 (4.7)	20.0 (3.8)	0.75*
HR$	84.0 (17.8)	90.0 (17.2)	85.0 (17.7)	0.91*
SBP$	135.0 (25.9)	136.0 (24.4)	132.0 (24.6)	0.79*
DBP&	70.0 (59.0-86.5)	71.0 (58.0-86.2)	67.5 (54.7-83.7)	0.41#
MBP&	89.0 (77.0-110.2)	95.5 (77.0-105.7)	89.0 (75.7-108.0)	0.48#

$: Mean and standard deviation; Median and interquartile range; SpO2: Saturation Peripheral Oxygen; FR: Respiratory rate; FC: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic Blood Pressure; MBP: Mean Blood Pressure; *One-way repeated measures ANOVA test; #Friedman test.

DISCUSSION

Based on the results obtained, the program of mobilization in critically ill patients can be considered safe, as no significant changes were demonstrated in SpO_2, RR, HR, SBP, nor the occurrence of adverse events such as accidental extubation, significant changes in HR or loss of venous access, even when patients were sedated, using analgesics and vasopressors, or had greater clinical severity. It is important to emphasize that the clinical and individual limits of each patient and conduct were respected at all times.

The safety of physical activity in critically ill patients has been studied for some years and can be considered a safe therapeutic when performed in a controlled environment such as the ICU[2]. In this context, a consensus on the safety of these exercises was established in 2014 by Hogson *et al*.[15], seeking to demystify possible barriers to their practice, such as the use of vasopressor drugs, mechanical ventilation, hypoxemia with SpO2 less than 90% and lactatemia, enabling mobilizations in various clinical phases in which the patient finds himself.

In this context, previous studies conducted in patients using vasopressor drugs did not identify severe adverse events[10] or significant hemodynamic and respiratory changes[12]. However, in the present study, a small number of patients were identified who developed changes in RR, SpO2, and BP, without loss of devices or significant changes in HR.

The clinical severity of the patients studied did not prevent the implementation of the mobilization program since patients with scores between 21 and 29 on the APACHE II had access to the program, which was prescribed individually and according to safety conditions. In this context, like the present study, Pinto *et al*.[12] in their study with critically ill patients with an average APACHE II of 29, intubated and using vasopressors, mobilized through neuromuscular electrical stimulation, also reported no adverse events and significant hemodynamic and respiratory changes.

In patients with lower severity (APACHE between 13 and 21), a greater progression of mobility was demonstrated, similar to previous studies [10,16-19]. In these, patients with an average APACHE between 15 and 21 received exercise prescriptions alternating between cycle ergometer and its variations, orthostatic plank, bedside sitting and scaled ambulation, directly depending on the patient's clinical and consciousness status, according to the intervention protocol used in the present study.

According to Lai *et al*.[20], exercise prescription can be better applied according to the existence of interdisciplinary institutional protocols resulting in a statistically significant decrease in mechanical ventilation time, ICU stay, and hospital stay. However, the impacts of exercise protocols on these findings and on primary outcomes such as mortality, functional recovery, and muscle strength need to be further studied. Some authors have conducted clinical trials submitting stratified and early physical exercise protocols versus conventional therapy and did not find statistically significant differences [17-19,21]. However, Dong *et al*.[17] in their study with patients with prolonged MV in the postoperative period of myocardial revascularization, demonstrated the efficiency of an early rehabilitation protocol by decreasing MV time, ICU and hospital stay, but there was no difference in mortality, which corroborates with the results of the present study, considering that more severe patients tend to have longer hospital stays.

Thus, it may be premature to establish a direct link between mortality in the ICU and the exercise program since this may be more associated with the individual clinical condition of each patient. Therefore, a strategy to better evaluate the impacts of mobility would be the relationship between discharge rates to home and follow-up seeking to relate weakness acquired in the ICU with rehabilitation and reintegration of this individual into society[2].

Previous studies have evaluated the situation of critically ill patients in follow-ups of 3[16,17], and 6 months[10-22], and only the studies by McWilliams et al. and Eggmann et al. found a positive outcome for the exercise group in terms of mental health dimension, without statistical differences in terms of muscle strength and re-hospitalizations. It is important to note that even though the present study did not aim to assess mental health within the ICU, physical exercise can decrease the incidence of delirium, especially in elderly patients and/or those with acquired muscle weakness[23], and can be implemented through the ABCDE Bundle (A - awaken and breathing coordination, B - breathing trial, C - choice of sedation, D - delirium management, E - early mobility and exercise), reducing mechanical ventilation time, ICU and hospital length of stay, and costs[24]. Similar to previous studies[10,12,16,17,19,22], the patients included in the present study had a mean age of 65 years, demonstrating that the management of elderly patients needs to be considered in the therapeutic plan formulation. This population often presents associated comorbidities or conditions such as cardiopathies, neuropathies, and pneumopathies, requiring individualized exercise prescriptions to avoid becoming barriers to functional goal progression.

The safety of physical exercise implementation can be confirmed by this study and previous studies[8,10,12]. However, barriers beyond safety may arise in three dimensions: from the patient, the clinical team, and the institution. These barriers may be related to patient adherence to the therapeutic plan, lack of knowledge and experience of the team in the implementation and/or support of the professional, as well as outdated concepts ("rest equals cure"), erroneous safety culture, and competition with other procedures[25]. In this regard, part of the difficulty in implementing higher levels of mobilization in the patients in this study was due to the level of consciousness, where 23.8% had a RASS score between -3 and -5.

Finally, potential limitations of the present study include (1) a small sample size, (2) heterogeneous population of patients with various levels of severity, respiratory support types (SV or MV), and different mobility levels. These factors may reduce the generalizability of the results, although they do not diminish the scientific knowledge presented here. Furthermore, it would be interesting to conduct a follow-up of patients to observe the behavior of variables some time after the mobilization sessions, checking whether the immediate response obtained is maintained in the long term. Therefore, we suggest conducting further studies using more robust methodological designs and larger and more homogeneous samples.

CONCLUSION

In this study, the physical exercise program proved to be a safe technique, feasible in any clinical setting, respecting safety limits, and that can bring potential benefits to patients hospitalized in the ICU. However, randomized clinical trials analyzing the risks and benefits of a mobilization protocol with short, medium, and long-term follow-up are still necessary.

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Conflicts of interest
The authors declare that they have no conflicts of interest.

Individual contributions of the authors
DATR: Writer, method delineation, field research, data organization and literature review;

KMA: Writer, method delineation, data organization and treatment, manuscript reviewer, project supervisor, and literature review;

HBD: Writer, data organization and treatment, manuscript reviewer, and literature review;

KMBM: Writer, field research, data organization, and literature review;

LFF: Writer, field research, data organization, and literature review.

Corresponding Author:
Kátia de Miranda Avena
katiaavena@hotmail.com

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