STUDIA UBB EDUCATIO ARTIS GYMN., LXVII, 4, 2022, pp. 183-192
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.67(4).46

THE EFFECTIVENESS OF PASSIVE EXERCISES ON ARTERIAL BLOOD GASES IN MECHANICALLY VENTILATED SUBJECTS FROM INTENSIVE CARE UNITS

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Received 2022 October 08; Revised 2022 November 22; Accepted 2022 December 07; Available online 2023 March 10; Available print 2023 March 30.

ABSTRACT. Introduction: Mechanically ventilated critically ill subjects are often given strict bed rest and sometimes completely immobilized because of the severity of their illness and the administration of drugs such as sedatives. Active mobilization is not possible in subjects under deep sedation and unable to follow commands. In this scenario, passive therapy is an interesting alternative. **Objective:** This study aimed to evaluate the effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units. **Methods:** Five mechanically ventilated subjects participated in the study. The subjects were assigned to one study group, which received passive exercises for one daily session, including ten repetitions in three series per articulation. Arterial Blood Gases were assessed by arterial blood sample analysis with the Stat Profile Prime Plus device. **Results:** The results revealed a marked improvement in arterial blood gas exchange as compared to baseline reflecting an increase in FIO2- the inspiratory fraction of oxygen, pO2- partial pressure of oxygen, and pO2/FIO2- the ratio between the partial pressure of oxygen and the inspiratory fraction of oxygen and a decrease in CO2- carbon dioxide. **Conclusions:** The passive exercise showed a slight trend of beneficial changes at the cellular level in mechanically ventilated subjects since the first day after admission, which may indicate a reduction in the inspiratory fraction of oxygen and at the end, extubation of subjects.

Keywords: *passive exercise, mechanical ventilation, intensive care, arterial blood gas*

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Introduction

Mechanically ventilated critically ill subjects are often given strict bed rest and sometimes completely immobilized because of the severity of their illness and the administration of drugs such as sedatives (Younis & Ahmed, 2015). The challenges to mobilizing critically ill subjects include the safety of tubes and lines, personnel and equipment resources, sedation practices, the patient's size, the time, and the priority of mobilization. All these factors may persist for days to weeks and delay active mobility use (Vollman, 2010). The impact of immobility on the subjects may encompass functional decline and associated neuromuscular, and musculoskeletal weakness, impaired coordination, delayed weaning from mechanical ventilation, and prolonged hospital stay (Berry et al., 2014). Early physical exercise is essential to limit the occurrence of complications related to bed rest. Active exercises are not possible in subjects under deep sedation and unable to follow commands, and in this scenario, passive exercises are an interesting alternative (Pinheiro et al., 2017). Another relevant aspect was the fact that the subject's movement was reproduced manually by a single physical therapist, demonstrating that the protocol can be performed in places with limited resources. A single session of manual therapy improves lung function, inspiratory muscle strength, and oxygen saturation, and reduces dyspnea, fatigue, and heart respiratory rate (Yilmaz et al., 2016). Early physical therapy programs for mechanically ventilated subjects increase oxygen saturation, and arterial oxygen pressure and decrease complications, length of intensive care stay, and reduction of healthcare costs (Meawad et al., 2018). Evidence suggests that passive range of motion exercise for mechanically ventilated subjects is a safe and effective intervention that can significantly impact a patient's clinical outcomes (Fahmy, Ibrahim & Kandeel, 2021). Passive exercises were well tolerated in critical intensive care subjects, ventilated, and sedated, such exercise could be the most appropriate form of activity for these subjects in the early phase (Amidei & Sole, 2013). The exercise that can be performed from the moment the subject is admitted to intensive care are low in intensity, since the subject usually remains in bed, especially those who are mechanically ventilated (Medrinal et al., 2018). Mechanically ventilated patients are traditionally considered too sick for early physical therapy and mobilization. It has been demonstrated that a loss of muscle mass and strength rapidly occur from the first days of bed rest together, with insulin resistance and an inflammatory process (Akoumianaki et al., 2017). The passive exercises showed a slight tendency for beneficial changes at the cellular level in mechanically ventilated intensive care subjects from the first days of admission (Vollenweider et al., 2022).

For intensive care subjects, the term "early mobilization" refers to the application of physical therapy (for example, passive mobilization, active mobilization, and respiratory muscle training) and possesses prominent superiority if it is initiated from an early stage (less than 5-7 days) (Yue et al., 2018). When initiated shortly after the start of mechanical ventilation, mobilization can play an important role in decreasing the duration of mechanical ventilation and hospital stay (Hashem, Nelliot & Needham, 2016). Physical exercise in intensive care should have the appropriate intensity and type depending on the condition of the subject (Jang, Shin & Shin, 2019). Invasive mechanical ventilation is a life-saving procedure applied to critically ill subjects to achieve adequate pulmonary gas exchange and unload excessive respiratory muscle work (Peñuelas, et al., 2019). Arterial blood gas analysis is a common test ordered in critically ill subjects, without influencing subject care. It is used to check the function of the subject's lungs and how well they can move oxygen into the blood and remove carbon dioxide (Chandran, et al., 2021). Sedative and analgesic treatment administered to critically ill patients need to be regularly assessed to ensure that pre-definite goals are well achieved as the risk of complications of oversedation is minimized. The choice of sedation scale measuring the level of consciousness could be made by the Richmond Agitation scale (RASS) (Thuong, 2008). Passive physical exercises are performed without voluntary muscle contractions, the articulated segments being mobilized by external forces, which replace the mobilizing muscle force (Trinity & Richardson, 2019). Pure-assisted passive mobilization is performed by a physical therapist, it is also called manual mobilization and is considered the most precise form of passive mobilization (Cordun, 1999).

Objective

This study aimed to evaluate the effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units.

Methods

The current study was carried out in the intensive care unit of Cluj-Napoca The Regional Institute of Gastroenterology and Hepatology "Prof. Dr. Octavian Fodor", in the period from September 2021 to February 2022, to identify the effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units.

Subjects

Five mechanically ventilated and sedated subjects (males=3 and females =2) with a score on the Richmond Agitation scale of -4 to -3 participated in this study. The subjects were recruited from the intensive care unit of Cluj-Napoca The Regional Institute of Gastroenterology and Hepatology "Prof. Dr. Octavian Fodor", in the period from September 2021 to February 2022. Their age was between 45 to 79 years. All subjects were assigned to one study group and received a passive exercise protocol for one session per day, for five days.

Inclusion criteria: the age subjects to be over 18 years and to be mechanically ventilated for at least 24 hours. Exclusion criteria: subjects with hemodynamic instability, who have active bleeding, with neuromuscular diseases, who have recently suffered a myocardial infarction, increased intracranial pressure, or recent fractures.

For assessment: Arterial gasometry was measured at the Stat Profile Prime Plus machine which is a complete analyzer that combines blood gases, electrolytes, metabolites, and CO-oximetry, normal values are: pH – 7.35-7.45; partial pressure of oxygen pO2 – 75 to 100 mmHg; partial pressure of carbon dioxide pCO2 – 35 to 45mmHg.

The subject's state of consciousness was assessed with the Richmond Agitation Scale (RASS) to describe their level of alertness, agitation, and sedation. This scale ranged from -5 to +4 which means: a score of 0 to +4 the subject is alert, restless, or agitated; -1 subject awakens with sustained eye opening and eye contact; -2 subject awakens with eye-opening and eye contact, but not sustained; -3 subject has any movement in voice response but no eye contact; -4 subject has any movement to physical stimulation; -5 subject has no response to any stimulation (Sessler el al., 2002).

Procedures

The procedure was explained to every subject's relative, and informed consent was signed. The study had approval from the Ethical Committee of the "Babeş-Bolyai" University and from The Regional Institute of Gastroenterology and Hepatology "Prof. Dr. Octavian Fodor".

Baseline data was noted before starting the protocol, including age, gender, region, admission diagnosis, ventilatory mode, and score on the Richmond Agitation Scale of all the subjects.

Before starting the protocol, the subjects were laying in dorsal decubitus with the head elevated at an angle of 30° without suffering any medical procedure for 30 min. The sample for arterial gasometry was collected by the resident doctor 5 min before the passive exercise session and 15min after ending the session (Saad, 2020).

The protocol was performed manually by a single physical therapist, for five days, one session per day in three series of ten repetitions. The physical therapist, initiated, led, and ended the movement rhythmically, with the tension of the soft parts at the end of the movement four times, the repetition rate is maintained at each tempo. The movement sequence was from distal to proximal, favoring also the veno-lymphatic return. The application of the socket and counter socket was also considered. The sockets change was gentle and minimal in position, avoiding any discomfort for subjects.

Ankle flexion (dorsiflexion), ankle extension (plantar flexion), and circumduction were performed in the lower limbs in the ankle joint. In the hip joint, the flexion consisted of near the anterior face of the thigh to the pelvis and circumduction. Flexion, abduction, and circumduction were performed at the level of the upper limbs in the shoulder. At the level of the elbow joint and fingers - flexion and extension. At the fist level, flexion, extension, and circumduction. At the level of the head and the cervical segment flexion, extension, and rotation movements to the right and the left.

Statistical design and data analysis

Statistical analyses were performed using EXCEL WINDOWS 10. Descriptive statistics of arterial blood gas parameter scores before and after the application of passive exercise in mechanically ventilated subjects were used for mean and standard deviation. The t-test for comparing the mean values obtained before and after the application of passive exercises. All statistically significant differences were determined at a 95% confidence interval and significance was set at $p \leq 0.05$.

Results

The purpose of this study was to evaluate the effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units. The subjects were assigned to one study group which included five mechanically ventilated and sedated subjects from The Regional Institute of Gastroenterology and Hepatology "Prof. Dr. Octavian Fodor" of Cluj-Napoca. Data obtained pre and post-protocol regarding arterial blood gases were statistically analyzed and compared.

The study included five subjects, three males, and two females with an average of 61.6 years and a standard deviation of 8.30. The subjects came from Cluj County, with a percentage of 60% from the rural environment and 40%

from the urban. Regarding the state of consciousness, 40% fell to -4 (no response to voice, only movement or eye-opening to physical stimulation) and 60% to -3 (movement or eye-opening to verbal stimulation).

PH - hydrogen potential, the average pH value before and after applying the protocol was 7.4±0.075 and 7.4 ± 0.032. There was no significant difference, the percentage of decrease was 0.0002. The average of FIO2-the inspiratory fraction of oxygen, before and after applying the protocol was 43.75±8.34, respectively 35.62±3.20. This registers a difference of 8.13 percent and a p-value of 0.006. The mean value of pO2-partial pressure of oxygen was 107.5±24.90 and 118.78±23.13 respectively, registering an increase of 11.28 percent and a p-value of 0.13. The average value of CO2- carbon dioxide before and after applying the protocol was 28.97±7.67 and 26.87±3.72, with a decreasing percentage of 2.1. The average of the pO2/FIO2-the ratio between the partial pressure of oxygen and the inspiratory fraction of oxygen was 278.12±80.61 respectively 315.28±87.23, with a significant increase of 37.16 percent.

Table 1. The result of variable

Variables	Before	After	Difference	t-test	p-value
pH	7.4±0.075	7.4±0.032	0.0002	- 0.01	0.98
FIO2	43.75±8.34	35.62±3.20	8.13	4.04	0.006
pO2	107.5±24.90	118.78±23.13	11.28	-1.60	0.13
CO2	28.97±7.67	26.87±3.72	2.1	1.31	0.21
pO2/FIO2	278.12±80.61	315.28±87.23	37.16	-1.99	0.0690

Data are expressed as mean ±standard deviation
PH- hydrogen potential; FIO2-the inspiratory fraction of oxygen; pO2-partial pressure of oxygen; CO2- carbon dioxide; pO2/FIO2-the ratio between the partial pressure of oxygen and the inspiratory fraction of oxygen.

Discussion

Mechanical ventilation is a life-support therapy that improves carbon dioxide retention, and acid-base equilibrium. Mechanically ventilated subjects develop intensive care unit-acquired weakness as a result of their immobility and sedative administration (Yue et al., 2018). Interest in early mobilization and rehabilitation of critically ill subjects has grown in the last decade in response to increasing insights into long-lasting impairments experienced by many survivors (Denehy, Lanphere & Needham, 2017).

This study was conducted to analyze and investigate the effectiveness of passive exercises on arterial blood gases in mechanically ventilated subjects from intensive care units. Five mechanically ventilated subjects from both genres were assigned to one group that received a passive exercise protocol. All the subjects were evaluated before and after the protocol measuring Arterial Blood Gases (PH- hydrogen potential; FIO2-the inspiratory fraction of oxygen; pO2-partial pressure of oxygen; CO2- carbon dioxide; pO2/FIO2-the ratio between the partial pressure of oxygen and the inspiratory fraction of oxygen). The result of the study proved that a marked improvement in arterial blood gas exchanges as compared to baseline was reflected by a significant statistical increase in the pO2-partial pressure of oxygen and the pO2/FIO2-the ratio between the partial pressure of oxygen and the inspiratory fraction of oxygen and a significant decrease in FIO2-the inspiratory fraction of oxygen and CO2- carbon dioxide.

The improvement of arterial blood gases could be explained that passive movement improves ventilation, central and peripheral perfusion, circulation, muscle metabolism and alertness, and countermeasures for venous stasis (Gosselink et al., 2008). Early mobilization was shown to improve forced vital capacity, maximum voluntary ventilation, and arterial oxygenation (Zafiropoulos, Alison & McCarren, 2004). The result of this study agreed with the result of (Saad et al., 2020) who found chest physiotherapy protocol in form of (manual hyperinflation, vibration, percussion, suctioning, upper and lower limbs exercise, and end position) is an effective method for improving arterial blood gases of mechanically ventilated subjects.

Conclusions

Based on the findings of this study passive exercise is an effective method for improving arterial blood gases in mechanically ventilated subjects. The passive exercise showed a slight trend of beneficial changes at the cellular level in mechanically ventilated subjects since the first day after application of the protocol, which may indicate a reduction in the inspiratory fraction of oxygen and at the end extubation of subjects, and fewer days of intensive care unit.

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