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Update Article

Exercise in intensive care units, safety and hemodynamic monitoring

Exercício em unidades de terapia intensiva, segurança e monitorização hemodinâmica

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ABSTRACT

Introduction: Patients in the intensive care unit (ICU) have several deleterious effects of immobilization, including weakness acquired in the ICU. Exercise appears as an alternative for early mobilization in these patients. **Objective:** This work aims to highlight the hemodynamic repercussions and the applicability of exercise in the ICU. **Methods:** An integrative literature review was carried out, with articles published between 2010 and 2018, in the Lilacs, PubMed and Scielo databases, using the following search terms: exercise, cycle ergometer, intensive care units, early mobilization, mechanical ventilation, artificial respiration. **Results:** 13 articles were included, addressing hemodynamic monitoring and the role of exercise as early mobilization, with or without ventilatory support. The exercise sessions were feasible and safe within the ICU environment. **Conclusion:** Physical exercise can be performed safely in an ICU environment, as long as respecting a series of criteria such as those presented here. It is important that the assistant professional seeks to prescribe interventions based on Exercise Physiology that can positively intervene in the functional prognosis in critically ill patients

Key-words: Exercise; Intensive Care Units; Patient Safety.

RESUMO

Introdução: Pacientes em unidade de terapia intensiva (UTI) apresentam diversos efeitos deletérios do imobilismo, entre eles a fraqueza adquirida na UTI. O Exercício surge como alternativa para mobilização precoce nesses pacientes. **Objetivo:** Esse trabalho tem o intuito de evidenciar as repercussões hemodinâmicas e a aplicabilidade do exercício na UTI. **Métodos:** Foi realizada uma revisão integrativa da literatura, com artigos publicados entre 2010 e 2018, nas bases de dados Lilacs, PubMed e Scielo, utilizando os seguintes termos para pesquisa: exercise, cycle ergometer, intensive care units, early mobilization, mechanical ventilation, artificial respiration. **Resultados:** Foram incluídos 13 artigos, abordando monitorização hemodinâmica e o papel do exercício como mobilização precoce, com ou sem suporte ventilatório. As sessões de exercício eram viáveis e seguras dentro do ambiente de UTI. **Conclusão:** Conclui-se que a mobilização precoce que emprega exercício físico, pode ser realizada de maneira segura e eficaz na Unidade de Terapia Intensiva, desde que os profissionais possuam conhecimento adequado para prescrição e atuação durante possíves intercorrências. Para tanto é necessário conhecimento da Fisiologia do Exercício e das evidências científicas disponíveis.

Palavras-chave: Exercício; Unidades de Terapia Intensiva; Segurança do Paciente.

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Introduction

Physical exercise in individuals hospitalized in a critical environment should be performed in order to minimize the complications of bed immobilization, which usually result in great loss of muscle mass and significant functional limitation. This review aims to discuss relevant aspects of cardiovascular and hemodynamic repercussions with the application of exercise in the Intensive Care Unit (ICU), aiming at a safe and effective intervention.

Methods

An integrative literature review was carried out, with articles published between 2010 and 2018, in the Lilacs, Medline databases via PubMed and Scielo, using the following search terms: exercise, cycle ergometer, intensive care units, early mobilization, mechanical ventilation, artificial respiration. After critical reading of the abstracts found, 13 articles were selected for the construction of this manuscript.

Risk for exercise associated with the use of vasoactive drugs

There is no consensus among experts on the dose of Vasoactive Drugs (VAD) (and the combination of these drugs) that would allow safe mobilization in the ICU, when considering the risk associated with early mobilization, specifically on cardiovascular parameters. It is believed that the administration of VAD, by itself, is not an absolute contraindication to mobilization, and it should be considered that there is a direct influence of the absolute dose or the change in the dose of VAD on the early mobilization pattern adopted. In a meeting in which a consensus was sought on the risks and barriers to early mobilization, it was not possible to reach consensus on a threshold dose of vasoactive drugs below which it was acceptable to mobilize patients. Therefore, it was agreed that ICU clinicians should discuss case by case the safe dose and combinations of vasoactive drugs that allow the mobilization of each patient, and such discussions should involve the entire ICU team [1].

Considering safety aspects, Hodgson *et al.* [1] proposed an explanatory scheme to identify and scale risks for early mobilization in an intensive care setting. Next, we will present four tables that will summarize the aspects that must be evaluated, specifically addressing cardiovascular / hemodynamic parameters, for early mobilization.

Chart 1. Aspects to be assessed before mobilization considering blood pressure.

Condition	In bed exercises	Out of bed exercises
Intravenous antihypertensive therapy for hypertensive emergency	🛑	🛑
Mean blood pressure below target and causing symptoms	⚠	🛑
Mean arterial pressure below the desired target despite support from VAD or mechanical support	⚠	🛑
Mean arterial pressure in the therapeutic zone* without any hemodynamic support or maintained at the expense of low doses of VAD	🟢	🟢
Mean arterial pressure in the therapeutic zone* maintained at the expense of moderate doses of VAD	🟢	⚠
Mean arterial pressure in the therapeutic zone* maintained at the expense of high doses of VAD	⚠	🛑
Pulmonary hypertension recognized or suspected	⚠	⚠

Subtitle: VAD – Vasoactive drugs; 🛑 Potential risk of adverse events with serious consequences; ⚠ There are risks for mobilization, but the benefits arising from it outweigh the risks provided that the team is qualified and trained in the processes; 🟢 Low risk of adverse events.

* desired therapeutic zone above 65 mmHg considering the mean arterial pressure.

Adapted from Hodgson CL, *et al.* Critical Care 2014;18(6):658. [1]

Chart 2. Aspects to be assessed before mobilization, considering cardiac arrhythmias.

Condition	In bed exercises	Out of bed exercises
Bradycardia requiring pharmacological intervention or awaiting emergency pacemaker implantation	🛑	🛑
Bradycardia that does not require pharmacological intervention or even where emergency pacemaker implantation is not necessary	⚠	⚠
Presence of transvenous or epicardial dependent-rhythm pacemaker	⚠	🛑
Presence of transvenous or epicardial pacemaker with stable base rhythm (not pacemaker dependent)	🟢	🟢
Stable tachyarrhythmia with ventricular rate greater than 150 bpm	⚠	🛑
Stable tachyarrhythmia with ventricular rate between 120 and 150 bpm	⚠	⚠
Any tachyarrhythmia with a ventricular rate below 120 bpm	🟢	🟢

Subtitles: bpm – beats per minute; 🛑 Potential risk of adverse events with serious consequences; ⚠ There are risks for mobilization, but the benefits arising from it outweigh the risks provided that the team is qualified and trained in the processes; 🟢 Low risk of adverse events.

Adapted from Hodgson CL, *et al.* Critical Care 2014;18(6):658 [1].

Chart 3. Aspects to be evaluated before mobilization, considering invasive mechanical devices for hemodynamic support or monitoring.

Condition	In bed exercises	Out of bed exercises
Presence of intra-aortic balloon pump *	●	⬢
Ventricular assist devices *	●	●
Pulmonary artery catheter or any other device for monitoring cardiac output	●	▲
ECMO with cannulation in central vein (bicaval)	●	▲
ECMO with cannulation in the femoral or subclavian artery *	●	⬢
Subtitle: ECMO – extracorporeal membrane oxygenation; ⬢ Potential risk of adverse events with serious consequences; ▲ There are risks for mobilization, but the benefits arising from it outweigh the risks provided that the team is qualified and trained in the processes; ● Low risk of adverse events. * Hip flexion is contraindicated in the lower limb where the device was inserted.		

Adapted from Hodgson CL, *et al*. Critical Care 2014;18(6):658 [1].

Chart 4. Aspects to be assessed before mobilization, considering other relevant cardiovascular aspects.

Condition	In bed exercises	Out of bed exercises
Diagnosed shock or serum lactate ≥ 4 mmol / L	▲	▲
Suspected or confirmed venous thromboembolism *	▲	▲
Suspected or confirmed severe aortic stenosis	●	▲
Cardiac ischemia with current chest pain or abnormal electrocardiogram	▲	⬢
Subtitle: mmol/L – milimol per liter; ⬢ Potential risk of adverse events with serious consequences; ▲ There are risks for mobilization, but the benefits arising from it outweigh the risks provided that the team is qualified and trained in the processes; ● Low risk of adverse events. *Venous thromboembolism involves situations of deep venous thrombosis and pulmonary embolism.		

Adapted from Hodgson CL, *et al*. Critical Care 2014;18(6):658 [1].

Individuals dependent on VAD in a pattern of elevating doses over time would result in caution or contraindication for early mobilization. Also mobilization would be contraindicated for individuals who, regardless of the dose administered, are poorly perfused, based on clinical signs such as increased blood lactate (greater than 2 mmol/L), increased arteriovenous difference, hypotension with systolic blood pressure lower than 90 mmHg or mean arterial pressure below 65 mmHg.

Hemodynamic monitoring and risks for exercise during the cycle ergometer in intensive therapy

Pires-Neto *et al.* [2] revealed that a single cycle ergometer intervention in 5 minutes of active exercise in the ICU can increase heart rate, respiratory rate and Borg's subjective perception in hemodynamically stable patients. In the end, the authors concluded that the adoption of the active cycle ergometer implied minor cardiorespiratory changes, in addition to be a viable activity to be performed in patients in the ICU. This intervention was associated with a high degree of acceptance by patients. It was also observed that 85% of the patients liked to perform this type of activity.

Specifically addressing the postoperative period of cardiac surgery, Gardenghi *et al.* [3] studied patients who underwent cardiac surgery and underwent an upper limb cycle ergometer, in five-minute sessions, on the first postoperative day. A clinical trial was carried out in which cardiovascular behavior and the incidence of loss of catheter were analyzed to monitor invasive blood pressure (inserted in the brachial artery). Figure 1 exemplifies the positioning of the patient when performing the cycle for the upper limbs. Patients were instructed to maintain 50 to 60 rotations per minute on the cycle ergometer, with the perception of subjective effort classified as moderate, based on the Borg scale. One of the groups studied received low-dose VADs, according to the attending medical team. As a result, no adverse events were observed in the cardiovascular responses, which behaved in a physiological way when stimulating exercise, even in individuals using VAD. There was no event of loss of brachial arterial catheter. It was demonstrated that the early performance of a cycle ergometer for upper limbs after cardiac surgery is safe and should, therefore, be encouraged, minimizing negative repercussions of bed immobilization.

Cordeiro *et al.* [4] also submitted patients after cardiac surgery to a cycle ergometer for upper limbs for 20 minutes and demonstrated that this type of exercise implied a small and not statistically significant increase in heart rate, blood pressure and oxyhemoglobin saturation, being also well tolerated and safe for this population.

Hirschhorn *et al.* [5] reported that three days after cardiac surgery, walking or exercise bike exercises can already be used. The article recommends two moderate-intensity exercise sessions, lasting 10 minutes, from the 3rd postoperative day until hospital discharge. The authors conclude that a well-planned fitness program using a stationary bicycle offers a well-tolerated and clinically effective alternative to walking in the immediate postoperative period after coronary artery bypass surgery, enabling better outcomes, especially in respiratory distress and returning to work activities. It is important to note that, in Hirschhorn's study, the exercise session did not start with the patient receiving VADs.

Source: image from the personal archive belonging to Giulliano Gardenghi.
Figure 1. Patient undergoing an upper limb cycle ergometer on the first postoperative day of cardiac surgery. The highlight (red circle) shows the insertion point of the invasive blood pressure catheter in the radial artery.

Safety for early mobilization considering cardiovascular / hemodynamic aspects

Nydahl *et al.* [6], in 2017, published an elegant systematic review with meta-analysis where they investigated several aspects related to the safety of early mobilization in critically ill patients. In the cardiovascular / hemodynamic aspect, they found 27 publications, which together totaled 6,082 patients studied. They found 3.8 episodes of adverse events for every 1,000 mobilization sessions. Among the cardiovascular events described, increases in heart rate (considering values greater than 125-140 bpm) were present in an incidence of 1.9 episodes for every 1,000 mobilization sessions. Falls in mean arterial pressure (to values less than 55-70 mmHg) had an incidence of 4.3 episodes for every 1,000 mobilization sessions. Falls in systolic blood pressure (to values less than 80-90 mmHg) have been reported at an incidence of 1.8 episodes for every 1,000 mobilization sessions. Still considering blood pressure, increases in blood pressure were also studied. In mean arterial pressure, considering values greater than 100-140 mmHg as increased, an incidence of 3.9 episodes was reported for every 1,000 mobilization sessions. Systolic blood pressure increased by an incidence of 0.3 episodes for every 1,000 mobilization sessions, considering values greater than 180-200 mmHg as increased.

The same authors also reported how cardiovascular / hemodynamic events that occurred during early mobilization sessions (34 events) were addressed. On four occasions, patients were repositioned from sitting to lying on the bed with remission of symptoms. On eight occasions, patients had to return to bed. In eight other situations, VADs had to be restarted or their doses increased, or fluids for fluid resuscitation were administered. Another 14 events were addressed only with temporary pauses or interruptions of the mobilization sessions. Dizziness and chest pain are also mentioned as reasons for returning to

bed [6].

Another study that focused on early mobilization during the first 24 hours of ICU admission, involving 171 patients admitted for a studied period of two months, reported an incidence of 0.8% of hemodynamic events that resulted in interruption of care, primarily due to hypotension or changes in heart rate resulting from exercise [7].

A Swiss study that included 53 patients showed that early mobilization (between 12 and 24 hours in the postoperative period) in cardiac surgery patients is a safe procedure in an intensive care setting, with few adverse events, even if such intervention may be associated with significant hemodynamic changes. All patients successfully completed the mobilization protocol without experiencing myocardial ischemia or other major complications. Eighteen patients had a significant decrease in mean arterial pressure, but only nine of them required treatment, seven of whom received additional intravenous fluids (approximately 500 ml) and two received vasopressors (low-dose norepinephrine infusion). Seven patients complained of self-limiting nausea with one of them reporting transient dizziness. Three patients had self-limited arrhythmias (two sinus tachycardias and one paroxysmal supraventricular arrhythmia) [7]. In conclusion, the authors further suggest that due to the impairment of the cardiovascular system after cardiac surgery, mobilization should be performed under clinical monitoring and strict hemodynamics in an intensive environment, with special attention to blood lactate and central venous saturation [8].

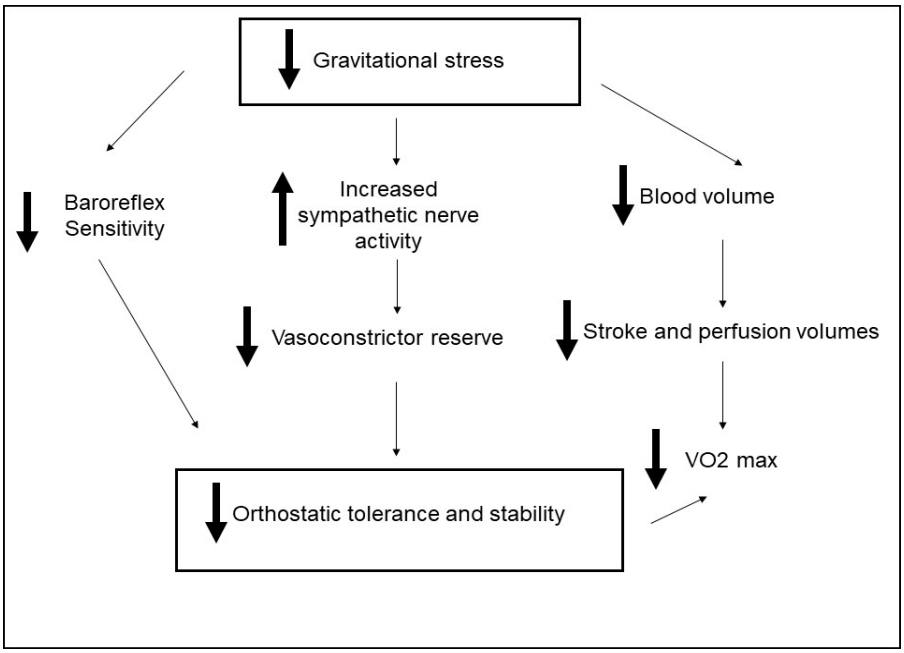
Considering the adoption of an early mobilization protocol in situations where patients were submitted to extracorporeal membrane oxygenation (ECMO), often associated with cases of acute respiratory distress syndrome, Munshi and collaborators, assisting 50 patients, demonstrated that 39% (n = 18) of these patients reached an activity level of 2 or more (active exercises in bed) and 17% (n = 8) reached an activity level 4 or higher (actively sitting on the side of the bed). In an exploratory analysis, the performance of the ICU physiotherapy team was associated with decreased mortality (odds ratio, 0.19; 95% confidence interval, 0.04-0.98). The authors concluded that mobilization during ECMO is feasible and safe when carried out by an experienced team and carried out in stages, although they still make it clear that future research is needed to identify potential barriers, optimal exercise intensity and optimal safety profile [9].

Orthostatic intolerance and risk of syncopes related to drug use and bed immobilism

Autonomic dysfunction is common in patients who stay in bed for long periods, a factor common to hospitalized patients, who end up suffering the effects of immobilization (cachexia, opportunistic infections, generalized muscle weakness, among others). It is known that conditions like this leads the patient to functional deterioration, physiological changes and loss of independence in daily activities.

The consequences of prolonged bed rest can also lead to cardiocirculatory changes and later hemodynamic changes and, with this, orthostatic dysfunction [10]. In patients with these characteristics, the presence of parasympathetic autonomic dysfunction (increased resting heart rate and decreased

heart rate variability) was noted [10]. It is important to note that individuals who have less exposure to orthostatic stress, that is, reduced gravitational gradient, a situation like bed restriction or exposure to microgravity, present cardiocirculatory changes, including hypovolemia, reduced baroreflex sensitivity and increased blood accumulation in the peripheral regions of the organism. These changes can be considered as cardiovascular deconditioning, which can lead to orthostatic intolerance [11]. Figure 2 summarizes the impact of bed immobilization on the cardiovascular system.



Source: Image from the personal archive belonging to Giulliano Gardenghi, adapted from an article by Kathleen M. Vollman [12].

Figure 2. Impact of bed immobilization and decreased gravitational stress due to the absence of postural changes on the cardiovascular system. Subtitle: $VO_{2\ max}$ - maximum oxygen consumption.

HIV / AIDS patients use drugs in combination. Among these drugs are protease inhibitors (PIs), which can cause endothelial dysfunction, whose pathophysiology is not yet fully understood, and decreased vasodilator capacity [11]. A study by Justino *et al.* [10] analyzed orthostatic tolerance and heart rate variability (HRV) in individuals with HIV / AIDS, including 21 patients (age: 37 ± 10 years) who underwent the Tilt test (TT) after seven days of hospitalization, still in the hospital ward. The patients were bedridden in bed for 19 ± 2 hours / day before the TT was performed. It is known that the prolonged decubitus leads to baroreflex dysfunction, generating changes in the systemic and brain blood flow. As a result, seven patients (33% of the sample) presented positive TT (+TT) at 25 ± 8 minutes of inclination. Patients with +TT presented a greater sympathetic predominance at rest and during orthostatic inclination, when compared to patients with a negative TT. The increased sympathetic component in the +TT group can trigger bradycardia and reflex vasodilation (Bezold-Jarisch reflex), which could justify the loss of consciousness in the studied population.

Systemic diseases like kidney failure and cancer can also cause hypotension and syncope. A link between orthostatic hypotension and Alzheimer's disease has also been demonstrated [8]. It is important to remember the vast amount of drugs with cardiovascular action that can worsen or cause orthostatic hypotension, such as angiotensin converting enzyme inhibitors, alpha re-

ceptor blockers, calcium channel blockers, beta blockers, diuretics, hydralazine, ganglion blocking agents, nitrates, sildenafil citrate, among others [11]. For patients using these drugs, attention to hemodynamic parameters should be greater, and the team should be prepared in case of hypotension or syncope during mobilization.

In addition, an increased frequency of syncope due to dysautonomy has been observed in patients with congestive heart failure. In this group, the combination of low cardiac output and volumetric depletion (due to the use of diuretics and vasodilator therapy) may interfere with the normal mechanisms of adaptation to the orthostatic position [11]. Centrally acting drugs, such as opiates and tricyclic antidepressants, reserpine and methyldopa, can also exacerbate previously moderate hypotension and trigger syncope [11].

Liu *et al.* [13] in 2018 studied a total of 232 patients who underwent 587 rehabilitation sessions. There were 13 adverse events (2.2%) and no specific treatment was needed. There were no cases of destruction / loss or obstruction of medical devices, tubes or arterial or venous accesses. The incidence of adverse events associated with mechanical ventilation or ECMO was 2.4 and 3.6%, respectively. Of 587 sessions, 387 (66%) were performed at the level of active rehabilitation, including off-bed sessions, active transfer to a chair, standing, stationary walking or walking through the ICU. ICU doctors participated in more than 95% of these active rehabilitation sessions. Of all patients, 143 (62%) got out of bed in two days. Adverse events included seven episodes of intolerance to the patient, requiring the interruption of the rehabilitation session and six episodes of orthostatic hypotension with symptoms [13].

Conclusion

It is concluded that the early mobilization that adopts physical exercise, can be performed safely and effectively in the ICU, as long as the professionals have adequate knowledge for prescription and performance during possible complications. Therefore, knowledge of Exercise Physiology and available scientific evidence is required.

Note

The term early intervention used by the author refers to physical mobilization activities immediately after surgical intervention with the stabilization of the following parameters: systemic blood pressure, heart rate, respiratory rate, peripheral oxygen saturation, mechanical ventilation parameters, intracranial pressure and level of consciousness.

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