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Original article

Physiological changes associated with virtual reality in patients undergoing coronary artery bypass grafting

Alterações fisiológicas associadas à realidade virtual em pacientes submetidos à cirurgia de revascularização do miocárdio

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ABSTRACT

Introduction: Coronary Artery Bypass Grafting (CABG) promotes physiological changes in patients, and Virtual Reality (VR) is an option within the cardiac rehabilitation program that may help them reduce discomfort and control physiological parameters. **Objective:** To describe the physiological changes caused by the practice of VR in patients undergoing CABG. **Methods:** Cross-sectional study. Patients undergoing CABG used VR using the XBOX 360 device plus Kinect from the third day after cardiac surgery. Systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), respiratory rate (RF), oxygen saturation (SaO2) and temperature were assessed on three occasions: before VR application, at the end of the session and one hour after recovery. **Results:** 31 patients were included, with a mean age of 54 ± 8 years, with a higher prevalence in males with 21 (68%) individuals. The SBP was 123mmHg ± 18 at baseline, 133mmHg ± 17 (p = 0.25) immediately after the intervention, and 121mmHg ± 15 (p = 0.43) at recovery. The HR variable was analyzed in the pre-test with 81bpm ± 11, in the post-test 92bpm ± 12 (p = 0.32), and in the recovery 83 bpm ± 13 (p = 0.83). SpO2 was found in the pre-test 96% ± 1, in the post-test 96% ± 1 (p = 0.83), and in the recovery 97% ± 2 (p = 0.84). Comparing the variables of the pre with post-test and this with those of recovery, despite the clinical changes, they did not show statistical significance. **Conclusion:** The physiological parameters evaluated, despite the variations, showed that their applicability to virtual reality is safe and viable.

Keywords: monitoring, physiologic; thoracic surgery; virtual reality; early ambulation

RESUMO

Introdução: A cirurgia de revascularização do miocárdio (CRM) promove alterações fisiológicas nos pacientes e a Realidade Virtual (RV) é uma opção dentro do programa de reabilitação cardíaca, que pode ajudar a reduzir o desconforto e controlar os parâmetros fisiológicos. **Objetivo:** Descrever as alterações fisiológicas causadas pela prática da RV em pacientes submetidos à CRM. **Métodos:** Estudo transversal. Os pacientes submetidos à CRM utilizaram a RV por meio do aparelho XBOX 360 mais Kinect a partir do terceiro dia após a cirurgia cardíaca. A pressão arterial sistólica (PAS), a pressão arterial diastólica (PAD), a frequência cardíaca (FC), a frequência respiratória (FR), a saturação de oxigênio (SaO2) e a temperatura foram avaliadas em três momentos: antes da aplicação da RV, após o término da sessão e uma hora após a recuperação. **Resultados:** Foram incluídos 31 pacientes, com média de idade de 54 ± 8 anos, com maior prevalência no sexo masculino com 21 (68%) indivíduos. A PAS foi inicialmente de 123mmHg ± 18, 133 mmHg ± 17 (p = 0,25) imediatamente após a intervenção e 121mmHg ± 15 (p = 0,43) na recuperação. A variável FC foi analisada no pré-teste com 81bpm ± 11, no pós-teste com 92bpm ± 12 (p = 0,32), e na recuperação com 83bpm ± 13 (p = 0,83). A SpO2 foi encontrada no pré com 96% ± 1, no pós-teste com 96% ± 1 (p = 0,83), e na recuperação com 97% ± 2 (p = 0,84). Comparando as variáveis do pré com o pós-teste e deste com as da recuperação, apesar das alterações clínicas, não se verificou uma diferença estatisticamente significativa. **Conclusão:** Os parâmetros fisiológicos avaliados, apesar das variações, mostraram que a sua aplicabilidade à realidade virtual é segura e viável.

Palavras-chave: monitoramento fisiológico; cirurgia cardíaca; realidade virtual; deambulação precoce

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Introduction

Cardiovascular disease is one of the main causes of morbidity and mortality in the world, and cardiac rehabilitation is a measure to reduce and/or prevent the progression of cardiovascular disease in approximately 50% of patients undergoing cardiac surgery. There is an association between patients affected by cardiovascular diseases and the occurrence of other complications such as functional dependence, which impacts on the quality of life of these patients [1,2].

The increasing average age of patients undergoing cardiac surgery (CS) and the consequent increase in the number of procedures performed, with myocardial revascularization being the most common, has led to a need for updating by healthcare professionals to improve the quality of life and increase the survival of these patients [3]. Thus, based on the literature, there are several complications commonly associated with this surgical intervention, which brings the need to update these professionals about them [4]

Cardiac surgery is a highly complex procedure that promotes physiological changes usually induced by anesthesia, extracorporeal circulation and cardioplegia, the effects of which can last until the postoperative period, with several complications such as hemodynamic instability [5]. The critical patient, during hospitalization in the Intensive Care Unit (ICU), lives with several factors that cause stress and, consequently, generate cognitive changes, respiratory rate, heart rate and blood pressure [6].

Virtual Reality (VR) is a resource that, when implemented, especially in ICU patients undergoing cardiac surgery, can favor the reduction of discomfort and physiological parameters, as a way to inhibit pain due to exposure to noise and stress psychological impact of this environment, which causes overload in the individual's functional capacity and long-term cognitive impairment [6]. When increasing the visual stimulus, strategies are used to distract the critical patient's attention and, consequently, the experience of the mental process of pain, causing an increase in temperature, a decrease in heart rate, respiratory rate and the intensity of chronic pain, which indicates relaxation through distraction during the acquisition of virtual technologies [7].

A recent study that added VR to a Cardiac Rehabilitation (CR) program showed that the hemodynamic responses in some variables were more intense than in conventional CR. Nevertheless, the values are similar, thus suggesting a new strategy that can be used in CR, and with the necessary care, such as: selection of stable patients, intensification of monitoring for better control and, whenever necessary, correction of the movement performed by the patient [8].

The physiological responses observed with the greatest intensity when using VR were heart rate, respiratory rate and maintenance of effort during activity and five minutes after application of the intervention [8]. Therefore, the present study aims to describe the physiological changes generated with the practice of VR in patients undergoing coronary artery bypass grafting (CABG).

Methods

This cross-sectional study was carried out with patients undergoing cardiac surgery at the Instituto Nobre de Cardiologia (incardio) in Feira de Santana, Bahia. The study was approved by the Research Ethics Committee of Faculdade Nobre under number 2,150,434. All volunteers signed a Free and Informed Consent Form.

Eligibility criteria

Individuals of both sexes, aged over 18 years, who signed the Free and Informed Consent Form (ICF) and underwent cardiac myocardial revascularization (MR) surgery, via median sternotomy and cardiopulmonary bypass, were included. Individuals with hemodynamic instability, before starting or during exercise, with Mean Arterial Pressure (MAP) (< 70 mmHg or > 110 mmHg), hypotension or hypertension, drop in oxygen saturation (< 90%), arrhythmias before or during the game, tachycardia (> 100 beats per minute), bradycardia (< 60 beats per minute), tachypnea (> 20 breaths per minute) and bradypnea (<12 breaths per minute) were excluded. Also excluded were those with angina or dyspnea at rest, inability to perform the proposed techniques (physical limitations and/or psychological alteration), withdrawal during the practice of the virtual reality protocol, reintubation, time in the Intensive Care Unit greater than three days, time of mechanical ventilation above 24 hours and proven pneumopathy.

Study protocol

On the third day after heart surgery, all vital signs, such as Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR), Respiratory Rate (RF), Oxygen Saturation (SaO_2) and temperature were evaluated before applying VR.

VR was performed with the XBOX 360 platform added to the Kinect electronic device. The game used was the Kinect Sports Ultimate Collection, Table Tennis mode. The orthostatic patient, facing the TV, with 20 minutes of daily game practice time, performed functional movements such as: elbow flexion-extension, internal and external rotation of the upper limbs as well as adduction and abduction, hip dissociation and weight loss in the lower limbs. After the game, patients had their vital signs checked again, with the same procedure repeated one hour after recovery.

SBP and DBP were assessed with the patient under sedation using a stethoscope (Littmann, Saint Paul, USA) and an aneroid sphygmomanometer (Welch Allyn--Tycos, New York, USA). HR was obtained using a validated heart rate monitor (Polar RS800CX, Polar Electro, Kempele, Finland). The RR was measured by counting the respiratory incursions per minute without the patient's knowledge of the procedure, so that the usual ventilation is not modified. SpO_2 was assessed using a pulse oximeter (Mindray PM-50 Pulse Oximeter, China). The temperature was assessed with a Digital Clinical Thermometer (Incoterm Termo Med).

Data analysis

For data analysis, the Statistical Package for Social Sciences (SPSS) version 20.0 was used. To assess the normality of the sample, the Shapiro Wilks Test was used. Categorical variables were assessed using the Chi-square. The comparison of numerical variables between groups was performed using the independent Student's T Test. It was considered significant when p <0.05.

Results

The sample of this study consisted of 76 patients who underwent cardiac surgery and were admitted to the Inpatient Unit (IU), after the procedure and discharge from the Intensive Care Unit (ICU), from August 2017 to April 2018. 45 patients were excluded from the study, according to the exclusion criteria, leaving 31 patients who met the inclusion criteria of the study.

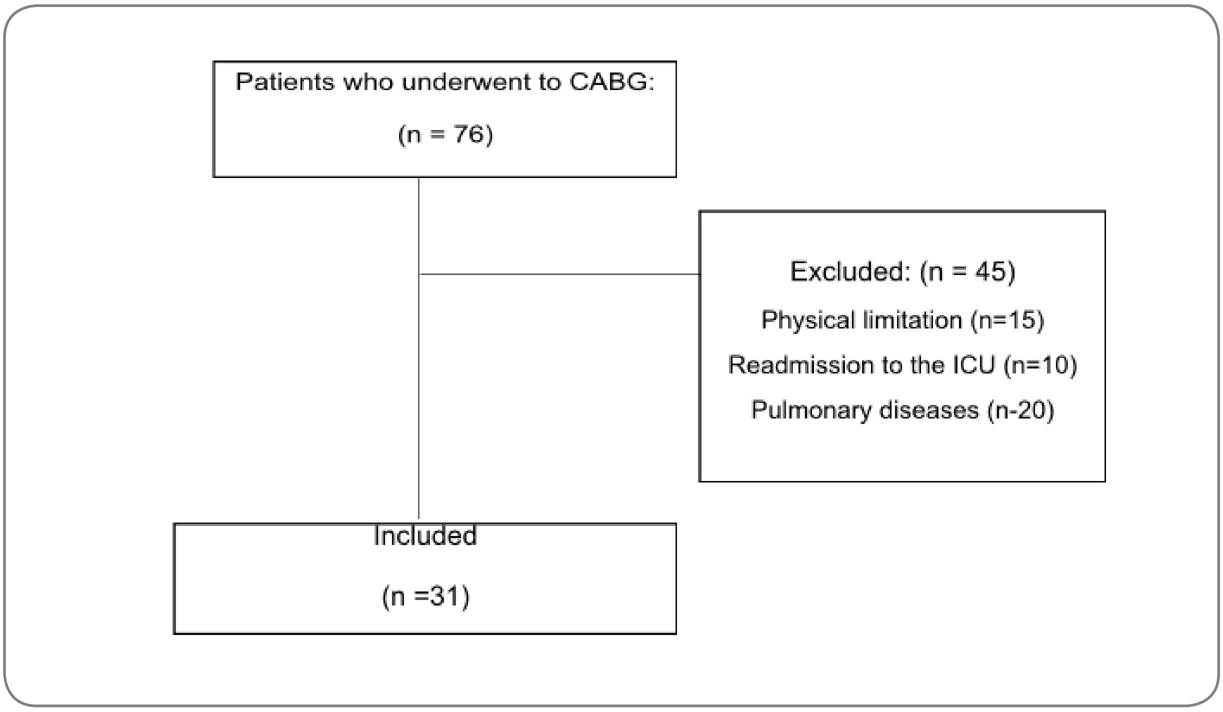

Figure 1 - Flowchart of inclusion of patients in the study

We included 31 patients, with a mean age of 54 ± 8 years, with a higher prevalence in males with 21 (68%) individuals. The most common comorbidities were sedentary lifestyle in 20 (65%) patients and SAH in 18 (58%) patients. Table I presents the clinical characteristics of the patients included in the study.

Table I - Clinical characteristics of patients included in the study

Variable	n = 31
Age (years)	54 ± 8
Gender	
Male	21 (68%)
Female	10 (32%)
BMI (kg/m^2)	
Eutrophic	22 (71%)
Obesity grade I e II	9 (29%)
Comorbidity	
SAH	18 (58%)
DM	7 (23%)
DLP	10 (32%)
AMI	7 (23%)
Ethics	8 (26%)
Sedentary lifestyle	20 (65%)

BMI = Body Mass Index; SAH = Systemic Arterial Hypertension; DM = Diabetes Mellitus; DLP = Dyslipidemia; AMI = Acute Myocardial Infarction

Table II describes the surgical characteristics of the patients included in the study. The mean time of cardiopulmonary bypass found in our study was 63 ± 22 minutes and mechanical ventilation found 7 ± 3 hours.

Table II - Surgical characteristics of the patients included in the study

Variable	Group
CPB time (min)	63 ± 22
MV time (hours)	7 ± 3
Grafts Number	2.1 ± 0.7
Drains number	2 ± 0.2

CPB = Cardiopulmonary bypass; MV = Mechanical Ventilation

Table III shows the behavior of cardiovascular and respiratory variables at different times of the study. The SBP was 123 mmHg ± 18 at baseline, 133 mmHg ± 17 ($p = 0.25$) immediately after intervention, and 121 mmHg ± 15 ($p = 0.43$) during recovery. The HR variable was analyzed in the pre-test with 81 bpm ± 11 and in the post-test with 92 bpm ± 12 ($p = 0.32$), being verified in the recovery with 83 bpm ± 13 ($p = 0.83$). SpO2 was found in the pre-test 96% ± 1 and in the post-test the same result 96% ± 1 ($p = 0.83$), and in the recovery period with 97% ± 2 ($p = 0.84$). Comparing the variables of the pre-test with those of the post-test and this with those of recovery, despite the clinical changes, did not show statistical significance.

Table III - Behavior of cardiovascular and respiratory variables at different times of the study

Variable	Before	After	Recovery	p^a	p^b
SBP (mmHg)	123 ± 18	133 ± 17	121 ± 15	0.25	0.43
DBP (mmHg)	84 ± 9	91 ± 12	83 ± 13	0.23	0.65
HR (bpm)	81 ± 11	92 ± 12	83 ± 13	0.32	0.83
DP (mmHgxbpm)	9963 ± 432	12236 ± 399	10043 ± 411	0.28	0.37
Borg	3 ± 1	8 ± 2	3 ± 2	0.43	0.72
SpO_2 (%)	96 ± 1	96 ± 1	97 ± 2	0.93	0.84

[a]Comparison between the pre-test and the post-test; [b]Comparison of the pre-test for recovery; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; HR = Heart rate; DP = Double Product; SpO2 = Peripheral Oxygen Saturation

Discussion

In the present study, it was possible to verify that there was no change in the physiological variables evaluated in patients who performed exercises through VR in the postoperative period compared to the preoperative period in patients who underwent coronary artery bypass surgery, which represents safety.

Studies have shown that surgical intervention associated with risk factors leads to changes throughout the body. Cardiac surgeries are usually performed through a sternotomy, an extensive and traumatic incision that causes chest instability [9], resulting in shallow breathing, difficulty in gas exchange, and predisposition to pulmonary changes [10], in addition, it is very common in patients to experience pain, limiting movements and bed positioning [11].

Immobility causes respiratory [12], neuromuscular, cardiovascular, cognitive and quality-of-life complications, and can persist for up to five years after hospital discharge [13]. Patients who develop postoperative complications spend more time in the ICU and in the hospital, resulting in increased healthcare costs and reduced quality of life [14,15]. In addition, it is common for patients to experience a melancholic state, with symptoms of anxiety, apprehension, worry and depression, impairing psychological and physiological recovery [16].

Yayla and Özer [17 highlighted the importance of early mobilization in the ICU and in the cardiac surgical clinic, reducing postoperative complications, length of hospital stay and improving sleep quality, confirming Ribeiro *et al*. [18], who also found an improvement in autonomic modulation. Early mobilization optimizes functionality, reduces the duration of mechanical ventilation, and provides psychological benefits, being considered the gold standard in cardiopulmonary dysfunctions [19]. From this perspective, they saw the need for a motivational strategy that could assist in the patient's recovery, thus initiating the use of VR as a strategy for cardiac rehabilitation [20].

VR is an intervention that, in addition to being well accepted, immersive, easy to apply [6], with punctuation feedback and mixed reality [21], studies have shown that VR causes relaxation by reducing psychophysiological stress [16], pain [22], anxiety [7], improves mood [23], restores cognitive and attention capacities [2], can be a promising and low-cost pharmacological intervention to prevent delirium and reduce the use of analgesics [22]. They can be used as a treatment method for balance, postural control, and rehabilitation of body segments [24]. Cacau *et al*. [20] demonstrated improved mobility in patients undergoing cardiac surgery, resulting in faster recovery and earlier hospital discharge.

In a study by Cruz *et al*. [8], in which they sought to verify the acute hemodynamic effects of adding VR using exergames for patients undergoing cardiac rehabilitation, they showed that VR produced a similar physiological pattern of acute hemodynamic effects in CR. However, there was a greater significance in HR, RR and perceived effort rate during VR and for up to five minutes after the session. Although the effects were greater, they were within the expected normal standards and the VR promoted enough intensity for the patients to reach their heart rate reserve. These results corroborate similar findings in our study, in which it was found that, despite the clinical changes, the physiological variables of the patients who underwent virtual reality did not show statistical significance when comparing the pre-test with the post-test, ensuring that the use of VR does not harm the patient's recovery.

Ribeiro *et al*. [18], in a study, analyzed different physiotherapy protocols in heart rate variability in patients undergoing CABG and observed in the virtual reality group that motor physiotherapy associated with VR activities was more effective, resulting in improved heart rate modulation and reduced hospital stay in this population, while in the control group it showed a worse cardiac autonomic response and no reduction in oxygen saturation, hypotension or arterial hypertension, syncope or arrhythmia was observed during the application of the protocols. For Masroor *et al*. [25], this fact may be associated with an increase in parasympathetic stimulation together with a decrease in the effect of adrenergic stimulation on the heart, thus reducing heart rate at rest and benefiting patients with cardiovascular disease in performing the activity.

In the study carried out by Rodrigues *et al*. [26], an improvement in the cardiorespiratory capacity of the participants was demonstrated, and the group that used virtual reality reached the pre-determined goals in a shorter time, when compared to the control group. This aspect was also confirmed in our study, showing that virtual reality is safe, since there was no significant change during or after the realization. However, it is worth mentioning that some precautions must be considered, such as greater monitoring of cardiovascular parameters to control the intensity.

As limitations, our study presented a reduced sample size and number of sessions, a lack of assessment of intensity and motivation and patient satisfaction.

Conclusion

CBased on the results, it was found that the virtual reality intervention in the postoperative period of cardiac rehabilitation promotes physiological responses within normal standards and is a safe and viable intervention in this patient profile.

Conflict of interest
The authors reported no conflict of interest

Sources of funding
There were no external sources of funding for this study

Author's contribution
Conception and design of the research: Cordeiro ALL; Data collection: Santos GO, Oliveira KMV, Silva NC, Sales RS; Data analysis and interpretation: Cordeiro ALL; Statistical analysis: Cordeiro ALL; Manuscript writing: Santos GO, Oliveira KMV, Silva NC, Sales RS; Critical revision of the manuscript for important intellectual content: Cordeiro ALL, Guimarães AR

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