

Association between peak oxygen consumption and six-minute walk test in patients after cardiac surgery

Associação entre consumo de oxigênio de pico e teste de caminhada de seis minutos em pacientes após cirurgia cardíaca

Asociación entre el consumo pico de oxígeno y la prueba de caminata de seis minutos en pacientes tras cirugía cardíaca

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ABSTRACT | Patients undergoing coronary artery bypass grafting (CABG) have reduced cardiorespiratory capacity after the procedure. An adequate assessment in the patients' postoperative period is essential, aiming at a better prescription for cardiopulmonary rehabilitation phase II and return to daily life activities. Our study sought to evaluate the correlation between peak oxygen consumption (peak VO_2), from cardiopulmonary exercise test (CPET) with the distance covered in the six-minute walk test (6MWT) in patients after 40 days of CABG. This is a cross-sectional study with sample consisting of patients submitted to CABG. Patients included were assessed 40 days after the surgery in a hospital environment through cardiopulmonary exercise test in a treadmill protocol and the 6MWT according to the American Thoracic Society. We used the Pearson's correlation test to analyze the outcomes. Thirty-nine patients participated in the study, of which 28 (71.8%) were men, with a mean age of $58 \pm$ years. It was possible to observe a sedentary lifestyle (74.4%), tobacco use (74.4%) and high prevalence of systemic arterial hypertension (82.1%). The mean distance walked on the 6MWT was $494m \pm 70m$ and the mean peak VO_2 was 19.5 ± 3.6 mL/kg/min and the correlation between them was $r=0.48$; $p=0.02$. There was a moderate and statistically significant correlation between the distance

walked in the 6MWT and the peak VO_2 in patients after 40 days of CABG.

Keywords | Myocardial Revascularization; Rehabilitation; Walking.

RESUMO | Pacientes submetidos a cirurgia de revascularização do miocárdio (CRM) apresentam redução da capacidade funcional cardiorrespiratória após o procedimento. Uma avaliação adequada no período pós-operatório desses indivíduos se faz fundamental, tendo em vista uma melhor prescrição para a reabilitação cardiopulmonar fase II e retorno às atividades de vida diária. Nosso objetivo foi verificar a associação entre a distância percorrida no teste de caminhada de 6 minutos (TC6) e o consumo de oxigênio de pico (VO_2 pico) obtido no teste cardiopulmonar de exercício (TCPE) em pacientes 40 dias após a CRM. Nesse estudo observacional transversal, foram incluídos pacientes submetidos a CRM. A avaliação ocorreu 40 dias após a realização da cirurgia em ambiente hospitalar. Os testes realizados foram o TCPE, o protocolo em esteira rolante e o TC6, de acordo com as normas da *American Thoracic Society*. Para a análise dos resultados, utilizamos o teste de correlação de Pearson. A amostra contém 39 pacientes, dos quais 28 (71,8%) são do sexo masculino, com idade média de

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58 anos. Foi possível observar predominância de sedentarismo (74,4%), uso de tabaco (74,4%) e alta prevalência de hipertensão arterial sistêmica (82,1%). Nos testes realizados, a distância média percorrida no TC6 foi de 494m±70m, e no TCPE o VO₂ pico médio foi de 19,5±3,6ml/kg/min. A correlação linear observada entre eles foi r=0,48; p=0,02. Concluindo, houve correlação moderada e estatisticamente significativa entre distância percorrida no TC6 e o VO₂ pico em pacientes 40 dias após CRM.

Descritores | Revascularização Miocárdica; Reabilitação; Caminhada.

RESUMEN | Los pacientes sometidos a cirugía de revascularización miocárdica (CRM) tienen una reducción de la capacidad funcional cardiorrespiratoria después del procedimiento. Una adecuada evaluación posoperatoria de estos individuos es esencial, con vistas a una mejor prescripción para la rehabilitación cardiopulmonar fase II y el retorno a las actividades de la vida diaria. El presente artículo tuvo como objetivo verificar la asociación entre la distancia recorrida en la prueba de caminata de 6 minutos (PC6) y el consumo pico de

oxígeno (VO₂ pico) obtenido en la prueba de ejercicio cardiopulmonar (PECP) en pacientes 40 días después de la CRM. Este estudio observacional transversal incluyó a pacientes sometidos a CRM. La evaluación se realizó 40 días después de la cirugía en el entorno hospitalario. Las pruebas realizadas fueron la PECP, el protocolo de cinta de correr y la PC6, de acuerdo con las normas de la *American Thoracic Society*. Para el análisis de los resultados, se utilizó la prueba de correlación de Pearson. La muestra constó de 39 pacientes; de estos, 28 (71,8%) son hombres, con una edad media de 58 años. Fue posible observar un predominio de sedentarismo (74,4%), consumo de tabaco (74,4%) y alta prevalencia de hipertensión arterial sistêmica (82,1%). En las pruebas realizadas, la distancia promedio recorrida en la PC6 fue de 494m±70m, y en la PECP el VO₂ pico promedio fue de 19,5±3,6 ml/kg/min. La correlación lineal observada entre ellos fue r=0,48; p=0,02. Se concluye que hubo una correlación moderada y estadísticamente significativa entre la distancia recorrida en la PC6 y el VO₂ pico en pacientes tras 40 días de CRM.

Palabras clave | Revascularización Miocárdica; Rehabilitación; Caminata.

INTRODUCTION

Atherosclerotic cardiovascular diseases constitute a public health problem, and coronary artery disease (CAD) is considered one of the main responsible disease for the increase in morbimortality among cardiac patients. CAD is characterized by insufficient blood irrigation in the heart by the coronary arteries, and coronary artery bypass grafting (CABG) is one of the alternatives for its treatment².

Patients in postoperative period usually have pain, alterations in lung mechanics and peripheral muscle dysfunction, associated with inflammatory state, alterations in perfusion and longer resting time in bed². Thus, functional capacity (FC) decreases, causing low tolerance to efforts³. Therefore, the assessment of FC is essential to obtain a better prescription and evolution of exercises for these patients in the cardiopulmonary rehabilitation phase⁴.

Cardiorespiratory FC has been an important indicator of comorbidities for cardiopathic patients⁵, being preferably evaluated through the cardiopulmonary exercise test (CPET). This test considers the analysis of respiratory and metabolic variables, determining the peak oxygen consumption (peak VO₂) to define the patient's physical condition. However, specific local and equipment are needed, demanding higher costs³.

Given this context, the 6-minute walk test (6MWT) has been an alternative to CPET, because it represents a safe and easy-to-perform option, and lower cost. The test provides a submaximal effort simulating daily life activities, being well tolerated by patients⁶. Despite its widespread use, there are controversies concerning the association between the 6MWT results and the peak VO₂ in cardiopathic patients^{7,8}. Considering these data, we sought to identify the correlation between the peak VO₂ and the distance covered in the 6MWT by ischemic cardiopathic patients 40 days after CABG.

METHODOLOGY

Delineation

A cross-sectional observational study conducted between 2012 and 2015.

Population and sample selection

The study sample consisted of patients with ischemic heart disease that underwent elective CABG at the *Hospital de Clínicas de Porto Alegre*. The patients were consecutively allocated based on a schedule of surgeries

of the cardiovascular surgery outpatient clinic. After identification, we analyzed the patients' online medical records to verify if they meet the inclusion and exclusion criteria. The candidates were interviewed and signed the informed consent form at the time of hospitalization on the day before the surgery. All patients underwent their surgeries, received all medical care, including physical therapy, and were discharged after approximately seven days. The patients returned to clinical evaluation, referral and guidance on the second phase of rehabilitation after 30 days of hospital discharge. The patients were evaluated in the CPET and 6MWT on the same day.

Inclusion and exclusion criteria

The study included men and women aged between 18 and 70 years. Those with chronic renal failure (dialysis for more than 3 months), unstable angina, symptomatic patients with small exertion, claudication, moderate and severe valvular dysfunction (with diagnosis and receiving treatment) and severe arrhythmias (with more than one episode and in drug treatment and/or with the use of implantable pacemaker), unpreserved cognitive, previous stroke or those with limiting motor disabilities were excluded.

Evaluation measures

The variables observed for the correlation analysis were the distance covered in the 6MWT and the peak VO_2 , measured on the same day with an interval of 2 hours.

We measured the peak VO_2 using the CPET. The patients were examined by the same evaluator and using the same equipment. Maximal CPET was performed on a treadmill (Inbramed KT 10200, Inbramed, Porto Alegre, Brazil; 0-16 km/h speed [0-10 mph], 0%-26% slope). We used a ramp protocol^{9,10} with 2 km/h initial speed and 0% inclination. The speed and slope were then increased every 10 seconds, from 0.1 to 0.15 km/h and from 0.1% to 0.2%, respectively, with the objective of achieving patient's fatigue at a time between 8 and 12 minutes (average of 10 minutes). The heart rate was monitored throughout the entire test by a 12-lead electrocardiograph (Nihon Kohden Corporation, Tokyo, Japan), with the electrodes placed according to the description of Mason and Likar¹¹. Blood pressure was measured with a sphygmomanometer every 3 minutes during the CPET and, additionally, at the physician's discretion. The expired gases were analyzed breath by breath with a Cortex Metalyzer 3B system

analyzer (Cortex Medical, Leipzig, Germany). All tests were performed by the same cardiologist, authorized by the Department of Exercise, Ergometry and Cardiovascular rehabilitation of the *Sociedade Brasileira de Cardiologia* (Brazilian Society of Cardiology).

The 6MWT followed the American Thoracic Society's guidelines¹² and performed in a 30-meter corridor, with a mark every 3 meter and verbal encouragement. The patients used a frequency meter (Polar S810i, Finland) and a sphygmomanometer to measure, respectively, heart rate and blood pressure pre and post-test. Moreover, we used the perceived exertion scale of Borg. The patients were questioned about the perceived exertion and the sensation of dyspnea every 2 minutes. The criteria for test interruption were dizziness, palpitation, disabling pain in the operated lower limb (saphenectomy), paresthesias and paresis, and any significant alterations in vital signs.

Statistical analysis

The collected data were analyzed using the Statistical Package For Social Sciences (SPSS version 20.0). The distribution of the variables was analyzed using the Shapiro-Wilk test. Continuous variables with normal distribution are shown by means and standard deviation. The nominal variables were described by absolute or relative frequencies.

We used Pearson's correlation coefficient to correlate quantitative variables. We adopted a two-tailed significance level of $p < 0.05$. All tests were two-tailed.

The sample size estimate was based on a 80% statistical power and a 0.45 minimum correlation between the variables. A significance level lower than 5% was considered. Therefore, the total estimated sample was 36 patients. Predicting a sample loss of up to 5%, it would require 38 patients.

Ethical Issues

All patients signed the informed consent form and the confidentiality of the data collected was guaranteed according to the current legislation.

RESULTS

In our study, 39 patients were included in the sample. Table 1 shows the patients' anthropometric and clinical

variables at the preoperative and perioperative periods. We can observe that most of the patients included were overweight men. Moreover, we observed a predominance of sedentarism, tobacco use and high prevalence of systemic arterial hypertension. All patients had above 50% left ventricular ejection fraction, without heart failure (HF). Most of the patients presented functional class II in the preoperative evaluation, according to the functional classification of the New York Heart Association (NYHA).

Table 1. Sample anthropometric and clinical characteristics

Variables	n=39
Age (years) M±SD	58±6
BMI (kg/m ²) M±SD	27±4
Sex (man)	28 (71.8)
Tobacco users (%)	29 (74.4)
Sedentary (%)	29 (74.4)
Diabetes (%)	19 (48.7)
SAH (%)	32 (82.1)
NYHA - I (%)	4 (10.3)
NYHA - II (%)	23 (59)
NYHA - III (%)	12 (30.8)
Time in Surgery (min) M±SD	171±38
ECC time (min) M±SD	58±21
Time in ischemia (min) M±SD	39±15
Time on mechanical ventilation (h) M±SD	10±5
Grafts M±SD	3±0.8
SBP Pre-CPET (mmHg) M±SD	124±15
SBP peak CPET (mmHg) M±SD	171±19
DBP Pre-CPET (mmHg) M±SD	77±7
DBP peak CPET (mmHg) M±SD	75±7

M±SD: mean±standard deviation; BMI: Body mass index; SAH: systemic arterial hypertension; NYHA: New York Heart Association ; I: no physical limitation; II: slight physical limitation; III: moderate physical limitation; ECC: extracorporeal circulation; SBP: systolic blood pressure; CPET: cardiopulmonary exercise test; DBP: diastolic blood pressure.

Based on the performance on cardiorespiratory FC tests 30 days after hospital discharge, we could observe that the distance covered by the patients in the 6MWT was 494±70 m, and the peak VO₂ was 19.5±3.6 mL/kg/min. Regarding the analysis of these variables, we found a moderate and statistically significant correlation (r=0.48; p=0.02), illustrated in the point dispersion chart shown in Figure 1.

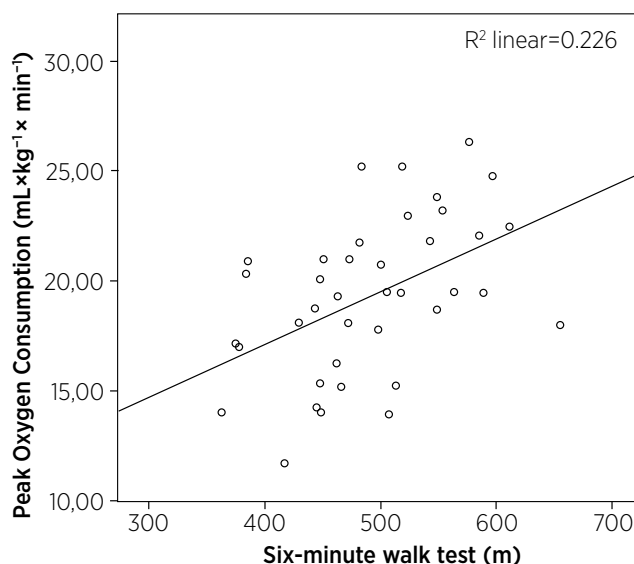


Figure 1. Correlation between the distance covered in the 6MWT and peak VO₂
R²: coefficient of determination.

DISCUSSION

The study showed that the performance on the distance covered in the 6MWT is directly associated with the performance on the measurement of the peak VO₂ obtained from the CPET in patients undergoing CABG, 40 days after surgery. In other words, the greater the distance covered in the 6MWT, the greater will also be the peak VO₂ in the postoperative period.

There are few studies on the association of these outcomes in the literature such as the study by Gayda et al.¹⁴, in which a significant correlation (r=0.58) was observed between the distance covered in the 6MWT and peak VO₂ in 25 patients that presented some cardiac event, agreeing with our findings. Chen et al.¹⁵ found in 36 physically active older adults with CAD a significant correlation (r=0.71) between the distance covered and the peak VO₂. The study conducted by Mandic et al.¹⁶ also compared the correlation of the variables in 58 patients with CAD and found a significant correlation (r=0.71). However, the CPET was performed in a cycle ergometer, different from the protocol used in our study.

Most of the studies have observed a significant correlation between the distance covered in the 6MWT and the peak VO₂; however, these studies were performed in other populations^{7,17-20}. There are still few studies correlating these findings in patients after CABG or with CAD. The study by Carvalho et al.⁷, performed

with patients diagnosed with left ventricular heart failure (LVHF), functional class I-II, found a moderate correlation between the distance covered in the 6MWT and the peak VO_2 ($r=0.70$). Other studies^{17,21} also observed a significant association between these variables in patients with LVHF, functional class II-IV. The performance of patients with heart failure with preserved ejection fraction in the 6MWT showed high correlation ($r=0.85$) with the peak VO_2 ²⁰.

The results of studies of other populations with other cardiac diseases reported in the literature are not linear and differ from the results found in our study. Lucas et al.¹⁸ compared the 6MWT and the peak VO_2 in patients with severe HF ($EF<35\%$), being possible to observe a low correlation between these variables in 213 patients ($r=0.28$), as well as in the study by Roul, et al.¹⁹, who analyzed the same variables in 121 patients with HF using the 6MWT and CPET and could not find a significant correlation between the variables. On the other hand, according to a recent review⁸, the 6MWT is unreliable to estimate the peak VO_2 in patients with HF; the test should be used only for the measurement of physical FC, and not for the measurement of cardiovascular FC.

We believe the difference in correlation levels between the results of the studies mentioned can be explained by the different characteristics of the populations analyzed in each study and the different heart diseases. Furthermore, in studies showing low correlation, the patients were in more advanced stages of their diseases.

The 6MWT and CPET are used to evaluate the cardiorespiratory FC of patients in the pre-and post-operative of CABG²². The CPET has been the standard test for cardiorespiratory evaluation; however, the difficult access and high cost of this test cause the most frequent use of other peak VO_2 indirect measurement tests. The 6MWT has been incorporated into clinical practice as a submaximal effort test, also being able to identify patients with worse prognosis^{6,24}. Different publications^{17,25,26} have approximated these variables to find the prediction equations of the peak VO_2 in the 6MWT, thus evidencing the importance of studies aiming at a reliable measurement of FC in cardiopathic patients, as our study.

An effective cardiac rehabilitation accelerates functional recovery and improves tolerance to exercises²⁷. Thus, the identification of real FC in patients after CABG is essential and contributes to the prescription and orientation of rehabilitation phase II according to the patient's needs and clinical conditions^{28,29}.

Given this context, the use of CPET is ideal for identification of several parameters to prescribe the appropriate physical exercise¹⁴. However, we have to opt for another method to identify the patient's cardiorespiratory condition when we cannot have access to this evaluation. Thus, the verification of the correlation between the results of two methods for assessing cardiorespiratory performance can clarify the proximity between measures and their proper interpretation in daily clinical practice.

As limitations of our study we can cite the sample of patients undergoing elective CABG. Our results cannot be extrapolated to patients undergoing other surgeries, emergency situations or other non-cardiac diseases. Moreover, this is an observational study unable to establish a relationship of cause and effect between the variables analyzed.

CONCLUSION

According to our findings, we conclude that there was a linear association between the distance covered in the 6MWT and the peak VO_2 in ischemic cardiopathic patients undergoing CABG.

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