



Original Article

An Alternative Method for Predicting the Risk of Postoperative Complications in Lung Resection ☆



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ABSTRACT

Objectives: The aims of this study were to design a best fit linear regression model to estimate VO_{2max} (estimated VO₂) and to compare the ability of VO₂ values (measured and estimated) predicting cardiorespiratory complications in a series of patients undergoing lung resection for lung cancer.

Method: This was a prospective, observational study performed in 83 patients. Variables analyzed were: demographic characteristics, comorbidity, body mass index (BMI), FEV1%, FVC%, diffusion capacity (DLCO%), mean daily distance walked in kilometers, VO_{2max} measured by cardio-pulmonary exercise test (CPET) and postoperative complications. Descriptive and comparative statistical analysis of the variables was performed using the Mann–Whitney test for categorical variables and the Student's *t*-test for continuous variables. A new linear regression model was designed, where the dependent variable (measured VO_{2max}) was estimated by the distance, DLCO% and age, resulting in the estimated VO₂. The predictive power of the measured and estimated consumption was analyzed using the Student's *t*-test, grouping by the occurrence or absence of cardiorespiratory complications.

Results: Both groups were homogeneous for age, sex, BMI, FEV1%, DLCO%, comorbidity, type of resection performed and mean distance walked per day. Estimated VO₂ and measured VO₂ were normally distributed (*K*–Smirnov test, *P*>.32). VO₂ means estimated by the model (age, DLCO% and mean distance walked per day) were significantly different between patients with and without complications (Student's *t*-test, *P*=.037) compared with measured VO₂ values, which did not differentiate groups (Student's *t*-test, *P*=.42).

Conclusion: The VO_{2max} estimated by the model is more predictive in this case series than the VO_{2max} measured during a standard exercise test.

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Un método alternativo para la predicción del riesgo de complicaciones postoperatorias en la resección pulmonar

RESUMEN

Objetivos: Los objetivos de este trabajo son rediseñar un modelo de regresión lineal para estimar el valor de VO_{2max} (VO₂ estimado) ya publicado y comparar la capacidad predictiva de los valores VO₂ medido y VO₂ estimado en la aparición de complicaciones cardiorrespiratorias en una serie de pacientes sometidos a resección pulmonar por cáncer de pulmón.

Método: Estudio prospectivo y observacional en 83 pacientes. Variables analizadas: demográficas, comorbilidad, IMC, FEV1%, FVC%, DLCO%, distancia recorrida media diaria (km), VO_{2max} medido en el test de ejercicio cardiopulmonar (CPET) y complicación postoperatoria. Estadística descriptiva y comparativa de

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variables usando Mann-Whitney test para categóricas y t de Student para continuas normales. Se diseña un modelo de regresión lineal donde VO_{2max} , la variable dependiente, se estima desde la distancia recorrida, DLCO% y edad del paciente y su resultado es la VO_2 estimada. Se compara la capacidad predictiva de los VO_{2max} medido y estimado mediante t de Student, agrupando por ocurrencia o no de complicaciones cardiorrespiratorias.

Resultados: Los 2 grupos son homogéneos en edad, distribución de sexos, IMC, FEV1%, DLCO%, comorbilidad, cirugía realizada y distancia media recorrida/día. VO_2 medida y VO_2 estimada tienen distribución normal (K-Smirnov $p > 0,32$). En la predicción de complicaciones, las medias del VO_2 estimado a partir del modelo son significativamente diferentes entre los pacientes con/sin complicación (t de Student $p = 0,037$); frente a los valores de VO_2 medido que no distinguen grupos (t de Student $p = 0,42$).

Conclusiones: El VO_{2max} estimado por el modelo es más predictivo en esta serie de casos que el VO_{2max} medido en una CPET.

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Introduction

Despite the refinement and adaptation of published algorithms and mathematical decision models,¹ prediction of surgical risk is difficult due to selection bias inherent to these models.² Comprehensive assessment of the cardiorespiratory system using standardized exercise tests provides a lot of information about the physiological status of the patient who is to undergo pulmonary resection.³ Calculation of peak exercise oxygen consumption (VO_{2max})⁴ is considered the most reliable test to quantify individual risk for postoperative complications. However, this technique is not available in all centers performing lung surgery, and it cannot be applied in all patients.⁵ The reasons are physical or medical contraindications, or structural problems in hospitals where it is implemented.

Among other options, performance at symptom-limited stair-climbing test has shown the best correlation with surgical morbidity,⁶ although its poor standardization and the difficulty for performing the test in a safe environment for the patient prevent routine use.

A previous study seeking possible alternatives⁷ found a correlation between VO_{2max} values measured by standard cardiopulmonary exercise test (CPET) and VO_{2max} values estimated with a regression model that included measurement of average distance (km) the patient walked each day, collected with a pedometer during the preoperative waiting period, and carbon monoxide diffusing capacity (%DLCO) adjusted for the patient's hemoglobin levels.

The objectives of the present study were to improve the previously designed linear regression model, in order to find the best correlation between oxygen consumption values (measured VO_2 and estimated VO_2), and to compare the ability of these two variables to predict the occurrence of cardiac complications in a series of patients undergoing anatomic pulmonary resection for lung cancer.

Methods

We conducted a prospective, observational study of repeated measures for each subject before and after lung resection.

Study Population

Ninety-five patients were initially included in the study, of which 12 were excluded due to inability to perform exercise testing because of joint problems that prevented smooth pedaling ($n=7$), vascular comorbidity (presence of aorta aneurysm and recent treatment for deep venous thrombosis; $n=2$), a vasovagal episode prior to the exercise test ($n=1$) or because of technical issues with the pedometer that prevented correct measurement of ambulatory activity ($n=2$).

The final sample included 83 consecutive patients with non-small-cell lung cancer scheduled for major anatomic lung resection (typical segmentectomy, lobectomy, bilobectomy or pneumonectomy) from May 2009 to December 2011, who agreed to be included in the study and signed informed consent. All patients who, due to limitation or contraindication, were not able to properly perform the CPET were excluded. Inclusion of patients with ischemic heart disease was conditional on the existence of a previous coronary revascularization or evidence of good functional capacity, demonstrated by exercise testing or equivalent examination.

The criteria for operability in this study have been previously published⁸: absence of a comorbidity of worse prognosis than cancer, Karnofski index $>50\%$, estimated postoperative forced expiratory volume in one second (FEV_1) greater than 30%, and estimated postoperative DLCO greater than 40%.

All patients were treated by the same multidisciplinary team and operated via axillary thoracotomy without muscle section, in which a 2-cm auxiliary incision was also performed.

Measurement of Maximum Oxygen Consumption

Cardiopulmonary exercise testing was carried out in the Respiratory Functional Test laboratory using the cardiopulmonary exercise test module (ergospirometry) MasterScreen CPX Jaeger-Vyaxis-Healthcare, which enables the measurement of ventilatory parameters, VO_2 , carbon dioxide production (VCO_2), anaerobic threshold, respiratory exchange ratio (RER), heart rate (HR), ventilatory equivalent for oxygen (EQO_2), and ventilatory equivalent for CO_2 ($EQCO_2$) in an open "breath-by-breath" type system.

The CPET modality used in our center is the symptom-limited incremental exercise test. In this modality, the patient performs exercise on a bicycle ergometer with continuous load increases over a period of about 10 min (according to Wasserman protocol).⁹

Measurement of Daily Physical Activity by Pedometer

An OmronWalking Style Pro HJ-720IT-E2 pedometer was used with the Bi-Link downloadable software specific to this supplier.

In the first visit, the pedometer the patient would use until the day of surgery was programmed with the date, time and footstep length. Participating in this study did not involve lengthening the preoperative waiting time.

For analysis, the activity recorded by pedometers was reviewed on a case-by-case and day-to-day basis, excluding from the calculation of parameter means those days without any registered activity because the patient did not use the pedometer.

Postoperative Complications

Data on the type of surgery, occurrence of postoperative complications and type of complications were collected during hospital

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