Time in the stair-climbing test as a predictor of thoracotomy postoperative complications

Alexandre Ricardo Pepe Ambrozin, PhD,[a] Daniele Cristina Cataneo, MD, PhD,[b] Karine Aparecida Arruda, MA,[a] and Antônio José Maria Cataneo, MD, PhD[b]

Objectives: The stair-climbing test as measured in meters or number of steps has been proposed to predict the risk of postoperative complications. The study objective was to determine whether the stair-climbing time can predict the risk of postoperative complications.

Methods: Patients aged more than 18 years with a recommendation of thoracotomy for lung resection were included in the study. Spirometry was performed according to the criteria by the American Thoracic Society. The stair-climbing test was performed on shaded stairs with a total of 12.16 m in height, and the stair-climbing time in seconds elapsed during the climb of the total height was measured. The accuracy test was applied to obtain stair-climbing time predictive values, and the receiver operating characteristic curve was calculated. Variables were tested for association with postoperative cardiopulmonary complications using the Student *t* test for independent populations, the Mann–Whitney test, and the chi-square or Fisher exact test. Logistic regression analysis was performed.

Results: Ninety-eight patients were evaluated. Of these, 27 showed postoperative complications. Differences were found between the groups for age and attributes obtained from the stair-climbing test. The cutoff point for stair-climbing time obtained from the receiver operating characteristic curve was 37.5 seconds. No differences were found between the groups for forced expiratory volume in 1 second. In the logistic regression, stair-climbing time was the only variable associated with postoperative complications, suggesting that the risk of postoperative complications increases with increased stair-climbing time.

Conclusions: The only variable showing association with complications, according to multivariate analysis, was stair-climbing time. (J Thorac Cardiovasc Surg 2013;145:1093-7)

Postoperative complications (POCs) occur in 6.8% to 30% of individuals who undergo noncardiac thoracic surgery.[1] Because POCs increase morbidity and mortality, and, secondarily, the duration and cost of hospitalization, it is important to identify patients who may have such complications to reduce their risk by means of preoperative preparation. However, to date, no agreement has been reached in regard to the best test to stratify surgical risk.[2]

The cardiopulmonary stress experienced by patients in the intraoperative and postoperative periods of thoracic surgery is responsible for POCs. Cardiopulmonary stress is complicated to measure and sometimes makes the decision to perform surgery difficult because of the uncertainty of whether the patient can withstand the procedure. However, few studies suggest that cardiorespiratory exercise tests can be applied for this purpose.[3]

The exercise test has been used in the last few years in patients who are eligible for thoracotomy. Of the variables obtained in the ergospirometric test, maximal oxygen uptake (VO_2) is considered to be the gold standard in surgical risk and postoperative prognosis prediction.[4] In the past, diffusing capacity of carbon monoxide also was considered the best predictor of postoperative pulmonary complications in lung resection,[5] but its use in the preoperative evaluation of patients undergoing lung resection has not been routine.[6]

VO_2 assessment by means of ergospirometric tests is costly and depends on specific equipment, an appropriate site, and properly trained staff. Diffusing capacity of carbon monoxide assessment also depends on specific equipment. However, many hospitals do not have such equipment, and thus other tests are used to predict surgical risk, among which is the stair-climbing test (SCT).[7]

There is a correlation between the results of VO_2 obtained on the ergospirometric test and various parameters obtained from the SCT, such as the estimated VO_2, height achieved,[8,9] testing speed,[10] desaturation during its performance,[11] and time spent to climb the steps.[12,13]

As described in the literature, height is the main variable in SCT, not taking into account the time spent to reach it. On

From the Program on General Basis of Surgery,[a] and Division of Thoracic Surgery,[b] Department of Surgery, Botucatu School of Medicine, São Paulo State University, UNESP, São Paulo, Brazil.

Disclosures: Authors have nothing to disclose with regard to commercial support.

Received for publication May 15, 2012; revisions received Aug 3, 2012; accepted for publication Sept 4, 2012; available ahead of print Oct 24, 2012.

Address for reprints: Daniele Cristina Cataneo, MD, PhD, Division of Thoracic Surgery, Department of Surgery, Botucatu School of Medicine, São Paulo State University, UNESP, São Paulo, Brazil, CEP 18.618-970, Botucatu SP, Brazil (E-mail: dcataneo@fmb.unesp.br).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2012.09.001

PM

Abbreviations and Acronyms

FEV_1 = forced expiratory volume in 1 second
$Paco_2$ = arterial pressure of carbon dioxide
POC = postoperative complication
ROC = receiver operating characteristic
SCT = stair-climbing test
SCt = stair-climbing time
VO_2 = maximal oxygen uptake

the basis of the findings by Cataneo and Cataneo,[12] our study proposes the use of stair-climbing time (SCt) as a predictor of POCs. Therefore, the present study aimed to determine whether the time for climbing all the steps during the SCT can be a predictor of post-thoracotomy complications and whether other tests, such as forced expiratory volume in 1 second (FEV_1) of spirometry, are capable of predicting POCs.

MATERIALS AND METHODS

Studied Population

Inpatients from the Thoracic Surgery Ward of the Botucatu School of Medicine University Hospital, São Paulo State University, UNESP, were studied from June 2006 to July 2009. This project was approved by the institution's research ethics committee (REB398/06).

Patients aged more than 18 years with a recommendation of thoracotomy for major lung resection were included in the study. Patients with a history of unstable angina, myocardial infarction less than 3 months before surgery, decompensated heart failure, decompensated obstructive pulmonary disease, difficulties in walking (muscle skeletal, neurologic, or vascular alterations), and resting pulse rate greater than 120 beats/min were excluded.[9]

Measurements

Spirometry was performed according to the criteria by the American Thoracic Society[14] on a Medgraphics Pulmonary Function System 1070 spirometer (Medical Graphics Corp, St Paul, Minn). The FEV_1 value was obtained in liters and predicted percentage.

The SCT was performed on shaded stairs with a 30-degree incline, which consisted of 6 flights with 12 steps each, thus totaling 72 steps. Each step measured 16.9 cm, with a total of 12.16 m in height. The patient was advised to climb all the steps at the shortest possible time with verbal stimulation standardized at every flight. Between the stair flights, the patient needed to take 2 or 3 steps, where speed should be maintained. The test would be interrupted by fatigue, intense dyspnea, thoracic pain, or exhaustion. The time in seconds that elapsed during the climb of the total height was denominated as the SCt. Stair-climbing power (P) was calculated as $P = m \times g \times h/SCt$, where m is the patient's body mass in kilograms, g is the acceleration of gravity (9.8 m/s^2), h is the total height of the stairs in meters (12.16 m), and SCt is the time spent to climb all the steps. The VO_2 was estimated from SCt ($VO_2t = 43.06 - 0.4 \times SCt$) and P ($VO_2P = 15.9 + 0.048 \times P$).[13] All intraoperative complications and surgical duration were recorded. In the postoperative period, patients were followed up daily, and cardiopulmonary complications were recorded. The following events unrelated to the surgical technique were considered to be complications[11]: myocardial infarction, congestive heart failure, arrhythmia, reintubation, orotracheal intubation for more than 24 hours after surgery, pneumonia, atelectasis requiring bronchoscopic aspiration, pulmonary thromboembolism, arterial pressure of carbon dioxide ($Paco_2$) of 50 mm Hg or more in patients who had normal $Paco_2$ preoperatively, acute pulmonary edema, and death. Postoperative hospitalization time and the time of maintenance of a thoracic drainage also were recorded.

Statistical Analysis

Patients were divided into 2 groups according to the absence (no POC group) or presence (POC group) of POCs. To define the cutoff points that could stratify surgical risk, SCt was categorized according to time as follows: less than 30 seconds, 30 to 50 seconds, and more than 50 seconds. Through these accuracy tests, predictive values for different SCt cutoff points were estimated. Two times (30 and 50 seconds) were selected to optimize the selection criteria: Patients who were able to climb all the steps in less than 30 seconds would have a low probability to develop POCs, and patients who took more than 50 seconds to climb all the steps would have a higher probability to develop POCs. SCt categorization for statistical analyses was based on previous studies.[9,12,13] The receiver operating characteristic (ROC) curve also was applied for SCt. Such a curve was constructed on the basis of the variable that classifies the individuals with and without complications, and then showed through the other variable (SCt) the cutoff point by sensitivity and specificity analyses. Independent variables were tested for association with POCs (dependent variable). These variables initially underwent univariate analysis and then multivariate analysis (logistic regression). The continuous variables with normal distribution were compared by the Student *t* test for independent populations, and those that did not show normal distribution were compared by the Mann–Whitney test. The categoric variables were compared by the chi-square or Fisher exact test.

To test the association of variables with the presence of complications, logistic regression (full model) was performed. The dependent variable was the presence of complications, and the independent continuous variables were age, FEV_1, and SCt. Statistical analyses were performed by using SAS version 9.2 (SAS Institute Inc, Cary, NC).

RESULTS

Ninety-eight patients (60 male) were evaluated. Seventy-one patients (72.4%) had no POCs (no POC group), and 27 patients (27.6%) had POCs (POC group). Of the several complications found in the POC group, 15 patients had only 1 complication and 12 patients had 2 or more complications. Eleven patients had atelectasis, 10 patients had pneumonia, 7 patients had prolonged orotracheal intubation, 5 patients had arrhythmia, 5 patients had $Paco_2$ greater than 50 mm Hg, 2 patients had congestive heart failure, 2 patients were reintubated, 2 patients died, 1 patient had acute myocardial infarction, 1 patient had pulmonary thromboembolism, and 1 patient had acute pulmonary edema. Patients' characteristics are shown in Table 1.

By stratifying the patients according to SCt, it is observed that the lower the SCt, the lower the percentage of patients with complications. Of the patients who took less than 30 seconds to climb the stairs, 14% had POCs, increasing to 26% for those who took 30 to 50 seconds and to 60% for those who took 50 seconds or more to climb the stairs (Table 2). The rate of complications for patients who took 50 seconds or more to climb the stairs is 4.3-fold that of those who took less than 30 seconds (9/15 vs 4/29).

By applying the accuracy test for different cutoff points, it is observed that a patient's probability to show