



# Exercise testing as a predictor of surgical risk after pneumonectomy for bronchogenic carcinoma

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## KEYWORDS

Bronchogenic carcinoma;  
Exercise test;  
Postsurgical complications

**Summary** The aim of the present investigation was to evaluate the predictive value of a symptom-limited exercise test in predicting postoperative morbidity and mortality in patients submitted to pneumonectomy.

The study was conducted in 150 patients (mean age, 57.1). Forty-four patients (29.3%) had postoperative complications. Four patients (2.7%) died within one month of the pneumonectomy. Patients with complications had significantly lower  $VO_{2\max}$ . The incidence of complications in relation to the amount of oxygen consumption showed that with the progressive decrease of oxygen consumption there was a progressive increase in frequency of complications. In particular patients with  $VO_{2\max} < 50\%$  of predicted should be considered at high risk of morbidity and mortality from cardiopulmonary causes.

This predictive capacity of  $VO_{2\max}$  was more evident in patients with a preoperative  $FEV_1$  less than 70% of predicted. The present data support the suggestion that exercise testing could be a useful adjunct in the evaluation of postoperative risk for pneumonectomy, especially in patients with obstructive pulmonary disease.

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## Introduction

Many studies have evaluated criteria for predicting postoperative mortality and cardiopulmonary complications after lung resection: they include spirometry, determination of lung diffusing capacity for CO, arterial blood gas measurement and radio-nuclide lung scanning.<sup>1</sup> There has been debate about the clinical significance of exercise testing in preoperative evaluation of patients candidate to lung resection, and conflicting results have been reported in the literature concerning the usefulness of symptom-limited exercise testing. Moreover, different exercise parameters and different recommendations were given in different studies.<sup>1</sup>

The aim of the present investigation was to study the value of a symptom-limited exercise test in predicting postoperative morbidity and mortality in patients with non-metastatic bronchogenic carcinoma scheduled for pneumonectomy.

## Patients and methods

We studied 150 patients who underwent elective pneumonectomy for bronchogenic carcinoma from 1992 to 2000. There were 141 males and 9 females. The mean age was 57.1 years (range 33–79). Seven patients (4.6%) were more than 70 years old, and 95% were smokers (mean pack year, 28).

Thirty patients (20%) had cardiovascular disease: hypertension (67%), arrhythmia (17%), ischemic heart disease (20%). Thirty-six patients (17.5%) had a previously diagnosed respiratory disease

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(chronic obstructive pulmonary disease), and 15.5% had been submitted to neoadjuvant chemotherapy prior to lung resection. Cardiopulmonary complications were defined as: respiratory failure requiring oxygen supplementation, lobar atelectasis, cardiac arrhythmia requiring therapy, pneumonia, non-cardiogenic pulmonary edema, pulmonary embolism. Postoperative death was defined as one occurring within 30 days of surgery or beyond that period if the patient had not left the hospital. All patients were examined with spirometry, radionuclide lung scanning, and arterial gas tension at rest and after exercise.

A multistage test (25 W at 3-min intervals) was performed on an upright cycle ergometer at a pedal frequency of 60 rpm with expired gases and minute ventilation (VE) measured, breath by breath, using a mass spectrometer (Amis 2000, Innovision, Odense, Denmark) to determine oxygen consumption, CO<sub>2</sub> production, minute ventilation, alveolar ventilation, and the physiologic dead space to tidal volume ratio. Patients exercised to exhaustion or to the occurrence of predefined criteria for termination of the test.

## Results

Forty-four (29.3%) had transient postoperative complications. Specifically, 36 had only one complication (17 atrial fibrillation, 10 pneumonia, 8 respiratory failure, and 1 pulmonary embolism), and 8 had more than one complication. There were 4 postoperative deaths within 1 month: 3 because of respiratory failure and 1 due to pulmonary embolism. Age, sex, stage of disease, smoking, histologic type of tumor, preexisting pulmonary or cardiac disease and side of resection, preoperative PaO<sub>2</sub> and CO<sub>2</sub>, and predicted postoperative FEV<sub>1</sub>

were not significantly associated with the development of pulmonary complications.

Patients without complications showed a significantly higher VO<sub>2max</sub> (ml kg<sup>-1</sup> min<sup>-1</sup> % pred.) (75.6% ± 1.3 vs. 71% ± 1.8, *P* < 0.05) than observed in patients with complications. This predictive capacity of VO<sub>2max</sub> (ml kg<sup>-1</sup> min<sup>-1</sup> % pred.) was more evident when we compared non-complicated with complicated patients but with a preoperative FEV<sub>1</sub> less than 70% of predicted (non-complicated 73.5% ± 2.1 vs. complicated 59% ± 4.9, *P* < 0.005).

Finally, the incidence of complications in relation to the amount of oxygen consumption was evaluated. As shown in Table 1, with the progressive decrease of oxygen consumption there was a progressive increase in frequency of complications.

Three of the 4 patients who died had a VO<sub>2max</sub> (ml kg<sup>-1</sup> min<sup>-1</sup>) < 50% of predicted.

## Discussion

Most complications and deaths after pneumonectomy are cardiorespiratory. The possibility to better identify patients at risk of complications is therefore very useful.<sup>2</sup> Many variables have been used to assess the risk of postoperative complications: spirometry and radionuclide scans (which are considered to accurately estimate postoperative pulmonary function) lack adequate sensitivity or specificity for cardiopulmonary postoperative complications.<sup>1</sup> In fact, in our study, it was confirmed that spirometric results and predicted postpneumonectomy variables, in particular ppoFEV<sub>1</sub>, are not useful for the prediction of postoperative complications.

There has been debate about the clinical significance of exercise testing in preoperative evaluation, and conflicting results have been

**Table 1** Distribution of patients with complications in relation to oxygen maximal consumption expressed as ml kg<sup>-1</sup> min<sup>-1</sup> % pred. and l min<sup>-1</sup> % pred. at the exercise test.

	All:150 c/no. (%)	FEV <sub>1</sub> > 70:114 c/no. (%)	FEV <sub>1</sub> < 70:36 c/no. (%)
VO <sub>2max</sub> ml kg <sup>-1</sup> min <sup>-1</sup> % pred			
≥ 70	22/92 (24)	19/72 (26)	3/20 (15)
69–50	16/46 (35)	13/35 (37)	3/11 (27)
< 50	6/12 (50)	3/7 (43)	3/5 (60)
VO <sub>2max</sub> l min <sup>-1</sup> % pred			
≥ 70	13/58 (22)	12/49 (24)	1/9 (11)
69–50	19/59 (32)	16/43 (37)	3/16 (18)
< 50	12/33 (36)	7/22 (32)	5/11 (45)

c, number of patients with complications; no., total patients.

reported in the literature about the applicability of a symptom-limited exercise. According to some authors, the exercise test is a good predictor of postoperative complication, but according to others it is not.<sup>1,3-6</sup>

The present study confirmed that  $\text{VO}_{2\text{max}}$  ( $\text{l min}^{-1}$  or  $\text{ml kg}^{-1} \text{min}^{-1}$ ), expressed as a percentage of the predicted, discriminated between patients suffering from complications and those who did not, particularly when a chronic obstructive pulmonary disease ( $\text{FEV}_1$  less than 70% of predicted) occurred.

We found that a  $\text{VO}_{2\text{max}}$  ( $\text{l min}^{-1}$  or  $\text{ml kg}^{-1} \text{min}^{-1}$ )  $< 50\%$  of predicted is associated with a very high risk of complications after pneumonectomy. In the present study,  $\text{VO}_{2\text{max}}$  measured in  $\text{ml kg}^{-1} \text{min}^{-1}$  and expressed as percentage of predicted seems to be a better single indicator of complications after lung resection than  $\text{VO}_{2\text{max}}$  measured in  $\text{l min}^{-1}$  and expressed as percentage of predicted.

Unfortunately, it was not possible to identify a clear cutoff limit that separated all the dying patients from the survivors. In fact, three of the four patients who died had a  $\text{VO}_{2\text{max}}$  ( $\text{ml kg}^{-1} \text{min}^{-1}$ ) less than 50% of predicted (sensitivity 75%), and 137 of the 146 patients still alive were above this limit (93.8% specificity). Similarly, 3 of the 4 patients who died had a  $\text{VO}_{2\text{max}}$  ( $\text{l min}^{-1}$ ) less than 50% of predicted (75% sensitivity), and 116 of 146 were above this limit (79.5% specificity). This result is in agreement with studies previously reported in the literature.<sup>6</sup>

In conclusion, cardiopulmonary exercise testing which evaluates the integrated performance of the respiratory and the cardiovascular system can be useful to evaluate the risk of postoperative complications since exercise induces or amplifies abnormalities not readily evident at rest. We therefore recommend routine exercise testing for the evaluation of patients candidate to pneumonectomy, particularly when  $\text{FEV}_1$  is less than 70% of predicted, since the information obtained by the test gives the clinician additional useful data on which to base a clinical decision.

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