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Utility of standardized exercise oximetry to predict cardiopulmonary morbidity after lung resection

G. Varela*, R. Cordovilla, M.F. Jiménez, N. Novoa

Section of Thoracic Surgery, Salamanca University Hospital, 37007 Salamanca, Spain

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Abstract

Objectives: To evaluate if desaturation, measured by finger oximetry on standardized exercise, accurately predicts cardiopulmonary morbidity after pulmonary resection. **Methods**: A prospective observational clinical study was carried out on 81 consecutive lung carcinoma patients scheduled for pulmonary resection from February 1998 to March 1999. Finger oximetry was monitored during an incremental to exhaustion cycle exercise test. The presence or absence of desaturation (cut-off value 90%) during exercise was recorded. Other independent analyzed variables were: age of the patient (over 75th percentile), body-mass index (BMI) (over 75th percentile), presence of major cardiovascular co-morbidity, and calculated postoperative FEV1% (under 25th percentile) according to the number of resected segments (ppoFEV1%). Postoperative cardiopulmonary morbidity was the evaluated dependent outcome. Fisher's exact test and risk calculation on contingency tables were used for statistical analysis. **Results**: A lobectomy was performed in 62 cases, a pneumonectomy was performed in 16 cases, and a segmentectomy was performed in three cases. The mean age of the patients was 63.6 years (SD 10.3, range 34–79 years, 75th percentile 72 years), the mean BMI was 25.9 (SD 4.9, range 16.9–38.1, 75th percentile 29.3), and the mean ppoFEV1% was 64.1 (SD 2016.1, range 29.5–98.6, 25th percentile 50.5). In 14 patients exercise desaturation was registered. Postoperative cardiopulmonary morbidity was presented in 32 cases (five deaths). No correlation was found between postoperative morbidity and any of the following variables: age of the patient, BMI, and co-morbidity. On univariate analysis only low ppoFEV1% ($P < 0.001$) was associated with the outcome, so no multivariate analysis has been carried out. **Conclusions**: We have shown that desaturation during standardized exercise in this series adds no relevant information to predict postoperative cardiorespiratory morbidity after lung resection.

Keywords: Lung resection; Adverse effects; Exercise oximetry; Predicted postoperative FEV1

1. Introduction

Pulmonary resection can be safely performed in patients with compromised pulmonary function if they are selected appropriately [1]. The current state of the art of functional evaluation before lung resection has been recently reviewed [2]. Apart from simple preoperative pulmonary function tests, more sophisticated studies of cardiopulmonary function have been recommended to predict both postoperative mortality and morbidity. Exercise testing in the preoperative evaluation of the lung resection candidate provides an integrated view of fitness of the respiratory and cardiovascular systems. Measurement of maximal oxygen uptake in exercise (VO_2max) [3] seems to be a better metabolic indicator of reserve that O_2 saturation. Nevertheless it is more expensive and not available in all centres. Simple exercise tests have been advocated for years [4] but some of them, such as walking and stair-climbing tests, lack standardization [2]. Recently, it has been published that standardized preoperative exercise oximetry predicts postpneumonectomy outcome [5] and that it is a superior screen of the high risk patients than preoperative forced expiratory volume in the first second (FEV1) [6]. On the other hand, Kearney et al. [7] have found that desaturation on exercise is not a good predictor of cardiorespiratory risk after lung resection.

The aim of this study is to evaluate if desaturation on standardized exercise can be used as an independent variable to predict postoperative cardiorespiratory morbidity when the effects of other potential risk factors are controlled by multivariate analysis.

2. Materials and methods

2.1. Patient population

From February 1998 to March 1999, 112 lung carcinoma patients were scheduled for pulmonary resection at our unit. Patients who underwent exploratory or staging procedures or pulmonary resection performed by a video-assisted technique without thoracotomy and patients unable to perform a preoperative exercise test have been excluded. The remaining

* Corresponding author. Tel./fax: +34-923-291-383.
E-mail address: gvs@gugu.usal.es (G. Varela).

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81 cases have been included in a prospective observational clinical study. The selection criteria for operation included the absence of major co-morbidity refractory to medical therapy, PO_2 at rest over 50 mmHg, PCO_2 under 46 mmHg and ppoFEV1% over 30% of the normal value. Calculation of the ppoFEV1% was based on the number of non-obstructed pulmonary segments to be resected [8]. Smoker patients were asked to stop smoking 2 weeks before surgery and the absence of significant levels of blood COHb was assessed by invasive arterial gasometry before admission.

2.2. Exercise test

The day before operation, patients were asked to perform an incremental cycle ergometer protocol to exhaustion. Exercise started at 35 W and the power increased by 35 W every 3 min. Patients were encouraged to maintain a constant cycling cadence of 60/min. The test was interrupted after 12 min or before if the patient presented extreme dyspnea or fatigue, bradycardia, hypotension, EKG ischemic changes or angina. Finger oximetry (by means of a calibrated Nonin 8600 pulse oximeter) and EKG were continuously monitored during the test and the occurrence of desaturation (cut-off value 90%) at any time was recorded.

2.3. Analyzed variables and outcomes

The independent variables included in the analysis were: age of the patient, body-mass index (BMI), presence or absence of cardiovascular co-morbidity, predicted postoperative FEV1 (ppoFEV1) value (as a percentage of the normal) and presence or absence of desaturation during exercise test.

The considered outcome was the occurrence of cardiorespiratory morbidity after surgery. Any of the following postoperative events were considered: pulmonary atelectasis or pneumonia [9], respiratory or ventilatory insufficiency at discharge (PO_2 under 60 mmHg or PCO_2 over 45 mmHg), need of mechanical ventilation at any time after extubation at the operating room, pulmonary thromboembolism, arrhythmia, myocardial ischemia or infarct and clinical cardiac insufficiency.

2.4. Statistics

For descriptive analysis of the continuous variables the mean, standard deviation and values of the 25th and 75th percentiles were calculated. The values of the 75th percentiles were used to convert the age and BMI into categorical variables when needed. The 25th percentile was the cut-off value to categorize ppoFEV1%.

The independence of variables and its univariate influence on the outcome were assessed by contingency tables, Fisher's bilateral exact test and risk calculation (odds ratio and its 95% confidence interval). For statistical analysis SPSS 9.0 software was used.

3. Results

Seventy-one cases were male and 10 were female. In 62 cases a lobectomy was performed, in 16 cases a pneumonectomy was performed and in three cases a segmentectomy was performed. The mean age of the patients was 63.6 years (SD 10.3, range 34–79 years, 75th percentile 72 years), the mean BMI was 25.9 (SD 4.9, range 16.9–38.1, 75th percentile 29.3), and the mean ppoFEV1% was 64.1 (SD 2016.1, range 29.5–98.6, 25th percentile 50.5). Thirty-five patients presented cardiovascular co-morbidity: abnormal electrocardiogram (EKG) (16 cases), hypertension (15 cases), cardiac arrhythmia (ten cases), coronary disease (four cases), peripheral arterial disease (3 cases), previous pulmonary embolism or stroke (two cases each) or cardiac insufficiency (one case).

Desaturation during exercise was found in 14 cases (Fig. 1) and it was not related to low ppoFEV1% ($P = 0.11$). In no case was the test stopped because of cardio-circulatory symptoms or EKG abnormalities.

Thirty-two patients presented one or more cardiopulmonary complication. Respiratory insufficiency occurred in 12 patients (one needed mechanical ventilation), seven patients presented one or more episodes of atelectasis, another seven had clinical cardiac insufficiency (one with pulmonary oedema), six patients were diagnosed with postoperative arrhythmia and five patients had a nosocomial pneumonia. The overall mortality was 6.1%.

On univariate analysis (Table 1) the probability of cardiorespiratory postoperative morbidity was higher in patients having low ppoFEV1% (odds ratio 7.1, 95% CI 2.3–22, $P < 0.001$) while an advanced age, high BMI, co-morbidity and exercise desaturation were unrelated to postoperative cardiorespiratory morbidity. According to the univariate results, no multivariate analysis was carried out.

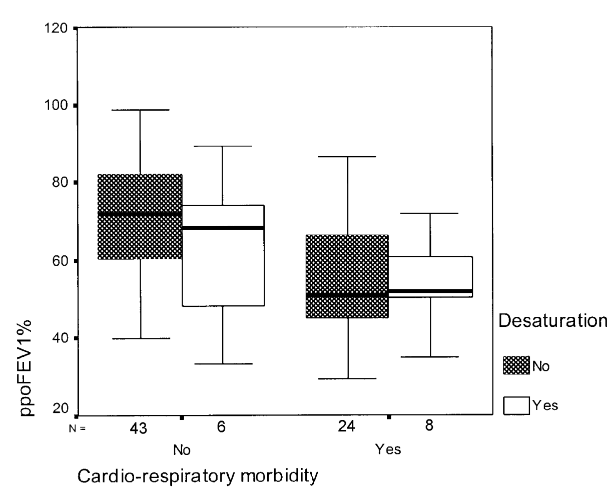

Fig. 1. Relation between ppoFEV1%, exercise desaturation and occurrence of postoperative cardiorespiratory morbidity. Means, black horizontal lines; error bars and quartiles, boxes.

Table 1
Influence of selected variables on the outcome by univariate analysis (Fisher's exact test)

	Cases with risk factor (complicated cases)	*P* value	Odds ratio (95% CI)
Cardiovascular co-morbidity	35 (11)	0.25	0.5 (0.2–1.4)
Obesity	20 (10)	0.3	1.8 (0.6–4.9)
Advanced age	24 (11)	0.15	1.4 (0.5–3.8)
ppoFEV1% in the 25th percentile	21 (15)	<0.001	7.1 (2.3–22)
Exercise desaturation	14 (8)	0.23	2.4 (0.7–7.7)

4. Discussion

In this study we have evaluated a cohort of 81 consecutive patients who underwent lung resection at our unit in a 12 month period and who were able to perform a preoperative incremental cycle exercise test. We have tried to identify clinical and functional independent predictors of cardiorespiratory postoperative morbidity to evaluate if exercise desaturation can be used as a simple and reliable tool in the preoperative risk assessment. Prediction of operative mortality is out of the scope of this study.

The prevalence of cardiorespiratory complications in this series (39%) is higher than expected. In a prospective multicentre Spanish study [10], 152 out of 605 (25.1%) lung carcinoma patients developed cardiorespiratory postoperative complications. The difference in morbidity did not affect the overall mortality (6.1% in our patients, 6.6% in the cited series) and probably depends on the definitions of the complications. We have tried to be exigent in defining cardiorespiratory morbidity. Therefore, we have considered PO_2 under 60 mmHg at discharge or any cardiac arrhythmia as a complication regardless of whether the patient needed any specific therapy. Some authors [11] consider postoperative atrial fibrillation as a minor complication and hence it is not reported in their studies.

The selected clinical independent variables were: age of the patient, obesity, and cardiovascular co-morbidity. An advanced age has been reported to be an independent predictor of postoperative mortality [12], cardiorespiratory morbidity [13] and overall morbidity [14] in lung carcinoma patients. As in other series [10], we have not found age to influence the outcome but we have to accept a patient selection bias since in our milieu physicians are reluctant to refer elderly cases for elective lung cancer surgery. We agree with other authors [10,15] that obesity is not a risk factor for lung resection.

A limitation of our study is that we have considered major cardiovascular co-morbidity as an independent variable instead of separately analyzing different diseases. Peripheral vascular [10] and coronary diseases [16] have been presented as independent predictors of postoperative morbidity. Due to the number of cases in our series we have not performed such a separate analysis.

Although the type of resection has an influence on mortality [10,14], its effect on morbidity has not been clearly demonstrated. Duque et al. [10] found only a slight increase in the probability of complications in a group of pneumonectomy patients (odds ratio 1.61), and Harpole et al. [14], analyzing overall morbidity, did not find the type of resection to have an influence on morbidity. According to the data presented by Bernet et al. [13] the rate of pneumonectomy is higher in younger patients and this fact must influence the outcome. Instead of analyzing the independent effect of the amount of resected lung on morbidity we have studied this factor jointly with the preoperative FEV1%. In spite of its limitations [2], a low ppoFEV1% is currently one of the most frequently reported risk factors for lung resection [2,15]. In our study we have used the formula proposed by Nakahara et al. [8] in 1985, who made a distinction between obstructed and non-obstructed pulmonary segments. Again, we have to suspect a possible bias in selecting poor pulmonary function patients for surgery. Some of the poor risk cases have probably not been referred for evaluation.

Exercise testing permits the evaluation of the respiratory and cardiovascular interactions and different tests have been used to predict the postoperative outcome. As we have stated above, simple walking or stair-climbing tests lack standardization [2] and the use of oxygen delivery parameters adds quantitative character to exercise testing. Calculation of VO_2max during exercise is a better parameter than measurement of O_2 saturation. Nevertheless, it has been published that there is a reasonable correlation between low VO_2max and desaturation on exercise, measured by an invasive technique [17,18]. The reliability of exercise pulse oximetry has been studied showing that this technique accurately estimates changes in arterial saturation between rest and exercise for clinical purposes [19].

In our series, all patients were asked to refrain from smoking for at least 2 weeks before surgery to try and avoid errors in estimating O_2 saturation due to the presence of blood COHb [20].

We have found a few published reports in the literature dealing with the prediction of postoperative morbidity by exercise oximetry [5–7]. Only one of the studies [7] fails to demonstrate a predictive value for exercise desaturation.

In the retrospective study of Rao et al. [6] on 396 cases, it is concluded that exercise desaturation is a superior screen of the high risk patients than preoperative spirometry, although they recommend the substantiation of this conclusion by means of a prospective study. Preoperative spirometry does not correlate with postoperative morbidity [7] so probably the authors should have selected other parameters to compare.

Ninan et al. [5], in a retrospective study on 46 pneumonectomy cases, also found a high correlation between desaturation and both major morbidity and prolonged intensive care unit stay after pneumonectomy. In their study major morbidity – cardiac postoperative events are not reported – and death are together considered the dependent outcome. Although no multivariate analysis is presented, the authors examine the influence of other functional variables on the outcome. In their experience, low ppoFEV1 is not a predictive variable. Unfortunately, functional selection criteria for operation are not clearly stated.

In 1994 Kearney et al. [7] published a prospective analysis of a series of 331 patients who underwent lung resection. They found low ppoFEV1 to be the only independent predictive variable for postoperative morbidity. These authors have included in their series patients who underwent surgery for benign conditions (20% of the cases). The inclusion of this subset of patients is interesting as it has been demonstrated that, in smokers, the lower the FEV1 the higher the probability of the patient having lung carcinoma [21], although in the study of Harpole et al. [14] malignancy was not a prognostic factor for postoperative morbidity. To avoid bias in the study design we have decided not to include patients diagnosed with non-malignant diseases. In our unit 15% of pulmonary resections are performed for chronic inflammatory or infectious diseases, such as bronchiectasis, aspergiloma, hydatidosis, etc. We have previously found that these patients represent another kind of population because of significant differences in age, preoperative FEV1 and lower operative morbi-mortality.

To conclude, in our experience, exercise oximetry desaturation is not correlated with postoperative cardiorespiratory morbidity controlling for ppoFEV1%. For this reason, this simple test should not be included in the preoperative work-up of lung resection candidates.

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