Measured FEV1 in the first postoperative day, and not ppoFEV1, is the best predictor of cardio-respiratory morbidity after lung resection

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Abstract

Introduction and objective: There is a low correlation between predicted postoperative FEV1 (ppoFEV1) and FEV1 measured the days after pulmonary resection, when most complications are developed. The hypothesis of this investigation is that ppoFEV1 does not predict postoperative morbidity in patients undergoing lung resection when immediate postoperative FEV1 is considered in the predictive model.

Methods: One hundred ninety-eight consecutive patients undergoing lobectomy or pneumonectomy were included in a prospective, multiinstitutional study. Independent variables: age, body mass index, ppoFEV1, surgical approach (VATS or muscle-sparing thoracotomy), type of analgesia (epidural or intravenous), postoperative visual analogue pain score and FEV1 measured the day after the operation. Target variable: occurrence of postoperative cardio-respiratory complications. Method of analysis: classification tree (CART) dividing the population at random in two subsets and developing a bootstrap set of 100 trees resampling training data. The relative importance of each variable and the accuracy of both initial and committee trees to predict the outcome were presented.

Results: One hundred seventy-seven lobectomies and 21 pneumonectomies were included. Overall cardio-respiratory morbidity was 22%. According to CART results, first day FEV1 was the most important variable to classify cases as primary splitter and as a surrogate of each primary splitter (100% importance). Patient age followed (51%) and ppoFEV1 was third (43%) with a score similar to postoperative pain score (42%) and type of analgesia (36%). Sensitivity and specificity of the initial tree were, respectively, 0.5 and 0.7; values for committee tree were 0.5 sensitivity and 0.7 specificity. Conclusion: Postoperative cardio-respiratory complications are more related to FEV1 measured in the first postoperative day than to ppoFEV1 value.

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1. Introduction

Although ppoFEV1% figures after lung resection have a high correlation with measured 3—6 months after the operations [1], we [2] have previously shown that its correlation with FEV1 recorded in the immediate postoperative days is poor. Then, it seems logical to hypothesise that ppoFEV1 cannot be as accurate as immediate postoperative FEV1 to predict postoperative morbidity in patients undergoing lung resection. This investigation has been designed to prove the aforementioned hypothesis.

2. Methods

2.1. Studied population

One hundred ninety-eight consecutive patients who underwent pulmonary anatomical resection (lobectomy or pneumonectomy) between November 2004 and September 2005 were prospectively included in the study. Patient selection criteria have been previously published [2] and were homogeneous in all participating centres. Shortly, patients were selected for lung resection if no coexisted major co-morbidity refractory to medical therapy and the following functional criteria were fulfilled: PO2 at rest over 50 mmHg, PCO2 under 46 mmHg, ppoFEV1% and ppoDLCO over 30% of the normal value, and a satisfactory cardio-respiratory reserve (height reached at stair climbing test higher than 12 m or VO2max above 10 ml/kg/min). Surgical approach was muscle-sparing or video-assisted small axillary thoracotomy in all cases. Postoperative management was...
comparable in all units but analgesia was achieved by epidural bupivacaine and opiates plus oral dexketoprophene in some cases while in others, continuous infusion of a combination of tramadol and ketorolac was indicated without random selection of cases.

2.2. Analysed variables

The following independent clinical variables were recorded: age of the patient, body mass index (BMI), predicted postoperative FEV1 (ppoFEV1), surgical approach (VATS or muscle-sparing thoracotomy), type of analgesia (epidural or intravenous), daily visual analogue pain score (VAS) and FEV1 measured the day after operation. FEV1 was measured in every patient at hospital admission and daily until discharge or up to postoperative day 6, under maximal bronchodilator therapy according to GOLD recommendations. FEV1 recordings were performed three times by means of a calibrated portable spirometer (SpiroPro E. Jaeger GmbH), with the patient seated or standing up, and the best value selected. FEV1 was expressed as percentage of predicted for age, gender and height, according to the European Community for Steel and Coal prediction equations [3]. ppoFEV1 was preoperatively calculated by taking into account the number of the functioning segments to be removed during operation and estimated by means of bronchoscopy or CT scan. All variables used in the study were complete.

Target variable was the occurrence of postoperative cardio-respiratory complications prospectively defined. Any of the following postoperative events were considered: pulmonary atelectasis or pneumonia, respiratory or ventilatory insufficiency at discharge (PO2 under 60 mmHg or PCO2 over 45 mmHg), need of mechanical ventilation at any time after extubation in the operating room, pulmonary thromboembolism, arrhythmia, myocardial ischemia or infarct and clinical cardiac insufficiency.

Data were prospectively entered in each centre and then sent to a centralised dataset where they were checked for accuracy and inconsistency by a data manager.

2.3. Statistical analysis

Normality of both continuous variables under analysis (ppoFEV1 and first postoperative FEV1) was tested and linear association between them was evaluated by Pearson correlation coefficient (with two-tailed significance test).

2.4. Data mining methodology

To evaluate the influence of each variable on the outcome we have followed the classification and regression tree method originally described by Breiman et al. [4] using the CART 5® software (Salford Systems, San Diego, California, USA). The population under study was randomly divided in two subsets; the largest (158 cases) was the training set and was used to build up the initial decision tree while the remaining cases served to test the model. Gini method [4] was selected to split each node in two up to terminal nodes. Once the initial tree was available, a bootstrap set of 100 trees (committee tree) was developed resampling training data (with replacement). The relative importance of each variable on the outcome was also calculated (In classification tree (CART) analysis, scores reflect the contribution of each variable to classify cases or to predict the value of target variable). Sensitivity and specificity (and its 95% CI, according to Diamond method [5]) of both initial and committee trees to predict the outcome have been evaluated on 2 × 2 tables describing case classification of the test set of cases.

3. Results

Performed procedures were lobectomy in 177 cases and pneumonectomy in 21. Overall thirty-day mortality was four cases (2%, 1% in lobectomy and 9% in pneumonectomy; two cases in each group). Forty-four patients (22%) had postoperative cardio-respiratory complications, the most frequent (15 cases, 8%) being atrial fibrillation requiring therapy. Mortality and morbidity are shown in Table 1.

Mean and SD values of ppoFEV1 and first day FEV1 were, respectively 64.8 (SD 16.4) and 44.9 (SD 13.32). A weak linear correlation was found between both variables (Pearson correlation 0.6; p < 0.01). As can be seen in Fig. 1, most dots are deviated to the X-axis, meaning that in the majority of cases, first day FEV1 was under the ppoFEV1. Fig. 2 shows the initially constructed decision tree. Information contained in each node represents the splitting rule (nodes 1—8), the number of cases, and the percentage of cases with
postoperative cardio-respiratory complications (terminal nodes 1—9).

Sensitivity and specificity of the initial tree were, respectively, 0.5 and 0.7; values for committee tree were 0.5 sensitivity and 0.7 specificity (Table 2).

The importance of each variable to predict the outcome is presented in Table 3. First day FEV1 was the most important variable to classify cases as primary splitter and as a surrogate of each primary splitter (100% importance). Patient age followed (51%) and ppoFEV1 was third (43%) with a score similar to postoperative pain score (42%) and type of analgesia (36%).

4. Discussion

Predicted postoperative FEV1 is one of the most commonly used predictors of postoperative mortality and morbidity after lung resection. It is widely applied for selection of surgical candidates [6,7] and for audit purposes [8] in risk model construction. Zeiher et al. [1] have reported high correlation between calculated postoperative FEV1 (based on the number of resected pulmonary segments) and residual pulmonary function as assessed 3—6 months after operation. However, most of the major cardiopulmonary complications do happen in the immediate days after operation and changes in expiratory volumes during this period has rarely been reported [9,10]; then, for the mere purpose of risk stratification, an attempt should be made to predict FEV1 in the early postoperative period.

In addition to the removal of lung tissue, other factors may account for the disproportionate loss in respiratory function observed early after lung resection: impairment in chest wall compliance; accumulated bronchial secretion; bronchial hyper-reactivity; microatelectasis; increased lung water; diaphragm dysfunction; reduced surfactant activity [11,12].

We have shown [2] that postoperative FEV1% in the immediate days after lobectomy is approximately 30% lower than ppoFEV1% and this fact could seriously affect the clinical reliability of ppoFEV1 when used for selecting surgical candidates.
In this investigation, we have tried to demonstrate that ppoFEV1 predictive value decreases when measured FEV1 in the first postoperative day is introduced in the prediction model. Instead of conventional logistic regression models, we have used data mining (or machine learning) techniques. These include several automated methods for pattern discovery and general learning from a set of data. The CART methodology is a binary recursive partitioning of data to look at all possible splits for all variables included in the analysis. Once a best split is found, the procedure is repeated for each child node until further splitting is not possible. Although not frequently used in clinical decision-taking processes, good performance using CART has been reported with the advantage that graphical probabilities results display may be easier to interpret and be prospectively tested under field conditions than the logistic regression formula, despite their equivalent performance [13].

We have found that the most predictive variable is first postoperative day FEV1 while ppoFEV1 has a lower role in case classification, similar to postoperative pain score. Probably the predictive value assigned to ppoFEV1 by several authors is due to the correlation existing between ppoFEV1 and FEV1 measured in the first day, as we have shown in this paper.

We have to acknowledge several limitations in our investigation. First of all, the multicentric design can introduce some bias due to non-adverted differences in patient management, spirometry techniques and spirometer calibration. Besides, many unveiled factors can have influence on the postoperative outcome, basically factors related to patient and to medical and nursing interventions, which cannot be controlled.

The accuracy of preoperative ppoFEV1 calculation can also be regarded as a limitation of the study. We have previously shown [14] that there is some discrepancy between ppoFEV1 calculated before and after surgery due to unexpected finding during the procedure. On the other hand, as if happens in most papers dealing surgical risk, the series is biased by the fact that no patient having very low ppoFEV1 underwent surgery. If such cases would have been included, surely the ppoFEV1 predictive value would have increased, but there is enough evidence against such a practice in the medical literature.

Neither the results of this analysis can be used in daily clinical practice nor it was our aim to describe a new tool to predict surgical outcome. We just want to suggest that the predictive value of ppoFEV1 should at least be regarded with caution. According to our data, the simple measurement of FEV1 with a portable instrument at the bedside of the patient in the early postoperative period can indicate whether he/she would need an advanced care management to prevent complications to occur or to detect them at an earlier phase and we have to go on working to investigate if some specific interventions would be useful to improve postoperative FEV1 value.

A model predicting first day FEV1 may be incorporated in future functional algorithms and its development and validation will be the subject of a future investigation.

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References