Vibration response imaging versus perfusion scan in lung cancer surgery evaluation

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Objective: Ventilation/perfusion scan is a standard procedure in high-risk surgical patients to predict pulmonary function after surgery. Vibration response imaging is a technique that could be used in these patients. The objective of our study was to compare this imaging technique with the usual scanning technique for predicting postoperative forced expiratory volume.

Methods: We assessed 48 patients with lung cancer who were candidates for lung resection. Forced spirometry, vibration response imaging, and ventilation/perfusion scan were performed in patients before surgery, and spirometry was performed after intervention.

Results: We included 48 patients (43 men; mean age, 64 years) undergoing lung cancer surgery (32 lobectomies/16 pneumonectomies). On comparison of both techniques, for pneumonectomy, we found a concordance of 0.84 (95% confidence interval, 0.76-0.92) and Bland–Altman limits of agreement of −0.33 to +0.45, with an average difference of 0.064. By comparing postoperative spirometry with vibration response imaging, we found a concordance of 0.66 (95% confidence interval, 0.38-0.93) and Bland–Altman limits of agreement of −0.60 to +0.33, with an average difference of −0.13.

Conclusions: The 2 techniques presented good concordance values. Vibration response imaging shows non-negligible confidence intervals. Vibration response imaging may be useful in preoperative algorithms in patients before lung cancer surgery. (J Thorac Cardiovasc Surg 2014;147:816-21)

Lung surgery remains the best therapeutic option for patients diagnosed with lung cancer and may lead to full recovery from the disease. However, deciding whether a patient should undergo lung resection requires a thorough assessment of lung function, frequently through the combination of different techniques that can predict surgical risk and postoperative lung function.

Available guidelines[1-3] for the evaluation of patients with lung cancer for radical surgery recommend different techniques, such as spirometry, diffusing capacity of the lung for carbon monoxide (DLCO), and exercise tests. When the parameters measured are below an agreed threshold, ventilation/perfusion scintigraphy (V/Q) should be performed.

V/Q techniques currently tend to be considered the reference gold standard to obtain predicted postoperative forced expiratory volume in 1 second (ppoFEV1). This value is estimated on the basis of the forced expiratory volume in 1 second (FEV1) before surgery, the extent of the planned resection, and the contribution of each lung segment in terms of ventilation or perfusion. This approach is expensive and complex, and V/Q scans have to be carried out in the Nuclear Medicine Department, requiring the administration of radioisotopes and radiation.

Vibration response imaging (VRI) is a new, noninvasive, simple to use technique that can provide an accurate estimate of ppoFEV1.[4] In a previous study by Jimenez and colleagues,[5] VRI-based measures have shown high accuracy in the prediction of ppoFEV1.

The hypothesis of this study is that VRI might have as good a predictive capacity of the ppoFEV1 as V/Q scan, and therefore our main objective was to compare the 2 techniques in patients with lung cancer who are candidates for lung resection.

MATERIALS AND METHODS

We conducted a prospective study that included all patients with lung cancer evaluated for lung resection before surgery, regardless of the degree of severity. All patients were first assessed by a multidisciplinary committee for lung cancer.

The study was performed at Cruces University Hospital (Bizkaia) and San Carlos Hospital (Madrid), Spain, during 9 months in 2009. During the course of the study, 63 patients were evaluated, of whom 48 underwent operation and were recruited (5 women and 43 men) (Table 1). Fifteen patients did not undergo surgery for various reasons (mostly no surgical stage). This study was approved by the ethics committees of

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Abbreviations and Acronyms

CI	= confidence interval
CT	= computed tomography
DLCO	= diffusing capacity of the lung for carbon monoxide
FEV1	= forced expiratory volume in 1 second
ppoFEV1	= predicted postoperative forced expiratory volume in 1 second
V/Q	= ventilation/perfusion scintigraphy
VRI	= vibration response imaging

both participating hospitals, and written informed consent was obtained from all participants.

Assessment of Patients

Patients were assessed in the Respiratory Function Units of each hospital. The assessment algorithm is depicted in Figure 1.

All 48 patients subsequently underwent surgery (lobectomy in 32 patients and pneumonectomy in 16 patients). Preoperative tests included spirometry, V/Q scan, and VRI to estimate the ppoFEV1. Spirometry was performed 4 to 6 weeks after surgery to assess the postoperative FEV1. This period of time was considered to be sufficiently prolonged to accurately assess the postoperative lung function of patients before the use of potential coadjuvant therapy.

Spirometry

Spirometry was performed using a spirometer Master Scope Jaeger (Wulzurg, Germany) in accordance with the American Thoracic Society/European Respiratory Society[6] procedure standards. All tests were performed by the same technician in each hospital.

Pulmonary Ventilation/Perfusion Scintigraphy

V/Q scans were performed in all patients using a gamma camera (InfiniaTM; General Electric Healthcare, Little Chalfont, Buckinghamshire, UK) and following standard procedures: Patients inhaled 30 mCi 99mTc-DTPA for ventilation assessment and were administered intravenous 99Tc-MAA for the perfusion images. Obtained images show the lung divided into 3 similar segments, with each area contributing a different percentage in terms of perfusion and ventilation.

To calculate ppoFEV1, we used the equations given in the study by Wernly and colleagues[7]:

Predicted postoperative FEV1 = preoperative FEV1 × (1% Q of lung to be resected) for perfusion scintigraphy;

Predicted postoperative FEV1 = preoperative FEV1 × (1% V of lung to be resected) for ventilation scintigraphy; and

Predicted postoperative FEV1 = preoperative FEV1 × % matched V/Q for combined V/Q scintigraphy.

Vibration Response Imaging

A pre-surgery VRI protocol previously described by our group[5] was applied to all patients. Briefly, the VRI system (VRIxpTM; Deep Breeze Ltd, Or-Akiva, Israel) evaluates pulmonary function by recording the sounds of consecutive regular respiratory cycles (3 to 5 for a period of 12 seconds), measuring the energy produced by the vibration of air as it passes through the airways. These vibrations are picked up by 2 arrays of sensors that are placed on the patient's back and via low vacuum cups. Dedicated software creates dynamic images of each lung and the signals are converted into percentages, reflecting the contribution of each segment to the vibrations during breathing. Each lung is divided into 3 segments, as in V/Q scan, so that this new technique allows the segmental counting as V/Q scan. The technique must be carried out in total silence, with no episodes of coughing or talking during the recordings, because these would interfere with the signal measurement process.

Once the respiratory cycles were recorded, the data were evaluated using the O-Plan software (Deep Breeze Ltd). The technician selected the most suitable and similar cycles to achieve the best possible data, with a standard deviation no more than 5% between them. The O-Plan software, using the selected cycles and FEV1 before surgery, calculates ppoFEV1.

Statistical Analysis

Our aim was to assess the relationship and degree of agreement among predictions of ppoFEV1 obtained using these 2 methods (VRI and V/Q scan) and compare the degree of agreement of these 2 estimates with the actual postoperative FEV1. To do so, we used 2 complementary tools, Lin's[8] concordance correlation coefficient, a numeric index ranging from 0 to 1, and Bland–Altman plots with average difference between measures and 95% limits of agreement.[9] For concordance coefficient, 95% confidence intervals (CIs) were calculated for concordance coefficient. We followed the agreement strength classification proposed by McBride.[10]

Statistical analysis was carried out using the Statistical Package for the Social Sciences (version 11; 5. 1, SPSS, Inc, Chicago, Ill) and Stata 11 for Windows (2009 Stata Statistical Software: Release 11; StataCorp LP, College Station, Tex).

RESULTS

Forty-eight patients undergoing lung resection were included in our study, of whom 32 had lobectomies and 16 had pneumonectomies.

1. Predicted postoperative FEV1 by both techniques (Figure 2): For a theoretic pneumonectomy in all patients (48 patients), we found a concordance coefficient of 0.84 (95% CI, 0.76-0.92) in absolute values and 0.73 (95% CI, 0.59-0.86) in percentage. In case of lobectomy as the planned operative approach (32 patients), the concordance was 0.88 (95% CI, 0.81-0.95) in absolute values and 0.75 (95% CI, 0.62-0.89) in percentage.
2. Concordance between postoperative FEV1 predicted with both techniques and observed postoperative FEV1:
   a. ppoFEV1 by V/Q scan versus postoperative FEV1 (Figure 3): For actual pneumonectomy (16 patients), we obtained a concordance coefficient of 0.80 (95% CI, 0.61-0.98) in absolute values and 0.67 (95% CI, 0.40-0.93) in percentage. In lobectomy cases (32 patients), a concordance of 0.81 (95% CI, 0.70-0.93) was found for absolute values and 0.70 (95% CI, 0.52-0.87) in percentage.
   b. ppoFEV1 by VRI versus postoperative FEV1 (Figure 4): In pneumonectomy cases (16 patients), we obtained a concordance of 0.66 (95% CI, 0.38-0.93) in absolute values and 0.52 (95% CI, 0.21-0.83) in percentage. In lobectomy cases (32 patients), concordance was 0.81 (95% CI, 0.68-0.93) for absolute values and 0.60 (95% CI, 0.38-0.82) in percentage.

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