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Short- and long-term outcome of lung volume reduction surgery. The predictive value of the preoperative clinical status and lung scintigraphy

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Summary The NETT study assessed the benefits of lung volume reduction surgery (LVRS) versus medical treatment. However, data is available only on the early outcome of LVRS (24 months). We evaluate the factors affecting the outcome at one-year and up to 6 years after LVRS.

Thirty-seven patients underwent LVRS. Thirty-five patients, who survived the operation for at least one-year, were followed up to 6 years. Patients' laboratory, clinical and scintigraphic data before surgery were reviewed retrospectively, and follow-up at one-year and at the end of data collection.

Successful LVRS with improvement of $FEV_1 \geqslant 30\%$ at one-year was observed in 13 of 35 patients. Five of these patients had initial FEV_1 values of $<20\%$ of the predicted. The group of patients with improvement was younger as compared to the 22 patients without improvement ($P<0.005$). The younger age group used less supplemental oxygen and had a PDiff of $>23\%$. Combinations of age under 60 years and PDiff $>23\%$ were a favorable factor ($P<0.002$) for successful LVRS. Thirty-four patients were followed up to 6 years. Fifteen of the 34 patients (44.1%) remained well. Use of

Abbreviations: LVRS, lung volume reduction surgery; NYHA, New York Heart Association; PDiff, Percent of perfusion difference. The difference in perfusion between lower and upper thirds of the lung fields. This parameter is calculated from perfusion lung scintigraphy; FEV_1, forced expiratory volume in 1 s. Maximum amount of air during forced vital capacity determination that can be expelled in 1 s; TLC, total lung capacity; RV, residual volume. The volume of air remaining in the lungs at the end of maximal expiration; DLCO, diffusion capacity of a gas mixture, containing carbon monoxide; PCO_2; partial pressure (tension) of carbon dioxide; PO_2, partial pressure of oxygen; PFTs, pulmonary function tests; MVV, maximal voluntary ventilation; ROI, region of interest; FVC, forced vital capacity, measured with the subject exhaling as rapidly as possible; NETT, National Emphysema Treatment Trial

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supplemental oxygen before surgery, and FEV_1 improvement of $\geqslant 30\%$ at one-year after surgery were good prognostic factors.

We concluded that the long-term success of LVRS is affected by non-dependence on oxygen supplementation before surgery, and the one-year post-surgical improvement of FEV_1 ($\geqslant 30\%$). Based on our findings, the subgroup of patients below 60 years old with severe disease ($FEV_1 < 20\%$) and heterogeneous upper lobe emphysema (Pdiff $> 23\%$) has improved outcome.

Introduction

Emphysema is a chronic progressive pulmonary disease associated with smoking and characterized by hyperinflation of the pulmonary alveoli and impairment of the expiratory outflow.[1] Lung volume reduction surgery (LVRS) has been offered in recent years as a promising surgical option for severe emphysema.[2,3] The procedure was described by Brantigan et al.[4] in 1959, and includes non-anatomical wedge resection directed, if possible, to the most affected emphysematous lung regions in order to reduce the pulmonary volume by 20–30%. The reduction of the emphysematous lung to a near normal size decreases the tension on the respiratory muscles, allowing them better contraction.[5,6] Removing areas of non-functional lung causes improvement in the elastic recoil and in diaphragmatic function.[7]

Lung imaging using chest X-ray, high-resolution CT and lung perfusion scintigraphy, has been used prior to LVRS for assessment of the areas for reduction, as well as for prediction of the short-term success of the procedure.[8–11] Recently, the National Emphysema Treatment Trial (NETT) study[12] assessed the benefits of LVRS versus medical treatment. However, data is available only on the early outcome (24 months) of LVRS.

The objective of this study was to evaluate the short (one-year) and the long-term (up to 6 years) predictive value of the preoperative clinical and pulmonary function tests (PFTs) as well as the quantitative analysis of preoperative perfusion lung scintigraphy in patients undergoing LVRS.

Material and methods

Patients

Thirty-seven patients with emphysema underwent bilateral upper lobe LVRS. The inclusion criterion for surgery was New York Heart Association class 3,[13] which was used to describe the extent of dyspnea and fatigue. Patients with TLC > 110, RV > 150, DLCO < 65 and 6 min walking distance of > 100 m were included. Exclusion criteria were: $PCO_2 > 50$, pulmonary hypertension > 50 mm Hg, 6 min walk of less than 100 m, and steroid use of more than 20 mg prednison, We did not exclude patients with FEV_1 values $< 20\%$. High-resolution CT was performed in all patients as a part of the diagnostic process, but homogenous pattern of emphysema was not an exclusion criterion.

Bilateral surgery was performed using a mid-sternotomy approach.

Two patients died postoperatively due to intractable air leak and infection, and therefore, were excluded from further analysis.

Preoperative and postoperative information was collected from patients' charts. Patients used continuous (24 h) supplemental rest oxygen when their oxygen saturation was less than 90% or PO_2 less than 55 mmHg.

The PFTs included spirometry, lung volume, maximal voluntary ventilation (MVV), 6 min walk and diffusion capacity (DLCO). PFT measurements were corrected for body temperature and pressure saturated (BTPS). Testing was performed with the Medical Graphics Pulmonary Function System (1070-series 2, St. Paul, MN, USA). Lung volumes were obtained by body plethysmography (model 1085, Medical Graphics, St. Paul, MN, USA). MVV was assessed by asking the patient to breath simultaneously as fast and as deep as possible for 12 s and the result was multiplied by 5. DLCO was measured by single breath technique with a gas mixture containing air, 10% helium, and 0.3% carbon monoxide. Each DLCO measurement was adjusted to standard temperature and pressure. The predicted value of the parameters was obtained from the regression equations of the European Community for Coal and Steel.[14] Information concerning 6 min walking distance, use of supplemental oxygen, use of steroids and the New York Heart Association class,[13] was also recorded. Patients' follow-up consisted of laboratory and clinical data collected at one-year, and at the end of data collection on December 2003, resulting in a follow-up period of up to 6 years.