Native lung volume reduction surgery relieves functional graft compression after single-lung transplantation for chronic obstructive pulmonary disease

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Objective: Single-lung transplantation is an accepted treatment for end-stage lung disease caused by chronic obstructive pulmonary disease. A complication unique to single-lung transplantation for chronic obstructive pulmonary disease is graft dysfunction due to compression caused by native lung hyperinflation. We hypothesized that patients with functional compromise from native lung hyperinflation would benefit from native lung volume reduction surgery.

Methods: The charts of all patients undergoing single-lung transplantation for chronic obstructive pulmonary disease were reviewed for lung volume reduction surgery of their native lung. Data regarding length of stay, surgical morbidity and mortality, overall survival, type of lung volume reduction surgery, and pulmonary function were recorded to evaluate the effect of lung volume reduction surgery.

Results: Between February 1992 and May 2007, 206 single-lung transplantations were performed for chronic obstructive pulmonary disease. Ten (5%) patients had clinically significant graft compression from native lung hyperinflation. After excluding other causes for functional decline, these patients underwent a modified lung volume reduction surgery between 12 and 142 months after single-lung transplantation (mean, 50 months). Lung volume reduction surgery consisted of anatomic resection. Two (20%) of 10 patients died during their hospitalization. Of the remaining 8 patients, 7 (87.5%) have demonstrated functional improvement on the basis of forced expiratory volume in 1 second improving from 12% to 200% (mean improvement, 57%). Within 6 months of lung volume reduction surgery, mean 6-minute walk values improved significantly (866 to 1055 feet), whereas desaturation with exertion decreased significantly.

Conclusions: Lung volume reduction surgery by means of formal lobectomy in patients with native lung hyperinflation undergoing single-lung transplantation and significant graft compression appears feasible. Additionally, improvements in forced expiratory volume in 1 second can be accomplished in nearly all properly selected patients. Lung volume reduction surgery should be considered in patients with decreasing graft function caused by graft compression from native lung hyperinflation.

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Read at the Thirty-third Annual Meeting of the Western Thoracic Surgical Association, Santa Ana Pueblo, NM, June 27–30, 2007.

Received for publication June 23, 2007; revisions received Sept 20, 2007; accepted for publication Oct 22, 2007.

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J Thorac Cardiovasc Surg 2008;135:931-7

0022-5223/$34.00

doi:10.1016/j.jtcvs.2007.10.069

Single-lung transplantation (SLT) is an accepted treatment for end-stage lung disease caused by chronic obstructive pulmonary disease (COPD). SLT for COPD has accounted for almost 40% of lung transplantations according to

Abbreviations and Acronyms

BOS = bronchiolitis obliterans syndrome
COPD = chronic obstructive pulmonary disease
CT = computed tomography
FEV_1 = forced expiratory volume in 1 second
LVRS = lung volume reduction surgery
NLH = native lung hyperinflation
SLT = single-lung transplantation

the most recent report from the International Society for Heart and Lung Transplantation Registry.[1] Moreover, from 1995 through 2005, more than 67% of lung transplantations for COPD were single-lung rather than double-lung transplantations.

A complication unique to SLT for COPD is graft dysfunction due to compression caused by native lung hyperinflation (NLH).[2] Clinically relevant graft compression is characterized by a decrease in clinical function as measured by a decrease in forced expiratory volume in 1 second (FEV_1), exercise tolerance, and increased oxygen requirements in the setting of radiographic evidence of graft compression. Lung volume reduction surgery (LVRS) has been proposed as a method of treatment for this phenomenon.[3-7] Table 1 summarizes the most comprehensive reports in the literature on lung volume reduction surgery after single lung transplants for COPD.

The purpose of this study was to determine whether native lung resection improves overall lung function in the setting of transplant graft compression caused by NLH. We hypothesized that patients with graft compromise caused by NLH would benefit from LVRS of the native lung. This study reports our experience in 10 patients undergoing LVRS for NLH and graft compression after SLT for COPD.

Materials and Methods

Approval of this study was obtained from the Colorado Multiple Institutional Review Board. The charts of all patients undergoing SLT for COPD at our institution between February 1992 and May 2007 were reviewed to capture those patients undergoing LVRS for SLT graft compression. Functional decline was defined primarily as a decrease in FEV_1, but a decrease in 6-minute walk values and an increase in the need for supplemental oxygen also contributed to this determination. Graft compression was suspected with chest radiographic findings of progressive mediastinal shift (Figure 1). Chest computed tomography (CT) was used to confirm mediastinal shift in the setting of an incremental decrease in transplanted lung volume. Other CT findings included evidence of compression of the intragraft vasculature or a large bronchus. Patients underwent bronchoscopy with transbronchial biopsy to rule out airway stenoses or bronchomalacia or acute or chronic rejection. A careful evaluation was performed to rule out other causes of decreased allograft function, as shown in Figure 2. The modified LVRS consisted of anatomic resections, both lobectomy and segmentectomy, rather than the more traditional extensive buttressed wedge resections.

Data were recorded regarding outcomes of LVRS, including length of hospital stay, perioperative morbidity, and mortality. Date and timing of both the original transplantation and the LVRS were noted. Furthermore, the patient's overall survival and specific LVRS procedure were reviewed. Most importantly, pulmonary function test results were recorded from evaluation for transplantation to the present. The patients' FEV_1, 6-minute walk values, and oxygen requirements were used as objective markers to determine the overall effect of LVRS procedure by comparing them at their peak after transplantation, before LVRS, and postoperatively after LVRS.

Statistical comparisons were performed by an independent statistician using repeated-measures analysis of variance, and differences were confirmed with Tukey HSD multiple-comparison analysis.

Results

From 404 lung transplantations, 206 SLTs were performed for COPD. Ten (5%) patients experienced significant functional graft compression and underwent LVRS. All patients underwent a modified LVRS consisting primarily of anatomic resections, as follows: 3 lower lobectomies, 5 upper lobectomies, a bilobectomy, and a lower lobe segmentectomy with upper lobe wedge resection. Three of the 10 patients also underwent intercostal muscle flap reinforcement of the bronchus. All LVRSs were performed by one of 3 surgical staff whose practice consists solely of thoracic surgery.

TABLE 1. Reported literature on native lung volume reduction surgery after single-lung transplantation

Author	Year	n	Indication	Procedure	Showing functional improvement (%)	Survival >1 y after LVRS
Kroshus and coworkers[6]	1996	3	NLH	LVRS	100%	1/3
Anderson and coworkers[3]	1997	3	NLH	LVRS	100%	Not reported
Schulman and coworkers[12]	1999	7	BOOP	LVRS	86%	3/7
Fitton and coworkers[11]	2003	5	NLH	LVRS	NA	2/4
Current study	2007	10	NLH	Lobectomy	70%	8/10

Most reports are small, demonstrating at least early functional improvement. These studies include all reports with more than 1 patient. The larger studies show that longer-term outcomes can be mixed, which stresses the importance of patient selection for this procedure. *LVRS*, Traditional lung volume reduction surgery with extended, buttressed wedge resection of the native lung; *NLH*, native lung hyperinflation; *BOOP*, bronchiolitis obliterans organizing pneumonia.