

Lung Volume Reduction Surgery

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WHAT IS LUNG VOLUME REDUCTION SURGERY?

Lung volume reduction surgery is a general term encompassing a variety of surgical procedures that are offered to alleviate the symptoms of advanced chronic obstructive lung disease due to emphysema. Currently, the operations used to treat emphysema include the excision of large bullae by thoracotomy or thoracoscopy and the resection of diffusely emphysematous lung tissue. This latter surgery, variably referred to as lung reduction surgery, pneumectomy, and reduction pneumoplasty, can be accomplished through a variety of incisions (sternotomy, clam shell, thoracotomy) or by thoracoscopy using a staple procedure or laser applications. Currently, the choice of techniques depends on the surgical expertise and preference of the operator.

The first series of patients who were treated with pulmonary resection for emphysema was reported by Brantigan and Mueller in the late 1950s (1). It was postulated that multiple wedge excisions of emphysematous lung tissue would reduce lung volume and thereby improve outward elastic recoil and airway patency of the intrathoracic airways. The authors also believed that lung volume reduction would result in a less expanded thoracic cage and diaphragm and that this would improve the mechanical function of the muscles of respiration. Also, by removing localized emphysematous areas, lung expansion of previously compressed, more normal lung tissue would occur. While Brantigan and Mueller's surgical intervention in the 1950s resulted in clinical benefit to most of the patients studied, a prohibitively high rate of postoperative morbidity and mortality resulted in limited acceptance of this procedure. Recently, there has been a resurgence of interest in lung volume reduction surgery for emphysema. Taking advantage of advances in anesthesia and postoperative care over the past three decades, as well as lessons learned from the management of patients undergoing lung transplantation, Cooper *et al.* (2) has reintroduced bilateral surgical lung resection for severe emphysema. In addition, several centers have reported their results with unilateral and bilateral volume reduction surgery by thoracoscopy using laser technology or by stapled lung reduction techniques (3-7). At the present time, the number of operations being performed in this country is increasing in an uncontrolled fashion and may number in the thousands. There has been extensive lay and medical media coverage at the local and national level, though reports in the peer reviewed medical literature at the present time are limited. This has generated extraordinary physician and patient demand for information on the procedure and specific advice regarding the efficacy, safety, patient selection, and choice of a surgeon or hospital for such surgery.

WHAT IS THE EFFICACY OF THE SURGERY?

On the basis of results reported in peer review journals, abstracts, and presentations at national meetings, the procedure appears efficacious for some, but not all, patients with advanced COPD due to emphysema. Unfortunately, limited follow-up experience to date does not provide adequate patient selection criteria. Several centers have documented postoperative improvement in exer-

tional dyspnea, measurements of pulmonary function, exercise capacity, and objectively scored quality of life indices. Improvements in exercise capacity have been reported preoperatively in patients undergoing a comprehensive program of pulmonary rehabilitation in preparation for surgery. The first published paper (2) on simultaneous bilateral pneumectomy suggested that postoperative patients continue to improve up to six months. A follow-up series from the same institution (8) showed that the improvement can be sustained for up to 12 mo. Patients have been evaluated postbilateral pneumectomy beyond 1 yr, but most operations appear to have been done in an uncontrolled fashion. A small number of published reports are available regarding thoracoscopic lung reduction surgery for emphysema (3-7). Some have been criticized for having physiologic evaluation data for only a minority of patients treated. In all the studies, however, there was a small but significant improvement in airflow obstruction and a reduction of lung volume. It seems that the bilateral pneumectomy yields improvements in spirometry that are roughly twice as great as these unilateral procedures. In the one available randomized prospective trial of stapled lung reduction versus laser bullectomy (6), patients who received the latter procedure were more likely to develop delayed pneumothorax and less likely to eliminate dependency on supplemental oxygen. Also, the mean postoperative improvement in the FEV₁ at 6 mo was greater in those who received the stapled lung reduction technique (32.9% improvement) than in those who received the laser treatment (13.4% improvement).

WHAT ARE THE MECHANISMS OF EFFICACY?

This is an area of controversy, and it is under active investigation. Whether Brantigan and Mueller's original theory, which suggested that physiologic and clinical improvements were due to improved elastic recoil and efficiency of diaphragmatic and chest wall mechanical function, has not been proved. Another untested hypothesis is that improvement occurs due to enhanced right ventricular filling, with consequent enhancement of oxygen delivery.

IS THE OPERATION SAFE?

Initial enthusiasm for bilateral reduction surgery was diminished by reports of high morbidity and mortality. Of the centers reporting their results (probably a minority), mortality varied between 5 and 10%. The most common complication is persistent air leak, which may persist for several weeks and is at least 7 d in the majority of patients. Because these patients are often debilitated or have other medical illnesses, surgery has been accompanied by both respiratory and nonrespiratory complications, including pneumonia, sepsis, myocardial infarction, and stroke. Reported results suggest improved morbidity and mortality of the procedure as the surgeon and center gain more experience.

WHAT IS THE COST OF LUNG VOLUME REDUCTION SURGERY?

At the present time the ultimate cost is difficult to gauge as developmental costs and inefficiencies have not yet been eliminated.

Estimates of hospital charges range from \$35,000 to 70,000 per case (exclusive of physician charges and preoperative evaluation). Given the greater than 10 million patients in this country who have COPD, the cost for individual hospitals and the entire health care system and the impact on funding of other programs could be significant. In view of this, the Health Care Financing Administration (HCFA), which administers the federal insurance program for the elderly, decided that Medicare will no longer pay for lung volume reduction surgery. HCFA has recently recommended that a randomized clinical trial be conducted to evaluate the risks and benefits of this procedure.

HOW SHOULD POTENTIAL CANDIDATES FOR LUNG VOLUME REDUCTION BE EVALUATED?

As an innovative procedure, the preoperative assessment and criteria for surgery have been evolving and have varied from institution to institution. In general, the patient should have severe emphysema, disabling dyspnea, and evidence of severe air trapping. Advanced age (> 75 yr) and significant comorbid illness (cardiac, neurologic, etc.) have been considered contraindications to lung reduction surgery (Table 1). Extensive preoperative testing may significantly add to the cost, but it is currently justified by most centers as part of the investigational process (Table 2).

WHO SHOULD PERFORM LUNG VOLUME REDUCTION AND WHERE SHOULD IT BE PERFORMED?

Given the potential for high morbidity and mortality associated with lung volume reduction, we currently recommend that this procedure be performed by experienced thoracic surgeons in centers where 24-h cardiopulmonary anesthesia and respiratory care are available. Pulmonary rehabilitation should be mandatory in the preoperative and postoperative period. The effort should be multidisciplinary and involve respiratory physicians, thoracic surgeons, nurses, and respiratory care practitioners. At this point in time, the operation should not be considered experimental, although insufficient data are available to determine if lung volume reduction surgery should be considered standard therapy. Because there are many questions to be answered, we recommend that this operation be performed only at centers where these procedures can be more completely studied through clinical trials and extensive physiologic evaluations. These data should be collected either in a national registry or in local registries on every patient who has lung volume reduction surgery. Controlled clinical trials should be expeditiously organized to establish efficacy.

TABLE 1
INDICATIONS FOR SURGERY

Inclusion Criteria	Exclusion Criteria
End-stage emphysema, refractory to medical therapy	Age > 75 yrs
Severe dyspnea	Cigarette use within 3–6 months prior to surgery
FEV ₁ < 35% of predicted	Severe obesity or cachexia
Hyperinflated lungs by chest roentgenogram and body plethysmography	Severe comorbid illness, or rapidly fatal medical illness
Able to complete pre-operative pulmonary rehabilitation program	Severe pulmonary hypertension
	Inability to participate in rehabilitation
	Severe hypercapnia (Paco ₂ ≥ 50 mm Hg)
	Ventilator dependence

TABLE 2
REQUIRED SCREENING
LUNG VOLUME REDUCTION

Pulmonary evaluation	Cardiac evaluation
Pulmonary function testing including arterial blood gas and 6 min. walk test	Psycho-social evaluation
Body plethysmography	Others (to be considered)
Pulmonary exercise test	Dynamic MRI
Chest roentgenogram	PET scan
Hi-resolution CT scan/spiral CT	Sleep studies
V/Q lung scan	Pressure/volume studies

CONCLUSIONS

1. Lung volume reduction surgery appears to be helpful in some, but not in all, patients with advanced emphysema.
2. Because there are few published data on the indications, patient selection criteria, preoperative assessment, choice of surgical technique, and long-term efficacy, further investigation is necessary before definitive recommendations can be made.
3. The conduct of clinical trials, preferably in a controlled, randomized fashion, is urgently needed. At present it is recommended that lung volume reduction surgery be conducted in institutions where a multidisciplinary team, including pulmonologists and thoracic surgeons and a high level of diagnostic and surgical expertise, are available. The ATS encourages that surgery be done only on those patients who are part of carefully planned clinical trials with well-defined protocols and outcome measures that will determine the role of lung volume reduction surgery in the future. To achieve this end, it is recommended that funding be provided for multicenter clinical trials.

This position paper was developed by an Ad Hoc Committee of the Assemblies on Clinical Problems and Respiratory Structure and Function. Members of the Committee were:

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