



Lung Volume Reduction Surgery

A position statement of the Thoracic Society of Australia and New Zealand

G. I. Snell, Department of Respiratory Medicine, Alfred Hospital, Melbourne, Victoria
M. Peacock Department of Thoracic Surgery, Queen Elizabeth Hospital, Adelaide, South Australia
I. Garrett, Department of Respiratory Medicine, Green Lane Hospital, Auckland, New Zealand

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Abstract

Lung volume reduction surgery involves the removal of emphysematous lung tissue with the aim of palliating symptoms in selected patients with severe emphysema. This form of surgery is being practised in Australia with favourable short-term outcomes, similar to those reported in the literature. Large multicentre trials are currently underway in North America and the United Kingdom to clarify issues of safety and long-term efficacy. As a result, it is too early to apply an evidence-based approach to this procedure. In the meantime, local audits of practice need to be undertaken to define patient subgroups at higher risk of morbidity and mortality. (Intern Med J 200 1 ;31; 112-115)

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Correspondence to:
Dr G I Snell
Department of Respiratory Medicine
Alfred Hospital
Prahran VIC 3181
Email: g.snell@alfred.org.au



Overview

Lung volume reduction surgery (LVRS) is a general term encompassing a variety of surgical procedures that involve resection of lung tissue with the aim of reducing symptoms in patients with severe emphysema.

The first series of patients treated with pulmonary resection for emphysema was reported by Brantigan *et al.* in 1957.¹ He postulated that removal of the most diseased lung tissue would increase radial traction on small airways, reversing the collapsibility that had caused airflow obstruction and normalizing diaphragm and chest wall respiratory mechanics. The postoperative mortality rate was 18% and the patient's subjective benefits were not confirmed objectively. Consequently, the procedure was not widely accepted.

In 1995, following observations made in lung transplant surgery and taking advantage of developments in anaesthesia and postoperative care, Cooper *et al.* revitalized the concept of surgical treatment of non-bullous emphysema utilizing a linear stapler reinforced with bovine pericardial strips to avoid excessive airleaks.² Vigorous exclusion criteria were applied and a peri-operative rehabilitation programme was included to optimize fitness. His first 20 patients had a surprisingly large improvement in forced expiratory volume in (FEV₁) of 82% and no mortality.

Other centres have subsequently published their results using a variety of surgical techniques.³ These studies confirm the improvement in FEV₁ and patient quality of life (QOL) noted by Cooper *et al.*²

Although Cooper advised caution and suggested LVRS be restricted to specialized centres initially, early success led to a rapid rise in the number of operations performed at multiple sites across the USA. It has since become clear that LVRS can be complicated by serious morbidity and mortality.³ A review of Medicare (USA) billing in 1995 noted a mortality rate of 26%.⁴ As a result, Medicare (USA) funding was withdrawn for LVRS in 1996 and a large National Heart, Lung and Blood Institute multicentre randomized trial was proposed to compare LVRS with best practice.^{4,5} This 7-year trial has now commenced⁶ and other large national trials are underway in Canada⁷ and the United Kingdom. Three studies, including two short-term small randomized studies, have been recently reported comparing LVRS and medical therapy.⁸⁻¹⁰ Although not uniform in their analyses or results, these three studies tend to favour improvements in measures of pulmonary function and QOL in the LVRS group.

By the end of 2000, LVRS will have been performed on over 400 patients in more than 15 Australian centres from all mainland states.¹¹⁻¹³ A National Lung Volume Reduction Surgery Database has been established, in conjunction with the Royal Australasian

College of Surgeons' Australian Safety and Efficacy Register of New Interventional Procedures -Surgical (ASERNIP-S), and analysis will help to define selection criteria, outcomes and resource allocation.^{13,14}

To avoid a repeat of the experience in the USA, the Australian medical profession needs to review continually local results, follow closely the evolving literature and, if necessary, set minimal Australian standards of medical care and technical excellence. This position statement, and the recent ASERNIP-S LVRS Review,^{14, 15} reflect a commitment to that process.

Mechanisms Of Improvement In Respiratory Symptoms With LVRS

An enhanced understanding of the pathophysiological mechanisms altered through LVRS has much to tell us about lung diseases in general. Recent studies tend to confirm Brantigan's hypotheses.³ Scirba *et al.* have confirmed an improvement in elastic recoil following LVRS¹⁶ and others have shown an improvement in respiratory muscle performance.^{3, 5} The procedure may also act by improving



ventilation/perfusion matching, decreasing the effects of dynamic hyperinflation on the venous circulation or even by improving cardiac output.^{5,16}

Variations In LVRS Technique

Generally, LVRS programmes advocate a pulmonary rehabilitation programme preoperatively. Purported benefits include the optimization of physical condition and the opportunity for patient education. Although the limited evidence available suggests that LVRS is complementary to pulmonary rehabilitation alone,^{2,17} patients may derive sufficient benefit from the pulmonary rehabilitation to forgo or defer surgery.

Different surgical approaches to LVRS have been used. There is general agreement that maximal benefit is obtained by operating on both lungs simultaneously using some form of reinforced excision-stapling technique.^{3, 5} Initial experience revealed that the unilateral operation afforded half the improvement, with the same risk of early mortality and an increased risk of late mortality,⁵ but recent studies have found no difference in survival outcomes between the procedures.¹⁸ Reinforcement material is expensive and its value in reducing air leaks has still to be determined. There seems to be no significant difference in clinical outcomes using midline sternotomy, bilateral thoracotomy or thoracoscopic techniques.^{5,15} Operator experience with any given approach appears to be the most important factor.

The limited Australian experience so far reveals that most units are performing bilateral LVRS using a stapling technique.¹³ Open¹¹ and thoracoscopic¹² techniques are practised equally.¹³

Expected Outcomes Of LVRS

Based on results reported in peer-reviewed journals, abstracts and presentations at international meetings, the procedure appears efficacious for some, but not all, patients with advanced chronic obstructive pulmonary disease due to emphysema.^{3,5,15}

Perioperative mortality should vary between 5 and 15%, depending on case selection and centre expertise. Causes of morbidity include respiratory failure, sepsis, persistent intercostal catheter drainage, late pneumothorax, atrial dysrhythmias and myocardial infarction.¹⁻¹² In a recent large series, mortality approached 30% at 3 years post-procedure.¹⁸

Two to 6 months following bilateral LVRS, an improvement in FEV₁ and the 6-min walk test of approximately 50% can be shown.³ Patient-reported dyspnoea, exercise tolerance and QOL improve similarly. The peak improvement in FEV₁ is noted after 6 months, with a variable decline back to baseline over the next 2-4 years.¹⁹⁻²¹ A small proportion of patients fail to improve lung function significantly.^{20, 21}

Selection And Assessment Of LVRS Candidates

Candidate selection will determine clinical and functional outcomes. Although trials have not been performed to compare different selection criteria, the literature allows some broad generalizations (Table 1).^{2,3,15} Certain preoperative variables, including a 6-min walk of less than 200 m, pCO₂ greater than 55 mmHg, gas transfer factor (DLCO) less than 30% predicted⁹ or pulmonary arterial hypertension, have been shown to portend a higher perioperative risk of morbidity and mortality. Advanced age (beyond 75 years), left ventricular impairment or significant coronary artery disease are also likely to define patients at higher risk.^{18,22}

Heterogeneous disease on nuclear ventilation perfusion scanning and chest computed tomography (CT) with clear-cut surgical 'target areas' at the apices or bases of the lungs, in the presence of gross hyperinflation, is associated with the greatest improvement in FEV₁ and symptom score.²³ In other words, the best results



are seen in hyperinflated patients, with some well-preserved areas of lung and well-defined destroyed emphysematous target areas. The role of LVRS in the treatment of patients with alpha-1-antitrypsin deficiency, uniformly diffuse emphysema or in patients without significant hyperinflation is controversial.¹⁵ It is not known which factors best predict the duration of improvement.²⁰

Assessment needs to include careful medical review of a potential candidate. Currently, the majority of patients referred do not meet selection criteria (Table I) and are rejected. The patient clearly needs to have a primary diagnosis of severe airflow obstruction secondary to emphysema. The extent and nature of the disease needs to be determined by detailed lung function tests, CT scanning and nuclear ventilation perfusion scans. Significant comorbidities, including cardiac disease, must be considered. Serious post-operative problems are not uncommon and careful explanation of the procedure and rehabilitation process is mandatory.⁵

Table 1 Suggested general inclusion and exclusion criteria for potential LVRS recipients

Inclusion criteria

- Emphysema, on optimal management
 - FEV₁ 15-40% predicted
 - RV > 150% predicted
- CT and V/Q scans show macroscopic target zones of particularly damaged lung suitable for resection
- Able to comply with rehabilitation programme

Exclusion criteria

- Unable/unwilling to exercise perioperatively, i.e. NYHA class IV, ventilator dependent
 - Age > 70 years
 - Previous thoracotomy/extensive pleural disease/pleurodesis
 - Intrinsic airway disease requiring prednisolone > 15 mg/day
 - Bronchiectasis
 - PCO₂ > 55 mmHg, pO₂ < 45 mmHg on air
 - Distance < 150 m in 6-min walk test
 - Pulmonary artery pressure > 50 mmHg (assessed on echodoppler)
 - DLCO < 30% predicted
 - Cigarette smoking in last 3 months
 - Other major organ dysfunction, i.e. significant coronary disease, CCF, cachexia, obesity etc.
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LVRS, lung volume reduction surgery; FEV₁ forced expiratory volume in 1 s; RV, residual volume; CT, computed tomography; V/Q, nuclear isotopic ventilation/perfusion scan; NYHA, New York Heart Association; DLCO, gas transfer factor; CCF, congestive cardiac failure.

Requirements For A LVRS Centre

Given the earlier comments, LVRS should only be practised in centres with access to specialist thoracic medical, surgical, anaesthetic and intensive care facilities with added expertise in pulmonary rehabilitation.^{5, 15,17}

Conclusion

Lung volume reduction surgery is still to establish its exact role in the management of severe emphysema and an evidence-based approach cannot be applied at this time. The recent ASERNIP-S review of LVRS has concluded that LVRS is an acceptable short-term treatment in highly selected cases, but longer follow up is needed to assess long-term outcomes.¹⁵ A Cochrane review on the subject preferred to await the results of the large randomized controlled trials in the USA, Canada and England before drawing any strong conclusions.^{6,7,24} While there are still many questions to be answered, the most important will be to define the subgroup who gain the greatest physiological improvement for the longest duration.^{15,21,24}

Audits of practice need to be undertaken to define patient subgroups at higher risk of morbidity and mortality. The National LVRS Database provides a mechanism to help answer some of these questions and aids in dissemination of information on



Australian and New Zealand clinical practice back to the profession.¹³⁻¹⁵ Open discussion and the opportunity to measure the experience carefully are both critical to the development of this new technology.

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