LVRS And Bullectomy

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Outline

History of Lung Surgery
Lung-Volume-Reduction Surgery
Overview of LVRS
  History
  Clinical Overview
  Mechanism
National Emphysema Treatment Trial
  Findings from NETT
Bronchoscopic Lung-Volume-Reduction Surgery
Bullectomy
History

Transverse sternotomy / Costochondrectomy
Stiff chest wall was thought to lead to emphysema so operations designed to increase movement of the thoracic cage
$\uparrow$VC(500–700 m)L and relief of dyspnea inconsistent results.

Thoracoplasty :-Shrink the chest
Pleurodesis Nourish the lung
Stabilize the airways –tracheal fixation & stents
History

Reduce bronchospasm/mucus secretion
  Sympathectomy
  Vagotomy
  Hilar denervation
Shrink the lung
  Phernectomy
  Radiation
Restore the curvature of diaphragm
  Pneumoperitonium
  Abdominal belts
Pneumoperitonium

22 patients
Emphysema, Chronic cough, Dulled mentality
1700-3000 cc air into peritoneal cavity
Refill, heliox q 2wks
13/22 subjective improvement
VC improved ~ 500 cc{ in 11/22}
↓RV , TLC

Carter et al NEJM 1950
LVRS- History

Otto Brantigan
56 patients, 1957-61, age 16-73 (58)
Staged thoracotomy + hilar dennervation
Subjective improvement in 75% of survivors
No physiologic measurements were taken
Mortality rate 16% immed. postoperative & 10% late
Selection criteria poorly described ? 16 yr emphysema

Otto Brantigan Am. Surgeon 1957
Brantigan hypothesized

- Relieves pressure on normal lung
- Restore shape of diaphragm
- Restores more negative pleural pressure
  - distends bronchi
  - ↑ venous return

Difficult to predict who will benefit from surgery

Brantigan *Am. Surgeon* 1957
Modern Era of LVRS-1995

B/L, LVRS, MS, 20 patients
FEV₁ 0.77 to 1.4L(82%, ↑)
FVC 2.2 to 2.8L(27%, ↑)
14/22 on O₂ to 2/15 at 3 mo
Mean TLC ↓(22%), RV ↓(39%)
Improvement in dyspnea, QOL score
No mortality
Mean LOS 15d (6-49d)
Air leak >7d in 11/20

cooper et al J. Thoracic cardiovasc surg. 1995
## Physiological outcome

<table>
<thead>
<tr>
<th>Physiologic measurement</th>
<th>Reported improv. after LVRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced vital capacity</td>
<td>15–49% increase</td>
</tr>
<tr>
<td>FEV1</td>
<td>20–80% increase</td>
</tr>
<tr>
<td>Total lung capacity</td>
<td>15–20% decrease</td>
</tr>
<tr>
<td>Residual volume</td>
<td>10–30% decrease</td>
</tr>
<tr>
<td>PaO2</td>
<td>10–24 mm Hg increase</td>
</tr>
<tr>
<td>6 minute walk distance</td>
<td>20–90% increase</td>
</tr>
<tr>
<td>Maximum oxygen consumption</td>
<td>5–30% increase</td>
</tr>
<tr>
<td>Dyspnea index</td>
<td>50–80% improvement</td>
</tr>
</tbody>
</table>
Suggested mechanism of benefit

- Improved respiratory function
- Lung recoil ↑
- Air way conductance ↑
- Resizing the lung to fit the chest
- Relieves "pulmonary tamponade."
  - improved cardiac function
  - increased exercise capacity
Mechanism of increase VC

- TLC
- Lung Volume
- Emphysema
- RV
- Normal

Pleural Pressure
Mechanism of increase VC

Lung Volume vs. Pleural Pressure

- Emphysema
- Targeted zones
- Homogenous
- Normal
Mechanism of increase VC

- Emphysema
- Targeted zones
- Homogenous
- Normal

VC after

VC before

Pleural Pressure

Lung Volume
DETERMINENTS OF INCREASE VC

Fraction of lung remove
Targeted zones
RV/TLC
Lung compliance
Inspiratory muscle function?
Indications for LVRS

- HRCT scan evidence of bilateral emphysema
- Severe nonreversible airflow obstruction FEV$_1$ 15 to 35% of predicted
- Evidence of hyperinflation and air trapping:
  - TLC $>$ 100% of predicted & RV $>$ 150% of predicted
  - HRCT: emphysematous lung changes and hyperinflation
- Marked restriction in daily activities
- Failure of maximal medical treatment
Contraindications

- Abnormal body weight (<70% or >130% of IBW)
- Coexisting major medical problems
- Significant cardiovascular disease
- Inability to participate in rehabilitation
- Unwillingness to accept the risk of morbidity and mortality of surgery
- Tobacco use within the last 6 months
- Recent or current diagnosis of malignancy
Contraindications

• Age >75 years
• Severe and refractory hypoxemia (Pao2/Fio2 ratio<150)
• Hypercapnic (PCO₂ >55mmHg)
• Ventilator-dependence
• Severe pulmonary hypertension (MPAP > 25 mm Hg)
• Psychosocial dysfunction
LVRS-PATIENT WORKUP

Severity and distribution of emphysema
Cxrav, HRCT chest, Quantitative ventilation/perfusion scan

Pulmonary function tests
Spirometry, Lung volume measurements, DLCO, ABG

Exercise test
6-minute walk test, Cardiopulmonary exercise test

Cardiac assessment.
EKG, echocardiogram, Dobutamine-radionuclide scan
Right and left heart catheterization (selected patients)
Surgical approaches

Median sternotomy with bilateral stapling resection
Video-assisted thoracoscopic surgery:
- U/L or B/L stapling lung resection
- U/L with laser ablation of emphysematous tissue
Goal targeted resection 30 to 40% emphysematous lung
Both leads to similar improvements in lung function and exercise capacity, though VATS may be associated with lower postoperative morbidity and mortality
Laser surgery is not recommended because of less satisfactory results than with stapled resection.
Typical hockey-stick-like staple lung volume reduction
Postoperative morbidity and mortality

<table>
<thead>
<tr>
<th>Complications</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air leak</td>
<td>68.0</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>14.0</td>
</tr>
<tr>
<td>Gastrointestinal complications</td>
<td>8.3</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>6.2</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>8.9</td>
</tr>
<tr>
<td>Heimlich valve at discharge</td>
<td>6.0</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Operative mortality

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory failure</td>
<td>2.0</td>
</tr>
<tr>
<td>Cardiac related</td>
<td>1.5</td>
</tr>
<tr>
<td>Sepsis</td>
<td>0.9</td>
</tr>
<tr>
<td>Multi-organ failure</td>
<td>1.2</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Has LVRS got Survival benefit?

LVRS group

Early mortality

Does it change natural H/O ds?
Durability of FEV$_1$ slope

Rate of decline in lung function after LVRS

- FEV$_1$
- COPD
- Normal
- FEV$_1$ slope
- LVRS
- Age

?
Why National Emphysema Treatment Trial was planned
What led to NETT

- Expensive procedure ~ 30000$
- Prevalent disease
- The surgical mortality 4 to 15%
- 1-year mortality 17%
- Review of Medicare claims: 6-mo. mortality 16.9%

Uncertainty about the risk of LVRS, the magnitude and duration of benefit, and optimal selection criteria led the NHLBI & HCFA to sponsor a MRCT-NETT (designed over a 1-year).

N Engl J Med 2001
NETT RESEARCH GROUP

Carried between January 1998 and July 2002
17 hospitals, data coordinating center JHSPH
Patients randomized to medical or surgery treatment
Data reviewed every 3 months- to find group most likely to benefit or likely to be harmed (30d mortality > 8 %)
Primary outcome variables mortality and exercise capacity
Secondary end points included quality of life, pulmonary function, 6-min walk distance

N Engl J Med 2001
3777 patients evaluated; 1218 underwent randomization
608 to surgery and 610 to medical therapy
580 (95.4 percent) underwent surgery
70 % MS & 30 % VATS
Prior to completion of the NETT, board identified a subset of patients who had very high mortality. **High-risk group:**
- FEV1 < 20%
- DLCO < 20%
- Homogenous emphysema
30 day mortality 16% (high-risk group) and constituted ~ 13% of NETT patients

* N Engl J Med 2001
Comparing LVRS with Medical Therapy
Effects on mortality

Overall mortality 0.11 death per person-year in both gr.
After excluding at high risk for death from surgery,
overall mortality in the surgery group was 0.09 death per person-year,
C/W 0.10 death per person-year in the medical-therapy group (RR 0.89; P=0.31)
No difference in mortality between the two groups
90-day mortality higher in the surgery (7.9% & 1.3 %)
similar among MS & VATS
No survival advantage over medical therapy

N Engl J Med 2003
Comparing LVRS with Medical Therapy
Magnitude and durability of benefits

Exercise capacity improved by $\geq 10$ W in 15% in LVRS group, C/W 3% in the medical-therapy group (P<0.001) at 24 months.

LVRS Improves exercise capacity, LFT, QOL & dyspnoea.
At 2yrs, LFT in survivors of surgery returned to baseline.

2 factors predicted different responses to LVRS:
1. Upper-lobe vs non-upper lobe distribution of emphysema
2. Low vs high exercise capacity

N Engl J Med 2003
Subgroups based on pattern of emphysema on CT & exercise capacity

High exercise capacity

Low exercise capacity

Upper lobe emphysema

↓ Mortality

↑ Exercise

↑ SGRQ

 ↔ Mortality

 ↑ Exercise

 ↑ SGRQ

Non-Upper lobe emphysema

 ↔ Mortality

 ↔ Exercise

 ↑ SGRQ

 ↑ Mortality

 ↓ Exercise

 ↔ SGRQ

N Engl J Med 2003
Comparing LVRS with Medical Therapy
Cost-effectiveness ratio

**Overall** C/W medical therapy (after excluding high risk gr.)
-$190,000 per quality-adjusted life-year gained at 3 years
$53,000 at 10 years

**Upper-lobe emphysema and low exercise capacity**
-$98,000 per quality-adjusted life-year gained at 3 years
and $21,000 at 10 years

Given its cost and benefits over 3yr of Fu, LVRS is costly relative to medical therapy
Bronchoscopic LVRS

Designed to reduce hyperinflation and obtain atelectasis of the most destroyed, functionless parts of the lungs
Safer alternatives to LVRS, in advanced disease
Occlusive stents /synthetic sealants with unidirectional- valves (silicon and nitilol)
Block segmental or subsegmental bronchi→
distal atelectasis & volume reduction
Clinical trial conducted in 8 centres worldwide
~70 patients have been treated

EDWARD P. Am J Respir Crit Care Med 2001
Matt Brenner, CHEST 2004
Bronchoscopic LVRS Procedure

Performed in OT under general anesthesia
Patient intubated and FB is advanced through ET
Target segmental bronchus is visualised and a guidewire is inserted into the operating channel of bronchoscope to reach the desired segment. Leaving the guidewire in place, the bronchoscope is withdrawn and the delivery catheter is passed on the guidewire. After the removal of the latter the valve is delivered.

EDWARD P. Am J Respir Crit Care Med 2001
Bronchoscopic LVRS

Between three and five valves
Postoperative hospital stay ~ 2 days
All show $\uparrow$ FEV$_1$ and $\downarrow$ RV
Improvement in dyspnoea score, supplemental O$_2$ requirement and quality of life

Complications
Pneumothoraces
Pneumonia in a non-treated lobe
Endobronchial blocker

Endobronchial valve

noncollapsible

collapsible

One-way valve with nitinol retainer
Bullae

**Bulla** :- markedly dilated air spaces within the lung parenchyma >1cm

**Bullae in emphysema**
Range from 1 to 4 cm in diameter
Upper lung zones
Etiology?
1. ball-valve mechanism
2. relatively lower blood flow to upper lung & presence pleural pressure gradient from apex to base, ↑ stress in the upper lung zones
Bullae

2:1 right-sided preponderance due to larger size of right lung
Basilar bullae in elderly nonsmokers R/O alpha1-protease inhibitor deficiency

**Giant bullae > 1/3 hemithorax**
Impairment of pulmonary function in giant bulla:-
Compression of underlying lung tissue
Lack of transmission of the respiration mechanics
Ventilation-perfusion mismatch
Indications for Bullectomy

- **Large bulla** occupying 30–50% of hemithorax, ↓ FEV1 and radiological signs of compression of normal lung

- **Complications arising in bullae:**
  - Hemoptysis
  - Complicated or repeated pneumothorax
  - Repeated infection.

Malignant degeneration of the bulla (nodular opacity, thickening of the bulla wall, and alteration in the bulla's appearance)
How Bullectomy Helps

- Allows expansion of underlying compressed lung
- Improve elastic lung recoil
- Decrease pulmonary vascular resistance

Who will benefit from bullectomy difficult to predict

INVESTIGATION

Objective

Size of bulla, extent of disease, underlying lung

CT is the most accurate in determining - size of bulla, compressed & normal underlying lung
Bullectomy - PATIENT WORKUP

Radioisotope ventilation lung scans → ventilatory defects are localized or diffuse

Single-breath DLCO → evaluate concomitant emphysema

Comparison of TLC measurements obtained by single-breath gas dilution and by body plethysmography → measures "trapped gas"

Serial Cxray and spirometry helps in judging whether compression of normal lung is responsible for current functional state or it represents progression of emphysema
Outcome of Bullectomy

In carefully selected patients outcomes appears to be good and durable in terms of symptom relief and improvement of pulmonary functions

FitzGerald et al

Followed 84 pat. who underwent bullectomy for 23yrs

• 2.1% operative deaths

• Significant ↑ FEV1 in those with bullae occupying >50% hemithorax without emphysema elsewhere

• Improvement in pulmonary function lasted for ~ 20 yrs
LVRS palliative Rx advanced symptomatic emphysema
Improve lung function, exercise capacity, and quality of life and dyspnea
High-risk group:-
  FEV1<20%, DLCO<20%, Homogenous emphysema
Predominantly upper-lobe emphysema and low exercise capacity had lower mortality and better functional status while non-upper-lobe emphysema and high exercise capacity had higher mortality
At 2yrs, LFT in survivors had returned to baseline
LVRS is costly relative to medical therapy