Surgical Management of Empysema

John A Odell MB ChB, FRCS(Ed), FACS
Emeritus Professor of Surgery Mayo Clinic College of Medicine
Previously Surgical Director Lung Transplantation
Problem case. How would you manage?

• 64yr male

• Previous RLL bullectomy.

• Recent left pneumothorax managed elsewhere with chest tube placement.

• Because of continued air-leak talc pleurodesis.

• Air-leak continues.
• On nasal oxygen. Dyspneic on walking
• Significant air-leak. More dyspneic when suction applied to chest drain.
• FEV1 40% predicted. DLCO 12% predicted.
Options?

- Thoracotomy and close air leak surgically
- Videothoracoscopy and closure of air-leak
- Thoracotomy and decortication
- Remove chest drain
- List for transplantation
Historical Treatment of Emphysema

- Abdominal compression belts. The stimulus was the observation that emphysematous patients lean forward when breathing.
- Pneumoperitoneum. In an attempt to restore diaphragmatic curvature.
- Lungs too large for the chest – costochondrectomy or transverse sternotomy to provide more room. Multiple wedge excisions.
- Chest grown too large – thoracoplasty
- Pleurodesis. Emphysema results from alveolar wall ischemia.
- Phrenectomy. Overvigerous inspiration was ripping alveolar walls.
- Hilar denervation. To decrease bronchoconstriction and mucous production mediated by the parasympathetic nervous system.
- Whole lung irradiation. To increase elastic recoil by inducing fibrosis.
Abb. 402. Fränkische Operation beim starr dilatierten Thorax.
Variants of Emphysema that may be Surgically Managed

- Congenital
  - Lobar emphysema
  - Bronchogenic cyst
- Post infectious bullous cavities
  - Tuberculosis
  - Staphlococcus
  - Bronchiolitis (Swyer-James)
- Emphysema associated with parenchymal lung disease
  - Birt-Hogg-Dube syndrome
  - Alpha one antitrypsin deficiency
  - Lymphangiosarcoma
  - “Undefined”
- Typical “COPD”
Congenital Lobar Emphysema
Post infectious
Post Tuberculosis Cavity
Large post TB Cavity Compressing RML + RLL
Cavitated PTB with Left pneumothorax
10/9/1984
Seven months treatment
Improvement on Right
Large cavities on Left
5/8/1985
Development large bullae
4/22/1989
Swyer-James syndrome
Swyer-James syndrome
Spontaneous Pneumothorax
What to look for

Familial History
- Birt-Hogg-Dube syndrome
- Alpha one antitrypsin deficiency
- Marfans syndrome
- Ehlers-Danlos syndrome

Female
- Catamenial pneumothorax
- Lymphangioleiomyomatosis (LAM)
Birt-Hogg-Dubé Syndrome

• Birt-Hogg-Dubé syndrome (BHD) is an autosomal dominant inherited disorder characterised by fibrofolliculomas, renal tumours, pulmonary cysts and pneumothorax. The pulmonary cysts and repeated episodes of pneumothorax are the clinical hallmarks for discovering families affected by the syndrome. This disorder is caused by mutations in the gene coding for folliculin (FLCN).
Bullous Emphysema
Surgical approaches

• Direct drainage


• Surgical excision
Monaldi technique

• Initially applied to management of post-tuberculosis cavities, then pyogenic abscess and later bullous disease.

• Done as a two-stage procedure.

• First stage was to obtain a pleurodesis with the extrapleural placement of an iodine soaked pack which was subsequently removed and the wound allowed to heal.

• Second stage – catheter insertion and suction.
20 patients. Median age 56yrs, median FEV1 740ml.

Technique. Limited thoracotomy centered at base of decompressed bulla. Bulla incised within two concentric prolene sutures. Talc instilled into bulla and pleural space. Folley placed into bulla, bulb inflated, concentric sutures tied. Foley pulled against chest wall. Intrapleural drain. Foley catheter removed at 8 days irrespective of residual air leak. Bronchocutaneous fistula usually closed spontaneously within 48hrs
Bullous Disease in association with generalized Emphysema

Described by Sir John Floyer as “cystic alterations in the lungs in broken winded horses.”

The cure of the broken wind cannot easily be projected any other way but by a paracentesis in the thorax, for if the external air be admitted, it will compress the flatulant tumor (bulla) and through the same hole a styptic and carminative hydromel (irritant) be injected, to restore by its stypicity the tone of the membranes and discuss by its aromatic acrimony the windy spirits or air retained in the lungs.

Floyer JA. A treatise of the asthma. 2nd Ed London 1717.
Results

- Three deaths, two respiratory failure (preop FEV1 220 and 350ml), one staphylococcal septicaemia.
- 22% median improvement in FEV1
- 11% median reduction in TLC
- Subjective improvement in all but one of the survivors
Infected giant bullae
Bullectomy for Symptomatic or Complicated Giant Lung Bullae

Pradheep Krishnamohan, MD, K. Robert Shen, MD, Dennis A. Wigle, MD, Mark S. Allen, MD, Francis C. Nichols, III, MD, Stephen D. Cassivi, MD, William S. Harmsen, MS, and Claude Deschamps, MD

Division of General Thoracic Surgery, Department of Surgery and Division of Biomedical Statistics and Informatics, Department of Health Sciences Research, Mayo Clinic, Rochester, Minnesota

**Background.** Giant bullae of the lung are rare. Little is known about functional results after surgical treatment.

**Methods.** This study retrospectively reviewed all patients who underwent surgical treatment for giant bullae between December 1988 and December 2010.

**Results.** There were 63 patients (51 men, 12 women) with a median age of 56 years (range, 26 to 85 years). Bullae were a median size of 14 cm (range, 9 to 30 cm). Forty-five patients (71%) had underlying diffuse emphysema. The indication for surgical intervention was symptoms alone in 30 patients (48%) and associated complications in 33 (52%). The operation was a bullectomy in 54 patients, lobectomy in 6, plication in 2, and bilobectomy in 1. Complications occurred in 27 patients (43%), and 2 patients (3.0%) died. At the last follow-up, 19 had died and 44 were alive. Of the 43 patients with shortness of breath preoperatively, 29 (67.4%) were improved. Thirty patients (46.1%) had preoperative and postoperative pulmonary function tests with improvement from a median forced expiratory volume in 1 second (FEV₁) of 1.0 L preoperatively to 1.4 L postoperatively ($p = 0.002$). Increasing bulla size ($p = 0.02$) and underlying emphysema ($p = 0.01$) were adversely associated with postoperative morbidity. Dyspnea improved in 21 of 33 patients (64%) with underlying diffuse emphysema compared with 5 of 7 patients (71%) without emphysema ($p = 0.70$).

**Conclusions.** Bullectomy improved pulmonary function in most patients with a symptomatic or complicated giant bulla, or both. However, increasing bulla size and underlying emphysema resulted in increased treatment morbidity. Underlying diffuse emphysema is not a contraindication to bullectomy.

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Lung Volume Reduction Surgery
Bilateral pneumectomy (volume reduction) for chronic obstructive pulmonary disease

We undertook surgical bilateral lung volume reduction in 20 patients with severe chronic obstructive pulmonary disease to relieve thoracic distention and improve respiratory mechanics. The operation, done through median sternotomy, involves excision of 20% to 30% of the volume of each lung. The most affected portions are excised with the use of a linear stapling device fitted with strips of bovine pericardium attached to both the anvil and the cartridge to buttress the staple lines and eliminate air leakage through the staple holes. Preoperative and postoperative assessment of results has included grading of dyspnea and quality of life, exercise performance, and objective measurements of lung function by spirometry and plethysmography. There has been no early or late mortality and no requirement for immediate postoperative ventilatory assistance. Follow-up ranges from 1 to 15 months (mean 6.4 months). The mean forced expiratory volume in 1 second has improved by 82% and the reduction in total lung capacity, residual volume, and trapped gas has been highly significant. These changes have been associated with marked relief of dyspnea and improvement in exercise tolerance and quality of life. Although the follow-up period is short, these preliminary results suggest that bilateral surgical volume reduction may be of significant value for selected patients with severe chronic obstructive pulmonary disease. (J THORAC CARDIOVASC SURG 1995;109:106-19)

J. D. Cooper, MD, E. P. Trulock, MD (by invitation), A. N. Triantafillou, MD (by invitation), G. A. Patterson, MD, M. S. Pohl, RN (by invitation), P. A. Deloney, RN (by invitation), R. S. Sundaresan, MD (by invitation), and C. L. Roper, MD, St. Louis, Mo.
Bilateral pneumectomy (volume reduction) for chronic obstructive pulmonary disease

Table III

<table>
<thead>
<tr>
<th></th>
<th>Before operation</th>
<th>After operation</th>
<th>Percent change</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV₁ in liters (% of predicted)</td>
<td>0.77 (25)</td>
<td>1.4 (44)</td>
<td>+82</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FVC in liters (% of predicted)</td>
<td>2.2 (56)</td>
<td>2.8 (73)</td>
<td>+27</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>TLC in liters (% of predicted)</td>
<td>8.5 (140)</td>
<td>6.6 (110)</td>
<td>−22</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RV in liters (% predicted)</td>
<td>5.9 (288)</td>
<td>3.6 (177)</td>
<td>−39</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Trapped gas in liters</td>
<td>2.4</td>
<td>1.2</td>
<td>−50</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PaO₂ in millimeters of mercury (room air)</td>
<td>64*</td>
<td>70</td>
<td></td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>PacO₂ in millimeters of mercury (room air)</td>
<td>40*</td>
<td>39</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
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FVC, Forced vital capacity; TLC, total lung capacity; RV, residual volume; NS, not significant.

*Two patients receiving oxygen excluded.
### Lung Volume Reduction Surgery
#### A Morbid Procedure

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative Mortality</td>
<td>4-17%</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>10-20%</td>
</tr>
<tr>
<td>Trach/reintubation</td>
<td>7-21%</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>10-20%</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>1-2%</td>
</tr>
<tr>
<td>Mean LOS</td>
<td>14-32 days</td>
</tr>
</tbody>
</table>
Initial Effects of LVRS which prompted the NETT trial

- No specific billing code. Billed by submitting preexisting non specific codes for multiple resections of lung tissue.
- In less than 18 months of the initial report >1200 LVRS procedures performed on Medicare beneficiaries.
- CMS (previously HCFA) learned from an internal claims review that mortality at 6 mths approached 17%
- In Dec 1995 CMS announced that Medicare would not pay for LVRS based on insufficient safety and efficacy. At the same time they announced sponsorship of the randomized controlled trial (NETT)
- AHRQ announced funding for a cost effectiveness analyses
- Washington University (Joel Cooper) withdrew on the grounds that such a trial was unethical given the obvious benefits. He likened the trial to: “hiding behind a scientific study to ration the procedure.”
Lung Volume Reduction Surgery – The NETT Trial

- LVRS vs Medical Rx
- NHLBI and HCFA collaborative funding with collaboration of The Agency for Healthcare Research and Quality (AHRQ)
- 17 centers, 1 statistical center
- Primary endpoint – survival, function
- Secondary endpoint – morbidity and patient selection.
3777 patients evaluated

2559 ineligible

1218 enrolled in NETT

610 Medical Treatment

608 Surgery

21 Declined, 7 unsuitable

580 LVRS

69 High-risk subset

511 Non high-risk LVRS
Surgical Approaches LVRS: Median Sternotomy vs VATS

• No difference in NETT data

• Improvement in pulmonary function may be better with Median sternotomy FEV1 58% vs 49%

• Weighted av mortality 1% with VATS; 4.4% with MS

• Length of stay VATS 12 day vs 15 days

Jb Shrager and LR Kaiser in Lung Volume Reduction Surgery for Emphysema pg 249 Marcel Dekker 2004
Advantages of Median Sternotomy

• Better able to visualize involved areas
• Able to combine with additional procedures ie. Remove small palpable nodules
• Current endoscopic staplers, due to limited “jaw opening,” tend to take less lung tissue
• Better able to assess and deal with air-leaks
Advantages of VATS LVRS

• If only unilateral LVRS indicated
• Prior contralateral surgery (lobectomy, LVRS, Lung Transplant
• Contralateral pleural disease (pleurodesis)
NETT Morbidity and Mortality

Pulmonary morbidity 29.8%
  Age
  FEV1
  DLCO

Cardiac morbidity 20.0%
  Age
  Constant O2 use
  Steroid use
  Non upper lobe

Operative mortality 5.5%
  Non upper lobe
Lung Volume Reduction Surgery
NETT Results: The take home message

- **High-risk Group** FEV1 and/or DLCO 20% and less – 16% 30 day mortality and with no meaningful benefit if survived.
- Pulmonary rehabilitation makes a difference
- No benefit for patients with lower zone emphysema
- Patients with upper lobe emphysema and poor exercise tolerance had improved survival, improved exercise capability through 3 years and improved symptoms through five years
- Patients with upper lobe emphysema and good exercise tolerance had no improved survival but had improved exercise capability and improved symptoms.
Complications of Lung Volume Reduction Surgery

- Major problem is air-leaks
  - 90% had air-leaks in NETT trial
  - Median air-leak duration 7 days
  - 12% had air-leaks for more than 30 days
- Risk of air-leak
  - Longer in white patients
  - Patients with lower FEV1 and DLCO
  - Inhaled steroids
  - Presence of upper lobe predominance
  - Presence of pleural adhesions
- No difference
  - Surgical approach
  - Surgical staplers or buttressing
- Higher rate of complications in those with air-leaks
- Longer hospital stay in those with air-leaks
Despite studies showing benefit from the procedure very few patients are offered the procedure

- 2004  254 Medicare patients
- 2005  120 Medicare patients
- 2006  105 Medicare patients
LVRS
Possible Reasons for underperformance of LVRS

- CMS restricting surgery to NETT trial centers, to lung transplant centers or JHACO-approved centers
- LVRS assessment perceived as too complicated
- Outpatient pulmonary rehabilitation programs have limited availability
- Ignorance concerning benefits of LVRS and what constitutes an appropriate patient
- The publication concerning high-risk patients erroneously misinterpreted that all patients having LVRS are at high-risk of death
- LVRS perceived as being too costly
- LVRS perceived as only of limited benefit
Severe Emphysema
Lung Volume Reduction Surgery and Transplantation

• LAS score and emphysema
• Can LVRS be considered as a bridge to transplantation?
• Does LVRS increase the morbidity and mortality of transplantation?
Lung Allocation Score (LAS)

- Implemented 2005
- Algorithm that incorporates clinical variables predictive of time that patient will live without a transplant and the additional length of time the patient is predicted to live following a lung transplant
- Goals
  - Reduce the number of deaths on the waiting list
  - Increase the benefit to the transplanted patient
  - Insure the efficient and equitable allocation of lungs to active transplant patients
Schematic of transplant benefit. The area under the curve (left panel) depicts wait list survival, a measure of transplant urgency. The area under the curve (middle panel) depicts post transplant survival, a measure of projected post transplant survival. The difference between the two curves (right panel) is the transplant benefit. Modified from Egan et al.
Lung Allocation Score (LAS)

- **Group A**
  - COPD
  - LAM
  - Bronchiectasis
  - Sarcoidosis with PA press <30 mmHg

- **Group B**
  - PPH
  - Eisenmengers syndrome
  - Other pulmonary vascular diseases

- **Group C**
  - Cystic fibrosis
  - Immunodeficiency disorders

- **Group D**
  - IPF
  - Pulmonary fibrosis due to other causes
  - Sarcoidosis with PA press >30 mmHg
  - Obliterative bronchiolitis (non retransplant)
DECEASED DONOR LUNG AND HEART-LUNG TRANSPLANTS: 5/4/04-5/3/10
By Diagnosis Grouping

% of Transplants

A B C D

28
14
52

43
15
37

47
15
34

48
13
35

51
13
32

52
12
30
SUMMARY – TRANSPLANT

• The percentage of lungs transplanted has increased from pre- to post-LAS.

• There was a huge increase in the number of transplants from pre-LAS to post-LAS. There was also a large increase in transplants during the most recent complete year.

• There has been a substantial shift in the distribution of diagnosis from pre-LAS (>50% group A) to post-LAS (>50% group D).

• Post-transplant survival is comparable pre- and post-LAS, overall and by diagnosis grouping.
Lung Allocation Score (LAS)

Effects of system

- Post transplant mortality may increase because surgery preferentially performed on sicker patients
  - Third-party payer contracts based on survival criteria

- Mean LAS scores increasing
  - Relatively fixed number of donor lungs
  - Pts previously considered too ill to accumulate time are now being considered for transplantation
Lung Transplant Patient Survival
Transplant Date Between 6/6/2001 and 6/7/2011

Survival %

Years

COPD
IPF
Lung Transplant Patient Survival

Transplant Date Between 6/6/2001 and 6/7/2011

Survival %

Years

Double Lung Transplant
Single Lung Transplant
Lung Transplant Patient Survival COPD/Emphysema

Transplant Date Between 6/7/2001 and 6/7/2011

Double Lung Transplant
Single Lung Transplant
LUNG ANALYSIS

Left Total Counts : 188220.000000
Right Total Counts: 523235.000000

SEGMENTAL

LUL (%) : 49.874600
LLL (%) : 50.125400
RUL (%) : 52.939100
RLL (%) : 47.060900

TOTAL

Left Lung (%) : 26.455600
Right Lung (%) : 73.544400
Lung Transplant Patient Survival - IPF

Transplant Date Between 6/7/2001 and 6/7/2011

Survival % vs. Years

- Blue line: Double Lung Transplant
- Red line: Single Lung Transplant

p value = 0.2636
LVRS and Transplantation

  - Post op bleeding and dialysis higher
  - 5 year survival not different
Newer Approaches

“Heterogeneous” disease
- Bronchial blockers
- 1-way valves
- Glue (Also blood patches)
- Bronchoscopic Thermal Vapor Ablation (BTVA)
- Coils

“Homogeneous” disease
- Transbronchial decompression
- Percutaneous Lung Decompression
Emphasis 2001

New Emphasis
VENT study
Endobronchial *Valving for Emphysema Palliation* Trial

977 patients screened
321 randomized (not blinded)

• 220 endobronchial valving (6 did not get procedure)
• 101 medical therapy

• 6 deaths in EBV group none in controls (p=0.19)
• 4.2% major complications in EBV vs 0% control (p=0.06) (Haemoptysis and hospitalized exacerbations)
• 20% in EBV and 25% controls lost to follow up

Sciurba NEJM 2010
VENT study

Reached primary efficacy endpoints. Mild improvements in FEV1 and 6MWD.

Risk vs benefit highly questionable

Sciurba NEJM 2010
Spiration Valve
Bronchoscopic Thermal Vapor Evaporation

- Thermal energy induces injury to diseased lung tissue
- Inflammatory response/fibrosis resulting in overall volume reduction of treated lobe

Utilizes thermal vapor (heated water) to achieve lung volume reduction
BTVA Phase 1 Clinical Trial

- Unilateral upper lobe
- 11 patients
- Target Vapor Dose = 5 cal/g
Change in PFT’s from Baseline at Six Months

FEV1  +4%
RV    -0.4%
DLCO  +18%
Radiographic Evidence of LVR

All pts had measurable volume loss (CT analysis) \textit{in treated lobe (mean 22\%)}
BTVA Phase 2 study

- 44 patients
- Unilateral BTVA
- At 6 months
  - FEV1 +161 ml (+15%)
  - RV -406 ml
  - SGRQ improved 14.0 points
  - 6MWD +46.5m

Snell et al ERJ 2012
Bronchoscopic LVRS with coils

PneumRx coils
Bronchoscopic LVRS with coils

- Phase 2 study of 16 emphysematous patients
- 12 bilateral RUL and LUL
- 2 RUL only 2 LUL only
- Median 10 coils per lobe
- No deaths
- Lots of AE’s all “manageable”

Slebos et al Chest 2012
Multiple coils
Coils: Efficacy

Slebos et al Chest 2012
Radiofrequency catheter (Bronchus Tech) creates passages from segmental bronchi into adjacent parenchyma plus insertion of 3 expandable 1.5cm x 3mm stents
Alfred Pilot study: Results

- 8-11 stents placed in each patient plus instillation of mitomycin C
- Procedure time ~ 2 hours
- All four patients discharged day after procedure
- No major complications
- One case of mild bleeding, resolved on suction
Alfred Pilot study: Results

• FEV1 improved 33% at day one but back to baseline at 12 weeks
• RV decreased 23% at day one but back to baseline at 12 weeks
EASE trial

- 315 patients (1522 assessed)
- Patient 2:1 Active vs Sham
- Up to 6 3mm Airway fenestrations with stenting
- Deaths 6 in active vs 4 in sham with trend to slightly more AE’s in active group

Shah Lancet 2011
Ease Trial

- Small effect but only short lived
- As consequence not FDA approved
PORTAERO PNEUMOSTOMA
FEV1 IMPROVEMENT

NETT LVRS (BL) - 35%
Uptake BTVA (UL) - 13%
Aeris (BL) - 15%
Emphasys (UL) - 7%
Spiration (UL) - 4%

*Clinically Meaningful Improvement
Emphysema Conclusions

• Bullous lung disease responds often to surgery
• Patients at high risk, or those with disease involving more than upper zones, who are fit should be offered transplantation
• LVRS in appropriate patients as definitive therapy or as a bridge to transplantation
• New, bronchoscopic techniques currently have a limited role
• Unfortunately, in the vast majority of patients, therapeutic options, including surgery are limited