Lung resection

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In Ramathibodi hospital (1983-1997, N= 20)

• Indication for lung resection
  – Congenital cystic disease 45%
  – Persistent pneumonia and/or atelectasis with bronchiectasis 25%
  – Lung abscess 20%
  – Abnormal mass with recurrent hemoptysis 10%
Lung resection

- **Pneumonectomy:** Surgical removal of an entire lung
- **Lobectomy:** Surgical excision of a lobe
- **Segmentectomy:** Surgical excision of segment of lung
- **Wedge resection:** A surgical procedure to remove a triangle-shaped slice of tissue. It may be used to remove a tumor and a small amount of normal tissue around it
Preoperative evaluation

- Pulmonary function
- Calculation of predicted postoperative pulmonary function
- Measurement of gas exchange
- Exercise testing
Pulmonary function test

- FEV$_1$ $<60\%$predicted was strongest predictor of postoperative complication
- DLCO
Current guidelines

- Preoperative FEV$_1$ >80% predicted can tolerate pneumonectomy
- Exertional dyspnea or coexistent interstitial lung disease → DLCO
- Preoperative FEV$_1$ and DLCO > 80% predicted → not need further testing

Predicted postoperative PFTs

• Combination of Preoperative spirometry and quantitative perfusion lung scanning to estimate the degree of functional loss
Predicted postoperative PFTs

- $FVC_c = FVC_{\text{preop}} \times S \times \frac{5.26}{100}$

$FVC_c = FVC$ calculated
$FVC_{\text{preop}} = FVC$ pre operation
$S = \text{segment left}$
Predicted postoperative PFTs

- $FVCA = 0.109 + 1.185FVC_c$
  ($R^2 = 91.30\%, p < 0.0001$)
- $FEV_{1a} = 0.006 + 1.138FEV_{1c}$
  ($R^2 = 87.97\%, p < 0.0001$)
- $FEF_{25-75a} = -0.186 + 1.053FEF_{25-75\%}$
  ($R^2 = 70.32\%, p < 0.0001$)

Current guidelines

• Increased risk for lung resection with predicted postoperative values for either \( \text{FEV}_1 \) or \( \text{DLCO} \) < 40% predicted

• Preoperative exercise testing is recommended

Gas exchange

- $P_aO_2$; not important predictor of postoperative complication
- $P_aCO_2$; not correlate with postoperative complication

Cardiopulmonary exercise testing (CPET)

- Correlate with postoperative complication
- Maximal oxygen consumption ($\text{VO}_2\text{max}$)
- $\text{VO}_2\text{max} < 15\text{ml/kg/min}$ or $< 50\%$ predicted $\rightarrow$ correlated with postop complication$^1$

Current guidelines

• $\text{VO}_2 \text{ max} < 10 \text{ ml/kg/min}$

or

• $\text{VO}_2 \text{ max} < 15\text{ml/kg/min}$ and both predicted postoperative FEV$_1$ and DLCO < 40% predicted

→ increase risk of perioperative death and complication

Physiology of lung resection

Postoperative lung resection
Postoperative lung resection

Insert ICD?
Postoperative lung resection

Pleurocentesis?
Anatomic changes

- **Immediately:**
  - air fills the space previously occupied by lung
  - Chest tube is not inserted

- **Over time:**
  - Elevation of hemidiaphragm, hyperinflation of the remaining lung and shifting of mediastinum to postpneumonectomy space (PPS)
  - Fluid accumulating in PPS (2 rib space per day)
Anatomic changes

- Complete opacification of hemithorax after pneumonectomy (3wks-7mo)
  - Unexpected rapid accumulation of fluid
  - Hemorrhage, infection or chylothorax
  - Vital organs shifted position
Anatomic changes

Day 1
Day 2
Day 14
Day 30

Early mortality

- 30 days mortality 2.4–11.6%
- Risk factors for early mortality
  - Right-sided pneumonectomy
  - Specific type of surgical resection
  - Underlying disease
  - Emergency surgery
  - The level of experience of surgeon
Postoperative pulmonary outcome

- FEV$_1$, FVC are decreased
- DLCO is decreased but normal corrected DLCO/lung volume ratio
- Lung compliance is decreased, airway resistance is increased
- Arterial oxygen saturation, PO$_2$, PCO$_2$ not changed
Postoperative cardiovascular outcome

- Right pneumonectomy
  - Rt. ventricular end diastolic volume is low but left ventricular function is normal
- Left pneumonectomy
  - Opposite Rt. pneumonectomy

Postoperative quality of life

- Quality of life scores (pain, physical function and dyspnea) decrease after pneumonectomy
- Lobectomy and wedge resection are normal

Postoperative complication

- Hemorrhage complication
- Cardiac complications
- Pulmonary complications
Postoperative complication

- Hemorrhage complication:
  - Inadequate hemostasis of the bronchial artery or a systemic vessel in the chest wall
  - Infrequently, slipping of a ligature or an unrecognized injury is a cause
  - Bleeding related to coagulation is rare
- Re-exploration is indicated if
  - failed response to blood replacement
  - a large amount of blood in the hemithorax
  - persistent massive bleeding from the chest tube
Postoperative complication

• Cardiac complications:
  – arrhythmias, cardiac herniation, cardiac temponade

• Pulmonary complications
Postoperative pulmonary complication

- Early complications:
  - Pulmonary edema, ARDS
  - Bronchopleural fistula
  - Postpneumonectomy empyema
  - Pneumonia of contralateral lung
- Late complications:
  - Postpneumonectomy syndrome
  - Late onset bronchopleural fistula
  - Infections
Postpneumonectomy pulmonary oedema (PPO)

- Incidence ~5% but high mortality >50%
- Histopathology:
  - First 5 days: endothelial integrity lost with extravasation of fluid, protein and inflammatory cells into alveolar spaces
  - First few days: marked proliferation of fibroblasts and type II pneumocytes
  - After 10 days: interstitial and intraalveolar fibrosis, thrombotic and obliteratorive change

Postpneumonectomy pulmonary oedema (PPO)

Postpneumonectomy pulmonary oedema (PPO)

- Risk factors;
  - Fluid balance?
Postpneumonectomy pulmonary oedema (PPO)

• A dog pneumonectomy model:
  – Higher fluid input and urine output not developing PPO if left heart filling pressure remained normal

• An intraoperative fluid input > 2L → risk of PPO

“Increased infusion of fluids in high permeability patients may be relevant in exacerbating or prolonging the clinical condition”

Postpneumonectomy pulmonary oedema (PPO)

- Risk factors;
  - Fluid balance?
  - Surgical technique?
    - Degree of parenchymal injury → inflammatory reaction
    - Duration of surgery → does not be implicated

Postpneumonectomy pulmonary oedema (PPO)

- Risk factors:
  - Fluid balance
  - Surgical technique
  - Tidal volume ventilation
    - Low tidal volume pressure limited technique can improve outcome
  - Age and preoperative lung function
    - Not correlate
Postpneumonectomy empyema

- Early empyema; 10–14 days after surgery, associated with bronchopleural fistula or and esophagopleural fistula
- Late empyema; more than 3 months, infection (via hematogenous route)
  - *S. aureus* and *P. aeruginosa* are common
Postpneumonectomy pulmonary oedema (PPO)

- Onset: 1-3 days postoperative
- Clinical presentation: same as pulmonary edema, ARDS
- May be difficult to differentiate between PPO and pneumonia

Postpneumonectomy pulmonary oedema (PPO)

- Pathophysiology:
  - Panendothelial inflammatory vascular injury → release of inflammatory mediators
  - Vasoconstrictor endothelins (ETs) lead to pulmonary vascular remodelling → pulm. HT
  - Others; vascular obstruction and positive pressure ventilation

Pulmonary vascular control

Postpneumonectomy syndrome (PPS)


**Table 1—Effect of Correction of PPS on Pulmonary Function and Bronchial Diameter**

<table>
<thead>
<tr>
<th>Patient</th>
<th>PEFR</th>
<th>FEV1/FVC</th>
<th>Bronchial Diameter*</th>
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<td>1</td>
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<td>20</td>
<td>300</td>
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<td>2</td>
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<td>2</td>
<td>100</td>
</tr>
<tr>
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<td>43</td>
<td>22</td>
<td>0</td>
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<tr>
<td>5</td>
<td>45</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>44.2</td>
<td>13.2</td>
<td>133.4</td>
</tr>
</tbody>
</table>

*Bronchial diameter was calculated from CT scan.
Postpneumonectomy syndrome (PPS)

- Extrinsic compression of distal trachea and mainstem bronchus
  - Left (right) PPS: (counter) clockwise rotation of great vessels and trachea → compression of right (left) main bronchus and right (left) pulmonary artery
- Shifting of the mediastinum and hyperinflation of remaining lung

Postpneumonectomy syndrome (PPS)

- Occur more than 6 months following surgery
- Progressive dyspnea, cough, inspiratory stridor and recurrent pneumonia
- PFTs: obstructive pattern
  (bronchial obstruction leads to decrease in flow rate and air trapping)
- Diagnosis: CXR, CT chest and awake fiberoptic bronchoscope

Postpneumonectomy syndrome (PPS)

- Surgical repositioning of mediastinum and filling of PPS with a non absorbable material
  - Saline solution-filled prosthesis and anterior pericardiorrhaphy
- Early diagnosis and treatment of PPS should prevent tracheobronchomalacia

Postpneumonectomy syndrome
Postpneumonectomy syndrome