Imaging the Post-Operative Thorax:
Complications of Lung and Esophagus Surgery

Jeffrey Alpert, M.D.
Tuesday, March 17th
2:00pm

Disclosures:
• No relationships to disclose.

Objectives:
• Review anticipated postsurgical anatomy following common thoracic surgery.
  – Limited lung resection
  – Pneumonectomy
• Discuss postsurgical complications of thoracotomy in early and late settings.
  – Lung
  – Esophagus

Lung resection:
• Indications:
  – Bronchogenic carcinoma
  – Advanced emphysema
  – Bronchiectasis
  – Trauma

Lung resection:
Bronchogenic carcinoma
• Lobectomy remains standard of care: early stage NSCLC
• Sublobar resection:
  – Traditionally used for high-risk patients
  – Used more frequently
  – Popular topic of debate

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Kilic et al. 2009
5 year study; stage I; elderly (>75)
78 106 46 47

Prospective clinical trial:
• Efficacy of sublobar lung resection for small peripheral tumors
  NCT00499330

Lung resection:
Bronchogenic carcinoma
• Sublobar resection
• Lobectomy
• Pneumonectomy
  – Multilobar
  – Central disease

Lung resection:
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Prospective clinical trial:
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Partial lung resection:

- **Goals:**
  - Adequate treatment
  - Preservation of lung function

- **Procedure:**
  - Non-anatomic wedge resection
  - Segmentectomy
  - Lobectomy

- **Technique:**
  - Thoracoscopy
  - Thoracotomy

- **Determination:**
  - Extent of disease
  - Location
  - Clinical status

Partial lung resection:

- **Wedge:**
  - U-shaped or V-shaped non-anatomic resection
  - Segmental bronchus/artery typically remain, distorted

- **Segmentectomy:**
  - Segmental bronchus/artery ligated and transected

- **Lobectomy:**
  - Lobar bronchus/artery ligated and transected
  - Lobe removed with pleura
  - Additional staple lines for incomplete interlobar fissures

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Partial lung resection:

- Sleeve lobectomy:
  - Central endobronchial disease
  - Technique:
    - En-bloc lung resection with common airway
    - End-to-end airway anastomosis
    - Reinforcement with pleura or omentum
  - RUL resection (75%): bronchus intermedius

Pneumonectomy:

- Intrapleural:
  - Lung and visceral pleura

- Extrapleural:
  - All surrounding pleura, pericardium and diaphragm
    - Locally advanced carcinoma, mesothelioma, invasive thymoma

- Intrapericardial:
  - Incision of pericardial sac for resection of tumor

- Sleeve:
  - Lung, mainstem bronchus, carina with anastomosis of contralateral mainstem bronchus to distal trachea
Post-pneumonectomy changes:

### Pneumonectomy:

<table>
<thead>
<tr>
<th>Study</th>
<th>Time (years)</th>
<th>NSCLC patients (n=)</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
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<td>Dancewicz, et al.</td>
<td>4</td>
<td>121</td>
<td>30.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Alloubi, et al.</td>
<td>5</td>
<td>168</td>
<td>41.6</td>
<td>4.2</td>
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<tr>
<td>Algar, et al.</td>
<td>12</td>
<td>242</td>
<td>59</td>
<td>5.4</td>
</tr>
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<td>Licker, et al.</td>
<td>10</td>
<td>193</td>
<td>47</td>
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<td>Marret, et al.</td>
<td>5</td>
<td>129</td>
<td>42.6</td>
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### Postoperative complications:

#### Early complications:
- Pulmonary edema
- Acute lung injury (ALI)/Acute respiratory distress syndrome (ARDS)
- Pneumonia
- Hemorrhage/Hemothorax
- Chylothorax
- Dehiscence of bronchial stump, formation of bronchopleural fistula
- Esophagopleural fistula
- Empyema
- Lobar torsion
- Cardiac herniation
- Gossypiboma

#### Late complications:
- Pneumonia
- Disease recurrence (tumor, infection)
- Dehiscence of bronchial stump, formation of bronchopleural fistula
- Esophagopleural fistula
- Empyema
- Stricture of bronchial anastomosis
- Pulmonary artery stump thrombosis
- Postpneumonectomy syndrome
- Herniation of lung or chest wall soft tissues via thoracotomy defect
- Gossypiboma

**Prospective 5-year observational study:**

- 604 lung cancer surgery patients
- Incidence 3.6%
- Mortality 31.8%
- Multi-variate analysis: Higher risk with
  - Predicted post-op FEV1 <50%
  - Re-intubation
  - BMI <25.5

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**Pneumonectomy:**

**Postoperative complications:**

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**Early complications:**

- Incidence: 3.3-25%
**Early complications:**

**Pneumonia**
- Inability to clear secretions, aspiration
- Colonization of atelectatic lung
- Compounded by mechanical ventilation during and after surgery
- Delayed imaging findings
- Nonspecific imaging findings

**Postpneumonectomy pulmonary edema**
- Rapidly occurring in perioperative, early postop
- Prevalence: 2.5-5%  Mortality: >80%
- Etiology:
  - Increased hydrostatic pressure to remaining lung (R>L)
  - Non-cardiogenic: incr permeability of capillary endothelial-alveolar barrier from vasoactive inflammatory mediators (histology resembling ARDS)
  - Perioperative fluid admin, transfusion of blood products

**Acute lung injury (ALI) / Acute respiratory distress syndrome (ARDS)**
- PaO2/FIO2: <300 mmHg
- PaO2/FIO2: <200 mmHg
**Early complications:**
**ALI/ARDS**

- Incidence: 2.5-5%
  - Dulu et al. Chest 2006;130:73-78.
  - Retrospective study: 2000+ pts, 2 yrs, tertiary care center
  - Overall incidence: 2.5%:
    - Pneumonectomy pts: 7.9% (10/126)
    - Lobectomy pts: 3% (3/1047)
    - Mean time to presentation: 4 days
- Mortality >70%
- High-permeability pulmonary edema → hypoxemia
- Etiology:
  - Activation of inflammatory cytokines?
  - Perioperative fluid administration?
  - Re-oxygenation injury in cases of lobectomy?

**Bronchopleural fistula:**

- Early or late complication
- Dehiscence of bronchial stump
- Incidence: 5% following pneumonectomy
  - Sleeve pneumo: incidence 15%, mortality 50%.
- Mortality: 25%, aspiration of pleural contents, hemorrhage
- Predisposition to pleural infection → empyema
**Bronchopleural fistula**

**Causative factors:**
  - Multi-variate analysis of >2300 pts >30 years
  - Diabetes, preoperative radiation, residual malignancy
  - Postoperative mechanical ventilation
- Right pneumonectomy: higher likelihood
  - Large caliber airway
  - Bronchial stump diameter >25mm conveys higher risk of BPF
  - Shorter stump length
  - Single bronchial artery supply
- Late postoperative period:
  - Recurrent malignancy
  - Infection

**Empyema:**

**Early or late complication**
**Overall incidence:** 2-7.5%
**Associated with dehiscence of bronchial stump in 75-80%
**Risk factors:**
- Preoperative radiation tx
- Right pneumonectomy
- Completion pneumonectomy
- Postoperative mechanical ventilation
**When not associated with airway dehiscence:**
- Gross contamination of surgical field
  - Residual infection
  - Intra-thoracic lymph node dissection
- Hematogenous spread of infection

**Empyema: Treatment strategies**

- Drainage with closed-tube thoracostomy
- Obliteration of pleural space: thoracoplasty
- Modified Clagett procedure
  - Three-part procedure
- Eloesser flap

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<td>Inverted U-shaped chest wall flap</td>
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<td>Empyema entered, evacuated</td>
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<td>Irrigation of pleural space with abx</td>
<td>Flap tucked into thoracostomy space, sutured</td>
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<tr>
<td>Closure of chest wall</td>
<td>Permanent open drainage</td>
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<td>90% success rate</td>
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**Early complications:**

**Hemothorax**
- Uncommon: <1%
- Injury to pulmonary, bronchial, internal mammary, intercostal vessels
- Friable vessels: infection, malignancy, radiation
- Coagulopathy
- Rapidly accumulating fluid, rapid clinical deterioration

**Chylothorax**
- Uncommon: <1%
- Injury to thoracic duct
  - Dissection of subaortic region, inferior right paravertebral region
- Low-pressure system
  - Slow fluid accumulation
- Variable fluid density: fat, protein

24 hours later: Dropping H/H. Large hemothorax found in OR.

**Lobar torsion**
- Incidence: 0.2%
- RML | LUL |
- Air, fluid in pleural space: decreased resistance of movement
- Rotation around bronchovascular pedicle
  - Obstructed airflow: hypoxia
  - Obstructed pulmonary arterial inflow: ischemia
  - Obstructed venous outflow: hemorrhagic infarction
- Rapid clinical deterioration (incl. fever, WBC)
- Mean time to diagnosis: 6-10 days
- Bronchoscopy; Urgent surgery

Right pneumonectomy

48 hours later
Postoperative complications:

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Late complications:

- Predictable anatomic changes
- Lobectomy:
  - Volume loss
  - Diaphragm elevation
  - Ipsilateral shift
- Pneumonectomy:
  - Fluid filled hemithorax
  - Fluid resorption, thickened pleura
  - Small stable air at apex
Late complications: Postpneumonectomy syndrome

- Anatomic changes → functional impairment
- Children, young adults, women
- Right > left

Late complications: Postpneumonectomy syndrome

- Airway compression:
  - Stridor
  - Impaired clearance
  - Promotes tracheo/bronchomalacia
- Treatment:
  - Surgical repositioning of mediastinum
  - Expandable prostheses
  - Fast and long-lasting relief

Late complications: Pulmonary artery stump thrombosis

- Often encountered incidentally
  - Retrospective study: 89 postpneumonectomy pts
    - 12.4% affected pts
    - Both convex and concave margins
    - Right = left stumps equally affected
    - Longer stump length: significant factor
    - Two year follow-up: no propagation
Late complications:
Pulmonary artery stump thrombosis

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Late complications:
Gossypiboma

- Retained surgical material
  - Often within pleural space
- Aseptic foreign-body reaction
  - Fibroblast proliferation, encapsulation
  - Nidus for infection
- Recognition challenging
  - Radiodense fibers
  - Sutures, abandoned leads, overlying leads, pleural plaque

Summary:

- Lung resection
  - Indications: Bronchogenic carcinoma
  - Limited non-anatomic resection → pneumonectomy
- Postsurgical complications: early and late
  - Early complications:
    - Pulmonary edema, ALI/ARDS, pneumonia
    - Hemorrhage, Lobar torsion
- Late complications:
  - Related to resultant anatomic changes
  - Postpneumonectomy syndrome, PA stump thrombus
- BPF and empyema: serious complications in both early and late settings

Questions?

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