Surgical treatment of empyema in children

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Pleural space

Function of the pleural fluid

• Guarantees a close apposition of the visceral and pleural membranes to ensure efficient mechanical coupling between the lung and chest wall.
• Frictionless sliding during breathing.
• Pleural fluid must be kept down to a minimum for effective coupling.
• Maintain a negative intrapleural pressure ( -6 cm to -9cm H₂O)
• Oligolamellar surfactant molecules stratified on top of microvilli are comparable to the best commercially available lubricants.

The forces governing pleural fluid turnover

- **Starling forces** through the mesothelium and the adjacent connective tissue capillaries,
- **Lymphatic drainage** through the parietal pleura stomata,
- **Mesothelial cells**
  - Metabolically active cells
  - Possess all the features required for active transerosal transport

Starling’s Law of transcapillary exchange:

\[ F = k[(P_{\text{cap}} - P_{\text{pl}}) - s(P_{\text{cap}} - P_{\text{pl}})] \]

- \( F \) = net fluid movement;
- \( k \) = filtration coefficient (a measure of membrane "leakiness");
- \( P_{\text{cap}} \) and \( P_{\text{pl}} \) = hydrostatic pressure in systemic capillaries and the pleural space
- \( s \) = the osmotic reflection coefficient for protein;
- \( P_{\text{cap}} \) and \( P_{\text{pl}} \) = the oncotic pressure in systemic capillaries and the pleural space
The forces governing pleural fluid turnover

1. Hydrostatic pressure (top value)
2. Oncotic pressure (bottom value)
3. Lymphatic drainage
4. Electrolyte coupled flow
5. Vesicular flow

Lymphatic control of pleural effusion

Lymphatic control of pleural effusion

• Pleural fluid production can increase at least 30-fold before overwhelming the lymphatic absorptive capacity.

Etiology of empyema

Complication from:

- Pneumonia
- Aspiration pneumonia
- Lung abscess
- Subdiaphragmatic abcess
- Post-thoracotomy

Etiology of Empyema

Predisposing conditions:

• Cerebral palsy
• Immunosuppression
• Congenital heart disease
• Prematurity
• Poor nutrition

Etiology of empyema

Offending organisms:

- Staphylococcus areus
- Streptococcus pneumonia
- Haemophylus Influenza
- Klebsiella, Pseudomonas
- Anaerobic
- Tuberculosis

Pathophysiology of pleural empyema

- Exudative stage
- Fibropurulent stage
- Organising stage
Three stages in the evolution of a pleural empyema

• *Exudative stage*
  – Fluid with a relatively low-cell count and low viscosity collects in the pleural space
  – Secondary to increased interstitial fluid or
  – Increased permeability of the visceral pleura.
  – Simple parapneumonic effusion
  – Normal pH and glucose level.
Three stages in the evolution of a pleural empyema

- **Fibrinopurulent stage**
  - Neutrophils and fibrin accumulate in the effusion;
  - Fluid pH and glucose fall,
  - Lactic dehydrogenase (LDH) rises.
  - Effusion becomes purulent and viscous with continued accumulation of neutrophils and fibrin
  - Empyema
  - Loculation of fluid
  - Compression of the lung.
Three stages in the evolution of a pleural empyema

• *Organizing stage*
  – Fibroblast activity on both pleural surfaces
  – Fibrous inelastic capsule (*Pleural peel or rind*)
  – Prevents the lung from expanding
  – Prevents the entry of antimicrobial drugs into the pleural space
  – May lead to emergence of organisms resistant to antimicrobial therapy.
Symptoms

- Fever
- Cough
- Sputum production,
- Dyspnea
- Chest pain
Diagnosis

• **CXR**
  – Lung disease, pleural effusions, air-fluid levels

• **Ultrasound**
  – Fluid collections, loculations
  – Density of fluid
  – Can guide thoracenteses

• **CT-chest**
  – Show entire pleura (post, ant, lateral, recesses)
  – Location and character of pleural fluid
  – Underlying lung parenchymal disease
  – Chest tube position
  – Can guide thoracentesis

• **Fluid aspiration, closed chest drainage**
  – Diagnostic and therapeutic
<table>
<thead>
<tr>
<th>Light Classification</th>
<th>Characteristics</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Small</td>
<td>No thoracentesis necessary</td>
</tr>
<tr>
<td>Nonsignificant</td>
<td>≤10 mm thick on decubitus radiograph</td>
<td>Antibiotic therapy</td>
</tr>
<tr>
<td>Parapneumonic effusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 2</td>
<td>&gt;10 mm thick</td>
<td>Antibiotics alone</td>
</tr>
<tr>
<td>Typical Parapneumonic effusion</td>
<td>Glucose &gt;40 mg/dL, pH &gt; 7.20</td>
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<tr>
<td>Gram stain and culture negative</td>
<td></td>
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</tr>
<tr>
<td>Class 3</td>
<td>7.00 &lt; pH &lt; 7.20 and/or LDH &gt; 1000 and glucose &gt;40 mg/dL.</td>
<td>Antibiotics plus serial thoracentesis</td>
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<tr>
<td>Borderline complicated Parapneumonic effusion</td>
<td>Gram stain and culture negative</td>
<td></td>
</tr>
<tr>
<td>Class 4</td>
<td>pH &lt; 7.00 and/or glucose &lt;40 mg/dL and/or gram stain or culture positive</td>
<td>Tube thoracostomy plus antibiotics</td>
</tr>
<tr>
<td>Simple complicated Parapneumonic effusion</td>
<td>Not loculated not frank pus</td>
<td></td>
</tr>
<tr>
<td>Class 5</td>
<td>pH &lt; 7.00 and/or glucose &lt;40 mg/dL and/or gram stain or culture positive</td>
<td>Tube thoracostomy plus thrombolytics (rarely require thoracoscopy or decortication)</td>
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<tr>
<td>Complex complicated Parapneumonic effusion</td>
<td>Multiloculated</td>
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<tr>
<td>Class 6</td>
<td>Frank pus present</td>
<td>Tube thoracostomy with/without decortication</td>
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<tr>
<td>Simple empyema</td>
<td>Single loculus or free flowing</td>
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<tr>
<td>Class 7</td>
<td>Frank pus present</td>
<td>Tube thoracostomy plus thrombolytics</td>
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<td>Complex empyema</td>
<td>Multiple loculi</td>
<td>Often require thoracoscopy or decortication</td>
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"And yet surely empyema is a disease which should vitally concern both physician and surgeon and which, almost more than any other, demands a close liaison between the two."
Pre-Antibiotic era (1938)

<table>
<thead>
<tr>
<th>Age</th>
<th>Conservative</th>
<th>Mortality per cent.</th>
<th>Radical</th>
<th>Mortality per cent.</th>
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<tbody>
<tr>
<td>Under 2 years</td>
<td>54</td>
<td>57.4</td>
<td>35</td>
<td>37.1</td>
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<tr>
<td>2–5 years</td>
<td>49</td>
<td>16.3</td>
<td>116</td>
<td>13.8</td>
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<tr>
<td>5–12 years</td>
<td>23</td>
<td>Nil</td>
<td>71</td>
<td>4.2</td>
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<tr>
<td>Totals</td>
<td>126</td>
<td>30.9</td>
<td>222</td>
<td>14.9</td>
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</table>
Treatment

Uncomplicated parapneumonic effusion (classes 1 and 2)

• Appropriate antibiotics (Augmentin, Cefuroxime, Clindamycin, Cloxacillin)
• Symptomatic treatment of hypoxia, fever, and pain
• Closed chest drainage
• Response is usually excellent, with resolution of fever, pain, and oxygen requirement.
Treatment

Complex stage (loculated, will not resolve with antibiotics and chest tube drainage alone)

- Thrombolytic therapy tPA (Alteplase)
  - Expensive (R8000 per vial)
  - Intrapleural instillation 2-3 times per day for 3 days (R30 000)
- VATS (Thoracoscopic drainage)
- Thoracotomy
# Tygerberg Children's Hospital Data

Jan 2005- Sept 2014 (Age 0-12yrs)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>N=375</th>
<th>%</th>
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<tbody>
<tr>
<td>Mediastinal lymph node enucleation</td>
<td>130</td>
<td>35</td>
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<tr>
<td>Open lung biopsy</td>
<td>54</td>
<td>14</td>
</tr>
<tr>
<td>Lobectomy</td>
<td>43</td>
<td>12</td>
</tr>
<tr>
<td>Pneumonectomy</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Aortopexy</td>
<td>39</td>
<td>10</td>
</tr>
<tr>
<td>Tracheal resection</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Double aortic arch</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Empyema drainage and removal of fibrinous peel</td>
<td>48</td>
<td>12</td>
</tr>
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<td>Excision mediastinal tumor or cyst</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Diaphragm plication</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Tracheo-esophageal fistula repair</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Diaphragmatic hernia repair</td>
<td>5</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Staph septiceamia with complicated empyema
Staph septicemia with complicated empyema
Complicated empyema
Thoracotomy for organised empyema
Fibrinous peel entrapping the lung
Removing fibrinous peel from lung
Removing fibrinous peel from lung
Large amount of fibrinous material removed from pleural space and freeing the lung
Post- surgery CXR

Pre-op

Post-op
Chest wall abscess
Empyema

- 10 month old child presents with pneumonia. Was treated with oral antibiotics. Seven days later swinging fever, toxically ill.

- CXR
- CT scan
- Bronchoscopy
  - Twig removed from distal right lower lobe bronchus

- Thoractomy
  - ++Pus in pleural space
  - Laceration in lung where twig perforated the lung, creating a bronchopleural fistula
• 10 month old child presents with pneumonia
• Treated with oral antibiotics.
• Seven days later swinging fever, tachypneic, very ill.
Empyema with air-fluid levels

Treatment algorithm for pediatric thoracic empyema. CXR indicates chest x-ray film; F/U, follow-up; TTD, thoracostomy tube drainage; CT, computed tomography; UK, urokinase; VATD, video-assisted thoracoscopic debridement.
Thank you