Chest Tube Thoracostomy

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Anatomy and Physiology of the Pleural Space.

• Visceral and Parietal pleura
  – Single layer of mesothelium

• Blood supply
  – Parietal pleura $\rightarrow$ intercostal vessels
  – Visceral pleura $\rightarrow$ pulmonary a. & v. and bronchial a.

• Lymphatic drainage
  – Drain into thoracic duct via intercostal and mediastinal lymphnodes
Pleural fluid

- **3 SOURCES**
  - Parietal capillaries
  - Visceral capillaries
  - Interstitium

**Stomas**
Drainage about 20 ml of pleural fluid /hr (hemithorax)

Net driving force
- 6 cmH2O
- 0 H2O cmH2O
Starling law of fluid movement

\[ \text{Net filtration rate} = K \left[ \left( P_c - P_i \right) - \left( \pi_c - \pi_i \right) \right] \]

where \( P_c \) = the hydrostatic pressure of intracapillary fluid  
\( \pi_c \) = the oncotic pressure of intracapillary fluid  
\( P_i \) and \( \pi_i \) = the same quantities for interstitial fluid  
\( K \) = a constant expressing how readily fluid can move across capillaries (essentially the reciprocal of the resistance to fluid flow through the capillary wall)
Drainage system

- **Trap bottle**: Collect the pleural fluid
- **Water-seal bottle**: Prevents air from returning to the pleural space
- **Manometer bottle**: Generate a negative pressure
Drainage system

To help remove air from the pleural space, but not to exceed -20 cm suction, attached to Wall Suction:

Chest Drainage Unit

Filtered room air is drawn into the Suction Control Chamber to ensure that the amount of suction does not exceed 20 cm.

-20

-20

-20

Suction Control Chamber

Water Seal Chamber

Fluid Collection Chambers

chamber for additional fluid drainage

chamber for additional fluid drainage

Blood/Fluid drained from the patient’s pleural space:

Air evacuated from the patient’s pleural space:

Air drawn from room to maintain added suction at 20 cm

Sterile saline or Sterile water
Indication

• Pneumothorax
  – defined as air that has entered the pleural space.
    • Spontaneous ➔ (consider needle aspiration)
    • result of traumatic tears in the pleura after chest injury after invasive procedures.

If the pneumothorax is small, and the patient is not mechanically ventilated, the pneumothorax can be observed.

If the pneumothorax is large, or the patient is mechanically ventilated, a chest tube should be placed.
Indication

- **Tension pneumothorax**  
  - emergent and immediate treatment

- mediastinum is shifted toward the contralateral side.
- Hypoventilation of contralateral compressed lung
- Decrease venous return (compress great vessels)
- Flatten diaphragm
Immediate large-bore needle decompression.

After decompression (conversion to a simple pneumothorax), the catheter is left in until a tube thoracostomy has been placed.
Pleural effusion

• In ICU
  – Pneumonia
  – complication of mechanical ventilation
  – Heart failure
  – Atelectasis
  – Hypoalbuminemia
  – liver disease

<table>
<thead>
<tr>
<th>Pleural fluid</th>
<th>PF/serum protein ratio</th>
<th>PF/serum LD ratio</th>
<th>PF LD (U/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transudative</td>
<td>&lt; 0.5</td>
<td>&lt; 0.6</td>
<td>&lt; 2/3 URL</td>
</tr>
<tr>
<td>Exudative*</td>
<td>≥ 0.5</td>
<td>≥ 0.6</td>
<td>≥ 2/3 URL</td>
</tr>
</tbody>
</table>

*Effusions are identified as exudative if one or more conditions are met.
LD – lactate dehydrogenase; PF – pleural fluid; URL – upper reference limit of serum LD.

Light Criteria

Negative Predictive Value 96%
Sensitivity 98%
Evaluation of a parapneumonic effusion or empyema

- initial therapeutic thoracentesis
  - Gram stain and culture
  - analysis of leukocyte
  - lactate dehydrogenase, glucose, and pH levels.

- Risk of poor prognosis from the pleural fluid include

  • +ve gram stain or culture
  • Glucose < 60 mg/dl
  • LDH > 3X of UNL of serum
  • pH < 7.20

### Table 1. Findings of pleural fluid analysis in parapneumonic effusions.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Uncomplicated parapneumonic effusion</th>
<th>Complicated parapneumonic effusion</th>
<th>Empyema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Slightly turbid</td>
<td>Cloudy</td>
<td>Pus</td>
</tr>
<tr>
<td>Biochemistry values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>&gt;7.30</td>
<td>&lt;7.20</td>
<td>NA</td>
</tr>
<tr>
<td>Glucose level, mg/dL</td>
<td>&gt;60</td>
<td>&lt;40</td>
<td></td>
</tr>
<tr>
<td>Ratio of pleural fluid to serum glucose</td>
<td>&gt;0.5</td>
<td>&lt;0.5</td>
<td>NA</td>
</tr>
<tr>
<td>Lactate dehydrogenase level, U/L</td>
<td>&lt;700</td>
<td>&gt;1000</td>
<td>NA</td>
</tr>
<tr>
<td>Polymorphonuclear leukocyte count, cells/µL</td>
<td>&lt;15,000</td>
<td>&gt;25,000</td>
<td>NA</td>
</tr>
<tr>
<td>Microbiologic test result</td>
<td>Negative</td>
<td>May be positive</td>
<td>May be positive</td>
</tr>
</tbody>
</table>

NOTE. NA, not applicable.
Stages of Empyema Thoracis

Stages:
- Exudative Stage
- Fibropurulent Stage
- Late Organizational Stage

Flowchart:
1. Aspiration of bacteria from oropharynx
   - ~ 2-7 days
2. Pneumonia
   - (periphery/dependent lobes)
   - ~ 2-5 days
3. Uncomplicated PPE
   - ~ 5-10 days
4. Complicated PPE
   - ~ 10-21 days
5. Empyema

Presence of pus
Development of loculation
Lung entrapment
Flow rate = \( \frac{\pi}{128} \frac{D^4 \Delta P}{\eta L} \)

- \( D \): Diameter
- \( \Delta P \): Pressure difference
- \( \eta \): Viscosity
- \( L \): Length
Technique Insertion

• Before procedure
  – Mild sedation and anxiolytic
  – IV access
  – Adequate coagulation
    • Platelet >50,000 , INR < 1.5
Technique Insertion

- **Position “Safe triangle”**

  minimizes risk to underlying structures

  such as the internal mammary artery and avoids damage to muscle and breast tissue

  Head elevate 30 degree
Technique Insertion

1- to 1.5-cm incision is made parallel to the rib and down to the subcutaneous fat at the lower border of the rib space.

Right hand opens and closes the instrument,

Left hand is placed close to the tip to prevent plunging into the chest,

Gentle forward pressure toward the upper border of the rib.
Technique Insertion

When possible, a gloved finger should be inserted into the chest cavity to ensure there are no adhesions between the lung and the chest wall.

When the intercostal muscle has been dissected, the pleura is entered.

There is a rush of air or fluid.
Technique Insertion

A closed clamp may be passed through the distal hole and out the end of the tube to facilitate placement.

The tube can then be passed over the clamp in a Seldinger-type technique.

OR

place the tube in the clamp prior to insertion into the chest. The tube should be positioned against the outside curve of the clamp.
The tube should be connected to the tubing in a sterile fashion.

The clamp can then be removed.
Suturing

Pursestring suture and sandal tie.

Mattress stitch

Surgical half hitch
Summary
Prophylactic antibiotic

• Non trauma
  – No data to support

• Trauma
  – The incidence of empyema ranges between 0% and 18%
    • decreased with the use of prophylactic antibiotics.
    • Administration of antibiotics for longer than 24 hours does not reduce this risk further.
Management of Thoracostomy Tubes

• ICU with positive pressure ventilation
  – a chest tube should be assessed as frequently as any vital sign,

• CXR
  – should be obtained immediately and reviewed after procedure
  – should be done every day for as long as the tube is in place.
Air leak (Bubbling) Assessment

Try differential clamp

When the bubbling stop ➔ leakage occur between clamp and the patient

Don’t forget to remove clamp !!!!!
Management of air leak

- **Dry suction system**
- **Water seal system**

“Conversion from suction to water seal”

Subcutaneous emphysema

The tube should be placed back to suction (usually 20 cm H2O), and a chest radiograph should be immediately obtained.

DRAINS SHOULD ALWAYS "SWING"

- **If not:**
  - **OUT OF PLEURAL SPACE**
    - Check CXR / Wound / CT
  - **BLOCKED**
    - 3-way tap turned off
    - Check not kinked by stitch / gauze / dressing
      - Flush . . . UNDER ASEPTIC TECHNIQUE
  - **ON SUCTION** (for pneumothoraces)
    - Disconnect briefly to assess

- Or the lung is up . . . And the drain is squashed
Routine milking and stripping of chest tubes

• The data do not support routine milking and stripping unless there is clot in the tubing.
Tubing position

Dependent loop ➔ Not adequate drainage
Removal of chest tube

- Drainage < 2ml/kg/day, no air leak for 24 hr

- Non-functioning chest tube. ➔ should be removed.

- Clamping a chest drain before removal
  – clamping followed by chest film may help determine if the patient is likely to develop a pneumothorax after removal.

- Obtaining a chest film after removal of a chest tube within 3 hours
Analgesia before chest tube removal

- Morphine 4 mg IV (20 min. before chest tube removal)
- Ketorolac 30 mg IV (60 min. before chest tube removal)

Either of these regimens was found to reduce pain substantially during chest tube removal without causing adverse sedative effects.
Chest drain removal
End inspiration VS End expiration

Removal of the chest tube must be timed with the breathing pattern of the patient.

The reason some advocate end inspiration is the patient may gasp from the pain and may be more likely to suck in air through the site.

A similar rate of post removal pneumothorax was found. Both methods were found to be safe.
Chest drain removal
Closing

• If sutures were placed
  – they are tied down.

• If no sutures were placed
  – an occlusive dressing must be made with 4 × 4 dressings and tape and petroleum jelly gauze.
Complication

- improper positioning
- Bleeding
- nerve damage
- injury to diaphragm or abdominal organs
- mechanical problems
- pain
- bronchopleural fistula.
Complication

• Reexpansion pulmonary edema
  – Rare but potential lethal (about 20% mortality rate)
  – Symptom
    • Onset immediate or can be delay to 24 hr
    • Severe coughing
    • Tachypneic, tachycardic and hypoxia
    • Rarely, bilateral or contralateral edema develops.

Table 3 Multivariate analysis of factors contributing to RPE

<table>
<thead>
<tr>
<th>Factor</th>
<th>OR</th>
<th>95% CI for OR</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleural effusion</td>
<td>1.557</td>
<td>1.290-1.880</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Size of pneumothorax</td>
<td>1.004</td>
<td>1.000-1.008</td>
<td>0.004</td>
</tr>
<tr>
<td>Duration of symptoms</td>
<td>0.996</td>
<td>0.980-1.011</td>
<td>0.610</td>
</tr>
</tbody>
</table>

OR, odds ratio; 95% CI, 95% confidence intervals; RPE, reexpansion pulmonary edema.

REPE (Reexpansion pulmonary edema)

Pulmonary collapse (typically 3-7 days) → Pulmonary reexpansion

Decrease in surfactant & Regional tissue hypoxemia

Mechanical alveolar injury
- Changes in alveolar-capillary barrier
- Polymorphonuclear cell migration
- Increases in: NO, IL-8, MCP-1, Free radicals

Injury to capillary wall with associated increase in capillary permeability

Rapid reestablishment of regional blood flow & Rapid alveolar reexpansion

Increase in pulmonary capillary pressure and hydrostatic pressure

Reexpansion pulmonary edema

REPE relate pneumothorax

• Average 14 days with minimum 3 days.
• Severity of pneumothorax more than duration
• No REPE in small pneumothorax < 30%

• Prevention
  – Not too much negative pressure
  – Small bore (either 14F or 16-22 F)
  – Water seal system
Treatment of REPE

- Oxygenation
- a low threshold for mechanical ventilation with positive end-expiratory pressure
- Diuresis
- hemodynamic support.

- Reexpansion pulmonary edema usually resolves in 24 to 72 hours.
• The use of ultrasound or CT guidance for loculate pleural effusion
  – (Specific success rate 92%)
Reference

Thank you