UV Light Wand for Elimination of Bacteria Found in Pediatric Endotracheal Tubes

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Problem Statement

• Ventilator Associated Pneumonia (VAP) is the second most common infection acquired by patients in the pediatric ICU
• 20% of nosocomial infections in the PICU can be identified as VAP
• Need a more efficient way to clear bacteria from pediatric endotracheal tubes to prevent VAP
Effects of VAP

**Cause of VAP**
- Extended mechanical ventilation

**VAP**
- Bacterial build-up in endotracheal tube

**Effects of VAP**
- 4 Day Extension of hospital stay
- Increased cost of care ($40,000 per patient)
- Increased mortality rate
Silver Nitrate Coated Endotracheal Tubes Reduce but Do Not Eliminate Bacterial Colonies

• **STUDY:**
  ▫ 12 of 21 bacteria populations the silver coated endotracheal tubes reduced bacterial counts
  ▫ 7 the counts stayed constant
  ▫ 2 (specifically *Enterobacter aerogenes* and *Enterobacter cloacae*) the colony count rose

• A more effective method of eliminating bacteria is necessary

UV Light Effectively Eliminates Bacterial Colonies Present in VAP

• *E. coli* is generally representative of a wide range of Gram negative bacteria

• High intensity UV light of wavelength 200-300 nm causes effective inactivation of the bacteria

• Maximum inactivation of *E. coli* occurs at 270 nm

Primary Objective

- **Design** a device using UV technology to reduce the occurrence of VAP in pediatric patients
Secondary Goals

- **Device goals**
  - Effectively kill bacteria
  - Fit through a 3mm diameter pediatric endotracheal tube
- Build a prototype of the device
- Test prototype to determine safety (Amount of UV light allowed to escape from the endotracheal tube) and efficacy against bacteria
Solution Description

- UV light source connected to fiber optic cables
- UV light, through fiber optics, irradiates endotracheal tube
- Irradiation kills the bacteria in the tube
- Silver tube lining used to protect patient from UV radiation
Solution Description

UV Light Source

Fiber Optic Cables

Metal Cap
Performance Criteria for Solution

• Time constraint for design and prototype completion - 5 months

• Cost and Reusability Constraints- protective sheath on any device desirable for efficiency

• Compatibility constraint
  ▫ Solution must be suitable for pediatric applications

• Effectively eliminate bacteria
Pediatric Endotracheal Tubes- 3 mm diameter

<table>
<thead>
<tr>
<th>Age group</th>
<th>Internal diameter of endotracheal tube</th>
<th>Suction cannula</th>
<th>Laryngoscope blade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm</td>
<td>2.5-3.0</td>
<td>4-5 fr</td>
<td>0</td>
</tr>
<tr>
<td>Newborn</td>
<td>3.0</td>
<td>6 fr</td>
<td>0</td>
</tr>
<tr>
<td>1-6 months</td>
<td>3.5</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>6-12 months</td>
<td>3.5-4.0</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>12-24 months</td>
<td>4.0-4.5</td>
<td>8</td>
<td>1-2</td>
</tr>
<tr>
<td>3-4 years</td>
<td>4.5-5.0</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>5-6 years</td>
<td>5.0-5.5</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>7-8 years</td>
<td>5.5-6.0</td>
<td>10</td>
<td>2-3</td>
</tr>
<tr>
<td>9-10 years</td>
<td>6.0-6.5</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>11-12 years</td>
<td>6.5-7.0</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>
Possible Materials

- UV light source - Water sterilization system (SteriPEN $80 at Bass Pro Shop)
- Pediatric Endotracheal Tubes
- Fiber optic cables - side glow and UV light compatible
Performance Metrics

- Success determined by:
  - Size appropriate prototype completed
  - Photodetector indicates no UV light escaping from the endotracheal tube
  - Bacterial cultures eliminated
## Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Supplier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Silver Lined Endotracheal Tubes</td>
<td>$20 each</td>
<td>To be determined</td>
<td>Silver nanoparticle lined endotracheal tubes.</td>
</tr>
<tr>
<td>2 Small UV light emitter</td>
<td>$100 each</td>
<td>Bass Pro Shops</td>
<td>UV light emitter designed for water purification. To expose inside of tube to kill bacteria.</td>
</tr>
<tr>
<td>Fiberoptic Cables</td>
<td>$150</td>
<td>To be determined</td>
<td>Purpose is to transmit light from UV light emitter down endotracheal tube</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>$430</strong></td>
<td></td>
<td>Budget subject to change as project progresses</td>
</tr>
</tbody>
</table>
Future Work

• Order/purchase materials for prototype
• Locate UV light detector
• Identify and obtain fiber optic cables
• Build prototype