Reduction of Total and Viable Air Particles in the OR Setting by using Ultraviolet In-room Air Disinfection and Recirculation Units

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November 4th, 2017
Disclosures

• This study was funded by Aerobiotix (Miamisburg, OH)

• Author disclosures can be found on the AAOS Website, aaos.com/disclosures
Airborne bacteria are a major cause of surgical site contamination [1,2].

Sources:
- OR staff
  - Shed 10,000 viable organisms/min [3]
- Door Openings
  - Primary TJA average 60 door openings [4]
  - Defeats positive-pressure 40% of the time [5]

Reducing airborne bioburden is critical for infection prevention.
T1 Crystalline Ultraviolet C (C-UVC) disinfection-recirculation unit

- Aerobiotix, Miamisburg, OH
  - 450 ft$^3$ of air/minute
  - HEPA filter
  - C-UVC radiation

Questions

1. Can the C-UVC unit reduce air particulate caused by OR traffic?

2. Does placement of the C-UVC unit within the OR affect its efficacy?
Methods

• **BioTrak Real-Time Viable Particle Counter** (TSI, Shoreview, MN)
  - Laser-Induced Fluorescence
  - Developed for biological warfare
  - Used in pharmaceutical ultraclean rooms
Methods

- **30 experiments**
  - Empty, + Pressure OR
  - Control vs. 4 m
  - 4 m vs. 8 m
- **23 minutes**
  - 16 air samples at 90 second intervals
  - 4 walkthroughs at pre-set times (3, 7.5, 15, 19.5 minutes)
Methods

- **Total Particle Counts (TPC)**
  - Nonviable particles (e.g. dust)
  - Viable particles
- **Viable Particle Counts (VPC)**
  - Bacteria
  - Squamous cells (e.g. skin)
Results

Total Particle Count (TPC)
Results

Total Particle Count (TPC)
Results

Viable Particle Count (VPC)
Results

Viable Particle Count (VPC)
Outcome Measurements

1. Overall Particle Counts
   - Mean sum of all particles counted during each experiment

2. Change ($\Delta$) in Particle Counts
   - Mean difference in particle count following each door opening and walkthrough

3. Maximum Particle Count
   - Mean single highest recorded particle count per experiment
Outcome Measurements

1. **Overall Particle Counts**
   - Mean sum of all particles counted during each experiment

2. **Change ($\Delta$) in Particle Counts**
   - Mean difference in particle count following each door opening and walkthrough

3. **Maximum Particle Count**
   - Mean single highest recorded particle count per experiment
Results

Overall TPC

Overall VPC
Results

Overall TPC

Particles/m³

- Control
- C-UVC (4m)
- C-UVC (8m)

71% decrease, P = 0.003

Overall VPC

- Control
- C-UVC (4m)
- C-UVC (8m)

58% decrease, P = 0.007
Results

Overall TPC

- Control
- C-UVC (4m)
- C-UVC (8m)

P > 0.999

Overall VPC

- Control
- C-UVC (4m)
- C-UVC (8m)

P = 0.796
Outcome Measurements

1. Overall Particle Counts
   - Mean sum of all particles counted during each experiment

2. Change (Δ) in Particle Counts
   - Mean difference in particle count following each door opening and walkthrough

3. Maximum Particle Count
   - Mean single highest recorded particle count per experiment
Results

Change ($\Delta$) TPC

Change ($\Delta$) VPC

Particles/m$^3$
Results

Change (Δ) TPC

<table>
<thead>
<tr>
<th></th>
<th>Particles/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>13000</td>
</tr>
<tr>
<td>C-UVC (4m)</td>
<td>11000</td>
</tr>
<tr>
<td>C-UVC (8m)</td>
<td>10000</td>
</tr>
</tbody>
</table>

81% decrease, P < 0.001

Change (Δ) VPC

<table>
<thead>
<tr>
<th></th>
<th>Particles/m³</th>
</tr>
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<tbody>
<tr>
<td>Control</td>
<td>700</td>
</tr>
<tr>
<td>C-UVC (4m)</td>
<td>500</td>
</tr>
<tr>
<td>C-UVC (8m)</td>
<td>300</td>
</tr>
</tbody>
</table>

79% decrease, P = 0.028
Results

Change (Δ) TPC

- Control
- C-UVC (4m)
- C-UVC (8m)

Change (Δ) VPC

- Control
- C-UVC (4m)
- C-UVC (8m)

P = 0.814

P = 0.395
Outcome Measurements

1. Overall Particle Counts
   - Mean sum of all particles counted during each experiment

2. Change ($\Delta$) in Particle Counts
   - Mean difference in particle count following each door opening and walkthrough

3. Maximum Particle Count
   - Mean single highest recorded particle count per experiment
Results

Maximum TPC

- Control
- C-UVC (4m)
- C-UVC (8m)

Maximum VPC

- Control
- C-UVC (4m)
- C-UVC (8m)
Results

Maximum TPC
- Control
- C-UVC (4m)
- C-UVC (8m)

72% decrease, P = 0.005

Maximum VPC
- Control
- C-UVC (4m)
- C-UVC (8m)

63% decrease, P = 0.019
Results

Maximum TPC
- Control: 30,000 particles/m³
- C-UVC (4m): 15,000 particles/m³ (6% decrease, P = 0.739)
- C-UVC (8m)

Maximum VPC
- Control: 800 particles/m³
- C-UVC (4m): 640 particles/m³ (18% decrease, P = 0.579)
- C-UVC (8m)
Limitations

- Controlled environment
  - Active OR’s may affect efficacy of C-UVC to reduce particles
- Horizontal laminar flow rooms were not studied
- Particle counters are an emerging tool for microbial surveillance
  - Studies [5,6] have reported their reliability in this setting
Conclusion

- C-UVC units can reduce airborne bioburden in a controlled OR setting
  - Potential to reduce surgical site contamination
- Placement did not affect the units ability to reduce air particles
- Future studies need to be conducted in live arthroplasty cases
Cleveland Clinic

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