Evaluation of operating room air contamination levels

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Study acceptance

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Aims and Study Design

This study was designed to evaluate the effectiveness of the Aerobiotix HEPA/Ultraviolet air recirculation system to reduce airborne particle levels in operating room air at Providence Alaska Center, a 371-bed tertiary care facility located in Anchorage Alaska, USA.

Air quality was monitored before and after use of the Aerobiotix system by using a continuous air particle measurement system, with readings taken every 2 minutes for the test period.

- Control measurement of the operating room before use of Aerobiotix system for 5 days
- Measurement of the operating room before use of Aerobiotix system for 1 day

Background

Airborne pathogen levels in healthcare settings are a significant, yet under-appreciated cause of hospital acquired infections and surgical site infections. Infections acquired at hospitals are the number four cause of death in the United States, exceeding the combined mortality of breast cancer, AIDS and traffic accidents at an annual cost estimated at $40 billion (McCaughey, 2008; Mitka 2008). Increasingly, the microorganisms causing these infections have mutated into antibiotic resistant strains, making the resulting morbidity/mortality of a healthcare associated infection greater than ever. Surprisingly, there is no minimum U.S. standard for the number of bacteria, viruses, or fungi in hospital air, including critical areas of surgery suites, immunocompromised patient areas, or intensive care units.

The ABX T1 (Aerobiotix, Dayton, OH) is a novel in-room air decontamination-recirculation unit. (Fig. 1) It utilizes a hybrid of biological and physical systems to remove bacteria, fungi and viruses from the air. Its key biocidal technology is a reactor system which provides simultaneous physical filtration and irradiation of high-volume air flow with minimal resistance. The reactor system utilizes C-band ultraviolet light (UVC) focused on a reaction chamber filled with a multitude of clear cylindrical silicate quartz crystals. Silicate quartz transmits UVC radiation with minimal loss of power. Additionally, quartz itself is impervious to UV irradiation, and will not discolor or degrade under long-term high-energy exposure. The cylindrical design allows for maximal air-flow and surface area. While organisms are slowed or trapped in the quartz matrix, they are inactivated by the penetrating UVC dosage. This has the effect of increasing the inactivation efficiency over prior UV technologies.

![Figure 1: Mechanism of Action for Aerobiotix T1 Air Decontamination unit.](image-url)
The indoor air quality assessment consisted of the measurement of the following particulate levels:

- 0.5 µM/m³
- 1.0 µM/m³
- 5.0 µM/m³
- 10 µM/m³

The Oberon IC Sentinel® (ICS) network-enabled real-time particulate monitoring system was placed in the operating room. During the control period, levels of air contamination were obtained for all particulate sizes using automated air sampling on a per-minute basis. For the Aerobiotix test period, the particle measurements were taken along with an Aerobiotix T1 unit running at a 450 CFM air treatment rate. Baseline levels of air contamination were obtained for all particulate sizes using automated air sampling on a per-minute basis. The T1 unit was then switched on, running at 450 CFM while regular readings continued to be taken. Measurements were taken in a fully occupied general operating room, with a mixture of general and orthopedic procedures.

**Figure 1.** Continuous air quality measurement device (Oberon IC-Sentinel)

**Figure 2.** Aerobiotix T1 air decontamination device
Results from the air quality testing are as follows:

<table>
<thead>
<tr>
<th>Date/Name</th>
<th>Particle 0.5µ (m3)</th>
<th>Particle 1.0µ (m3)</th>
<th>Particle 5.0µ (m3)</th>
<th>Particle 10.0µ (m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-9-2014 Baseline</td>
<td>8395896</td>
<td>3096593</td>
<td>183959</td>
<td>49311</td>
</tr>
<tr>
<td>10-10-2014 Baseline</td>
<td>169703142</td>
<td>42703817</td>
<td>1125189</td>
<td>287896</td>
</tr>
<tr>
<td>10-13-2014 Baseline</td>
<td>8982498</td>
<td>3976511</td>
<td>377233</td>
<td>151927</td>
</tr>
<tr>
<td>10-14-2014 Baseline</td>
<td>15280535</td>
<td>4929880</td>
<td>338594</td>
<td>99288</td>
</tr>
<tr>
<td>10-15-2015 Baseline</td>
<td>16171199</td>
<td>5451209</td>
<td>423903</td>
<td>151272</td>
</tr>
<tr>
<td>CONTROL 5D MEAN</td>
<td>43706654</td>
<td>12031602</td>
<td>489775.6</td>
<td>147938.8</td>
</tr>
<tr>
<td>ABX</td>
<td>9888519</td>
<td>3352538</td>
<td>235933</td>
<td>74628</td>
</tr>
</tbody>
</table>

*5 days vs. ABX  77.40%  72.10%  51.80%  49.60%

Discussion and Conclusion

The collected data demonstrate a marked reduction in air contamination for the particle sizes measured using the T1 device. Reductions ranged from 49.6% to 77.4%, with a trend of greater reduction of the smaller measured particles. In this study, we concentrated on airborne particles in the 0.5 to 10.0 µm size. This particle size range has been most closely identified with pathogenic airborne bacterial populations (Kowalski, 2012).
There are no regulated standards for airborne particulate levels in most health care settings in the United States. However, international literature recommends the use of ISO 14644-1 cleanroom standards (Scaltriti 2007, Wan 2011, Charkoska 2008) to create performance benchmarks. The ISO 9 level has been promulgated under ISO 14644-1 to describe the minimal standard for clean room air, without the specific air-handling or room enclosure requirements. ISO 9 Standards are as follows:

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>ISO 9 Standard</th>
<th>OR CTL Mean</th>
<th>ISO 9?</th>
<th>OR ABX Mean</th>
<th>ISO 9?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 µM/m³</td>
<td>35,200,000</td>
<td>43,706,654</td>
<td>NO</td>
<td>9,888,519</td>
<td>YES</td>
</tr>
<tr>
<td>1.0 µM/m³</td>
<td>8,320,000</td>
<td>12,031,602</td>
<td>NO</td>
<td>3,352,538</td>
<td>YES</td>
</tr>
<tr>
<td>5.0 µM/m³</td>
<td>293,000</td>
<td>489,775</td>
<td>NO</td>
<td>235,933</td>
<td>YES</td>
</tr>
<tr>
<td>10 µM/m³</td>
<td>no standard</td>
<td>147,938</td>
<td>-</td>
<td>74,628</td>
<td>-</td>
</tr>
</tbody>
</table>

CTL = Control, ABX = Aerobiotix

For the standardized particle sizes measured, the ABX unit brought mean airborne particulate levels from ISO noncompliance into ISO 9 compliance (red box above).

In conclusion, the ABX technology successfully reduced airborne contamination under the test parameters and environment described. The addition of ABX supplemental air decontamination to this facility should be considered, as part of a comprehensive environmental management plan.

References


