Airborne Bacteria in the Operating Room Can Be Reduced by HEPA/Ultraviolet Air Recirculation System (HUAIRS)

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Soumitra R. Eachempati, MD FACS, FCCM
Professor of Surgery
Professor of Medicine, Division of Medical Ethics
Weill Cornell Medical College
New York-Presbyterian Hospital-Weill Cornell Medical Center

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Aims and Study Design

Surgical site infections (SSI) are a major cause of morbidity and mortality in the US hospitals. Airborne bacteria in operating rooms (OR) may contribute to SSI. In Europe, regulations exist to limit the airborne bioburden in the ORs. Unfortunately, no equivalent environmental indoor air quality standards exist in the US. With emerging scientific data regarding the contribution of air contamination to SSI, there is increased interest in considering innovative supplemental technologies to support best air quality in the ORs.

A newly commercialized HEPA/UV-C air recirculation/filtration system (HUAIRS) was evaluated as to its efficacy in reducing airborne bacteria present in a plastic surgery OR at an outpatient surgery center. An air sampling impactor and agar media plates were placed in multiple locations in the OR and used to measure the number of bacterial colony forming units per cubic meter (CFU/m^3). Twenty four samples were included in the analysis. The agar plates were incubated and counted by an independent microbiological laboratory.

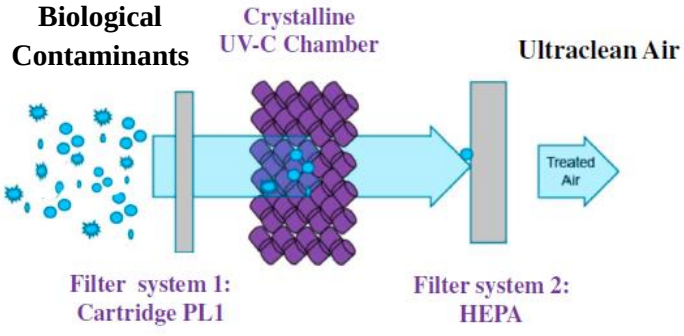
Particle content in the OR air was monitored with a continuous air particle measurement system. Continuous air samples were collected every 2 minutes for the duration of the test period.

Background

Infections acquired at the healthcare facilities are the 4th largest 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[1, 2]. Increasingly, the microorganisms causing these infections have mutated into antibiotic resistant strains, making the resulting morbidity and mortality 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[3-7].

The HUAIRS in-room decontamination/recirculation unit (**Figure 1**) utilizes a hybrid of biological and physical systems to remove bacteria, fungi and viruses from the air. Its key biocidal technology is a solid-state germicidal irradiation system which provides simultaneous physical filtration and irradiation of high-volume air flow. The system utilizes C-band ultraviolet light (UV-C) at a 254 nm wavelength diffused into a solid media which is gas and radiation permeable. While organisms are slowed or trapped in the solid media, they are inactivated by the internal UV-C dosage. This has the effect of increasing the inactivation efficiency over prior UV technologies.

FIGURE 1



HUAIRS: Systems overview. Incoming contaminated air is filtered via cartridge Performance level 1 (PL1) designed to trap debris and particulates such as dust, textile fibers and skin scales. Smaller particles are directed towards the C-UVC (254nm) reactor located in the middle of the system along the path of the airflow. The silicate crystals within the reactor form a solid UV-permeable media prolonging C-UVC exposure of airborne pathogens for maximum killing of viable bacteria, viruses and spores. The C-UVC irradiated microorganisms and smaller particles are removed by clean air exhaust/HEPA filter assembly to generate ultraclean air.

Methods

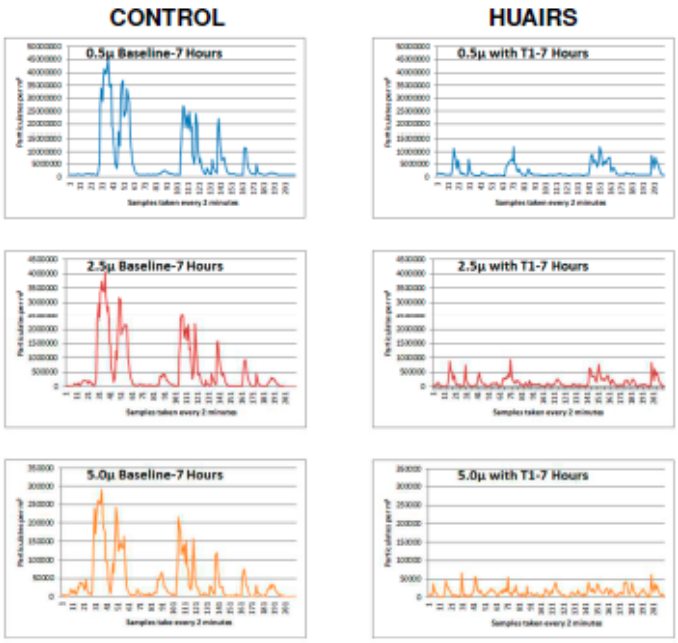
OR indoor air quality assessment was performed using continuous air quality monitor (IC Sentinel, Oberon Technologies). Airborne particle levels were reported as the numbers of particles per cubic meter for the following size categories: 0.5 µm/m^3, 2.5 µm/m^3 and 5.0 µm/m^3. Continuous sampling was performed every 2 minutes. In control group, levels of air contamination were measures in the absence of supplemental air filtration. In the test group, the particle measurements were acquired with an Aerobiotix T1 unit running at a 450 CFM air treatment rate. All measurements were taken in a fully occupied general OR. A mixture of plastic and reconstructive surgical procedures was performed using standard techniques and protocols.

AEROBIOTIX T1 Unit

OBERON IC-Sentinel

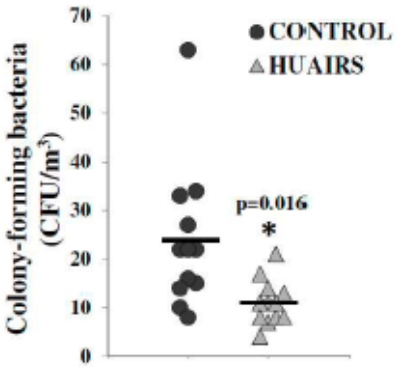
Results

FIGURE 2



Particle content per cubic meter in the OR air for 0.5 µm, 2.5 µ and 5µm particles sizes before (left side) and after the treatment with HUAIRS air filtration device (right side).

FIGURE 3



Airborne bacterial levels in outpatient surgery center before and after the treatment with ABX air filtration device. 67.7% reduction on CFU/m^3 in twelve paired samples

Discussion and Conclusion

Aforementioned graphical data representations (**Figure 2**) demonstrate marked reductions in particulate OR air contamination. Decreases in particle counts ranged from 66.3% to 72.5%, with comparable reductions across all measured particle sizes. For this study we intentionally focused on particles in the 0.5 to 5.0 µm size range. These particles are likely to include the majority of pathogenic airborne bacterial populations[8]. It is important to note that for any given environmental air sample there will be orders of magnitude higher amounts of particles than culturable bacterial CFUs. Particles include a broad population of inorganic matter, non-viable organic particles, and prokaryotic and eukaryotic cells.

Particle quantification data is well aligned with airborne bacterial contamination findings. For the cultured samples obtained, there was a 67.7% reduction in CFU count in twelve paired samples (**Figure 3**). This reduction is statistically significant (p=.0163).

The HUAIRS device is effective in reducing airborne contamination and improving air quality in the OR, supporting reduced SSI risk for patients and improved safety for the surgical team. Overall, greater awareness and application of novel technological solutions is required in order for infection prevention protocols and hospital administration to continue incorporating airborne factors in a comprehensive infection prevention strategy.

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