Technical White Paper

Reduced air contamination rates in active surgical sterile processing department using HEPA-ultraviolet air recirculation system.

Background Surgical site infection (SSI) has significant economic and human costs. Contamination of surgical instrumentation is known to be etiologic for SSI, yet little attention has been paid to potential air contamination during the instrument preparation process.

Objective To determine whether supplemental air treatment with HEPA-Ultraviolet air recirculation system (HUAIRS) reduces the rate of air contamination in surgical sterile processing areas.

Methods This observational study utilized laser-based particle counting to analyze airborne particles of 0.3, 1.0 and 5.0 µm sizes in an active surgical sterile processing department of an acute care hospital. For the control group, a total of 12 measurements were taken. In the experimental group, a HUAIRS unit was placed in the SPD department and 24 additional measurements were taken.

Results For the control group mean counts of 0.3 µm particles were 84,346,500/m^3; 1.0 µm were 761,188/m^3 and 5.0 µm were 53,250/m^3. For the HUAIRS group, mean counts of 0.3 µm particles were 42,597,375/m^3; 1.0 µm were 348,125/m^3 and 5.0 µm were 23,250/m^3. This represented reductions of 49.4%, 54.2% and 56.3%, respectively. For all particle sizes, the reductions were statistically significant with 0.3 µm p=.00014, 1.0 µm p=.000018, and 5.0 µm p=.0059.

Conclusions The use of HEPA ultraviolet air recirculation in the surgical sterile processing department will reduce levels of air contamination in areas of exposed instrumentation.

Contamination of air in the surgical sterile processing department (SPD) is an underappreciated risk factor for introducing pathogenic bacterial contamination into the operating room via the surgical instrument vector. Current engineering controls require significantly less air exchange in SPDs than in ORs, potentially leading to a weak link in the chain of sterility. For example, the ASHRAE 170:2008 standard calls for 20 air exchanges per hour (ACH) in the operating room but only 10 ACH in the sterilizer equipment room and 4 ACH in sterile storage areas.[1] Dalstrom et al. documented that surgical instrumentation is vulnerable to settling airborne bacteria, as a function of environmental exposure time.[2] Additional studies have demonstrated that bacterial fallout onto instrumentation was 28.2 times higher in the preparation room than in the OR itself.[3] Sterile supply areas are at risk for airborne contamination from personnel, bioaerosols released from steam and washing equipment, and cross-contamination from instrument handling.

Over the last 20 years several peer-reviewed publications have presented evidence that airborne microbial populations can play a role in the etiology of surgical site infection (SSI), especially in procedures involving implantable biomedical devices, such as prosthetic joints. These airborne particles include dust, textile fibers, skin scales, and respiratory aerosols, loaded with viable microorganisms (including *Staphylococcus aureus*) having been released into the surrounding air of the OR. These particles have been shown to settle onto surfaces including the surgical wound and instruments.[4-5]

Recently, the HEPA-Ultraviolet Air Recirculation System (HUAIRS, Aerobiotix Illuvia, West Carrollton, OH) has been introduced which provides supplemental air decontamination within the SPDs (Fig. 1). The unit delivers 450 cubic feet (12.7 m^3) per minute of non-turbulent ultraclean air. The efficacy of this system has been recently evaluated for reducing airborne microorganisms present within active operating rooms. The system incorporates crystalline UV-C technology (C-UVC), in which air undergoes germicidal UV irradiation within a photolytic chamber filled with silicate crystal. In one study, an air sampling impactor and agar media plates were placed in multiple locations in the OR and used to measure the number of CFU per cubic meter of bacteria in the air before and after use of the HUAIRS system. From the cultured samples obtained, there was a 53.4% (p = .0163) reduction in CFU count overall.[6]

In this study, the goal was to determine if the HUAIRS system could significantly reduce airborne contamination in the active SPD setting.

Methods All readings were taken in the sterile processing department of a 420-bed acute care hospital located in California, USA, which performs approximately 1000 major surgical procedures annually. In order to determine baseline particle concentration of the SPD air, a handheld laser-based particle counter, (Particles Plus, Stoughton, MA) was used (Fig. 2). The unit was set to give output in units of particles per cubic meter for sizes 0.3µm, 1.0µm and 5.0µm. Multiple readings were taken in the following locations: Entryway, near autoclave, side wall, and tray preparation area. Readings were taken in an occupied area under normal daily acitvities. Appropriate sterile field precautions were maintained during the measurement process. For control readings, the HUAIRS was placed centrally in the SPD area and was inactivated. For the experimental readings a HUAIRS was activated at 30 minutes before the reading period to allow for adequate room recirculation to occur. Significance values were calculated using a two-tailed Student's t-test.

Figure 1. HUAIRS unit.

Results

There were a total of 36 air particulate readings obtained. For the control group mean counts of 0.3 µm particles were 84,346,500/m^3; 1.0 µm were 761,188/m^3 and 5.0 µm were 53,250/m^3. For the HUAIRS group, mean counts of 0.3 µm particles were 42,597,375/m^3; 1.0 µm were 348,125/m^3 and 5.0 µm were 23,250/m^3. This was a reduction of 49.4% for 0.3 µm particles, 54.2% for 1.0 µm particles and 56.3% for 5.0 µm particles.

Figure 2. Particle counter.

For all particle sizes, the reductions were statistically significant with 0.3 µm p=.00014, 1.0 µm p=.000018, and 5.0 µm p=.0059. There were no significant differences in particle levels or results for the different areas of the SPD tested.

	Control Group		
	0.3 µm particles	**1.0 µm particles**	**5.0 µm particles**
Air Sample 1	80191000	785750	81000
Air Sample 2	86229000	756000	41000
Air Sample 3	89302000	722000	25000
Air Sample 4	81664000	781000	66000
MEAN	**84346500**	**761187.5**	**53250**
	HUAIRS Group		
Air Sample 1	30012000	270000	23000
Air Sample 2	51962000	433000	26000
Air Sample 3	61619000	483000	29000
Air Sample 4	35730000	281000	20000
Air Sample 7	27384000	248000	27000
Air Sample 8	47129000	449000	21000
Air Sample 9	56615000	401000	22000
Air Sample 10	30328000	220000	18000
MEAN	**42597375**	**348125**	**23250**
Change	**-49.5%**	**-54.3%**	**-56.3%**
***p* value**	**0.00013**	**.000017**	**0.0059**

Table 1. Results of air particulate readings in Control and HUAIRS groups.

Discussion

Although operating room air quality has undergone a resurgence in interest for its potential etiology in surgical site infection, relatively little has been investigated regarding the role of air quality in SPDs. This study demonstrates that supplemental SPD air treatment with the HUAIRS system results in a marked and statistically significant reduction of air contamination.

The chain of the sterility of surgical instruments is paramount, not only in the OR itself but in central preparation areas as well. Whyte demonstrated that indeed the majority of bacterial contamination in orthopedic surgical site originated outside of the immediate sterile field, including from instruments which can carry contaminant into the wound.[7] A comprehensive surgical site infection control plan should take into consideration any risk for contamination to reach the surgical site and instrumentation. As such the SPD environment, and specifically SPD air contamination deserves increased scrutiny and mitigation.

Consideration should be given to institutional deployment of new technologies, such as HUAIRS to mitigate this contamination risk. Ongoing research will continue in this area.

REFERENCES

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