Ultraviolet-C light as a means of disinfecting anesthesia workstations

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Major Article

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Background: Anesthesia workstations (AWs) are a reservoir for pathogenic organisms potentially associated with surgical site infections. This study examined the effectiveness of the Tru-D SmartUVC device (Tru-D LLC, Nashville, TN) on bioburden reduction (BR) on AWs.

Methods: Strips of tissue inoculated with a known concentration of either Staphylococcus aureus, Enterococcus faecalis, or Acinetobacter sp were placed on 22 high-touch surfaces of an AW. Half of the AW surfaces received direct ultraviolet (UV) light exposure and half received indirect exposure. Two inoculated strips, in sterile tubes outside of the room, represented the control. Trials were conducted on AWs in an operating room and a small room. Strips were placed in a saline solution, vortexed, and plated on blood agar to assess BR by the number of colony forming units.

Results: All experimental trials, compared with controls, exhibited a BR >99%. There was a significantly greater reduction of E faecalis colony forming units in the operating room AW under direct exposure (P = .019) compared with indirect exposure. There was no significant difference in reduction when comparing AWs between rooms.

Conclusion: Regardless of room size and exposure type, automated UV-C treatment greatly influences BR on AW high-touch surfaces. Hospitals instituting an automated UV-C system as an infection prevention adjunct should consider utilizing it in operating rooms for BR as part of a horizontal infection prevention surgical site infection-reduction strategy.

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Methods

High-touch areas of a training AW, including surfaces that are directly and indirectly exposed to UV light during decontamination, were chosen for evaluation in a simulated operating room (Fig 1).

Decontamination with the Tru-D SmartUVC was performed using the “Vegetative Bacteria” setting, ensuring that the sensor with the lowest reflected light receives an exposure of 12,000 µW/cm². Experiments were conducted in both small (12 ft × 18 ft 4 in/220 sq ft/20 m²) and large rooms (21 ft × 29 ft/609 sq ft/56.6 m²). The device was placed in approximately the middle of both rooms (135 cm and 254 cm from AWs in small and large rooms, respectively). Run times were approximately 20 minutes in the small room and 55 minutes in the large room, per the device's algorithm. Two decontamination runs were conducted in each room, for a total of 4 runs.

To assess organism killing in difficult-to-access areas of the AW, a method capable of delivering known quantities of organism to these areas was developed. Initially, 2 delivery substrates were evaluated: 0.25 cm² sterile Wypal squares (Kimberly-Clark Worldwide, Irving, TX) and 6 mm sterile disks (as used in disk diffusion).
Three organisms (Enterococcus faecalis [ATCC 29212], Acinetobacter baumannii [ATCC 19606], and Staphylococcus aureus [ATCC 43300]), which are commonly implicated in postsurgical infections, were used in all experiments. The 0.5 MacFarland suspensions (10^6 CFU/mL) of organism were made in 0.9% sterile saline from overnight growth of the bacteria incubated for 18-24 hours at 37°C in ambient air. Colony counts were calculated the following day. This experimental method generated quantifiable growth of organisms on an AW surface is unknown, as is the necessary bioburden reduction for halting cross-transmission to patients. The porous nature of the carrier should also be considered when comparing these results with those of other studies testing UV decontamination on nonporous carriers or surfaces. Finally, the A baumannii and E faecalis control carriers produced too many colonies to count and, given our limited access to the simulation center, we were only able to complete a single repeat run of the E faecalis, from which we produced a 1:10 dilution while plating. As a result, although the E faecalis control colony forming unit counts were accurate, A baumannii control colony forming unit counts were estimated. This study demonstrates that UV light significantly reduces bioburden of 3 organisms commonly implicated in surgical infections. Importantly, our findings show that UV-C technology effectively decontaminates surfaces that are not readily cleaned with manual techniques. Using the methods developed here, a similar study may demonstrated a 2 log_{10} CFU reduction in bioburden compared with untreated controls. This reduction was observed for all organisms regardless of position or room size (Table 1). Details of CFU growth by site, exposure, and room size may be found in the Supplementary Appendix.

**DISCUSSION**

Several studies have demonstrated the efficacy of UVC device decontamination of flat hospital surfaces. However, none of these studies evaluated the efficacy of UVC decontamination of complex surfaces. We developed a novel method for assessing UV light decontamination of complex hospital surfaces that will facilitate future evaluations of UVC decontamination performance.

No difference was observed between UV light decontamination of directly and indirectly exposed surfaces, with the exception of E faecalis in the large room (Table 1). No difference in decontamination effectiveness was seen between large and small room experiments. Importantly, our study included high-touch surfaces such as knobs, drawer handles, and dials that are difficult to clean manually. Our findings suggest that UV light could be an important supplement to manual cleaning of equipment such as AWs, adding to the body of literature on novel deployment strategies for UV-light decontamination.

There are several limitations to this study. First, the true burden of organisms on an AW surface is unknown, as is the necessary bioburden reduction for halting cross-transmission to patients. Second, the model derived for this study employed a porous Wypall wipe that does not perfectly represent the surface of the anesthesia instruments being assessed. However, we believe that the porous nature of the wipes would likely have a protective effect for bacterial viability and would thus underestimate the influence of UVC killing. Thus, we believe our findings of significant reduction in organism burden can be extrapolated to make conclusions about the effectiveness of UVC sanitization of AW surfaces. The porous nature of the carrier should also be considered when comparing these results with those of other studies testing UV decontamination on nonporous carriers or surfaces. Finally, the A baumannii and E faecalis control carriers produced too many colonies to count and, given our limited access to the simulation center, we were only able to complete a single repeat run of the E faecalis, from which we produced a 1:10 dilution while plating. As a result, although the E faecalis control colony forming unit counts were accurate, A baumannii control colony forming unit counts were estimated.

This study demonstrates that UV light significantly reduces bioburden of 3 organisms commonly implicated in surgical infections. Importantly, our findings show that UV-C technology effectively decontaminates surfaces that are not readily cleaned with manual techniques. Using the methods developed here, a similar study may
be performed on a larger scale. Further studies are required to assess whether reductions in bioburden on AWs influence surgical site infections.

Acknowledgments

This project is dedicated in memoriam to Dr. Gene Peterson, MD, PhD, a steadfast, dedicated physician and a champion for patient safety.

APPENDIX. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ajic.2016.01.025.

References