Purpose-built UV-C Enclosure for Portable Medical Equipment: Controlling the Environment is the Key to Consistent Results

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Abstract

Continuous quality and process improvement is needed related to the cleaning and disinfection of portable medical equipment (PME) in the healthcare environment. These efforts should minimize the risks of this equipment becoming a vector of transmission and reduce the likelihood of transmission of healthcare-associated infections.

A digitally-connected automated no-touch UV-C enclosure purpose-built for PME has been developed to achieve consistent pathogen reduction in an efficient cycle time (60 seconds). The UV-C enclosure reduced recovery of *Candida auris (C. auris)* 5.28 $\log_{10}$ at 60 seconds. The UV-C enclosure reduced recovery of methicillin-resistant *Staphylococcus aureus* (MRSA) 6.10 $\log_{10}$ at 60 seconds.

By controlling the environment where UV-C irradiation is delivered, consistent results can be achieved. By digitally connecting the UV-C enclosure to the equipment and a cloud-based process management platform, improvements in protocol adherence could lead to a safer environment for patients, visitors, and healthcare workers.

Background

- Evidence suggests the hygiene of the hospital environment correlates directly to the risk of transmission of healthcare-associated infections[1] and high-touch surfaces of portable medical equipment (PME) are a potential vector of transmission.[2]
- While mainstream initiatives have centered around hand hygiene and whole room cleaning and disinfection protocols, there continues to be less adherence to the cleaning and disinfection of PME.
- This ecosystem is challenging due to the variability of the manual processes, the portability of PME, and the lack of data and equipment interconnectivity.
- A digitally-connected automated no-touch UV-C enclosure is part of a novel ecosystem solution purpose-built for PME and is intended to provide a controlled environment for the delivery of UV-C irradiation and should yield consistent pathogen reduction while tracking protocol adherence.

Methods

- Ultraviolet (UV-C) dose, methicillin-resistant *Staphylococcus aureus* (MRSA) bacterial killing efficacy, and *Candida auris* (*C. auris*) fungal killing efficacy were tested at a single point centered in the UV-C enclosure for 20, 40, 60, & 90 seconds. (Figure 1)
- Two replicate stainless steel discs were inoculated with 10 microliters of fresh live fungal or bacterial cell suspension at a concentration of at least $1x10^8$ colony forming units per milliliter (CFU/mL) in a solution of 1x phosphate buffered saline (PBS) with 5% serum organic soil and dried.
- The experiment was performed three times for a total of 72 test disc data points (n=6 per time point for each organism) and any outlier data points were dropped for analysis.

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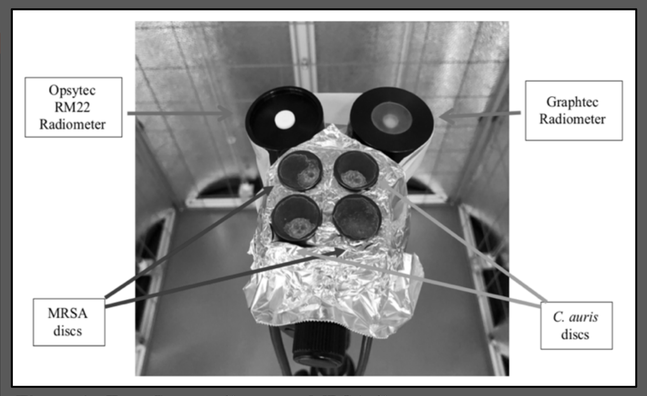


Figure 1. Two *C. auris* discs, two MRSA discs

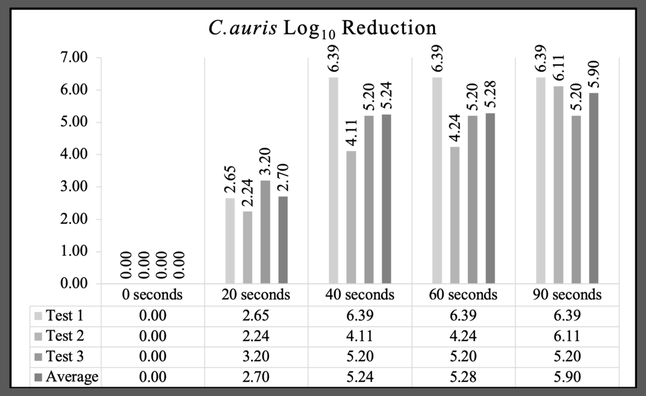


Figure 2. *C. auris* $\log_{10}$ reduction

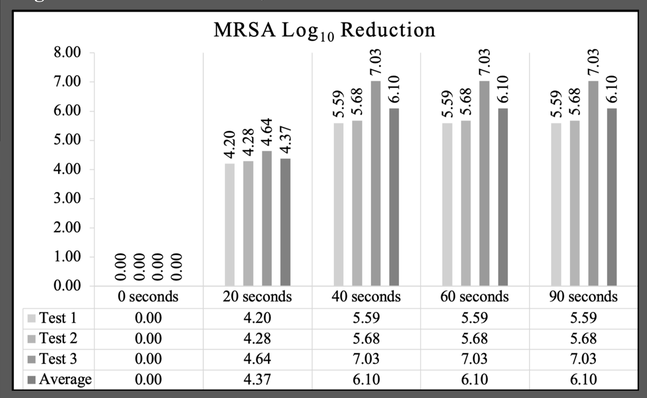


Figure 3. MRSA $\log_{10}$ reduction

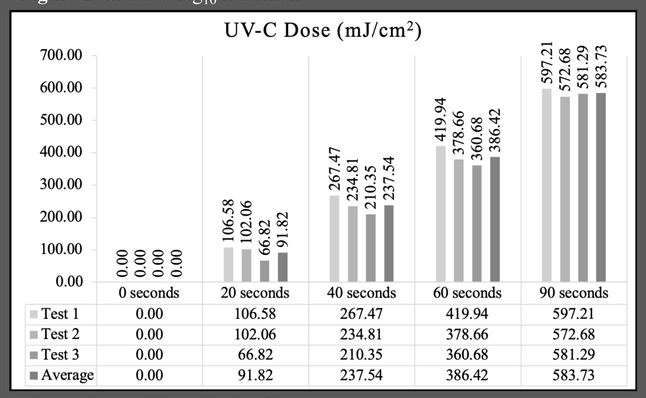


Figure 4. UV-C dose (mJ/cm^2)

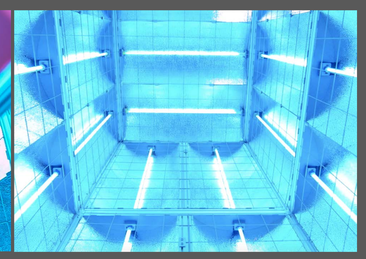
MRSA Testing

Time	0 seconds			20 seconds			40 seconds			60 seconds			90 seconds		
	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)
Test 1	3.93E+05	0.00	0.00	2.50E+01	4.20	106.58	0.00E+00	5.59	267.47	0.00E+00	5.59	419.94	0.00E+00	5.59	597.21
Test 2	4.75E+05	0.00	0.00	2.50E+01	4.28	102.06	0.00E+00	5.68	234.81	0.00E+00	5.68	378.66	0.00E+00	5.68	572.68
Test 3	1.08E+07	0.00	0.00	2.50E+01	4.64	66.82	0.00E+00	7.03	210.35	0.00E+00	7.03	360.68	0.00E+00	7.03	581.29
Average	3.89E+06	0.00	0.00	1.00+02	4.37	91.82	0.00E+00	6.10	237.54	0.00E+00	6.10	386.42	0.00E+00	6.10	583.73

***C. auris* Testing**

Time	0 seconds			20 seconds			40 seconds			60 seconds			90 seconds		
	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)	Bacterial Burden (CFU/disc)	$\log_{10}$ Reduction	UV-C Dose (mJ/cm^2)
Test 1	2.48E+06	0.00	0.00	5.50E+03	2.65	106.58	0.00E+00	6.39	267.47	0.00E+00	6.39	419.94	0.00E+00	6.39	597.21
Test 2	1.30E+06	0.00	0.00	7.48E+03	2.24	73.24	1.00E+02	4.11	227.17	7.50E+01	4.24	397.28	0.00E+00	6.11	611.33
Test 3	1.60E+05	0.00	0.00	1.00E+02	3.20	66.82	0.00E+00	5.20	210.35	0.00E+00	5.20	360.68	0.00E+00	5.20	581.29
Average	1.31E+06	0.00	0.00	4.36E+03	2.70	82.21	3.33E+01	5.24	234.99	2.50E+01	5.28	392.63	0.00E+00	5.90	596.61

Table 1. UV-C enclosure testing results



Results

- The UV-C enclosure reduced recovery of *C. auris* by 4.11-6.39 (avg. 5.24) $\log_{10}$ at 40 seconds, 4.24-6.39 (avg. 5.28) $\log_{10}$ at 60 seconds, and 5.20-6.39 (avg. 5.90) $\log_{10}$ at 90 seconds. (Figure 2)
- The UV-C enclosure reduced recovery of MRSA by 5.59-7.03 (avg. 6.10) $\log_{10}$ at 40 seconds, 5.59-7.03 (avg. 6.10) $\log_{10}$ at 60 seconds, and 5.59-7.03 (avg. 6.10) $\log_{10}$ at 90 seconds. (Figure 3)
- UV-C dose was measured on average 237.54 mJ/cm2 (237,540 µJ/cm2) at 40 seconds, 386.42 mJ/cm2 (386,420 µJ/cm2) at 60 seconds, 583.73 mJ/cm2 (583,730 µJ/cm2) at 90 seconds. (Figure 4)
- At 40, 60, and 90 seconds, 7 of the 9 *C. auris* experiments reduced bacterial burden (CFU/disc) to 0.00E+00.
- At 40, 60, and 90 seconds, 9 of the 9 MRSA experiments reduced bacterial burden (CFU/disc) to 0.00E+00. (Table 1)

Conclusion

- There is a need for quality and process improvement with the existing state of the art for the cleaning and disinfection of PME.
- A digitally-connected automated no-touch UV-C enclosure purpose-built for PME, which controls the critical variables of distance and line-of-sight, creates a highly-controlled environment.
- This produces repeatable UV-C dosage and consistent $\log_{10}$ reductions; however, this is only a portion of the solution needed.
- Digitally connecting the UV-C enclosure to the equipment and cloud-based process management platform is designed to drive better protocol adherence.
- Improvements in protocol adherence and more effective purpose-built UV-C solutions for PME could lead to safer environment for patients, visitors, and healthcare workers.

References

[1] Donskey CJ. Does improving surface cleaning and disinfection reduce health care-associated infections? Am J Infect Control 2013;41:12-9.
[2] Jencson AL, Cadnum JL, Wilson BM, Donskey CJ. Spores on wheels: wheelchairs are a potential vector for dissemination of pathogens in healthcare facilities. Am J Infect Control 2019;47:459-61.