

Potential Applications of Ultraviolet Light Disinfection in the Prevention of Central Line Associated Bloodstream Infections in the Home Infusion Setting

Mitsuhiro Jo, MTM¹ Julia Rasooly, MS¹ Gregory Schears, MD¹
¹PuraCath Medical, Newark, CA ²Mayo Clinic, Rochester, MN



Background

Intravenous (IV) catheters such as central venous catheters (CVC) can provide long-term access for drug, nutrition, and chemotherapy delivery in home or alternate infusion patients. However, inadequate adherence to access site management guidelines and training can lead to central line associated bloodstream infections (CLABSI), which are associated with significantly increased healthcare costs and patient morbidity. Needleless connectors (NC) are often used as central line access points with benefits of quick access and the absence of needles, but are a leading cause of indwelling microorganisms associated with CLABSIs. Recent studies show that despite CDC CLABSI prevention recommendations include guidelines for home infusion settings, few home infusion agencies have policies consistent with all CLABSI prevention and surveillance elements^{1,2}. The current standard of care for disinfecting NCs include a 15-second alcohol-based wipe or alcohol caps, which do not guarantee disinfection of indwelling microorganisms³. There is a significant need for improved aseptic compliance and disinfection techniques in preventing CLABSI in home and alternate infusion settings.

Purpose

In this study, we investigate the efficacy of our organization's novel UV light disinfection device on UV light-transmissive NCs inoculated with common CLABSI-associated organisms. Ultraviolet light (UV) is a proven technology often used for inactivating microorganisms in hospital rooms and clinics and is hypothesized to be effective against CLABSI-associated organisms. This study assessed 265-nm and 285-nm UVC wavelengths, both of which are within the germicidal UV zone.

References

1. Rinke ML, Bundy DG, Milstone AM, et al. Bringing Central Line-Associated Bloodstream Infection Prevention Home: CLABSI Definitions and Prevention Policies in Home Health Care Agencies. *Jt Comm J Qual Patient Saf.* 2013;39(8):361-370.
2. Oladapo-Shittu O, Hannum SM, Salinas AB, et al. The Need to Expand the Infection Prevention Workforce in Home Infusion Therapy. *Am J Infect Control.* 2023;51(5):594-596. doi:10.1016/j.ajic.2022.11.008
3. Moureau NL, Flynn J. Disinfection of Needleless Connector Hubs: Clinical Evidence Systematic Review. *Nurs Res Pract.* 2015;2015:796762. doi:10.1155/2015/796762

Table 1: Log reduction after exposure to 48 mW/cm² 285-nm UV-C for 1 second

Test Organism	Positive Control Concentration (cfu/mL)	Log Reduction ± Standard Deviation
<i>Staphylococcus aureus</i>	1.93×10 ⁴	5.29 ± 0.11
<i>Candida albicans</i>	5.47×10 ⁴	5.73 ± 0.10
<i>Candida auris</i>	1.13×10 ⁴	5.05 ± 0.06
<i>Escherichia coli</i>	1.73×10 ⁴	5.24 ± 0.08
<i>Pseudomonas aeruginosa</i>	1.27×10 ⁴	5.10 ± 0.05
<i>Staphylococcus epidermidis</i>	1.53×10 ⁴	5.19 ± 0.18

Table 2: Log reduction after exposure to 55 mW/cm² 265-nm UV-C for 1 second

Test Organism	Positive Control Concentration (cfu/mL)	Log Reduction ± Standard Deviation
<i>Staphylococcus epidermidis</i>	1.38×10 ⁵	6.32 ± 0.00
<i>Staphylococcus aureus</i>	1.09×10 ⁵	6.21 ± 0.13
<i>Pseudomonas aeruginosa</i>	7.61×10 ⁴	6.18 ± 0.00

Methods

Staphylococcus aureus (ATCC #6538), *Candida albicans* (ATCC #10231), *Candida auris* (CDC B11903), *Escherichia coli* (ATCC #8739), *Pseudomonas aeruginosa* (ATCC #9027), and *Staphylococcus epidermidis* (ATCC #12228) were used as target CLABSI organisms in this study. Testing was performed at our organization's testing facility and at an external testing lab. A total of 29 NC samples were tested for each organism with 3 positive controls and 1 negative control to achieve 90% CI and 95% R assuming no failures. A failure was defined as a less than 4 log reduction in cfu/mL. Each UV light-transmissive NC was inoculated with 10 µl of cultured inoculum (4-7 log) and were exposed to an average of 48 mW/cm² of 285-nm UVC light for 1 second. *S. epidermidis*, *S. aureus*, and *P. aeruginosa* were exposed to an average of 55 mW/cm² of 265-nm UVC light for 1 second. After UV disinfection, 10 mL of 0.9% saline solution was flushed through the NC and filtered through a 0.45µm membrane. The membrane filter was plated onto an agar medium matched to the organism and was incubated overnight at 37°C for *S. aureus*, *E. coli*, *S. epidermidis*, and *P. aeruginosa*, and two days at room temperature for *C. albicans* and *C. auris*. Positive controls followed the same procedure without exposure to UV light and diluted to 10⁻² before being spread onto agar plates in triplicates. The negative controls followed the same procedure without inoculation. After plates were incubated, the number of colonies on each plate were counted and recorded. A 4-log reduction was used as the success criteria based on US Food and Drug Administration (FDA) requirements. Log reduction was calculated by determining the positive control log concentration over the sample concentration in cfu/mL. 1 cfu/10mL was used for total inactivation.

Disclosures: Authors of this presentation have the following to disclose regarding possible financial or personal relationships with commercial entities that may have a direct or indirect interest in the subject matter of this presentation: Gregory Schears; nothing to disclose; Mitsuhiro Jo, Julia Rasooly; salaried employee of PuraCath Medical, Inc.

Results

Using our UV light generating device, we were able to achieve greater than 4 log reduction average and complete inactivations for all test organisms. The log reduction for *S. aureus*, *C. albicans*, *C. auris*, *E. coli*, *P. aeruginosa*, and *S. epidermidis* were 5.29 (90% CI: 5.18, 5.40), 5.73 (90% CI: 5.63, 5.83), 5.05 (90% CI: 4.99, 5.11), 5.24 (90% CI: 5.16, 5.32), 5.10 (90% CI: 5.05, 5.15) and 5.19 (90% CI: 5.01, 5.37), respectively with 285-nm UVC. Further testing at our facility with 265-nm UVC demonstrated a 6.32 (90% CI: 6.32, 6.32) log reduction for *S. epidermidis*, 6.21 (90% CI: 6.21, 6.21) log reduction for *S. aureus*, and 6.18 (90% CI: 6.18, 6.18) log reduction for *P. aeruginosa*.

Discussion

Greater than 4-log reduction in microorganisms within one second both inside and outside our UV-transmissive NCs was achieved. Notably, further testing demonstrated a greater than 6-log reduction in *S. epidermidis*, *S. aureus*, and *P. aeruginosa* with 265-nm UV. Achieving sufficient disinfection within one second can potentially improve workflow in home and alternate infusion settings through significantly reducing disinfection time compared to a 15-second alcohol wipe. A limitation of the study was the use of planktonic microorganisms, which requires further studies to demonstrate disinfection efficacy against biofilm formation within NCs.

Conclusion

This study demonstrated a greater than 4-log reduction in common CLABSI-associated organisms within one second using our UV light disinfection device and UV-transmissive NCs. By injecting inoculum directly inside the NC, we demonstrated that disinfection inside NCs can be achieved, which is not possible with conventional scrubbing methods. A one second NC disinfection time and ease of disinfection has the potential for improved asepsis of vascular access connectors in home and alternate infusion settings where compliance with CLABSI-prevention guidelines may be lacking.

Additional information: info@puracath.com

Financial Support: This research was funded by grant number R44AI134553 from the National Institute of Health (NIH), division of National Institute of Allergy and Infectious Diseases (NIAID)