American Journal of Infection Control 43 (2015) 940-5

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

# *Clostridium difficile* infections before and during use of ultraviolet disinfection

Aarathi Nagaraja MD [a], Paul Visintainer PhD [b], Janet P. Haas PhD [a,c], Jonathan Menz MBA [d], Gary P. Wormser MD [a], Marisa A. Montecalvo MD [a,*]

[a] Division of Infectious Diseases, Department of Medicine, New York Medical College, Valhalla, NY
[b] Tufts University School of Medicine, Division of Academic Affairs, Baystate Medical Center, Springfield, MA
[c] Department of Infection Prevention and Control, Westchester Medical Center, Valhalla, NY
[d] Department of Performance Management, Westchester Medical Center, Valhalla, NY

*Key Words:*
Ultraviolet disinfection
Hospital acquired
*Clostridium difficile*

***Background:*** We previously reported a significant decrease in hospital-acquired (HA) *Clostridium difficile* infection (CDI) coincident with the introduction of pulsed xenon ultraviolet light for room disinfection (UVD). The purpose of this study was to evaluate CDI cases in greater detail to understand the effect of UVD.

***Methods:*** CDI rates (HA and community acquired [CA]), CDI patient length of stay, room occupancy, and number of days between a CDI case in a room and an HA CDI case in the same room were studied for the first year of UVD compared with the 1-year period pre-UVD.

***Results:*** Compared with pre-UVD, during UVD, HA CDI was 22% less ($P = .06$). There was a 70% decrease for the adult intensive care units (ICUs) ($P < .001$), where the percentage of room discharges with UVD was greater ($P < .001$). During UVD, CA CDI increased by 18%, and length of stay of all CDI cases was lower because of the greater proportion of CA CDI. No significant difference was found in days to HA CDI in rooms with a prior CDI occupant.

***Conclusion:*** These data suggest that UVD contributed to a reduction in ICU-acquired CDI where UVD was used for a larger proportion of discharges. Evaluation of UVD should include data for hospitalized CA CDI cases because these cases may impact the HA CDI rate.



Hospital-acquired *Clostridium difficile* infection (CDI) is a major cause of morbidity and mortality.[1] CDI is considered to be a preventable infection, and hospital-specific CDI rates are now available to the public in several states, including New York. Environmental cleaning, hand hygiene, contact precautions, and close attention to antibiotic prescription are all considered essential measures to limit the acquisition of *C difficile*.[2,3]

The recovery of *C difficile* from the environment of rooms housing patients with *C difficile* ranges from 29% for asymptomatic carriers to 49%-100% for patients with CDI.[4-13] Patients occupying rooms in which a prior occupant had CDI can be at significantly higher risk of acquiring CDI.[14] *C difficile* spores can survive on hard surfaces for up to 5 months.[15] Bleach can be used to kill the spore and is recommended to reduce the environmental reservoir of *C difficile*.[16,17] However, regardless of the product used, studies examining discharge cleaning practices have shown that cleaning is often suboptimal[18-24]; for example, in a multicenter study of 16 intensive care units (ICUs), on average only 57% of surfaces were cleaned effectively.[18]

In view of the importance of environmental contamination with *C difficile*, disinfection procedures that are not solely dependent on individual practice are being used. Machines that emit ultraviolet-C (UV-C) light can be used for room disinfection. UV-C light (200-320 nm) denatures DNA, halting the growth and reproduction of microorganisms. Ultraviolet light for room disinfection (UVD) machines cannot be used in occupied rooms. Two types of ultraviolet (UV) light machines are available for room disinfection: UV-C emitting devices, which provide continuous UV-C light from a mercury bulb in either a portable machine or a disinfecting wand, and pulsed xenon UV-C light. UVD has been shown to eradicate methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), *Acinetobacter*, and *C difficile* under the

* Address correspondence to Marisa A. Montecalvo, MD, New York Medical College, 40 Sunshine Cottage Rd, Valhalla NY 10595.
*E-mail address:* marisa_montecalvo@nymc.edu (M.A. Montecalvo).

Conflicts of interest: None to report.

0196-6553/$36.00 - Copyright © 2015 by the Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ajic.2015.05.003

artificial conditions of inoculating surfaces with bacteria, exposing the bacteria to UV light and then culturing the surface.[25-27] Studies have evaluated the impact of UVD in rooms that have housed patients by culturing surfaces before and after exposure to UVD. UVD was shown to significantly reduce positive *C difficile* and MRSA cultures from hospital rooms[28,29] and was associated with halting the transmission of CDI between 2 roommates in a long-term care facility,[30] whereas pulsed xenon UVD was associated with significant reductions in the microbial load of VRE in patient rooms.[31]

At our hospital, pulsed xenon UVD was added to standard cleaning of contact precautions rooms in May 2011. In a previously published study we observed a 17% reduction in hospital-acquired CDI coincident with the use of UVD for 22 months compared with a preintervention period of 30 months, which was statistically significant.[32] The purpose of this study was to evaluate CDI during the first year of UVD in greater detail than was provided by the prior report,[32] by including all CDI cases (hospital acquired and community acquired), evaluating length of stay and room occupancy, and assessing time from a CDI occupant in a room to a hospital-acquired CDI case occurring in the same room.

## METHODS

This study compares a pre-UVD period (May 1, 2010-April 30, 2011) with the UVD period (July 1, 2011-June 30, 2012) for total CDI rates, hospital-acquired CDI rates, length of stay, and room occupancy. The months of May and June in 2011 were excluded because UV disinfection was not used consistently until late June 2011. This study was conducted at Westchester Medical Center, a tertiary care hospital located in Valhalla, New York. The hospital has 180 ICU beds and is a referral center for highly immunocompromised patients. All ICUs and pediatric rooms are single occupancy. On the adult service, 13% of the non-ICU rooms are single occupancy.

The UVD procedures were standardized as follows. In each room, drawers, bed rails, phone, television remote, and blood pressure cuffs were placed in the path of UV light; the closets were also opened to be in the path of the UV light. Glass windows and door were covered with special curtains. In each room, doors were closed. In single-bed rooms, bathrooms were disinfected for 6 minutes. Then the machine was placed at the head and foot end of the bed for 12 minutes each. In semiprivate rooms, the bathrooms were cleaned first for 6 minutes. Then the UV machine was placed near the foot end of each bed for 6 minutes for a total of 12 minutes.

Contact precautions were required for all CDI cases until the patient had no diarrhea for a minimum of 3 consecutive days. Beginning in May 2011, UVD with pulsed xenon ultraviolet light (YANEX model; Xenex Healthcare Services, San Antonio, TX) was added after discharge cleaning for rooms housing contact precautions patients, as previously reported.[32] Changes occurring during this study that could impact infection rates are as follows: on January 1, 2011 (4 months before UVD was implemented), a new environmental services company began providing services for the hospital; and in the spring of 2011 (just before UVD started), the pediatric oncology service was expanded to include more highly immunosuppressed patients.

For all CDI cases the following data were collected: length of stay before CDI, during contact precautions, and after discontinuation of contact precautions; rooms occupied throughout the hospital stay; and rates of new hospital-acquired and nonhospital-acquired CDI. During the UVD period the number of UVDs performed for CDI discharge and any discharge and the reason(s) for no UVD were tabulated. To assess how long rooms with a prior CDI occupant remained without a hospital-acquired CDI case during the 2 periods, rooms housing any CDI patient were followed from the day of room discharge cleaning until one of the following end points occurred: a hospital-acquired CDI case, the study period ended, or 5 months (150 days) had elapsed postdischarge cleaning. Days without a hospital-acquired CDI case in the room were compared for the 2 periods.

### *Definitions*

CDI was defined as a patient with diarrhea and a positive stool test for *C difficile*. Hospital-acquired CDI was defined as a CDI case diagnosed at least 72 hours after admission that was not incubating at the time of admission[16] and without a previously positive *C difficile* test during the prior 8 weeks. Community-acquired CDI was defined as all cases not acquired at Westchester Medical Center. Testing for CDI was performed using a polymerase chain reaction test for the toxin b gene (Cepheid GeneXpert System; Cepheid, Sunnyvale, CA). CDI cases were attributed to specific units by infection prevention and control staff based on the patient's location during the 48 hours prior to symptom onset. Incidence rates were the number of new CDI cases per 1,000 patient days. Days in a room were the number of days from the date of admission until the date of room discharge; for transfers within the hospital, the day of transfer was counted as a day in the new room. The number of UVD opportunities was the number of room discharges for patients on contact precautions for CDI.

### *Statistics*

The sample size required for comparing the rates over the study time period was calculated based on an approach by Rosner.[33] This computation requires an estimate of the effect size and an estimate of the average person-time contribution per patient. Based on a known rate of hospital-acquired CDI of 1.1 per 1,000 patient days per year at the Westchester Medical Center and a median length of stay of 11 days per patient, approximately 200,000 patient days per arm would provide 80% power to detect a 25% reduction in the rate of hospital-acquired CDI at a significance level of 5%. All data were entered into a standardized database. Median and interquartile ranges of lengths of stay were compared using the Wilcoxon rank-sum test. Categorical variables were compared using the Fisher exact test, and continuous variables were compared using the Student *t* test. Rates of CDI were compared by calculating incidence rate ratios with 95% confidence intervals. To compare time to hospital-acquired CDI cases in rooms previously housing a CDI patient, the median number of infection-free days in rooms during the preintervention and UVD period was compared using the Kaplan-Meier product-moment estimator and the log-rank test. Analyses were conducted in Stata (version 12.1; StataCorp, College Station, TX).

The protocol was approved by the New York Medical College Committee for the Protection of Human Subjects.

## RESULTS

There were 525 CDI cases (including both hospital-acquired and community-acquired cases) throughout the study: 251 cases occurred during the UVD period, and 274 cases occurred during the pre-UVD period. The total CDI rate (community acquired plus hospital acquired) was similar during the 2 periods (1.89 vs 1.96 CDI per 1,000 patient days; rate ratio [RR], 0.97; 95% confidence interval [CI], 0.81-1.15; $P = .72$). The rate of hospital-acquired CDI was 22% less during the UVD period, which was at borderline statistical significance (0.83 vs 1.06 CDI per 1,000 patient days; RR, 0.78; 95% CI, 0.61-1.009; $P = .06$) (Table 1, Fig 1). The rate of community-acquired CDI was 18% higher during the UVD period (1.06 vs 0.90 CDI per 1,000 patient days; RR, 1.18; 95% CI, 0.92-1.51; $P = .20$). The length of hospital stay for all CDI (hospital and community acquired) cases was significantly shorter during the UVD period