American Journal of Infection Control 42 (2014) 586-90

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Implementation and impact of ultraviolet environmental disinfection in an acute care setting

Janet P. Haas PhD, RN [a,b,*], Jonathan Menz MBA [c], Stephen Dusza DrPH [d], Marisa A. Montecalvo MD [a,b]

[a] Westchester Medical Center Department of Infection Prevention and Control, Valhalla, NY
[b] Department of Medicine, New York Medical College, Valhalla, NY
[c] Westchester Medical Center Department of Performance Management, Valhalla, NY
[d] Department of Epidemiology and Community Health, New York Medical College, Valhalla, NY

Key Words:
Clostridium difficile
Multiple-drug-resistant organisms

Background: Multiple-drug-resistant organisms (MDROs) and *Clostridium difficile* (CD) are significant problems in health care. Evidence suggests that these organisms are transmitted to patients by the contaminated environment.

Methods: This is a retrospective study of the implementation of ultraviolet environmental disinfection (UVD) following discharge cleaning of contact precautions rooms and other high-risk areas at Westchester Medical Center, a 643-bed tertiary care academic medical center. Incidence rates of hospital-acquired MDROs plus CD before and during the UVD use were evaluated using rate ratios and piecewise regression.

Results: The average time per UVD was 51 minutes, and machines were in use 30% of available time. UVD was used 11,389 times; 3,833 (34%) of uses were for contact precautions discharges. UVD was completed for 76% of contact precautions discharges. There was a significant 20% decrease in hospital-acquired MDRO plus CD rates during the 22-month UVD period compared with the 30-month pre-UVD period (2.14 cases/1,000 patient-days vs 2.67 cases per 1,000 patient-days, respectively; rate ratio, 0.80; 95% confidence interval: 0.73-0.88, $P < .001$).

Conclusion: During the time period UVD was in use, there was a significant decrease in overall hospital-acquired MDRO plus CD in spite of missing 24% of opportunities to disinfect contact precautions rooms. This technology was feasible to use in our acute care setting and appeared to have a beneficial effect.

Multiple-drug-resistant organisms (MDROs) and *Clostridium difficile* (CD) are significant problems in health care. Evidence suggests that these organisms are transmitted to patients by the contaminated environment. Patients occupying a room that previously housed a patient with vancomycin-resistant *Enterococcus* (VRE),[1,2] methicillin-resistant *Staphylococcus aureus* (MRSA),[2] or CD infection[3] are at increased risk for acquisition of these organisms. Increased monitoring of cleaning procedures is associated with improved cleaning,[4] less environmental contamination,[2,5-8] and decreases in acquisition of VRE[9,10] and MRSA.[9]

Recently, supplemental methods for environmental disinfection, including ultraviolet light, have become available for use in patient care environments. Ultraviolet disinfection (UVD) technology uses either mercury bulb devices or pulsed xenon bulb devices. Rutala et al reported that mercury UVD reduced colony counts of MRSA and CD by more than 99% in test conditions and decreased both the number of positive cultures and the colony counts per positive culture when tested in rooms that had been occupied by patients with MRSA.[11] Boyce et al also reported significant reductions in aerobic bacterial colony counts from bedside rails, overbed tables, television remotes, bathroom grab bars, and patient bathroom toilet seats after using mercury UVD and significant reduction of CD spores with test plates located strategically in patient rooms.[12] In both studies, objects and surfaces in direct line of sight were more effectively decontaminated by UVD than areas in shadow. Although these studies have demonstrated significant reductions of bacteria in vitro and in clinical settings, there are limited studies on patient outcomes[13] or on the feasibility of use of mercury UVD in the health care environment.

* Address correspondence to Janet P. Haas, PhD, RN, Westchester Medical Center Macy Pavilion SW 246, 100 Woods Road, Valhalla, NY 10595.
E-mail address: haasj@wcmc.com (J.P. Haas).

Conflicts of interest: None to report.

http://dx.doi.org/10.1016/j.ajic.2013.12.013

Pulsed xenon UVD became available after mercury UVD. Literature to support the efficacy of pulsed xenon UVD in decreasing vegetative bacteria[14,15] and bacterial spores[14] indicates it is comparable with mercury UVD. In the first peer-reviewed study on patient outcomes, pulsed xenon UV was associated with a 53% decrease in CD cases in a community hospital,[16] and preliminary data demonstrated an 80% to 90% decrease in CD room contamination and decreasing trends in CD infection and VRE colonization and infection among oncology patients.[14] The purpose of this study is to describe the implementation of a pulsed xenon UVD system for environmental disinfection in an acute care setting and to quantify the rates of hospital acquired MDROs plus CD before and during UVD.

METHODS

This is a retrospective study of the implementation of UVD and the rates of hospital-acquired MDROs plus CD before and during the UVD use. The period before UVD was 30 months (January 2009-June 2011), and the UVD period was 22 months (July 2011-April 2013). This study was conducted at Westchester Medical Center, a 643-bed tertiary care hospital, near New York City. The hospital offers full services to adult and pediatric patients including specialized services for trauma, burn, neurosurgery, cardiothoracic surgery, transplant, and oncology.

The Infection Prevention and Control Department works collaboratively with Environmental Services, which is an outsourced department, to assure that cleaning protocols are appropriate. Bleach-based (sodium hypochlorite 0.55%) disinfectants are used daily and at discharge for all rooms occupied by adults. Pediatric rooms are disinfected daily using a quaternary ammonium compound; a sodium hypochlorite 0.55% disinfectant is used daily for contact precautions rooms and for all discharge cleaning. Most adult patient rooms outside of the intensive care units are double occupancy; all pediatric rooms are single occupancy. Patients with MDROs or CD receive care in a private room, are placed in a semiprivate room with the other bed blocked from occupancy, or are cohorted with another patient who harbors the same organism.

Pulsed xenon UVD (Xenex Corporation, Austin, TX) began in May 2011. In preparation for UVD use at our institution, we performed an assessment of the number and timing of contact precautions discharges and found the mean rate of contact precautions discharges was 0.87 per hour during peak discharge times of 2 p.m. to 6 p.m.[17] These data guided the decision of how many machines would be needed. Two machines were leased with the primary goal of disinfecting contact precautions rooms upon patient discharge or transfer. Training of Environmental Services staff began in May, and UVD was in routine use in July of 2011. In addition to use for contact precautions discharges, UVD was used after end of day cleaning in the operating rooms, weekly in the dialysis unit, and for all burn unit discharges. UVD could be requested for rooms of long-stay patients or for discharges in units with high prevalence of MDRO or CD. In rooms with more than 1 occupant, UVD was deferred until the room was no longer occupied.

The UVD procedure was the following: The bed management system (Teletracking, Pittsburgh, PA) used text pagers to notify Environmental Services staff of room cleaning needs. This system displays contact isolation status. The Environmental Services supervisor received the text page and was responsible for delivery of the UVD machine to the room and for the UVD. Housekeepers were instructed to start cleaning in the bathroom for contact precautions rooms. After cleaning, the UVD machine was started in the bathroom with the door closed, while the housekeeper cleaned the patient room. To reduce the opportunity for user error, UVD was used exclusively at the longer setting appropriate to inactivate CD spores; this included 6 minutes in the bathroom and 6 minutes each at 2 positions within the patient room. The time required was determined by the room size and protocol for machine placement. This was based on the manufacturer's measurement of the UV dose on high-touch surfaces and measured log reductions of microbes after UVD. The time for cleaning and UVD was recorded into the bed management system. The location of UVD use was entered in a logbook until October 2012. After that date, the UVD machines were upgraded, and location data were entered directly into the machines.

The use of UVD was monitored on a weekly basis by the Infection Prevention and Control, Environmental Services, and Performance Management departments. The number and reasons for use based on logbook entries and the machine location input were compared with the contact precautions discharges from the bed management system. When UVD was not performed, reasons were categorized as roommate, no machine available, urgent need for room, or unknown reason. When the reason was unknown, Environmental Services further investigated the cause.

During both the pre-UVD and the UVD periods, there were several initiatives to optimize environmental disinfection. Before UVD use, from July 2008 to December 2009, the hospital participated in the Greater New York Hospital Association CD initiative.[18] This initiative required use of checklists for environmental cleaning and engaging the Environmental Services Department in assuring discharge cleaning was adequate. Mercury UVD (Lumalier, Memphis, TN) was used on a limited basis in the medical intensive care and burn units from January 2009 to June 2010. A new Environmental Services contractor began in January of 2011. Throughout this study, cleaning was monitored using supplemental methods; Adenosine triphosphate (3M Cleantrace; 3M, Minneapolis, MN) was used in 2010, and UV fluorescent tracking markers (Dazo; Ecolab, St. Paul, MN) were used in the 2011 to 2013 period. In September 2012, during the UVD period, a new discharge cleaning checklist was adopted for use by Environmental Services supervisors.

Other health care-associated infection reduction initiatives included public reporting of CD to the New York State Department of Health starting in January 2010 and a change from CD cytotoxin A+B enzyme immunoassay (Meridian Bioscience, Cincinnati, OH) to real-time polymerase chain reaction (Cepheid, Sunnyvale, CA) in July 2010. In addition, a randomized double-blind trial of chlorhexidine bathing was conducted on a single unit, and weekly intensive cleaning of occupied rooms in high-risk units occurred throughout both the pre-UVD and UVD periods.

Definitions

MDRO cases were patients with organisms recovered from clinical cultures that include MRSA, VRE, or gram-negative bacteria susceptible to 2 or fewer classes of antibiotics. CD cases were defined as cases with a stool diagnostic test positive for CD. MDRO or CD cases were considered hospital acquired if there was no history of the organism and the onset of symptoms that led to recovery of the organism was present after 3 days of hospitalization and not incubating at admission or recovered within 48 hours after discharge. Incidence rates of MDROs and CD were defined as new hospital-acquired cases per 1,000 patient-days. Rate data were abstracted from Infection Prevention and Control databases without any links to individual patient information. This study was a quality improvement initiative that assessed summary data without individual patient identifiers.

Data analysis

Descriptive statistics were used to report the number of UVD cycles completed, the reasons for use, the percent of contact