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Major article

Is the pulsed xenon ultraviolet light no-touch disinfection system effective on methicillin-resistant *Staphylococcus aureus* in the absence of manual cleaning?

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Background: Methicillin-resistant *Staphylococcus aureus* (MRSA) has been shown to survive on ambient surfaces for extended periods of time. Leftover MRSA environmental contamination in a hospital room places future patients at risk. Manual disinfection supplemented by pulsed xenon ultraviolet (PX-UV) light disinfection has been shown to greatly decrease the MRSA bioburden in hospital rooms. However, the effect of PX-UV in the absence of manual disinfection has not been evaluated.

Methods: Rooms that were previously occupied by a MRSA-positive patient (current colonization or infection) were selected for the study immediately postdischarge. Five high-touch surfaces were sampled, before and after PX-UV disinfection, in each hospital room. The effectiveness of the PX-UV device on the concentration of MRSA was assessed employing a Wilcoxon signed-rank test for all 70 samples with MRSA in 14 rooms, as well as by surface location.

Results: The final analysis included 14 rooms. Before PX-UV disinfection there were a total of 393 MRSA colonies isolated from the 5 high-touch surfaces. There were 100 MRSA colonies after disinfection by the PX-UV device and the overall reduction was statistically significant ($P < .01$).

Conclusions: Our study results suggest that PX-UV light effectively reduces MRSA colony counts in the absence of manual disinfection. These findings are important for hospital and environmental services supervisors who plan to adapt new technologies as an adjunct to routine manual disinfection.

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CJ and NGM developed the methodology and protocol and performed data collection and manuscript preparation. MR, FV, IL, JZ, LC, and ES participated in study design, statistical analysis, and contributed to the manuscript. All authors read and approved the final manuscript. Part of this manuscript was presented as a poster at IDWeek 2014, Philadelphia, Pa.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) infections in the United States have accounted for $9.7 billion in additional costs to health care systems.[1-3] Surfaces in a patient room play an important role in the transmission of infectious diseases, including MRSA and vancomycin-resistant enterococci.[4,5] MRSA survives on surfaces for several months, possibly contributing to hospital-acquired infections (HAIs).[6] The current recommended cleaning process involves manual disinfection of surfaces using chemical disinfectants. Several studies have shown that a manual disinfection process is inadequate, leaving residual contamination.[7,8] Residual contamination on surfaces can place a future occupant at a 2- to 3-fold increased risk of acquiring an infection from the previous occupant.[9] No-touch disinfection (NTD) systems that produce germicidal spectrum ultraviolet (UV) light from mercury or pulsed xenon (PX)-based sources have been shown to be effective in conjunction with manual disinfection leading to superior terminal cleaning, especially for MRSA.[10,11] Certain mercury-based NTD systems have been shown to be effective even in the presence of organic material and absence of manual disinfection before use of the device.[12] There is currently a dearth of similar evidence for devices that use PX technology. In an attempt to address this deficiency, we devised a study to evaluate the effectiveness of a PX-UV light NTD device against MRSA in the absence of manual cleaning.

METHODS

This quasiexperimental study was conducted at a tertiary care hospital from March-June 2014 in the Central Texas Veterans Health Care System, Temple, Tex. By policy, polymerase chain reaction or cultures for MRSA are performed on nasal swabs collected on all patients at admission, transfer, and discharge. Hence the MRSA status (colonization, infection, or neither) of a patient is known from the outset. Patients with MRSA infection, either community-acquired or hospital-acquired, MRSA colonization, or with prior-year positive polymerase chain reaction/culture are placed on contact isolation for MRSA during their entire hospitalization. Rooms that were previously occupied and designated as contact isolation by a MRSA-positive patient were selected for the study immediately postdischarge. Patients who did not have MRSA on nasal screening or clinical cultures but were prior colonizers or had prior infection were excluded from the study. Furthermore, these rooms had to meet the following criteria to be included in our study:

1. Room had been occupied for at least 48 hours.
2. Room was single-bed occupancy with a private bathroom.
3. Study team was available to collect samples pre- and post-irradiation (typically between 8 am and 5 pm, Monday through Friday) immediately following discharge of the patient.

Once the study rooms were identified, samples were collected from 5 high-touch surfaces (ie, bedrail, toilet seat, bathroom handrail, call button, and tray table) before and after PX-UV exposure. The device used in this study has been previously described by our laboratory.[10] The PX-UV light was placed and run for 5 minutes per location: once on both sides of the bed and once in the bathroom, exposing the above-mentioned high-touch surfaces for a total of 15 minutes of PX-UV exposure per room.[10]

The samples were collected adjacent to 1 another to minimize variability. Microbiologic sampling was performed using Rodac contact plates (Hardy Diagnostics, Santa Monica, Calif). For flat surfaces, the contact plate was firmly pressed for 5 seconds. For nonflat surfaces, we used a roll-plate technique. If visible soiling was observed, the samples for that surface were taken adjacent to the soiling. The plates were then incubated at 35°C-37°C for 48 hours. Suspected MRSA was confirmed as MRSA using standard methods. If the MRSA colony counts were >200, the count was recorded as 200. This was done to limit the effect of a few outliers skewing the data and hence overestimating the potential effect of PX-UV light on MRSA. The effectiveness of the PX-UV light device on the concentration of MRSA was assessed employing a Wilcoxon signed-rank test for all 70 [pre/post] samples in 14 rooms, as well as by surface location. A type I error of $\alpha = 0.05$ was assumed. Data were analyzed using SAS version 9.3 (SAS Institute Inc, Cary, NC) and R version 3.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

Table 1
Surface colony counts in rooms with methicillin-resistant *Staphylococcus aureus*

Location	No. Samples	Before PX-UV light	After PX-UV light	Count reduction	*P* value*
Bathroom handrail	14	4.8 ± 9.2 1 (0, 35; 0-6)	0.4 ± 0.9 0 (0, 3; 0-0)	4.4 ± 9.4 1 (-3, 35; 0-5)	.02
Bedrail	14	1.9 ± 3.1 0.5 (0, 10; 0-3)	0.43 ± 1.2 0 (0, 4; 0-0)	1.5 ± 3.2 0 (-2, 10; 0-1)	.13
Call button	13	3.5 ± 7.5 1 (0, 26; 0-2)	0.2 ± 0.4 0 (0, 1; 0-0)	3.4 ± 7.5 0 (0, 26; 0-2)	.03
Toilet seat	14	14.1 ± 31.4 0 (0, 90; 0-5)	6.0 ± 12.3 0 (0, 38; 0-1)	8.1 ± 22.0 0 (-10, 70; 0-2)	.31
Tray table	14	3.9 ± 7.1 0.5 (0, 23; 0-3)	0.2 ± 0.6 0 (0, 2; 0-0)	3.7 ± 6.7 0.5 (0, 21; 0-3)	.02
Total	69	5.7 ± 15.6 1 (0, 90; 0-4)	1.5 ± 5.9 0 (0, 38; 0-0)	4.3 ± 11.6 0 (-10, 70; 0-3)	<.01

NOTE. Values are presented as mean ± standard deviation and median (minimum, maximum; interquartile range).
PX-UV, pulsed xenon ultraviolet.
*Wilcoxon signed-rank tests were employed, assuming a significance level of $\alpha = 0.05$.

RESULTS

We sampled 40 patient rooms. Of the 40 rooms selected only 14 (35%) contained MRSA on at least 1 high-touch surface before UV light exposure. Only these 14 rooms were included in the final analysis. Before PX-UV light use there were a total of 393 MRSA colonies isolated from the high-touch surfaces in the 14 rooms. Of the 393 MRSA colonies, 67 (17%) were on the bathroom handrail, 27 (7%) were on the bedrail, 46 (12%) were on the call button, 198 (50%) were on the toilet seat, and 55 (14%) were on the tray table. The surfaces with the highest contamination were the toilet seat, bathroom handrail, and tray table with mean colony counts of 14.1, 4.8, and 3.9, respectively. After use of the PX-UV light device there were a total of 100 MRSA colonies. Of the 100 MRSA colonies, there were 5 (5%) on the bathroom handrail, 6 (6%) on the bedrail, 2 (2%) on the call button, 84 (84%) on the toilet seat, and 3 (3%) on the tray table (Table 1). However, there was a significant outlier on the call button surface in 1 of the samples after PX-UV light device use. This outlier was considerably higher than any of the other samples after PX-UV light use, with 116 MRSA colonies. The outlier was attributed to cross-contamination and thus removed from the final analysis.

DISCUSSION

Through this study we demonstrated a reduction in surface MRSA colony counts after PX-UV irradiation. NTD technologies, such as PX-UV light, use high-intensity broad-spectrum UV irradiation to disrupt the molecular bonds in the DNA of microorganisms.[13,14] UV light exposure causes bonding within DNA, creating thymine dimers that inhibit proliferation of the organism.[13] PX-UV along with

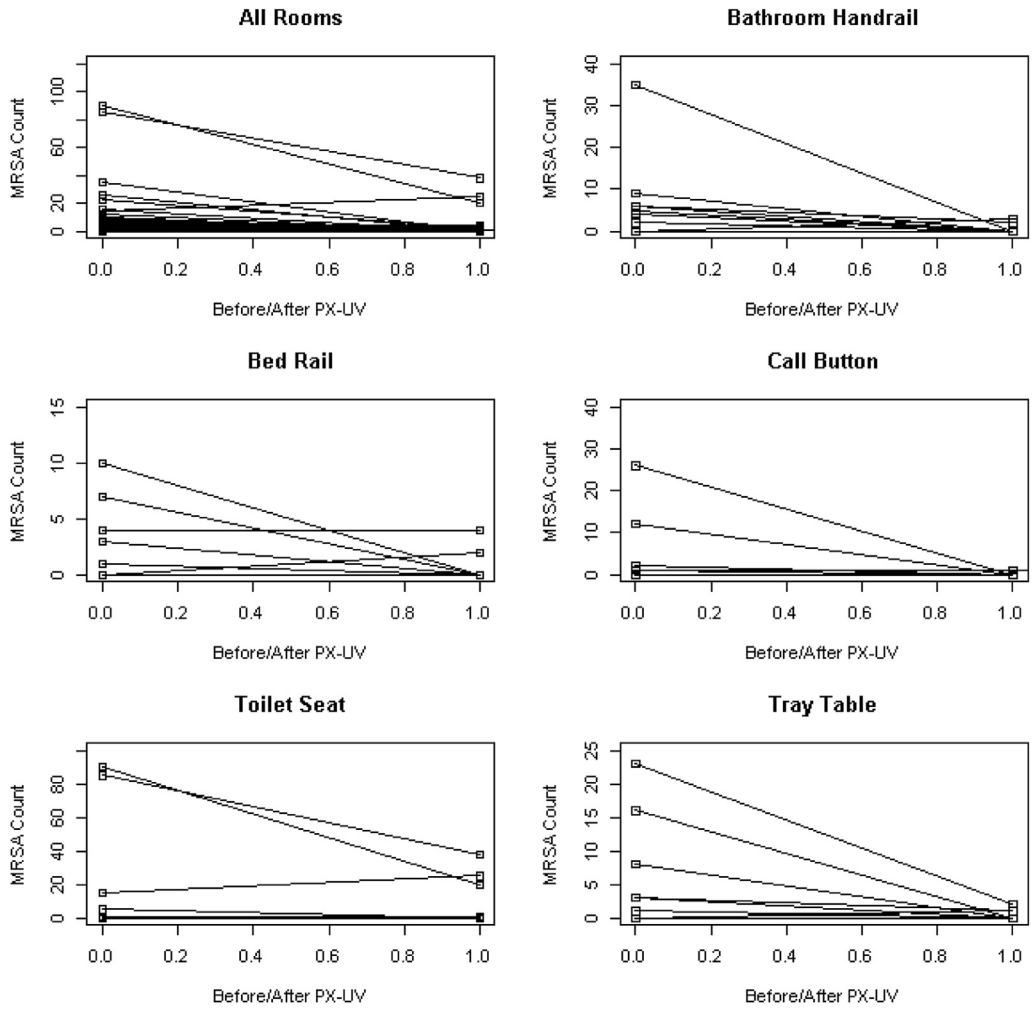

Fig 1. Effect of pulsed xenon ultraviolet light (PX-UV) on different surfaces.

manual disinfection significantly decreases the amount of proliferating MRSA on hospital surfaces.[10]

Current hospital protocols using NTDs require pre-NTD manual disinfection for 2 main reasons: aesthetics and effectiveness. UV light is believed be less effective in the presence of organic material and research supporting its effectiveness is ongoing. Mercury-based device trials have shown that UV light is effective in the absence of any manual disinfection and in the presence of organic material.[12] Although their effectiveness is statistically significant, a loss of efficacy is observed in the absence of manual disinfection. Our data are consistent with literature published on other NTDs, including those that employ mercury.[10,11] When the results from Table 1 were compared for MRSA reduction after standard manual disinfection without use of PX-UV light, the results were similar.[10] It is possible that after careful manual disinfection important areas with high bacterial load could be missed. Therefore, adding NTD methods such as PX-UV light to standard manual disinfection would achieve superior disinfection.[10]

Although PX-UV is effective, we are not advocating abandonment of manual disinfection mainly for aesthetics reasons. However, combination methods may achieve the highest levels of disinfection. Our study provides insight into what happens when a surface is missed during the pre-NTD cleaning routine, and offers reassurance when a PX-UV device is employed terminally. We found that PX-UV light effectively reduces MRSA colonies on hard surfaces such as handrails, call buttons, bedrails, toilet seats, and tray tables (Fig 1).We view PX-UV light as an adjunct to existing terminal cleaning protocols that offers a safety net when the primary approaches fail.

The use of NTDs has steadily increased across Veterans Administration hospitals over the past 2 years (personal communication, Xenex Healthcare Services, June 26, 2014). As novel NTDs become available, and as they are deployed across hospitals, there may be fear that environmental services personnel may not perform as well as before as a result of overconfidence that these devices will cover potential mistakes. When this technology was implemented in our hospitals, many of our environmental services supervisors feared that their staff would decrease the effort put into manual disinfection. It was already known that manual disinfection was inadequate in certain circumstances, and by relying on NTD methods such as the PX-UV light, this problem might increase patients' risk of developing an HAI.[7,15] Inadequate manual disinfection of hospital surfaces is related to inadvertant human error, with the inability to identify with certainty all the areas where high bacterial load might be present.[7,15] Do no harm is a guiding principal in modern health care; the concern that we might be inadvertently doing harm by implementing NTDs such as PX-UV light was not evident in our study. We expect that incorporation of PX-UV light devices into routine cleaning protocols can be achieved elsewhere without detriment, as well.

We have previously demonstrated similar a reduction in aerobic bacterial counts on surfaces in the absence of manual disinfection.[16] Our goal in this study was to further enhance the evidence as it relates to organism-specific bioburden on surfaces highly likely to contain large MRSA bioburden. Studies are underway to evaluate the influence of PX-UV light on HAI and transmission rates for MRSA and *Clostridium difficile*.

Our study has a few limitations that require acknowledgment. First, we did not evaluate the efficacy of PX-UV on *C difficile* reduction. This is the focus of an ongoing study at our institution. Second, this study was conducted in a Veterans Administration hospital setting and these results may not be generalizable to community hospitals and hospitals with a different workforce. Whereas the sample size of rooms evaluated in this study was small, it does represents a larger cohort than other previously reported studies.[10-12] Because we restricted the upper limit of the colony counts to 200, we may have underestimated the effect of PX-UV light, thus minimizing the overall effect. Our previously published study showed that manual disinfection supplemented by PX-UV light was superior to manual cleaning alone.[10] Finally, we did not assess the effect of organism reduction on HAI rates, but a larger multisite study is underway to evaluate the effect of PX-UV light on HAI rates (IIR 12-347).

CONCLUSIONS

Our study suggests that PX-UV light effectively reduces MRSA colony counts in the absence of manual disinfection. These findings are important for hospitals and environmental services supervisors who plan to adapt new technologies as an adjunct to routine manual disinfection. In addition, we believe that these findings give added support to improved disinfection outcomes when manual disinfection may be less than adequate.

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