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Brief report

Assessment of an innovative antimicrobial surface disinfectant in the operating room environment using adenosine triphosphate bioluminescence assay

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Terminal cleaning in the operating room is a critical step in preventing the transmission of health care–associated pathogens. The persistent disinfectant activity of a novel isopropyl alcohol/organofunctional silane solution (ISO) was evaluated in 4 operating rooms after terminal cleaning. Adenosine triphosphate bioluminescence documented a significant difference ($P < .048$) in surface bioburden on IOS-treated surfaces versus controls. RODAC plate cultures revealed a significant ($P < .001$) reduction in microbial contamination on IOS-treated surfaces compared with controls. Further studies are warranted to validate the persistent disinfectant activity of ISO within selective health care settings.

The role of terminal cleaning is to reduce the risk of microbial contamination within the operating room (OR) environment.[1] Previous studies have suggested that ineffective cleaning processes can result in the contamination or transmission of health care–associated pathogens throughout the health care environment.[2-4] The present investigation assesses the level of residual bioburden contamination in 4 ORs after routine terminal cleaning and the efficacy of a novel antimicrobial isopropyl alcohol/organofunctional silane solution (IOS) to reduce microbial contamination on selective OR surfaces over a 6-week study period. Surface bioburden levels were reported as relative light units (RLUs) using an adenosine triphosphate (ATP) bioluminescence assay.

METHODS

OR environment

Four ORs (out of 18) were randomly selected for study: a hybrid OR (A) where open and endovascular procedures are performed; an OR used for kidney and liver transplantation (B); and 2 general surgical ORs (C and D).

Baseline ATP bioluminescence testing

Prior to IOS treatment of study surfaces, baseline ATP bioluminescence analysis of residual surface bioburden (Getinge SafeStep Handheld Luminometer, Getinge USA, Rochester, NY) was conducted on multiple sites (10) in 4 randomly selected ORs (A-D) twice a week for 2 weeks (160 samples) immediately after terminal cleaning (quaternary disinfectant). Testing protocol involved sampling a uniform 2 cm^2 surface area (SafeStep Test Swabs, Getinge USA, Rochester, NY) by rubbing test swabs back and forth using a rotating motion for 15 seconds. A value $\leq$45 RLUs reflected a surface containing little or no bioburden (designated clean), whereas a value $\geq$46 RLUs was designated as dirty. During baseline testing, 5 individual touch surfaces common to all study ORs documenting high RLU ($\geq$46) values after terminal cleaning were selected for

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Conflicts of interest: None to report.

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Table 1
Mean baseline relative light values and range per sampled operating room after terminal cleaning*

Operating room	Relative light values (range)
A	137.5 (15.0-176.2)
B	298.4 (4.0-543.6)
C	994.2 (18.2-2,112.3)
D	167.8 (9.3-269.7)

*There were 160 total baseline samples; 40 samples per operating room.

further study. The 5 test surfaces in each OR included the following: anesthesiology monitors positioned at the end of the OR table, staff computer keyboards positioned behind the sterile field, large flat screen monitors positioned <1 m from the sterile field, wall-mounted room telephones positioned outside of the sterile field, and back utility tables located outside of sterile field.

ATP bioluminescence assay of IOS-treated OR surfaces

After terminal cleaning, IOS antimicrobial disinfectant solution (MicrobeCare XLP, MicrobeCare, Allendale, MI) was liberally applied to each test surfaces using a cloth (microfiber) covered sponge and allowed to dry. Prior to application, test surfaces were divided into treated and nontreated sections. ATP bioluminescence testing was conducted and interpreted as per baseline analysis. All samples were analyzed within 60 seconds of collection. Although the 5 specific test sites were agreed on prior to testing, technical personnel performing the sampling were blinded to the paired treated and nontreated sites. Test surfaces in each OR were sampled 3 times a week for 6 weeks (720 total samples) after terminal cleaning. Comparative BBL RODAC plate (BD Diagnostics, Sparks, MD) cultures (N = 240) were obtained from test surfaces immediately adjacent to sites sampled for ATP bioluminescence on alternating weeks to assess microbial recovery. All plates were incubated for 24-48 hours at 35°C followed by colony counting under magnification. Individual colonies were selected for identification. Surfaces yielding 0-5 colonies were assessed as low, 6-15 colonies were assessed as fair to moderate, and ≥16 colonies were viewed as poor or significant contamination.[5] At the end of the 6-week period, the individual site test codes were broken and analyzed using paired 2-sample *t* tests and analysis of variance (Minitab 15 Statistical Software, Minitab, State College, PA).

RESULTS

Table 1 reports mean baseline relative light values (RLU and range) determined from multiple test surfaces (N = 10) in each of the 4 ORs. Overall, baseline analysis documented that 29.9%, 43.7%, 57.8%, and 45.7% of selected test surfaces in surfaces of ORs A, B, C, and D were designated as dirty (≥46 RLUs) by ATP bioluminescence assay, respectively. Based on these observed values, 5 test surfaces in each OR were selected to be treated with IOS.

The mean RLUs observed on treated and nontreated surfaces and BBL RODAC colony counts are reported in Table 2. The mean RLUs for nontreated control sites were 242.0 (range, 19.4-2,872.6), whereas the mean RLUs for IOS-treated sites were 67.6 (range, 0-297.5). Eighty percent of nontreated OR test surfaces were culture positive, whereas 82.5% of IOS-treated surfaces were culture negative. The mean microbial recovery (colony forming units) from culture-positive nontreated surfaces was 14.3 (moderate contamination), whereas the mean microbial recovery from IOS-treated surfaces was 1.7 (low). The predominant microbial isolates recovered from both nontreated and IOS-treated culture-positive sites were coagulase-negative staphylococci and *Micrococcus* sp. No significant degradation of antimicrobial activity based on BBL RODAC plate cultures was noted in the IOS-treated sites over the 6-week test interval.

Table 2
Mean RLUs per treated surface and mean RCCs for treated and nontreated surfaces

Sites*	Mean RLU/mean RCC†			
	Operating room A	Operating room B	Operating room C	Operating room D
Monitor				
Nontreated surfaces‡,§	226.7/39.1	266.6/13.3	267.1/19.4	238.1/15.9
Treated surfaces‖,§	98.4/0	94.6/1.9	110/0.9	99.6/1.0
Keyboard				
Nontreated surfaces‡,§	137.4/17.1	117.8/8.8	80.1/6.6	198.5/41.6
Treated surfaces‖,§	87.2/1.8	74.2/1.0	37.8/2.1	92.7/1.7
Monitor flat screen				
Nontreated surfaces‡,§	61.4/8.6	441.2/13.6	2,056.4/47.3	87.4/11.6
Treated surfaces‖,§	44.3/2.3	71.6/2.8	298.7/2.9	49.1/0
Room phones				
Nontreated surfaces‡,§	113.8/5.7	709.9/10.9	65.8/26.1	192.3/9.4
Treated surfaces‖,§	29.6/1.4	87.8/0	32.8/3.8	84.4/2.2
Back table				
Nontreated surfaces‡,§	98.9/6.6	29.6/1.8	145.8/11.9	85.8/17.8
Treated surfaces‖,§	21.4/1.9	41.7/0	45.6/4.1	29.9/5.3

ATP, adenosine triphosphate; *IOS*, isopropyl alcohol/organofunctional silane solution; *RCC*, BBL RODAC colony count; *RLU*, relative light unit.
*There were 36 separate RLU determinations made for each treated and nontreated site tested over the 6-week study period (N = 720).
†$P < .001$, IOS-treated surfaces compared with nontreated by BBL RODAC plate culture.
‡Surfaces with ≥46 RLUs are designated as dirty.
§$P = .048$, IOS-treated surfaces compared with nontreated by ATP bioluminescence.
‖Surfaces with ≤45 RLUs are designated as clean.

CONCLUSION

The terminal cleaning process is a critical step in preventing the transmission of health care–associated pathogens.[2-4] Baseline analysis (Table 1) documented multiple sites within the sampled ORs with ≥46 RLUs, suggesting inadequate terminal cleaning. ATP bioluminescence assay has been proposed as a surrogate marker for measuring the effectiveness of the routine cleaning process by documenting the presence of residual ATP.[6] In the present study, ATP bioluminescence assay demonstrated a significant reduction ($P = .048$) in RLUs on inert surfaces treated with an innovative antimicrobial IOS compared with nontreated control surfaces. However, ATP bioluminescence does not differentiate between microbial and nonmicrobial (blood and tissue protein) surface bioburden. Therefore, BBL RODAC plates were used to validate the disinfectant activity of IOS, demonstrating a significant reduction ($P < .001$) in microbial surface contamination on all test surfaces over the 6-week study period compared with control surfaces. Selective IOS-treated OR surfaces (ie, monitors, keyboards) revealed mean RLU readings ≥46, which would designate the surface as dirty. However, these elevated RLU values likely represented residual nonmicrobial (blood and body fluid) bioburden. ATP bioluminescence technology was effective in assessing surface bioburden contamination after routine terminal cleaning. These results are in agreement with previous published studies documenting the benefit of ATP bioluminescence technology to assess the efficacy of surface cleanliness within the health care environment.[7-10]

The findings of this study suggest that a single application of IOS provides a persistent disinfectant activity, minimizing microbial surface contamination in an environment where terminal cleaning may be inadequate or have limited effectiveness. These results, however, are in contrast with a recently published article by Boyce

et al[11], suggesting that selective organosilane compounds may not provide a sustained antimicrobial activity when applied to high-touch surfaces within the hospital environment. Unfortunately, these agents were not available to the authors for comparative analysis. Further studies are warranted to validate the persistent disinfectant activity of IOS within selective health care settings.

References

1. Otter JA, Vesli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. Infect Control Hosp Epidemiol 2011;32:687-99.
2. Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA. Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. Clin Infect Dis 2006;42:1552-60.
3. Datta R, Platt R, Yokoe DS, Huang SS. Environmental cleaning intervention and risk of acquiring multidrug-resistant organisms from prior room occupants. Arch Intern Med 2011;171:491-4.
4. Passaretti CL, Otter JA, Reich NG, Myers J, Shepard J, Ross T, et al. An evaluation of environmental decontamination with hydrogen peroxide vapor for reducing the risk of patient acquisition of multidrug-resistant organisms. Clin Infect Dis 2013;56:27-35.
5. Dell LA. Aspects of microbiological monitoring for nonsterile and sterile manufacturing environments. Pharm Technol 1979;3:47-51.
6. Guh A, Carling P, Environmental Evaluation Workgroup. Options for evaluating environmental cleaning. Available from: http://www.cdc.gov/HAI/pdfs/toolkits/Environ-Cleaning-Eval-Toolkit12-2-2010.pdf. Accessed October 6, 2014.
7. Boyce JM, Havill NL, Dumigan DG, Golebiewski M, Balogun O, Rszvani R. Monitoring the effectiveness of hospital cleaning practices by use of an adenosine triphosphate bioluminescence assay. Infect Control Hosp Epidemiol 2009;30:678-84.
8. Mulvey D, Redding P, Robertson C, Woodall C, Kingsmore P, Bedwell D, et al. Finding a benchmark for monitoring hospital cleaniness. J Hosp Infect 2011;77:25-30.
9. Branch-Elliman W, Robillard E, McCrthy G, Gupta K. Direct feedback with ATP luminometer as a process improvement tool for terminal cleaning of patient rooms. Am J Infect Control 2014;42:195-7.
10. Smith PW, Beam E, Sayles H, Rupp ME, Cavaliere RJ, Gibbs S, et al. Impact of adenosine triphosphate detection and feedback on hospital room cleaning. Infect Control Hosp Epidemiol 2014;35:564-9.
11. Boyce JM, Havill NL, Guerica KW, Schweon SJ, Moore BA. Evaluation of two organosilane products for sustained antimicrobial activity on high touch surfaces in patient rooms. Am J Infect Control 2014;42:326-8.