

Disinfection and Sterilization

74. Feasibility of Ongoing Use of Hydrogen Peroxide Vapor (HPV) Technology to Decontaminate Rooms Vacated by Patients with Multidrug-Resistant Organisms

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Background: Environmental contamination with *Clostridium difficile* (C. diff), methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE) and other pathogens can contribute to nosocomial transmission of these organisms. Terminal decontamination of patient rooms using HPV (BIOQUELL, Andover, UK) has been shown to effectively eliminate environmental contamination due to these organisms.

Objective: To evaluate the feasibility of ongoing use of HPV to decontaminate rooms vacated by patients with multidrug-resistant organisms (MDROs) in a busy university-affiliated hospital.

Methods: We prospectively maintained a list of rooms targeted for HPV decontamination following occupancy by patients with active Cdiff and other selected MDROs. Daily census data were obtained from the hospital's Admissions Department and mean weekly percent occupancy rates, based on census measured every 4 hrs, were obtained from the Information Services Department. Linear regression was used to assess the association between variables.

Results: From January 2006 through October 2007, 1565 rooms were decontaminated using HPV. In the same time period, we identified an additional 1194 rooms for HPV decontamination, which was not possible (missed rooms). The number of rooms decontaminated per week varied from 8 to 29 (median 17). Rooms decontaminated were vacated by patients with Cdiff (69.9% of rooms), Norovirus (7.0%), *Acinetobacter* (4.1%), MRSA (2.2%), VRE (0.8%) or other organisms (16%). Monthly mean daily total hospital census ranged from 362 to 409 (median 382). Weak correlation ($r^2 = 0.21$) existed between the monthly mean daily hospital census and the number of missed rooms each month and between the total number of missed rooms per month and the number nosocomial Cdiff-associated disease acquisitions ($r^2 = 0.35$). Weekly mean percent occupancy rates varied from 77% to 103% (median 94%). Use of HPV decontamination was temporarily suspended when the hospital was in contingency.

Conclusions: Terminal decontamination of selected patient rooms using HPV technology is feasible in a busy hospital with relatively high occupancy rates, although more rooms targeted for decontamination were missed at times of high census. Further evaluation of the use of HPV decontamination technology in healthcare settings is warranted.

75. Evaluation of the Biocidal Efficacy of Ortho-Phthalaldehyde Solution With Vegetative And Spore Forms Of *Clostridium difficile*

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Background: In the healthcare setting *Clostridium difficile* has emerged as an important nosocomial pathogen along with MRSA, VRE, and MDRTB. The emergence of this organism created great concern because of epidemic contamination of hospital environments and the increased in the rate of nosocomial infections. To control the spread of *C. difficile*, high-level disinfectants (HLD) are used to disinfect medical devices used in patient care. To date, there is little efficacy data available on *C. difficile* especially with aldehyde-based high-level disinfectants.

Objective: The purpose of this paper is to report the results of studies conducted to evaluate the biocidal activity of an ortho-phthalaldehyde (OPA) based high-level disinfectant solution.

Methods: Using a suspension test and membrane filtration methods, *Clostridium difficile* vegetative cells (ATCC® 9689) were evaluated with a 0.3% ortho-phthalaldehyde solution at 20°C. Additionally, the spore form of *C. difficile* (ATCC 700792) was tested against 0.3% and 0.5% ortho-phthalaldehyde solutions at 25°C. Both vegetative and spore forms were testing with added organic matter (5% final concentration of fetal bovine serum). At predetermined time exposure periods, aliquots were sampled from the test solutions (contaminated with at least 10⁵ cells/spores), neutralized and cultured.

Results: The results show that with *C. difficile* vegetative cells, there were no surviving cells observed after a 2 minute exposure in 0.3% OPA at 20°C. With the spore form of *C. difficile* at 25°C, a 2.4 log₁₀ reduction was demonstrated with 0.3% OPA and at least 4.9 log₁₀ reduction with 0.5% OPA after a 5 minute exposure.

Conclusions: High-level disinfectant ortho-phthalaldehyde (OPA) solution is efficacious against *C. difficile*, both vegetative and spore forms.

76. Pitfalls in Efficacy Testing - How Important Is the Validation Of Neutralization?

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Background: Effective neutralization of active agents is essential to obtain valid efficacy results, especially if non-volatile active agents like chlorhexidine gluconate are tested.

Objective: Aim of the study was to determine an effective and non-toxic neutralizer mixture for an alcoholic solution containing 2% chlorhexidine gluconate.

Methods: Experiments were done according to ASTM E 1054-02. The neutralization capacity was separately tested with five challenge microorganisms (*Micrococcus luteus*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Corynebacterium jeikeium*, *Candida albicans*), with a cotton swab carrier and in suspension. For the suspension test 0.5 mL of solution were added to 5 mL tryptic soy broth with neutralizing agents (3% polysorbate 80, 0.3% lecithin, 0.1% L-histidine, 0.5%

sodium thiosulfate, 3% saponin, 1% ether sulfate). For the carrier-test the cotton swab was saturated 20 s with the antiseptic solution and vortexed 30 s in neutralizing broth. Broth was spread immediately after inoculation and after storage of the broth for 3 h at 2-8 °C on tryptic soy agar containing 0.1% L-histidine, 0.3% lecithin and 3% polysorbate 80. The neutralizer toxicity, test organism viability and test material control were in addition determined.

Results: In the carrier test the neutralizer mixture was found to be effective and non toxic regarding all challenge microorganisms when spread immediately. But a 3 h storage of the neutralized active agents resulted in a significant carry-over activity of chlorhexidine against *Micrococcus luteus* ($p = 0.004$; Tukey HSD test). The neutralizer was, however, not consistently effective in the suspension test.

Immediate spread yielded a valid neutralization of *Staphylococcus aureus* and *Staphylococcus epidermidis* but not of *Micrococcus luteus* ($p < 0.001$), *Candida albicans* ($p < 0.001$) and *Corynebacterium jeikeium* ($p = 0.024$). A 3 h storage of the neutralized active agents in suspension resulted in a significant carry-over activity of chlorhexidine in addition against *Staphylococcus epidermidis* ($p < 0.001$).

Conclusions: Without effective neutralization in the sampling fluid non-volatile active ingredients will continue to reduce the number of surviving microorganisms of antiseptic treatment even if the sampling fluid is kept cold straight after the test. This can result in false-positive efficacy data of an antiseptic. Based on our data immediate spread is strongly recommended with chlorhexidine-containing antiseptics to avoid false positive efficacy data.

77. Treatment of Hospital Water System with Cu/Ag Ionization for the Reduction of Legionella species

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Reduction of Legionella species in Hospital Water System Using Copper/Silver Ionization

Background: Routine water sampling for *Legionella pneumophila* (LP) is conducted at our hospital. Prior to opening a newly constructed wing of the hospital *Legionella* spp. were not detected in the water supply. However, sampling 6 weeks later revealed high levels of *Legionella* contamination. An inspection of the newly installed water system revealed several problem areas which were addressed by the maintenance department. Super heating and flushing was undertaken as a first line approach. Failure of this process to eliminate LP from the system led to the installation of a Cu/Ag ionization unit. Initial post installation results were disappointing and water samples remained positive for LP. The maintenance department worked with the ionization company to address the problem. It was discovered that incoming city water was pH 9.5 and that this interfered with the process. When the pH was adjusted by the addition of acid, not only were the percentage of LP positive cultures reduced but the bacterial counts in positive samples were low. This has remained so for the 9 months since pH adjustment was introduced (Chart 1).

Objective: To reduce the amount of *Legionella* present in the hospital water system.

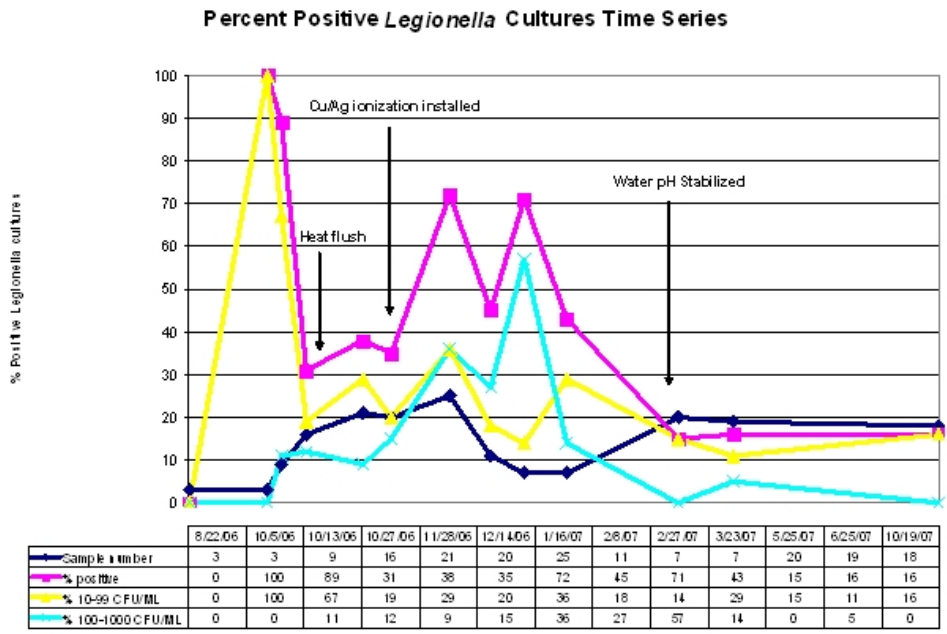
Methods: Water samples were collected and plated for quantitative analysis using buffered CYE selective agar DGVP (BCYE with dyes, glycine, Vancomycin, polymyxin B; Remel Inc.). Detection limit = 10 cfu/ml. Water heating and flushing was performed at 145OF for 30 minutes per faucet. The Cu/Ag ionization unit is manufactured by Liquitech, Inc. and used according to manufacturer's instructions.

Results: Legionella isolates were identified as *L. pneumophila* serotype 1. Initial problem areas found on inspection prior to system heat flushing:

- Circulation and holding tank temperature
- Alarms not working or set incorrectly
- Infrequent use of showers, sinks and tubs

Temperature and alarm settings were corrected prior to heat flushing and installation of the copper/silver ionization unit. Initial heat flushing did not reduce Legionella levels to < 10 cfu/ml.

Results and intervention points are given in Chart 1, Table 1
Chart 1, Table 1



Conclusions: LP is a common contaminant in water systems and difficult to eradicate. Testing the new water system a few days before move-in date showed that Legionella levels were <10 cfu/ml, 6 weeks later repeat testing revealed widespread contamination. These findings prompted immediate inspection of the water system. Heat flushing of the new water system was not effective. After initial problems post installation the Cu/Ag ionization unit is maintaining levels below or at detection limits. No cases of LP pneumonia were identified.

78. Improving Disinfection Cleaning of Implant Surgery Operating Rooms in Seven Hospitals

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Background: Interventions to minimize transmission of viral and bacterial pathogens as well as to minimize the risk of surgical site infections have long been recognized as an integral part of patient safety enhancement in the operating room. Despite AORN standards which mandate disinfection cleaning of areas possibly contaminated by transmissible pathogens as part of daily terminal cleaning and the CDC's recommendation that hospitals "Ensure compliance by housekeeping staff with cleaning and disinfection procedures" (Guidelines for Environmental Infection Control in Healthcare Facilities. MMWR. June 6, 2003/52, RR 10; Environmental Services IV. B. 2-Category IB), there is currently no means to objectively evaluate such activities programmatically.

Objective: To objectively evaluate in a standardized manner the thoroughness of daily disinfection cleaning of device implantation operating rooms prior to and following programmatic interventions in a diverse group of hospitals.

Methods: An invisible fluorescent targeting method was used to confidentially evaluate the cleaning of 14 standardized objects in the operating room environment (walls, floor and OR table - excluded) which were chosen on the basis of AORN standards as well as the CDC's recommendation that "enhanced cleaning activities" should be directed at high touch objects which would be expected to be frequently contaminated with hospital associated pathogens. The targeting material was placed on areas easily accessible to cleaning and the thoroughness with which it was removed was evaluated following two or more terminal cleanings of each operating room suite.

Results: 113 implant surgery operating rooms and 1319 objects were evaluated in the 7 hospitals. The mean proportion of objects cleaned was 34% (95% CI 23.9 to 43.4) prior to educational interventions. While side tables were relatively well cleaned (65%), many objects, including those closely associated with the operating field such as overhead procedure lights (23%) and portable x-ray C-arms (17%), were not well cleaned. Following the use of standardized structured educational programs and process improvement feedback, the terminal cleaning of 77 rooms and 864 objects was evaluated in the same manner. Overall thoroughness of cleaning improved to 61% (95% CI 46.7 to 75.9) or 79% above baseline. Both individually and as a group the hospitals realized significant improvement over preintervention results ($p < .001$ for each).

Conclusion: The use of an objective targeting method in device implantation operating rooms in 7 hospitals disclosed substantial opportunities for improving end-of-day disinfection cleaning activities. Following structured educational interventions and ongoing performance feedback to the environmental services staff, highly significant improvement in operating room environmental cleaning was documented in all hospitals.

79. Ineffectiveness of Probe Covers in Preventing Contamination of Endocavitary Ultrasound Transducers under Routine Conditions and Evaluation of a New Disinfection procedure using UV light

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Background: Contamination of endocavitary ultrasound transducer probes may result in transmission of micro-organisms responsible for infections between patients. The effectiveness of probe covers in preventing the bacterial contamination of transrectal and transvaginal ultrasound probes has rarely been studied under routine conditions.

Objectives: The aims of the study were (i) to determine the rate of bacterial contamination of endocavitary ultrasound probes after use and removal of latex condoms and probe sheaths under routine conditions and (ii) to evaluate a new disinfection procedure using Ultra-Violet (UV) C light.

Methods: Following 440 ultrasound (318 transrectal and 122 transvaginal) examinations performed in three Radiology wards during a 4-month period, cotton-tipped sterile swabs were taken from transducer heads (i) after removal of the probe cover and (ii) after cleaning of the probe with a towel impregnated with a disinfectant spray followed by disinfection of the probe during a 5-min cycle performed in a UVC disinfection chamber (Antigermix, Germitec, France). Swabs were streaked onto plates which were incubated for 48h. The number of colony-forming units (CFUs) were counted per plate and organisms were identified. Data were expressed as medians (min-max).

Results: After removal of probe covers, microbial flora was recovered from 301/440 (68.4%) samples (median : 4 CFUs/plate ; 1-1000 CFUs). Pathogenic flora was recovered in 15/440 (3.4%) samples (median : 14 CFUs/plate ; 3-1000 CFUs), comprising 8 Enterobacteriaceae, 3 Acinetobacter, 2 Pseudomonas and 2 Burkholderia. The rate of contamination with pathogenic flora was 2.5% for transvaginal and 3.8% for transrectal probes ($p=0.8$); this rate was 1.7% when probe sheaths were used and 3.7% when latex condoms were used ($p=0.2$). After cleaning and disinfection of the probes in the UVC chamber, microbial flora was recovered from 36/440 (8%) samples (median : 0 CFU/plate ; 2-17 CFUs). Pathogenic flora was not recovered.

Conclusions: Probe covers were found inefficient in preventing contamination of the endocavitary ultrasound probes under routine conditions. UVC disinfection may provide a useful and fast method for disinfecting endocavitary ultrasound probes.

80. Does Hydrogen Peroxide Vapor (HPV) Enhance Decontamination for Multidrug-Resistant Organisms (MDROs) in Intensive Care Units?

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Background: MDROs can contaminate inanimate environmental surfaces/equipment and persist for months despite routine cleaning. This may increase risk of patient acquisition of MDROs especially in ICUs. Novel techniques of decontamination are of interest. HPV is a sporicidal, vapor-phase method to decontaminate enclosed areas.

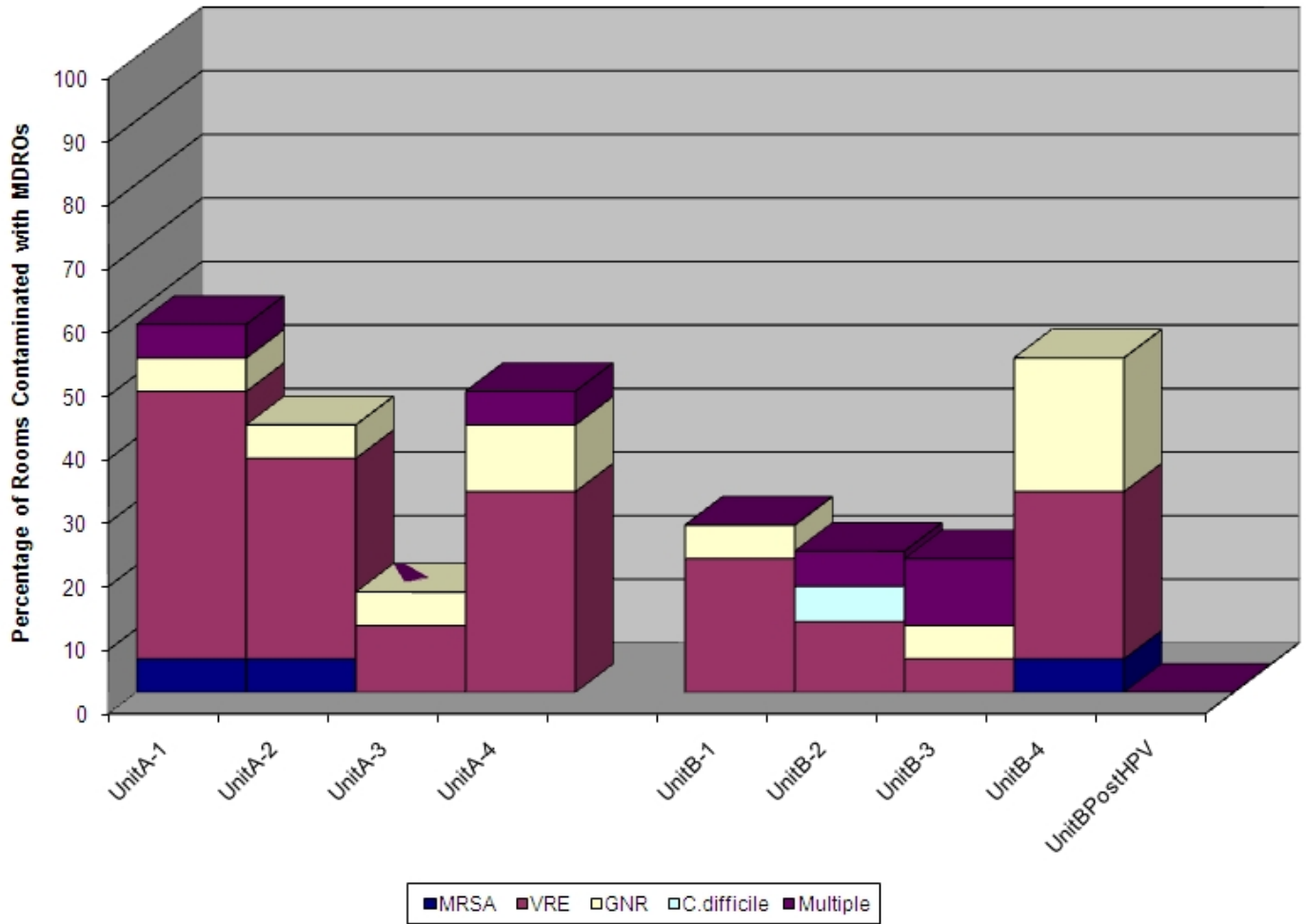
It has in vitro efficacy against a wide range of MDROs and can decontaminate difficult to clean surfaces in hospitals.

Objective: To investigate the extent of environmental contamination with MDROs in two ICUs of a large tertiary care center, one with standard environmental cleaning practices and one with additional HPV decontamination.

Methods: Between 8/2007 and 11/2007, premoistened swabs were used to obtain monthly environmental cultures for methicillin resistant *Staphylococcus aureus* (MRSA), vancomycin resistant enterococci (VRE), and multi-drug resistant gram negative rods (MDR-GNR) in units A and B. Cultured sites included: one composite swab from bedrails, computer keyboard and electronic monitoring equipment in all patient rooms and 3 communal surfaces. Following swab collection, pre-moistened cellulose sponges were used to culture the same surfaces for *C. difficile* (CD). All swabs and sponges were cultured using standard microbiologic methods. After each set of cultures, data were fed back to unit staff. In unit A, standard environmental cleaning protocols were followed. In unit B, within 24 hours of culturing (4th round), patients were transferred out, and the unit was decontaminated with HPV. Repeat environmental cultures were obtained after HPV.

Results: 101 and 115 samples were obtained in units A and B, respectively. 32%, 6%, 2% and 1% in unit A and 19%, 11%, 2% and 2% of samples in unit B grew VRE, MDR-GNR, MRSA and CD respectively. In unit A, 58% of rooms/surfaces were contaminated initially. After feedback of culture results the percentage of contaminated rooms/surfaces decreased by 72 %, but the effect was not sustained. Subsequently, contamination rates increased to 81% of baseline. In unit B, 21 to 53% of rooms and communal surfaces cultured were contaminated during pre-HPV culturing. Following HPV decontamination, no surfaces were contaminated (Figure 1). No adverse patient, staff or medical equipment events attributed to HPV occurred.

Environmental Contamination with Multidrug Resistant Organisms in Two Intensive Care Units



Conclusions: Feedback of environmental culture results alone did reduce environmental contamination but results may not be sustainable. HPV decontamination was safely implemented and eliminated environmental contamination with MDROs in Unit B. Research to investigate the long-term impact of HPV decontamination on background levels of environmental contamination and on rates of patient MDRO acquisition is ongoing.