Topics for Discussion

- General principles for use of surface disinfectants
- Current options for surface disinfectants
  - Which one(s) should you choose
- Methods for application (towels, microfiber, wipes)
  - Things your Environmental Services department needs to know
- Automated “No-Touch” methods for surface disinfection
  - Ultra-violet light (UVC)
  - Hydrogen peroxide vapor and mist
  - 405 nm light
  - Others
General Principles to Follow When Using Surface Disinfectants

- Use disinfectants approved by federal agencies (in USA, EPA)
- Use disinfectants at their recommended concentration or dilution
  - Do not overdilute products
- Use disinfectants for the recommended contact times
- Do not use antiseptic solutions for surface disinfection
- Follow recommended procedures for preparation of products
- Small-volume dispensers that are refilled from large-volume stock containers should be used until entirely empty, then rinsed with tap water and air-dried before they are refilled
- Store stock solutions as recommended by the manufacturer


Choices of Surfaces Disinfectants

- Commonly used disinfectants in hospitals contain
  - Quaternary ammonium compounds +/- alcohol
  - Sodium hypochlorite (bleach), other chlorine-releasing products
  - Improved hydrogen peroxide products
  - Peracetic acid/hydrogen peroxide combinations
  - Alcohols
  - Phenolics
  - Aldehydes
  - Iodophors (not recommended for surface disinfection)
- Ideal disinfectant for all purposes and against all pathogens does not currently exist

Quaternary Ammonium-Based Disinfectants

- Quaternary ammonium-based disinfectants (Quats) are widely for low-level disinfection of surfaces in healthcare facilities in the USA and a number of other countries

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inexpensive (in dilutable form)</td>
<td>Not sporicidal</td>
</tr>
<tr>
<td>Good cleaning agents</td>
<td>Not good for non-enveloped viruses</td>
</tr>
<tr>
<td>Compatible with many surfaces</td>
<td>Some products require use of PPE</td>
</tr>
<tr>
<td>Persistent antimicrobial activity</td>
<td>Affected by organic material</td>
</tr>
<tr>
<td></td>
<td>Some products have long contact times</td>
</tr>
<tr>
<td></td>
<td>Bind to cotton &amp; cellulose wipes</td>
</tr>
<tr>
<td></td>
<td>Outbreaks due to contaminated quats</td>
</tr>
</tbody>
</table>

Engelbrecht K et al. Am J Infect Control 2013;41:908

Using Dilutable Quat Disinfectants

- A popular approach to surface disinfection in several countries:
  - Diluting concentrated quat disinfectant
  - Placing diluted disinfectant in a reusable bucket with disposable wipes
Issues Related to Use of Dilutable Quats

• Recently, we tested disinfectant solutions obtained from 33 automated dispensing stations in a hospital
  – Quat concentration was tested using a simple strip test
• Results:
  – 2 stations delivered solutions with no detectable Quat
  – 7 stations yielded Quat disinfectant with < 200 ppm
  – 17 stations yielded solutions with 200-400 ppm
  – 6 stations delivered solutions with 400-600 ppm
  – 1 station was inoperative
• Differences in water pressure in parts of the hospital and design of concentrated jugs of disinfectant were responsible for delivery of inappropriate in-use concentrations
• Recommendation: consider periodic testing of diluted solutions to assure the in-use concentration is correct

Contamination of Reusable Buckets used to Dispense Disinfectant Wipes

• Two studies in Germany assessed the frequency of contamination of reusable buckets used to dispense disinfectant wipes used for surface disinfection in multiple hospitals.
• In one study, 42.4% of buckets containing surface-active disinfectants (e.g. Quats, glucoprotamin) were heavily contaminated with bacteria (e.g., Achromobacter species)
• In a second study, 47% of reusable buckets were contaminated
• Failure to process reusable buckets according to manufacturer recommendations contributed to frequent contamination of disinfectant solutions

Kampf G et al.. BMC Infect Dis 2014;14:37
Quat Disinfectants Are Prone to Contamination

![Image of cultures of overbed table before and after cleaning](image)

- Investigation revealed that the reusable bucket of quaternary ammonium disinfectant contained high concentrations of *Serratia marcescens*.
- Testing of the disinfectant in the bucket showed that it still inhibited the growth of a sensitive strain of *Serratia*.
- Whole genome sequencing of the contaminating strain of *Serratia* by collaborators revealed the presence of four Qac-resistance genes.
- Recommendation: follow manufacturer’s recommendations for how to clean/disinfect buckets before re-filling.
Sodium Hypochlorite and Other Chlorine-Releasing Disinfectants

- Frequently used when *Clostridium difficile*, Ebola virus, and Norovirus or other non-enveloped viruses are of concern

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal, tuberculocidal, virucidal, and sporidical</td>
<td>Reaction hazard with acids and ammonias</td>
</tr>
<tr>
<td>Fast efficacy</td>
<td>May be corrosive to metals</td>
</tr>
<tr>
<td>Inexpensive (in dilutable forms)</td>
<td>Affected by organic matter</td>
</tr>
<tr>
<td>Not flammable</td>
<td>Discolors/stains fabrics</td>
</tr>
<tr>
<td>Reduces biofilm on surfaces</td>
<td>May have unpleasant odor</td>
</tr>
<tr>
<td>Relatively stable</td>
<td>Irritating in high concentrations</td>
</tr>
<tr>
<td></td>
<td>Leaves salt residue</td>
</tr>
</tbody>
</table>


Sodium Hypochlorite and Other Chlorine-Releasing Disinfectants

- Multiple studies have confirmed the effectiveness of sodium hypochlorite or other chlorine-releasing agents or wipes to reduce environmental surface contamination and/or *C. difficile* infection (CDI)
- Most effective if used for both daily and terminal disinfection of rooms occupied by patients with CDI

Orenstein R et al. Infect Control Hosp Epidemiol 2011;32:1137
Sitzlar B et al. Infect Control Hosp Epidemiol 2013;34:459
Sodium Hypochlorite and Other Chlorine-Releasing Disinfectants

- Sodium hypochlorite or other chlorine-releasing products have been widely used to control outbreaks of Norovirus
- These surface disinfectants were widely used to prevent transmission of Ebola virus
  - CDC recommends using a disinfectant active against non-enveloped viruses as a special precaution
  - WHO suggests use of 0.5% chlorine solution


Improved Hydrogen Peroxide Surface Disinfectants

- In Canada, and to lesser degree in other countries, improved hydrogen peroxide (IHP) disinfectants are being used instead of Quat disinfectants for surface disinfection

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective against many pathogens</td>
<td>More expensive than other disinfectants</td>
</tr>
<tr>
<td>Fast efficacy</td>
<td>Not sporicidal in low concentrations</td>
</tr>
<tr>
<td>Easy compliance with “wet times”</td>
<td></td>
</tr>
<tr>
<td>Safe for workers</td>
<td></td>
</tr>
<tr>
<td>Benign for the environment</td>
<td></td>
</tr>
<tr>
<td>Good compatibility with surfaces</td>
<td></td>
</tr>
<tr>
<td>Non-staining</td>
<td></td>
</tr>
</tbody>
</table>

Improved Hydrogen Peroxide (IHP) Surface Disinfectants

- A prospective study of a 0.5% IHP product significantly reduced *C. difficile* spores on toilet seats of CDI patients

- A laboratory-based study found that IHP liquid disinfectants containing 0.5% or 1.4% H₂O₂ were superior to or equal to the Quat tested

- A study using the ASTM E2967-15 standard for evaluating disinfectant wipes found that all wipes achieved > 4 log₁₀ reduction of *S. aureus* and *Acinetobacter baumannii*
  - Only the IHP wipe containing 0.5% H₂O₂ prevented transfer of bacteria to another surface

Alfa MJ et al. BMC Infect Dis 2010;10:268
Rutala WA et al. Infect Control Hosp Epidemiol 2012;33:1159
Sattar SA et al. J Hosp Infect 2015;91:319

Improved Hydrogen Peroxide (IHP) Surface Disinfectants

- A IHP wipe with 1.4% H₂O₂ used to disinfect 10 high-touch surfaces in 72 patient rooms resulted in 99% of surfaces having < 2.5 CFU/cm² (75% yielded no growth)

- A IHP spray product containing 1.4% IHP reduced microbial load on patient privacy curtains by 96.8%

- IHP wipes effectively disinfected surfaces in operating room

- A study of soft surfaces sprayed with a 1.4% IHP product or 1:10 dilution of household bleach found that both reduced MRSA and VRE by > 6 log₁₀ with a 1-min contact time

Boyce JM et al. Infect Control Hosp Epidemiol 2013;34:521
Improved Hydrogen Peroxide (IHP) Surface Disinfectants

- An hospital-based interrupted time series study compared
  - $\text{H}_2\text{O}_2$ cleaning agent
  - 0.5% IHP disposable wipe
- When > 80% of surfaces were wiped by housekeepers, use of IHP wipes was associated with a significant reduction in healthcare-associated infections caused by MRSA, VRE and C. difficile
- A 12-month prospective, cross-over controlled study involving 4 units in a hospital compared a Quat and 0.5% IHP wipes for daily and terminal room disinfection
  - IHP wipes yielded significantly lower colony counts after cleaning and significantly greater proportion of surfaces with no growth
  - There was a 23% reduction in a composite healthcare outcome that included MDRO acquisition and infection ($p = 0.068$, 95% CI $0.579 - 1.029$)

Boyce JM et al. APIC 2016, Abstract #25

Peracetic Acid/Hydrogen Peroxide Disinfectants

- Due to the continuing difficulties in preventing C. difficile infections, new sporicidal disinfectants have been introduced

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal, fungicidal, virucidal, and sporicidal</td>
<td>Problems with stability</td>
</tr>
<tr>
<td>Active in presence of organic matter</td>
<td>Has potential to be incompatible with brass and copper</td>
</tr>
<tr>
<td>Environmentally-friendly by-products (e.g., acetic acid, $\text{O}_2$, $\text{H}_2\text{O}$)</td>
<td>More expensive than most other disinfectants</td>
</tr>
<tr>
<td>Surface compatible</td>
<td>Odor may be irritating</td>
</tr>
</tbody>
</table>

Kundrapu S et al. Infect Control Hosp Epidemiol 2012;33:1039
Deshpande A Infect Control Hosp Epidemiol 2014;35:1414
Carling PC et al. Infect Control Hosp Epidemiol 2014;35:1349
Saha A et al. Am J Infect Control 2016 (Epub ahead of print)
Peracetic Acid (PAA)-Based Disinfectant

- Prospective randomized trial in long-term care facility
- High-touch surfaces were cleaned
  - Only when visibly soiled
  - Daily with PAA-based disinfectant
- Daily cleaning with PAA-based product reduced frequency (and colony counts) of *C. difficile* and MRSA
- Reduced contamination of hands of healthcare personnel

Kundrapu S et al. Infect Control Hosp Epidemiol 2012;33:1039

Peracetic Acid/Hydrogen Peroxide Disinfectants

- Peracetic acid (PAA)/Hydrogen peroxide disinfectant was as effective as bleach in killing MRSA, VRE and *C. difficile* spores in vitro, and was highly effective of removing the 3 pathogens from high-touch surfaces
- A comparison of a Quat and a PAA/Hydrogen peroxide disinfectant found no growth of bacteria after cleaning
  - 40% of surfaces with Quat disinfectant
  - 77% of surfaces with PAA/Hydrogen peroxide disinfectant

Deshpande A et al. Infect Control Hosp Epidemiol 2014;35:1414
Carling PC et al. Infect Control Hosp Epidemiol 2014;35:1349
Peracetic Acid/Hydrogen Peroxide Disinfectants

- Problems reported with PAA/Hydrogen peroxide products
  - Odor of some products may be quite irritating to housekeepers
    - A few hospitals have discontinued use due to complaints about odor
  - At least some combination products require activation by mixing 2 components on site due to stability problems
  - One product was removed from market in 2015 due to insufficient activity against *C. difficile* spores of both unactivated and activated product

Alcohols as Disinfectants

- Because isopropanol & ethanol evaporate rapidly, they have not been recommended for disinfecting large surfaces

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal, tuberculocidal, virucidal, fungicidal</td>
<td>Not sporicidal</td>
</tr>
<tr>
<td>Fast acting</td>
<td>Affected by organic matter</td>
</tr>
<tr>
<td>Noncorrosive</td>
<td>Poor cleaning properties</td>
</tr>
<tr>
<td>Nonstaining</td>
<td>Not EPA registered</td>
</tr>
<tr>
<td>No toxic residue</td>
<td>Damages some instruments</td>
</tr>
<tr>
<td>Used to disinfect small surfaces (e.g., medication vials)</td>
<td>Rapid evaporation makes contact time compliance difficult</td>
</tr>
<tr>
<td></td>
<td>Flammable</td>
</tr>
</tbody>
</table>

Alcohols as Disinfectants

- Alcohol concentrations of 60% - 90% have been used to disinfect small objects
- New alcohol-based formulation was recently marketed
  - Low concentration of alcohol plus other ingredients
  - Bactericidal, tuberculocidal, fungicidal, virucidal
    - Effective against Norovirus and enveloped viruses
  - Short contact time (30 seconds for 22 different microrganisms)
  - EPA registered for use on healthcare environmental surfaces
  - EPA Category IV (no personal protective equipment needed)
  - Can be used on food-contact surfaces
  - Not Sporicidal

Phenolics as Disinfectants

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal, tuberculocidal, virucidal, fungicidal</td>
<td>Not sporicidal</td>
</tr>
<tr>
<td>Inexpensive (in dilutable form)</td>
<td>Absorbed by porous materials, and residua may irritate tissue</td>
</tr>
<tr>
<td>Nonstaining</td>
<td>Some products cause skin depigmentation</td>
</tr>
<tr>
<td>No toxic residue</td>
<td>Can cause hyperbilirubinemia in infants if not used correctly</td>
</tr>
<tr>
<td>Not flammable</td>
<td></td>
</tr>
</tbody>
</table>

- Used on laboratory surfaces
- Extent of use in patient areas not clear

Aldehydes as Disinfectants

- Aldehyde-based products are used for surface disinfection in some countries, especially in Europe, but are not used for this purpose in the United States

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal, tuberculocidal, fungicidal, virucidal (enveloped viruses)</td>
<td>Not all formulations are sporicidal</td>
</tr>
<tr>
<td>Short contact times</td>
<td>Can cause skin and respiratory irritation</td>
</tr>
<tr>
<td>Good cleaning ability</td>
<td>Some concern over environmental impact</td>
</tr>
<tr>
<td>Good material compatibility</td>
<td></td>
</tr>
</tbody>
</table>

Meinke R et al. Infect Control Hosp Epidemiol 2012;33:1077
Kampf G et al. BMC Infect Dis 2014;14:37

Methods Used to Apply Disinfectants to Surfaces

- Methods used to apply disinfectants to surfaces include:
  - Cotton towels or rags
  - Reusable microfiber cloths
  - Disposable cellulose-based wipes
  - Non-woven spunlace wipes
    - Disposable meltblown polypropylene wipes

- Cotton and cellulose-based wipes, and to a lesser extent microfiber, can bind Quat disinfectants
  - Reduces the concentration of Quat delivered to surfaces
  - Impact of this phenomenon on reducing pathogens on surfaces requires further study

Bloss R et al. J Hosp Infect 2010;75:56
Engelbrecht K et al. Am J Infect Control 2013;41:908
Cotton Towels and Microfiber Cloths

- **Cotton towels and cloths are inexpensive**
  - May still be contaminated even after being laundered
  - Can spread *C. difficile* spores to other surfaces

- **Microfiber cloths**
  - New cloths remove bacteria from surfaces better than cotton cloths
  - Commercially available microfiber cloths vary considerably in how well they remove bacteria from surfaces
  - Ability to clean surfaces is adversely affected
    - After laundering/drying multiple times at high temperatures
    - Exposure to sodium hypochlorite
  - Depending on method of use, may spread bacteria to surfaces

Sifuentes LY Am J Infect Control 2013;41:912
Trajtman AN Am J Infect Control 2015;43:686
Diab-Elschahawi M et al. Am J Infect Control 38:289
Disposable Wipes

• Advantages
  – Eliminates need for laundering cotton and microfiber cloths
  – Ease of use
  – Ready-to-use pre-packaged wipes eliminate need for dilution/preparation of disinfectant by housekeepers
  – Personnel may prefer wipes vs bucket
  – Require less time to use than bucket method

• Disadvantages
  – More expensive than dilutable disinfectants
  – More waste disposal
  – Ability to remove bacteria may vary by type

Sattar SA et al. J Hosp Infect 2015;91:319

Follow Recommended Procedures

• Use recommended number of wipes per room
• Using too few wipes per room can spread bacteria

Cadnum JL Infect Control Hosp Epidemiol 2013;34:441
Costs of Disinfectant Solutions and Wipes

- Few publications have reported the cost of disinfectants
- Dilutable Quats and bleach solutions are relatively inexpensive
- Acquisition costs of disposable wipes are higher, but avoid the costs of cotton towels, microfiber cloths, and laundering expenses

<table>
<thead>
<tr>
<th>Cost</th>
<th>Quaternary ammonium compound (Tuffie 51)</th>
<th>Alcohol wipes (Sani-Cloth 70F)</th>
<th>Peracetic acid (Clinell Sporicidal9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per wipe</td>
<td>$0.03</td>
<td>$0.014</td>
<td>$0.47</td>
</tr>
<tr>
<td>Per pack</td>
<td>$3.59</td>
<td>$3.30</td>
<td>$1.173</td>
</tr>
<tr>
<td>A month’s supply</td>
<td>$269.62</td>
<td>$16.48</td>
<td>$1,817.55</td>
</tr>
<tr>
<td>Total cost to the control ward (per mo):</td>
<td>$286.09</td>
<td>Total cost to the study ward (per mo):</td>
<td>$1,817.55</td>
</tr>
</tbody>
</table>

Saha A et al. Am J Infect Control 2016 (Epub ahead of print)

No-Touch Room Decontamination Methods

- In many facilities, ≤ 50% of high-touch surfaces are wiped by housekeepers at the time of terminal room cleaning
- In response, “no-touch” automated systems have been developed to decontaminate patient rooms after discharge
- Examples include:
  - Aerosolized hydrogen peroxide
  - Hydrogen peroxide vapor systems
  - Gaseous ozone
  - Saturated steam systems
  - Mobile ultraviolet and pulsed-Xenon light devices
  - High-Intensity Narrow-Spectrum light

Otter JA et al. J Hosp Infect 2013;83:1
Aerosolized Hydrogen Peroxide Dry Mist Systems

- Portable units aerosolize hydrogen peroxide
- 5-6% hydrogen peroxide +/- 50-60 ppm silver plus stabilisers
- Aerosolized (droplets – not gas) have particle size of 0.5-12 μm
- Systems use passive aeration. Hydrogen peroxide is left to degrade naturally
- Cycle time >2 hr for a single room

Examples of hydrogen peroxide aerosol systems

Aerosolized Hydrogen Peroxide

- Generally reduces indicator spores by < 4 logs

- Cultures obtained Before/After cycles have demonstrated significant reductions in bacterial (including spore) counts in laboratory settings and patient care areas
  - Did not completely eradicate *C. difficile* spores in 2 studies

- One system has sporicidal claim from EPA in USA

Shapey S et al. J Hosp Infect 2008;70:136
Bartels MD et al. J Hosp Infect 2008;70:35
Landelle et al. ICHE 2013;34:119-124
Aerosolized Hydrogen Peroxide

- More recently, an aerosolized hydrogen peroxide system which emits 7.5% H$_2$O$_2$ was tested for activity against spores on *G. stearothermophilus* and 2 strains of *C. difficile* on carriers located 80 cm from device

- After a 1-hr exposure in a ½-open drawer,
  - few *C. difficile* spores were killed
  - a 10$^3$ log reduction of *G. stearothermophilus* spores occurred

- After 3-hr exposure,
  - no viable *C. difficile* spores were recovered
  - A 5-log reduction of both *C. difficile* strains occurred

Steindl G et al. Wiener Klinische Wochenschrift 2014
DOI 10.1007/s00508-014-0682-6

Impact of Aerosolized Hydrogen Peroxide Systems on Healthcare-Associated Infections

- One Before/After study compared
  - Aerosolized hydrogen peroxide system
  - Use of detergent for room cleaning

- Results: aerosolized hydrogen peroxide system
  - Was associated with a significant reduction in MRSA acquisition
  - Some reduction in MRSA infection

- No randomized controlled trials of the impact on healthcare-associated infections

Vaporized Hydrogen Peroxide System

- “Dry gas” vaporized hydrogen peroxide (VHP) system that utilizes ~30% \( \text{H}_2\text{O}_2 \) has been shown to be effective against
  - *Mycobacterium tuberculosis*, *Mycoplasma*, *Acinetobacter*, *Clostridium difficile*, *Bacillus anthracis*, viruses, prions
- In Before/After studies, “dry gas” VHP system, when combined with other infection control measures, appeared to contribute to control of outbreaks of *Acinetobacter*
  In long-term acute care facility and in two ICUs in a hospital

- No randomized controlled trials of impact on HAIs

Heckert RA Appl Environ Microbiol 1997;63:3916
Ray A et al. Infect Control Hosp Epidemiol 2010;31:1236

Hydrogen Peroxide Vapor System

- Micro-condensation HPV system, which utilizes 35% \( \text{H}_2\text{O}_2 \) is effective in eradicating important pathogens
  - Methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), *Clostridium difficile*, *Klebsiella*, *Acinetobacter*, *Serratia*, *Mycobacterium tuberculosis*, fungi, viruses
- Laboratory and in-hospital studies document significant reductions (often log 10\(^6\)) of a number of these pathogens, with 92% to 100% reduction of pathogens on surfaces

Hall L et al. Med Mycol 2008;46:189
Boyce JM et al. Infect Control Hosp Epidemiol 2008;29:723
Pottage T et al. J Hosp Infect 2010;24:55
Manian FA et al. Infect Control Hosp Epidemiol 2011;32:667
Landelle et al. Infect Control Hosp Epidemiol 2013;34:119
**Impact of Microcondensation Hydrogen Peroxide Vapor (HPV) Room Decontamination on Risk of Acquiring MDROs**

- 30-month prospective cohort study on 3 intervention wards and 3 control units in a tertiary hospital
- Environmental contamination by, and patient acquisition of VRE, MRSA, *C. difficile* and MDR GNRs were studied in rooms decontaminated with HPV vs standard cleaning
- **Results:** Patients admitted to rooms decontaminated with HPV were 64% less likely to acquire an MDRO (p < 0.001), and 80% less likely to acquire VRE (p < 0.001)
  - Fewer patients acquired MRSA, *C. difficile* and MDR GNR, but the reduction was not statistically significant
  - The percent of rooms contaminated with MDROs was reduced significantly on HPV units, but not control units


**Impact of Microcondensation HPV System on Healthcare-Associated Infections**

- In Before/After trials, when used in conjunction with other measures, HPV appears to have contributed to control of outbreaks caused by MRSA, resistant Gram-negative bacteria, and *C. difficile*
  - 37% - 60% reductions in incidence density of *C. difficile*
  - Has been used to decontaminate rooms previously occupied by patients with Lassa fever and Ebola virus infection
  - No randomized, controlled trials of impact on HAIs

Boyce JM et al. Infect Control Hosp Epidemiol 2008;29:723
Cooper et al. J Hosp Infect 2011;78:238-240
Manian FA Amer J Infect Control 2013;41:537
Gopinath et al. Infect Control Hosp Epidemiol 2013;34:99-100
McCord J et al. ID Week 2014,Poster 1648
Hydrogen Peroxide Vapor vs Aerosolized Hydrogen Peroxide

- HPV and aerosolized HP are different processes with differing effectiveness in eliminating pathogens
- 2 head-to-head comparisons of one aerosolized hydrogen peroxide system vs microcondensation HPV system revealed:
  - HPV was significantly more effective than aerosolized H₂O₂ system against spores
  - Cycle times were similar for the 2 processes
- Conclusion: HPV is significantly more effective in eradicating spores than the aerosol H₂O₂ system tested

Otter JA et al. ICHE 2010;31:1201
Holmdahl T et al. ICHE 2011;32:831
Fu TY et al. J Hosp Infect 2012;80:199

Concerns Regarding Vapor-Based Hydrogen Peroxide Systems

- Need to seal air vents and doors increases cycle times
- Total cycle times (room prep/decontamination/breakdown)
  - Micro-condensation process: 2 – 2.3 hrs, less with newer equipment
  - Dry Gas process: 8 hrs
- Micro-condensation HPV process is feasible in hospitals with high census levels
- Level of training and expertise of operators is greater than with other no-touch systems such as mobile UV-C light units
- No randomized, controlled trials of impact on infection rates

Otter JA et al. Infect Control Hosp Epidemiol 2009;30:574
Ray A et al. Infect Control Hosp Epidemiol 2010;31:1236
UVC Light Room Decontamination Systems

- Automated mobile UV light units that emit UV-C (254 nm range) can be placed in patient rooms after patient discharge and terminal cleaning has been performed
- Some units can be set to kill vegetative bacteria (12,000 uWs/cm$^2$) or to kill spores (22,000 uWs/cm$^2$)

UV-C Light Room Decontamination Systems

- Cultures obtained from surfaces inoculated with *C. difficile*, MRSA, VRE were obtained before/after UVC light decontamination
  - 3-5 $\log_{10}$ reduction of MRSA and VRE and 1-3 $\log_{10}$ reduction of *C. difficile* under experimental conditions
  - Significant reduction, without complete eradication of pathogens
- Less effective in “shadowed” areas, in several studies
- Efficacy is affected by cycle time, distance from device, and presence of organic material

Nerandzic M et al. BMC Infect Dis 2010;10:197
Rutala WA et al. ICHE 2010;31:1025
Boyce JM et al. ICHE 2011;32:737
Havill NL et al. ICHE 2012;33:507
Anderson DJ et al. ICHE 2013;34:466
Mahida N et al. J Hosp Infect 2013;84:332
Parameters Affecting UV-C Effectiveness

- UV-C irradiance and antimicrobial efficacy are affected by test methods
  - Area over which the inoculum is spread on test surfaces
  - Distance and orientation of test surfaces relative to the UV-C device
  - Types of organic load used in tests

![Graph showing mean UV-C irradiance at different angles and distances.]

Cadnum JL et al. Infect Control Hosp Epidemiol 2016;37:555

Impact of UV-C Decontamination Systems on Healthcare-Associated Infections

- Currently, limited published data on impact of UV-C light systems on incidence of healthcare-associated infections
- Multicenter prospective, cluster-randomized crossover trial of UV-C light for terminal disinfection of hospital rooms has been completed in nine hospitals, comparing
  - Standard quat disinfectant alone
  - Standard quat disinfectant + UV-C
  - Sodium hypochlorite (bleach) alone
  - Sodium hypochlorite + UV-C
- Outcome measures
  - Colonization or infection among patients exposed to rooms previously occupied by a patient with MRSA, VRE or C. difficile

Anderson DJ et al. IDWeek 2015, Abstract

A Webber Training Teleclass
Hosted by Paul Webber paul@webbertraining.com
www.webbertraining.com
Impact of UV-C Decontamination Systems on Healthcare-Associated Infections

- Results
  - Bleach and/or UV-C enhanced room decontamination decreased the clinical incidence of MRSA, VRE and C. difficile by 10% to 30% (p = 0.036)

Issues to Address When Considering Mobile Ultraviolet Light Systems

- Ease of use
- Duration of cycle times recommended by manufacturer
- Evidence of microbiological efficacy published by independent investigators
- Cost per device ($40,000 - $125,000)
- Cost of replacement bulbs/service contracts
- Availability of digital recording, storage & retrieval of data
**Comparison of HPV vs Mobile UV Light System**

- Prospective study involving 15 rooms, each decontaminated once with HPV and UV-C light processes, at intervals > 2 months
- Of sites which had (+) ACCs before decontamination
  - 93% yielded no growth after HPV treatment
  - 52% yielded no growth after UV-C light treatment
- Mean *C. difficile* log reductions: > 6 logs for HPV vs ~ 2 logs for UV-C
- Mean cycle times: 153 min for HPV vs 73 min for UV-C
- HPV was significantly more effective in rendering surfaces culture-negative; more effective vs spores
- UV-C was faster and easier to use

*Havill NL & Boyce JM ICHE 2012;33:507*

**Hydrogen Peroxide Vapor vs Ultraviolet Light Systems**

- Choice between hydrogen peroxide vapor and ultraviolet light systems will depend on a number of factors, including its intended use and practicalities of application

<table>
<thead>
<tr>
<th>Variable</th>
<th>Continuous UV-C or Pulsed-Xenon UV</th>
<th>Hydrogen Peroxide Vapor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intended use</td>
<td>Decontaminate a relatively large proportion of rooms</td>
<td>Decontaminate primarily rooms with difficult-to-kill or highly virulent pathogens</td>
</tr>
<tr>
<td>Level of efficacy needed</td>
<td>Significant reduction of pathogens</td>
<td>Near-total or total eradication of pathogen</td>
</tr>
<tr>
<td>Cycle times</td>
<td>15 min – 45 min</td>
<td>2 – 2.3 hrs</td>
</tr>
</tbody>
</table>

*Havill NL et al. Infect Control Hosp Epidemiol 2012;33:507*  
*Otter JA et al. J Hosp Infect 2013;83:1*
Pulsed-Xenon UV Light System

- System uses pulsed-xenon instead of mercury bulbs to produce UV light
- Emits flashes of UV light in the 200-320nm range
- Manufacturer recommends placing device in 3 locations in a room with 5-7 min cycles
- Several studies have shown significant reduction of pathogens in patient rooms

Levin et al. Am J Infect Control 2013;41:746-748
Jinadatha et al. BMC Infect Dis 2014;14:187

Comparison of Continuous UV-C vs Pulsed-Xenon UV Light System

<table>
<thead>
<tr>
<th>Device</th>
<th>Pathogen</th>
<th>$\log_{10}$ Reduction Per cm$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulsed-Xenon UV</td>
<td>C. difficile</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>MRSA</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>VRE</td>
<td>0.6</td>
</tr>
<tr>
<td>Continuous UV-C</td>
<td>C. difficile</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>MRSA</td>
<td>~3.1</td>
</tr>
<tr>
<td></td>
<td>VRE</td>
<td>~3.6</td>
</tr>
</tbody>
</table>

- Both systems reduced pathogens on surfaces
- UV-C showing greater log reductions

Nerandzic MM Infect Control Hosp Epidemiol 2015;36:192
Concerns Regarding Mobile UV-C and Pulsed Xenon Room Decontamination Devices

• Currently, no randomized controlled trials of the impact of Pulsed Xenon system on healthcare-associated infection rates

• Number of systems currently being marketed, often with limited documentation of effectiveness, makes choice of device difficult

• There are substantial differences between systems regarding
  – Recommended cycle times
  – Up-front and maintenance costs

• Odor generated by use of UV-C devices is initially of concern to some healthcare workers
  – To date, no evidence that odor is harmful

High-Intensity, Narrow Spectrum Light (405 nm)

• High-Intensity, narrow spectrum light system emits visible light in 405 nm range

• Light can be set to blue color or white color

• Can be left on when patients or personnel are in room

• Has been shown to reduce staphylococci on surfaces

• Further data are needed to determine its role in air and surface disinfection

Maclean M et al. J Hosp Infect 2010;76:247
Bache SE et al. Burns 2012;38:69
Maclean M et al. J Hosp Infect 2014;88:1
Health-Economic Evaluation of New Disinfection Methods

• Very few data are available on the cost-effectiveness of new “no-touch” room disinfection technologies
• In one hospital, *C. difficile* disease incidence density decreased from 11.8/10,000 Pt-Days during 10 months before use of HPV to 8.7/10,000 Pt-Days during 10 months use of HPV (39% reduction)
  – Estimated number of *C. difficile* cases prevented in 10 mo = 33
  – 33 prevented cases x $6522/case = projected cost saving in 10 mo of $215,000 ($258,000 annually)
  – Cost of HPV implant team was less than projected cost saving
• A study of using HPV to decontaminate disposable medical supplies that are usually discarded at patient discharge revealed an potential annual cost saving of $387,000

Otter JA et al. Infect Control Hosp Epidemiol 2013;34:472

Costs of “No-Touch” Room Disinfection Systems

• HPV technology costs vary, depending on whether devices are purchased by hospital vs paying for services of an “implant team” from the manufacturer
• Mobile UV-C light and pulsed-xenon devices vary in price from $40,000 to $125,000/device
  – Service contracts and bulb replacement costs must be considered
• Further studies of the cost-effectiveness of HPV and UV-C and pulsed-xenon systems are needed.
Other Gaseous or Fogging Technologies

- Gaseous ozone has been proposed as a method of room decontamination, but few clinical studies are available
  - Sharma M Am J Infect Control 2008;36:559
- Alcohol-based fogging system was shown to be less effective than bleach
- Chlorine dioxide fogging is promoted for room decontamination, but few published studies in hospital settings are available
- Hydrogen peroxide/peracetic acid fogging showed significant log reductions of spores in laboratory setting

Summary

- There are an increasing number of newer surface disinfectants available for use in healthcare facilities
  - No disinfectant is ideal for every situation
- Greater attention should be devoted to making sure that disinfectants are used as recommended
  - To Assure that the product will be effective
  - Avoid contamination
- Wipes/cloths should be compatible with disinfectant used
- There is increasing evidence that “No-Touch” room decontamination systems can be used in conjunction with manual disinfection processes to reduce the risk of healthcare-associated infections
Update on Methods for Cleaning and Disinfection of Environmental Surfaces
Dr. John M. Boyce, J.M. Consulting LLC
Sponsored by Sealed Air Diversey Care (www.sealedair.com)

October 19  (South Pacific Teleclass)
TECHNOLOGY FOR MONITORING HAND HYGIENE IN THE 21ST CENTURY – WHY ARE WE USING IT?
Prof. Mary-Louise McLaws, University of New South Wales, Australia

October 20  (FREE Teleclass)
THE HISTORY OF CBIC AND WHY CERTIFICATION IS STILL IMPORTANT TODAY
Certification Board of Infection Control

October 27  ANTIMICROBIAL ENVIRONMENTAL SURFACES IN HEALTHCARE SETTINGS – CAN THEY REALLY BE BENEFICIAL?
Prof. Jean-Yves Maillard, Cardiff University, Wales

November 10  NOROVIRUSES AND HEALTHCARE FACILITIES: HOW TO KEEP THE VIRUS OUT AND WHAT TO DO WHEN IT GETS IN
Dr. Ben Lopman, Centers for Disease Control and Prevention, and Prof. Miren Ituriza-Gomara, University of Liverpool

www.webbertraining.com/schedule1.php

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