Update on “No Touch” Room Disinfection Systems
Dr. Dick Zoutman, Queen’s University, Kingston, Canada
A Webber Training Teleclass

Update on "no touch" room disinfection systems- uv lights, hydrogen peroxide and ozone
Dick Zoutman, MD, FRCP
Emeritus Professor
Medical Microbiology & Infectious Diseases
Queen’s University

Hosted by Martin Kiernan  martin@webbertraining.com
www.webbertraining.com  March 14, 2013

Conflict Of Interest Disclosure
• An inventor of AsepticSure®
• Chief Medical Officer of Medizone International Inc.
• Shareholder of Medizone International Inc
• Rapidly evolving field
  – Data can be hard to come by
  – Not possible to include ALL technologies out there

Objectives
• At the end of this presentation I hope you:
  – Will be able to describe the two types of UV lamp
technologies, their characteristics and efficacy
  – Will be able to describe the basis for the hydrogen
peroxide vapor and mist technologies and their efficacy
  – Will be able to describe how effective ozone based
methods are as a space disinfection technology
  – Understand the synergy of combining ozone and hydrogen
peroxide as a novel high level disinfection technology for
health care spaces and other applications
  – Will know what to look for in in vitro, in vivo and clinical
studies of the new technologies for room decontamination
and disinfection

The Problem
• Too many healthcare infections
• Needless suffering and mortality
• Despite innovations and best efforts
• Environment a major source and reservoir
• We need to find a transformational technology!
• Just cleaning where the “dots are” is not good enough!

Characteristics of the Ideal Room Disinfection System
✓ Highest possible kill of all relevant organisms especially C. difficile spores
✓ Fast
✓ Simple to perform
✓ Cost effective
✓ Can be safely deployed
✓ No environmental residues
✓ Reduces incidence of healthcare infections
✓ High quality supportive scientific evidence

Quality of Evidence Concerning H₂O₂, UV, O₃
• Can be very mixed so read it critically
• Peer reviewed literature best
• in vitro studies
  – Using test chambers etc
  – Bacteria or other organisms on various materials
    • Steel discs/coupons
    • Fabric, carpet, plastics, various building finishes
  – Good controls with many replicates
  – Quantitative Carrier Tests (QCT) Protocol by Springthorpe
    and Sattar et al
  – Use of a soil load
  – Each organism brings unique challenges

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**in vivo Testing**

- In hospital rooms, laboratories, various field locations
  - Random assignment of rooms/spaces
  - No overlap of methods, “wash out times”
  - Detailed surface culture protocol with large number of samples
    - Highly standardized, with different methods
  - Supplemented with microbe loaded coupons in standard locations in the room
  - Always use spores of spore forming pathogens
    - eg C. difficile, Bacillus spp., Geobacillus spp., etc.

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**Interpreting Results**

- Want to see expression of data as \( \log_{10} \) kill (or \( \log_{10} \) survivor)
  
  - Kill = starting inoculum-survivors
    - Expressed as \( \log_{10} \) kill
  
  - Use geometric means for large number of samples
  
  - Need dozens of replicates under any one set of conditions especially for in vitro testing

- Surface swabs
  
  - Typically expressed as cfu/cm²
    - Typically see 10’s to 100’s cfu/cm²
    - Count specific pathogens
    - Or count all heterotrophic bacteria on the surface

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**Clinical Studies**

- Before and after studies citing reductions in infections
  
  - Rates of HAI vary significantly over time
  
  - Be cautious in the interpretation of these results

- Prefer randomized and multicenter design ideally
  
  - Difficult to do and costly
  
  - Combined with surface cultures and loaded coupons and clinical outcomes to make a comprehensive evaluation

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**A Bit of Physics About UV Light**

- Ultraviolet germicidal irradiation (UVGI)
  
  - Wavelength shorter than that of visible light
    - UVA 400 nm to 315 nm
    - UVB 315 nm to 280 nm
    - UVC 280 nm to 200 nm
  
  - The entire UV spectrum can kill or inactivate many different microorganisms
  
  - UVC energy provides the most germicidal
    - 265 nm optimum wavelength

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**Susceptibility of Organisms to UVC**

From Martin SII et al. ASHRE Journal. August 2008

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**Mercury Vapor Lamps**

- In mercury vapor lamps, the mercury vapor is excited to create UV-C
  
  - Create UV at 253.7 nm.
  
  - This is close to the average peak DNA absorbed at 260-265 nm.
  
  - Mercury lamps produce continuous UV light

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**Xenon Vapor Lamps**

- Pulsing a xenon UV lamp PX-UV
- Results in a flash of light with a broad spectrum from 200 nm to 320 nm
- Millisecond pulses
- More UV-C wavelengths are produced
- High intensity of the fast pulses may give PX-UV better disinfection efficacy?

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**Tru-D Unit by Lumalier**

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**Mercury UV System Tru-D**

- An automated mobile UV-C unit
- Tru-D; by Lumalier
- Shown to produce a 3 log10 kill of vegetative bacteria
  - MRSA, VRE, and *A. baumannii*
- 2.4-log10 kill of *C. difficile* seeded onto Formica surfaces in experimentally contaminated patient room

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**Tru-D**

- Tru-D, Lumalier studied in reducing environmental contamination with vegetative bacteria
- Measured using aerobic colony counts and *C. difficile* inoculated onto stainless steel carrier disks

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**Tru-D**

- Room decontamination with the Tru-D UV system
- Reductions in aerobic bacteria on 5 high-touch surfaces.
- Mean *C. difficile* log10 reductions ranged from 1.8 to 2.9 when cycle times of 34.2–100.1 minutes were used.
- Surfaces in direct line of sight were significantly more likely to yield negative culture results after UV decontamination than before decontamination

---

**Tru-D**

- On inoculated surfaces
  - Reflected dose of 22,000 μWs/cm2 for 45 minutes
  - Kill of *C. difficile* spores and MRSA by >2-3 log10 colony forming units (CFU)/cm2
  - Kill of VRE by >3-4 log10 CFU/cm2
  - Same level of kill of MRSA and VRE was achieved in 20 minutes at a reflected dose of 12,000 μWs/cm2,
  - But killing of *C. difficile* spores was reduced significantly.

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**Tru-D**

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Tru-D Log10 Bacterial Kill

From Nerandzic MM et al. BMC Infect Dis 2010;10:197

Tru-D Surface Swabs

• High touch surfaces of a bathroom
  – 60,000 cm²
  – C. difficile spores
    • Before: 600 spores
    • After: 24 spores
  – MRSA bacteria
    • Before: 1,200
    • After: 240
  – VRE bacteria
    • Before: 180
    • After: 0

From Nerandzic MM et al. BMC Infect Dis 2010;10:197

Xenex

Pulsed xenon UV light

From: www.xenex.com

XENEX in vitro Lab Study

<table>
<thead>
<tr>
<th>Organism</th>
<th>Control (cfu)</th>
<th>Log10 Kill 480 sec (8 min)</th>
<th>Log10 Kill 720 sec (12 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>1.23 x 10⁵</td>
<td>5.01</td>
<td>na</td>
</tr>
<tr>
<td>VRE</td>
<td>2.75 x 10⁴</td>
<td>4.44</td>
<td>na</td>
</tr>
<tr>
<td>C. difficile</td>
<td>3.33 x 10⁵</td>
<td>4.52</td>
<td>5.52</td>
</tr>
</tbody>
</table>

• C. difficile was 1 meter from lamp, MRSA and VRE 2 meters from lamp.
• C. difficile 9 samples, MRSA & VRE 4 samples.
• “The experiment was conducted at an independent microbial testing laboratory.”
• Modified from: Stibich M. Abstract presented at SHEA/FIH Decennial Meeting 2010

Xenex Study at MD Anderson

• January to March 2010 at MD Anderson Cancer Center, Houston Tx
• 12 rooms extensively surface cultured at discharge for VRE isolation
• Isolation clean with germicide x 30 mins.
• 3 x 4 min exposures to Xenex lamp
• Cultures taken before cleaning, after cleaning and using the Xenex lamp

Stibich et al. Infect Control Hosp Epidemiol 2011;32(3)

XENEX

<p>| TABLE 2. Impact of Standard Cleaning and Pulsed-Xenex Ultraviolet (PS-UV) Disinfection on Room Bacterial Heterotrophic Plate Count (HPC) |</p>
<table>
<thead>
<tr>
<th>Room status</th>
<th>No. of samples</th>
<th>HPC mean, CFU/cm²</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before cleaning</td>
<td>73</td>
<td>33.0</td>
<td>2.658</td>
<td>.0085</td>
</tr>
<tr>
<td>After standard terminal cleaning</td>
<td>91</td>
<td>27.4</td>
<td>6.430</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Comparison 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before cleaning</td>
<td>73</td>
<td>33.0</td>
<td>.827</td>
<td>.411</td>
</tr>
<tr>
<td>After PS-UV treatment</td>
<td>75</td>
<td>1.2</td>
<td>4.809</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Comparison 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before standard terminal cleaning</td>
<td>91</td>
<td>27.4</td>
<td>1.2</td>
<td>.241</td>
</tr>
<tr>
<td>After PS-UV treatment</td>
<td>75</td>
<td>1.2</td>
<td>.411</td>
<td>.681</td>
</tr>
</tbody>
</table>

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Xenex Cooley Dickinson Hospital Study

- 140 bed acute hospital, Northampton MA
- January-September 2011 Xenex used
- Uncontrolled observational study
  - 2x7 min in room
  - 3x7 min in bathroom
- Pre-cleaned with chlorine bleach [SOP throughout]
- CDI Rates
  - 2009: not stated
  - 2010: 0.95/1000 PtDay
  - 2008-2010 Q1-3: 0.98/1000 PtDay
  - 2011 (Q1-3): 0.32/1000 PtDay

Levin J et al. IDSA 2011 Abstract

UV Light Summary

<table>
<thead>
<tr>
<th>Property</th>
<th>UVC Light</th>
<th>Xenon Pulse Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Mercury bulb</td>
<td>Xenon bulb</td>
</tr>
<tr>
<td>Exposure time</td>
<td>20-300 min</td>
<td>6-12 mins over 2-3 doses</td>
</tr>
<tr>
<td>Vegetative bacterial kill</td>
<td>3-5 log</td>
<td>4-5 log</td>
</tr>
<tr>
<td>C. difficile spore kill</td>
<td>2-5 log</td>
<td>4-5 log (limited data)</td>
</tr>
<tr>
<td>Risks</td>
<td>UV exposure</td>
<td>UV exposure</td>
</tr>
<tr>
<td>Toxins/By Products</td>
<td>Mercury vapor</td>
<td>None</td>
</tr>
<tr>
<td>Controlled Clinical Trials</td>
<td>No</td>
<td>None yet</td>
</tr>
<tr>
<td>Costs</td>
<td>$124,500 capital</td>
<td>$1,600 for lamps (9000 h)</td>
</tr>
<tr>
<td>Other</td>
<td>Line of sight effect</td>
<td>Scant data, line of sight effect</td>
</tr>
</tbody>
</table>

Steris VHP 1000 ED System

From: www.steris.com

BioGienie

- Hyproxi®
  - 5% H2O2 with silver ions
  - Hyproxi as a liquid as 4-6 log10, kill of MRSA, E coli, P aeruginosa
  - No published data on efficacy as HP vapour system
  - 23 hour cycle time

BioQuell Q-10

www.bioquell.com

H2O2 Technologies

- Bioquell
  - 30% H2O2 solution
  - H2O2 vapor
- Glosair (ASP)
  - 5-6% H2O2 solution
  - ASP (J&J) acquired Sterinis in 2009
  - H2O2 mist/aerosol
- VHP (Steris)
  - 35% H2O2 solution
  - H2O2 vapor

BioQuell Q-10

www.bioquell.com

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Glosair (ASP)

VHP (Steris) Against Aerobic Spores

Sealing Ducts in a Room

Bioquell Efficacy for CDI

Bioquell and CDI Cont’d

Bioquell and MRSA

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Bioquell Clinical Study

• HPV process took 1.5-3.0 hours
• The only reduction in MDRO was the reduced incidence seen for VRE acquisitions
  – 5 times less likely in the HPV treated rooms
  – adjusted IRR, 0.20
  – 95% CI, .08-.52
• No statistically significant reduction in acquisitions of MRSA, C. difficile or MDR gram negative bacilli

Bioquell Clinical Study

• 218 (21.0%) of the 1039 patient rooms sampled were contaminated with ≥1 MDRO
• HPV demonstrated reduced bacterial contamination in:
  – rooms contaminated with multiple MDROs (RR, 0.16; P < .01),
  – MDROs cultured from a room that differed from the room occupant’s known MDRO (RR, 0.37; P = .02)
  – and MDROs cultured from empty rooms (RR, 0.31; P = .05)
• But not individually for MRSA, VRE, C difficile or MDR Gram Negative Bacilli containing rooms, but frequency of these was low
• Mostly VRE 35±5±64% of rooms during the HPV intervention
• One brand of paint used on the walls of one of the HPV
• units showed some incompatibility with the process

Sterinis Trial (becomes Glosair)

• Teaching hospital in Zonguldak, Turkey
• Steel discs inoculated and placed in many locations in patient rooms 53m²
• MRSA and A. baumannii
• Applied Sterinis HP Mist
• 2.5 hr cycles

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• units showed some incompatibility with the process

Tru-D vs Bioquell “Head to Head”

• Results
  – HPV (Bioquell)
    – 93% ACC negative
    – 6 log10 C. difficile kill
    – 99-100% BI’s killed
    – 2.5-3 hr cycles
  – UV-C (TRU-D)
    – 52% ACC negative
    – <2 log10 C. difficile kill
    – 0-22% % BI’s killed
    – 0.6-1.7 hr cycles


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Comparison of H₂O₂ Systems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Glosair (ASP)</th>
<th>VHP (Steris)</th>
<th>BioGienie</th>
<th>BioQuell</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O₂ %</td>
<td>5-6%</td>
<td>35%</td>
<td>8%</td>
<td>35%</td>
</tr>
<tr>
<td>Dispersion</td>
<td>Dry Mist/Aerosol</td>
<td>Vapor</td>
<td>Dry Mist/Aerosol</td>
<td>Vapor</td>
</tr>
<tr>
<td>Final Conc H₂O₂</td>
<td>50-80 ppm</td>
<td>~500 ppm</td>
<td>~500 ppm</td>
<td>~500 ppm</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>~2-3 hr</td>
<td>2-8 hrs</td>
<td>≥3 hr</td>
<td>≥2 hr, up to 5 hr</td>
</tr>
<tr>
<td>C. difficile log10 kill</td>
<td>No data for C. difficile</td>
<td>No data for C. difficile</td>
<td>6 log for C. difficile</td>
<td>6 log for Bacillus</td>
</tr>
<tr>
<td>Controlled Clinical Trials</td>
<td>Some small</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
</tr>
<tr>
<td>Cost</td>
<td>$60,000</td>
<td>?</td>
<td>?</td>
<td>$44,000 capital per room</td>
</tr>
</tbody>
</table>

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Ozone & Hydrogen Peroxide in Biological Systems

- Antibodies have been shown to have catalytic activity that produces BOTH H₂O₂ AND O₃
  - BUT the amount produced of each is so low that neither could kill any microorganism
- Trioxidane (H₂O₃) has been detected as the extremely reactive intermediary molecule of this reaction
- Trioxidane is lethal to organisms in minute amounts!

Pure O₃ as Antibacterial

<table>
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<th>VHP (Steris)</th>
<th>BioGienie</th>
<th>BioQuell</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₃ %</td>
<td>1-2%</td>
<td>1.7%</td>
<td>4-4.5%</td>
<td>1-2%</td>
</tr>
<tr>
<td>Disinfection time</td>
<td>~1 hr</td>
<td>2-8 hrs</td>
<td>≥3 hr</td>
<td>≥2 hr, up to 5 hr</td>
</tr>
<tr>
<td>C. difficile log10 kill</td>
<td>No data</td>
<td>No data</td>
<td>6 log</td>
<td>6 log</td>
</tr>
<tr>
<td>Bacillus</td>
<td>~500 ppm</td>
<td>≥500 ppm</td>
<td>~500 ppm</td>
<td>~500 ppm</td>
</tr>
<tr>
<td>Controlled Clinical Trials</td>
<td>Some small</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
</tr>
<tr>
<td>Cost</td>
<td>$65,000</td>
<td>$50 per room</td>
<td>$44,000 capital per room</td>
<td></td>
</tr>
</tbody>
</table>


The Science of AsepticSure’s Synergy

AsepticSure® Microbiology Techniques

1 cm stainless steel disks as the bacteria & spore carriers
The quantitative carrier test (QCT-2) standard used or modified

In vitro Testing System for AsepticSure

- Polycarbonate chamber
- Fully instrumented to measure conditions
- Computer controlled and recorded results
- Used MRSA as test organism initially to define optimal conditions

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In vivo Testing System AsepticSure

Testing Materials
- AsepticSure system also effective on:
  - Stainless steel
  - Plastic from toilet seats
  - Laminate
  - Carpeting
  - Cotton or synthetic cloth
  - With and without organic soil load

AsepticSure Results

<table>
<thead>
<tr>
<th>Organism</th>
<th>Ozone (PPM)</th>
<th>H2O2 (%)</th>
<th>Exposure (min)</th>
<th>Microbial Kill (Log10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>80</td>
<td>1</td>
<td>15</td>
<td>6.3</td>
</tr>
<tr>
<td>VRE</td>
<td>80</td>
<td>1</td>
<td>15</td>
<td>6.2</td>
</tr>
<tr>
<td>E. coli</td>
<td>80</td>
<td>1</td>
<td>15</td>
<td>6.5</td>
</tr>
<tr>
<td>S. typhimurium</td>
<td>80</td>
<td>1</td>
<td>15</td>
<td>6.1</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>80</td>
<td>1</td>
<td>15</td>
<td>6.0</td>
</tr>
<tr>
<td>L. monocytogenes</td>
<td>80</td>
<td>1</td>
<td>15</td>
<td>6.3</td>
</tr>
<tr>
<td>C. difficile spores</td>
<td>80</td>
<td>1</td>
<td>15-30</td>
<td>6.1</td>
</tr>
<tr>
<td>B. subtilis spores</td>
<td>80</td>
<td>1</td>
<td>30</td>
<td>6.1</td>
</tr>
<tr>
<td>Mycobacterium terrae</td>
<td>80</td>
<td>1</td>
<td>30</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Summary of AsepticSure
- First ever use of ozone and hydrogen peroxide for high level disinfection of clinical spaces and surfaces
- Capitalizes upon HUGE synergy between ozone and hydrogen peroxide producing trioxidane
- Very fast
- Broad spectrum
- Consistent high level disinfection (6 log10sterilization)
- Penetrating gas goes everywhere
- Low doses of ozone and hydrogen peroxide reduces costs, risks and damage to infrastructure
- Technology proven to be very robust and reliable
- Capital Cost: $95,000 + ~$10-20 per room

Am J Inf Control 2011;39:873-9

Effectiveness of a novel ozone-based system for the rapid high-level disinfection of health care spaces and surfaces

AsepticSure

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✓ Cost effective
✓ Can be safely deployed
✓ No environmental residues
✓ Reduces incidence of healthcare infections
✓ High quality supportive scientific evidence

The Final Result

Coming Soon
21 March TB INFECTION CONTROL IN HIGH HIV BURDENED COUNTRIES
Speaker: Virinia Lipke, Centers for Disease Control, Atlanta
19 April (WHO Teleclass) INNOVATION AND NEW INDICATORS IN HAND HYGIENE
Speaker: Prof. John Boyce, Yale University
11 April UTILIZING HOSPITAL-TO-HOSPITAL PARTNERSHIPS TO STRENGTHEN INFECTION PREVENTION AND CONTROL
Speaker: Dr. Shams B. Syed, World Health Organisation, Geneva
16 April (WHO Teleclass) REVIEW OF THE EUROPEAN UNION SHARPS LEGISLATION
Speaker: Jane Aston, NHS
17 April (WHO Teleclass) CLOSTRIDIUM DIFFICILE IN THE COMMUNITY: FOOD FOR THOUGHT
Speaker: Prof. Tomas Riley, University of Western Australia
18 April LEADERSHIP IN INFECTION PREVENTION AND CONTROL

www.webbertraining.com/schedule1.php

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