Current Issues in Disinfection and Sterilization

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Current Issues in Disinfection and Sterilization

- Disinfection and sterilization principles
- Current issues
  - Critical-cleaning with washer disinfectors, Class 6 chemical indicator
  - Semicritical items (e.g., endoscopes and *C. difficile* spores, new AERs)
  - Noncritical-surface disinfection
    - Norovirus and *C. difficile* spores
    - Microfiber
    - Computers-sustained antimicrobial activity, touchscreen cleaning
    - Germicides-MRSA inactivation by disinfectants, technique
    - Green products

Disinfection and Sterilization

EH Spaulding believed that how an object will be disinfected depended on the object's intended use.

CRITICAL - objects which enter normally sterile tissue or the vascular system or through which blood flows should be **sterile.**

SEMICRITICAL - objects that touch mucous membranes or skin that is not intact require a disinfection process (**high-level disinfection [HLD]**) that kills all microorganisms but high numbers of bacterial spores.

NONCRITICAL -objects that touch only intact skin require **low-level disinfection.**

Cleaning

- Mechanical cleaning machines-automated equipment may increase productivity, improve cleaning effectiveness, and decrease worker exposure
  - Utensil washer-sanitizer
  - Ultrasonic cleaner
  - Washer sterilizer
  - Dishwasher
  - Washer disinfector
- Manual

Bioburden on Surgical Devices

- Bioburden on instruments used in surgery (Nystrom, 1981)
  - 62% contaminated with $<10^1$
  - 82% contaminated with $<10^2$
  - 91% contaminated with $<10^3$
- Bioburden on surgical instruments (Rutala, 1997)
  - 72% contained $<10^1$
  - 86% contained $<10^2$

Washer/Disinfector

Rutala WA, Gergen MF, Weber DJ, Unpublished results, 2007

- Five Chambers
  - Pre-wash: water/enzymatic is circulated over the load for 1 min
  - Wash: detergent wash solution (150°F) is sprayed over load for 4 min
  - Ultrasonic cleaning: basket is lowered into ultrasonic cleaning tank with detergent for 4 min
  - Thermal and lubricant rinse: hot water (180°F) is sprayed over load for 1 min; instrument milk lubricant is added to the water and is sprayed over the load
  - Drying: blower starts for 4 min and temperature in drying chamber 180F

Washer/Disinfector

Removal/Inactivation of Inoculum (Exposed) on Instruments

WD Conditions	Organism	Inoculum	Log Reduction	Positives
Routine	MRSA	$2.6x10^7$	Complete	0/8
Routine	VRE	$2.6x10^7$	Complete	0/8
Routine	*P aeruginosa*	$2.1x10^7$	Complete	0/8
Routine	*M terrae*	$1.4x10^8$	7.8	2/8
Routine	GS spores	$5.3x10^6$	4.8	11/14
No Enz/Det	VRE	$2.5x10^7$	Complete	0/10
No Enz/Det	GS spores	$8.3x10^6$	5.5	8/10

Washer/Disinfector

Removal/Inactivation of Inoculum (Non-Exposed) on Instruments

WD Conditions	Organism	Inoculum	Log Reduction	Positives
Routine	MRSA	$2.6x10^7$	Complete	0/8
Routine	VRE	$2.9x10^7$	Complete	0/8
Routine	*P aeruginosa*	$2.1x10^7$	Complete	0/8
Routine	*M terrae*	$1.2x10^8$	7.6	6/8
Routine	GS spores	$8.1x10^6$	~1	12/12
No Enz/Det	VRE	$2.4x10^7$	Complete	0/10
No Enz/Det	GS spores	$8.7x10^6$	1.6	10/10

Washer/disinfectors are very effective in removing/inactivating microorganisms from instruments

Recommendations
Monitoring of Sterilizers

- Monitor each load with physical and chemical (internal and external) indicators. If the internal indicator is visible, an external indicator is not needed.
- Use biological indicators to monitor effectiveness of sterilizers at least weekly with spores intended for the type of sterilizer (Class 6 emulating indicators not a substitute).
- Use biological indicators for every load containing implantable items and quarantine items, whenever possible, until the biological indicator is negative.

Types of Sterilization Monitoring Devices

- Chemical Indicators
  - External chemical indicators
    - Class 1 (process indicator, indicator tape)-outside of every package
  - Internal chemical indicators
    - Class 2 (Bowie Dick)-routine testing of vacuum; within a test pack daily in an empty sterilizer
    - Class 3 (single variable indicator; temperature, ETO conc)-may be used as internal monitor
    - Class 4 (multi-variable indicator)-may be use as internal monitor

Types of Sterilization Monitoring Devices

- Chemical Indicators
  - Internal chemical indicator
    - Class 5 (integrating indicator)-may be used as internal monitor, suppose to mimic the behavior of a biological indicator (BI)
    - Class 6 (emulating indicator)-suppose to emulate or mimic the behavior of a biological indicator; are cycle-specific (need a emulating indicator designed to valid a 10 min/270F cycle and a different indicator to validate a 3 min/270F). No professional organization (e.g., AORN, AAMI) has recommended the use of Class 6 emulating indicator as a substitute for biological indicators and there are no data that demonstrate that it mimics a BI at suboptimal sterilization times.

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C. difficile spores

Disinfectants and Antiseptics

***C. difficile* spores at 10 and 20 min, Rutala et al, 2006**

- ~4 $\log_{10}$ reduction (3 *C. difficile* strains including BI-9)
  - Clorox, 1:10, ~6,000 ppm chlorine (but not 1:50, ~1,200 ppm)
  - Clorox Clean-up, ~1,910 ppm chlorine
  - Tilex, ~25,000 ppm chlorine
  - Steris 20 sterilant, 0.35% peracetic acid
  - Cidex, 2.4% glutaraldehyde
  - Cidex-OPA, 0.55% OPA
  - Wavicide, 2.65% glutaraldehyde
  - Aldahol, 3.4% glutaraldehyde and 26% alcohol

High-Level Disinfection

***C. difficile* spores**

- 2% glutaraldehyde is effective against *C. difficile* at 20 minutes
- 0.55% ortho-phthalaldehyde is effective against *C. difficile* at 10 minutes
- Steris 20 is effective against *C. difficile* at 10 and 20 minutes

Semicritical Equipment

- Reprocessing semicritical items has been shown to have a narrow margin of safety
- Generally, the narrow margin of safety attributed to high microbial load and complex instruments with lumens
- Any deviation from the recommended reprocessing protocol can lead to the survival of microorganisms and an increased risk of infection
- Problems encountered with reprocessing semicritical equipment often related to improper cleaning

Errors in designing and reprocessing semicritical items continue and place patients at risk of infection

Automatic Endoscope Reprocessors (AERs)

- Manual cleaning of endoscopes is prone to error.
- AER Advantages: automate and standardize reprocessing steps, reduce personnel exposure to chemicals, filtered tap water
- AER Disadvantages: failure of AERs linked to outbreaks, does not eliminate precleaning, does not monitor HLD concentration
- Problems: incompatible AER (side-viewing duodenoscope); biofilm buildup; contaminated AER; inadequate channel connectors; used wrong set-up or connector MMWR 1999;48:557
- Must ensure exposure of internal surfaces with HLD/sterilant

Automatic Endoscope Reprocessors

- EvoTech-integrates cleaning (FDA-cleared claim) and disinfection. Automated cleaning comparable to manual cleaning. All residual data for cleaning of the internal channels as well as external insertion tube surfaces were below the limit of <8.5ug/cm^2
- Reliance-requires a minimal number of connections to the endoscope channels and uses a control boot (housing apparatus the creates pressure differentials to ensure connectorless fluid flow through all channels that are accessible through the endoscope's control handle channel ports). Data demonstrate that the soil and microbial removal effected by Reliance washing phase was equivalent to that achieved by optimal manual cleaning. Alfa, Olson, DeGagne. AJIC 2006;34:561.

Infrared Coagulation (IRC)

- IRC is a widely used method for treating hemorrhoids. The procedure involves applying infrared light to compress and seal hemorrhoid veins.
- The manufacture sells a sterile disposable sheath and states removing and soaking lightguides between procedures is no longer required.
- The manufacture also states that the lightguide is damaged by immersion in a disinfectant (as the lightguide is not sealed at the end and disinfectant gets between the quartz glass and the covering)

Infrared Coagulation (IRC)

- CDC guideline (In press) recommends immersion for reprocessing endocavitary probes with covers because integrity of the cover is compromised (failure rate 1-80%)
- Since the lightguide cannot be immersed we investigated an alternative procedure
  - Wipe the probe for 2 minutes with 1:10 bleach
  - Wipe probe with sterile water and let air dry

Infrared Coagulation Testing

(Rutala, Gergen, Weber, Unpublished results, 2006)

Test Organism	Inoculum	Log_{10} Reduction (%)
Mycobacterium terrae	7.8×10^6	6.9

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Low-Level Disinfection for "Noncritical" Objects

Exposure time ≥ 1 min

Germicide	Use Concentration
Ethyl or isopropyl alcohol	70-90%
Chlorine	100ppm (1:500 dilution)
Phenolic	UD
Iodophor	UD
Quaternary ammonium	UD

UD=Manufacturer's recommended use dilution

Disinfection and Sterilization of Emerging Pathogens

- Hepatitis C virus
- *Clostridium difficile*
- *Cryptosporidium*
- *Helicobacter pylori*
- *E.coli* 0157:H7
- Antibiotic-resistant microbes (MDR-TB, VRE, MRSA)
- SARS Coronavirus, avian influenza, norovirus, prions
- Bioterrorism agents (anthrax, plague, smallpox)

C. difficile and Norovirus

Due to the relative resistance of *C. difficile* spores and norovirus, during clusters, surfaces should be disinfected with a product shown to be effective (e.g., chlorine 5000ppm [1:10 bleach]

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Microfiber Cleaning

- Pad contains fibers (polyester and polyamide) that provide a cleaning surface 40 times greater than conventional string mops
- Proposed advantages: reduce chemical use and disposal (disinfectant solution not changed after every third room, clean microfiber per room [washing lifetime 500-1000x]); light (~5 lb less than string mop) and ergonomic; reduce cleaning times.
- Does the microfiber provide the same or better removal of microorganisms on surfaces?

Effectiveness of Microfiber Mop

- Test conditions with a EPA-registered disinfectant: compared routine mop and bucket; microfiber mop and bucket; microfiber mop and system bucket. Twenty-four replicates per condition.
- Conducted RODAC sampling before and after floor disinfection (5 samples per room)
- New disinfectant solution for each test condition
- Dry time varied from 2 (routine mop and bucket)-8 (microfiber mop and bucket) minutes

Effectiveness of Microfiber Mop

(Rutala, Gergen and Weber, Am J Infect Control, 2007;35:569)

Disinfectant-regular mop	95%
Disinfectant-microfiber system	95%
Disinfectant-microfiber mop and regular mop bucket	88%
Detergent-regular mop	68%
Detergent-microfiber system	95%
Detergent-microfiber mop and regular mop bucket	78%

Microfiber

Summary

- The microfiber system demonstrated superior microbial removal compared to cotton string mops when used with a detergent cleaner
- The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system
- Use of a disinfectant did significantly improve microbial removal when a cotton string mop was used

Disinfection of Computer Keyboards

Computer Keyboards, ICHE 2006;27:372

- Increased use of computers in patient areas has led to contamination of keyboards as reservoirs of pathogens
- Study performed to
  - Examine the efficacy of different disinfectants on the computer keyboard
  - Determine if there were cosmetic (key lettering removed) or functional changes after 300 wipes

Disinfection of Computer Keyboards

- All tested products were effective (>95%) in removing and/or inactivating the test pathogens (MRSA, *P. aeruginosa*). No functional/cosmetic damage after 300 wipes.
- Disinfectants included: 3 quaternary ammonium compounds, 70% isopropyl alcohol, phenolic, chlorine (80ppm)
- At present, recommend that keyboards be disinfected daily (for 5 sec) and when visibly soiled

TABLE 3. Sustained Efficacy of Disinfectants Applied to Keyboard Against Vancomycin-Resistant *Enterococcus* Species

	Efficacy of Disinfectant, by Time of Microbial Challenge and Duration of Disinfectant Exposure, %					
	Challenge at 6 Hours		Challenge at 24 Hours		Challenge at 48 Hours	
Disinfectant	10-min Exposure	60-min Exposure	10-min Exposure	60-min Exposure	10-min Exposure	60-min Exposure
Alcohol	3.05	5.67	12.58	3.31	10.89	5.59
CaviWipes	100.00	100.00	100.00	100.00	100.00	100.00
Clorox Disinfecting Wipes	100.00	100.00	100.00	100.00	100.00	100.00
Sani-Cloth Plus	100.00	100.00	100.00	100.00	100.00	100.00
Sterile water	0.00	0.28	9.69	0.00	0.00	9.09

NOTE. Efficacy was calculated as the percentage difference in the number of colony-forming units on the treated keys, compared with the number of colony-forming units on the control keys. Challenge times are hours since disinfectant exposure.

QUATS demonstrated excellent sustained activity against VRE and antimicrobial activity was maintained over the 48 test period

Touchscreen Cleaning

- Follow the manufacturer's recommendations
- Prepare the cleaning solution according to the manufacturer's instructions (e.g., alcohol, glutaraldehyde, mild soap, phenolic)
- Wet a clean, soft cloth with the selected cleaning solution
- Remove excess liquid from the cloth and squeeze damp
- Wipe exposed surfaces (do not allow liquid to enter interior)
- Remove any soap residue by gently wiping with clean cloth
- QUATS are not recommended by some manufacturers

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MRSA

MRSA

- Frequency of environmental contamination in areas housing MRSA patients has ranged from 1 to 74% (23.1%, 53.6% from isolation rooms) of surfaces cultured.
- MRSA viable in the environment for days to weeks
- HCW can contaminate their hands or gloves by touching contaminated surfaces
- Cleaning or disinfecting the environment can reduce transmission but cleaning regimens, as currently practiced, may not eliminate MRSA from surfaces
- Since MRSA sensitive to all germicides, likely due to surfaces not cleaned/disinfected
- Need targeted methods to evaluate the thoroughness of room cleaning

Practice or Product

Susceptibility of MSSA and MRSA to a Phenolic and Quaternary

Rutala et al. ICHE 1997;18:417

	Phenolic 1:256	Phenolic 1:128	QUAT 1:64	QUAT 1:32
MSSA	2/60	0/60	5/60	1/60
MRSA	0/60	0/60	4/60	1/60

TABLE 2
DISINFECTANT ACTIVITY AGAINST ANTIBIOTIC-SUSCEPTIBLE AND ANTIBIOTIC-RESISTANT BACTERIA

Product	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>4.3	>4.2	>4.6	>4.3	>5.1	>5.1	>4.5	>4.0
Clorox	>5.4	>5.1	>4.9	>4.2	>5.0	>5.0	>4.6	>4.5
Lysol Disinfectant	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.5	>4.6
Lysol Antibacterial	>5.5	>5.3	>5.0	>5.6	>5.1	>5.1	>4.8	>4.6
Vinegar	0.1	0.3	1.9	3.7	>1.1	>0.9	−0.6	0.3

Abbreviations: MSSA, methicillin-resistant Staphylococcus aureus; VRE, vancomycin-resistant Enterococcus faecium. Data represent means of two study runs. Values preceded by ">" represent the limit of detection at 24 hours. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of N0/N1, where N0 is the titer of bacteria surviving after exposure and N1 is the titer of the control.

Rutala WA, Barbee SL, Aguiar NC, Sobsey MD, Weber DJ. Antimicrobial Activity of Home Disinfectants and Natural Products Against Potential Human Pathogens. *Infection Control and Hospital Epidemiology* 2000;21:33-38.

Not Product: Is It Practice?

Surface Disinfection
Effectiveness of Different Methods

Technique (with cotton)	MRSA Log_{10} Reduction (QUAT)
Saturated cloth	4.56
Spray (10s) and wipe	4.56
Spray, wipe, spray (1m), wipe	4.56
Spray	4.56
Spray, wipe, spray (until dry)	4.56
Control: detergent	2.83

Patient Area Cleaning/Disinfecting
PC Carling et al, SHEA 2007 and ICHE 2008;29:1

- Monitor cleaning performance using an invisible fluorescent targeting method. Rooms (14 high-touch objects) were marked and evaluated after terminal cleaning.
- Results: 1,119 rooms and 13,369 objects were evaluated in 23 hospitals. Mean proportion of objects cleaned was 49%. Following education and process improvement feedback, cleaning improved to 77%
- Conclusion: Substantial opportunity for improving terminal cleaning/disinfecting activities.

Practice* NOT Product

*surfaces not wiped

The Green Hospital
Keslar. Proto (Mass Gen Hosp). Fall 2007

- Hospitals are feeling the pressure to go green, both from eco-conscious donors and governmental agencies
- Some features of The Green Hospital
  - Roof garden-wildlife habitat, adds insulation, absorbs rain
  - Fewer contaminants-upholstery and mattresses without flame retardants, formaldehyde-free insulation, green cleaning products (no hazardous fumes), triple-filtered air
  - Exposure to natural light
  - Reduced water usage-water efficient toilets and faucets
  - Greater energy efficiency-low energy fluorescent bulbs
  - More quiet-number 1 complaint is noise, better insulation between rooms

TABLE 1
EFFECTIVENESS OF DISINFECTANT AGAINST POTENTIAL PATHOGENS

	Log_{10} Reductions							
	Staphylococcus aureus		*Salmonella choleraesuis*		*Escherichia coli* O157:H7		*Pseudomonas aeruginosa*	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vespheme IIse	>5.2	>5.2	>5.7	>5.7	>5.6	>5.6	>5.7	>5.7
TBQ	>5.4	>5.4	>5.6	>5.6	>5.4	>5.4	>5.2	>5.2
Clorox	>5.5	>5.5	>5.9	>5.9	>5.6	>5.6	>5.3	>5.3
Ethanol	5.2	>5.7	>6.0	>6.0	>5.8	>5.8	>5.4	>5.4
Lysol Disinfectant	1.2	4.3	4.0	3.9	4.0	4.1	4.2	4.0
Lysol Antibacterial	>5.6	>5.6	>5.8	>5.8	>5.7	>5.7	>5.5	>5.5
Mr. Clean	4.1	>5.0	>5.7	>5.7	>5.1	4.7	>5.7	>5.7
Vinegar	0.03	0.3	>6.0	>6.0	0.4	2.4	>5.6	>5.6
Baking soda	0.2	0.5	2.3	2.3	0.4	0.7	1.1	1.1

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TABLE 2
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	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vespheme IIse	>4.3	>4.3	>4.3	>4.3	>5.1	>5.1	>4.6	>4.6
Clorox	>5.4	>5.4	>4.9	>4.9	>5.0	>5.0	>4.6	>4.6
Lysol Disinfectant	>4.3	>4.3	>4.3	>4.3	>5.1	>5.1	>4.6	>4.6
Lysol Antibacterial	>5.5	>5.5	>5.5	>5.5	>5.1	>5.1	>4.6	>4.6
Vinegar	0.1	5.3	1.0	3.7	+1.1	−0.9	+0.6	2.3

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"Green" cleaners will remove microbial contaminants but will not dependably kill

Summary

- D/S guidelines must be followed to prevent exposure to pathogens that may lead to infection. Semicritical items represent the greatest risk. Class 6 indicators not a substitute for biological indicators.
- During clusters, surfaces potentially contaminated with norovirus or *C. difficile* spores should be disinfected with with an agent shown to have efficacy (e.g., hypochlorite, 5000 ppm)
- Washer-disinfectors are very effective in removing/inactivating microbes
- Microfiber demonstrated superior microbial removal compared to cotton-string mops with a detergent
- Disinfectants (but not natural products) demonstrate excellent activity against MRSA but practices are deficient. QUATS have sustained antimicrobial activity.

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Thank you

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