Disinfection & Sterilization: Current Issues & New Technologies

William Rutala, University of North Carolina

A Webber Training Teleclass

Disinfection and Sterilization:
Current Issues and New Technologies

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Disinfection and Sterilization: Current Issues and New Technologies

- Disinfection and sterilization principles
- Current issues
  - Critical-cleaning with washer disinfectors, Class 6 chemical indicator, flash sterilization, ozone, ETO, prions
  - Semicritical items-*C. difficile* spores, laryngoscopes, new AERs/HLDs
  - Noncritical-surface disinfection
    - **Accelerated hydrogen peroxide (AHP)**
    - **Norovirus and *C. difficile* spores (HP vapor)**
    - **Microfiber**
    - **Computers-sustained antimicrobial activity, touchscreen cleaning**
    - **Germicides-MRSA inactivation by disinfectants, technique**

disinfectionandsterilization.org

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.**

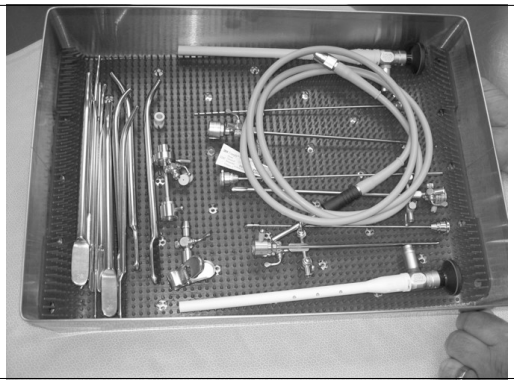
SEMICRITICAL - objects that touch mucous membranes or skin that is not intact require a disinfection process (**high-level disinfection [HLD]**) that kills all microorganisms but high numbers of bacterial spores.

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

Disinfection and Sterilization in Healthcare Facilities

WA Rutala, DJ Weber, and HICPAC, "In press"

- Overview
  - Last Centers for Disease Control and Prevention guideline in 1985
  - 274 pages (>130 pages preamble, 21 pages recommendations, glossary of terms, tables/figures, >1100 references)
  - Evidence-based guideline
  - Cleared by HICPAC February 2003; delayed by FDA
  - Publication expected in Summer 2008



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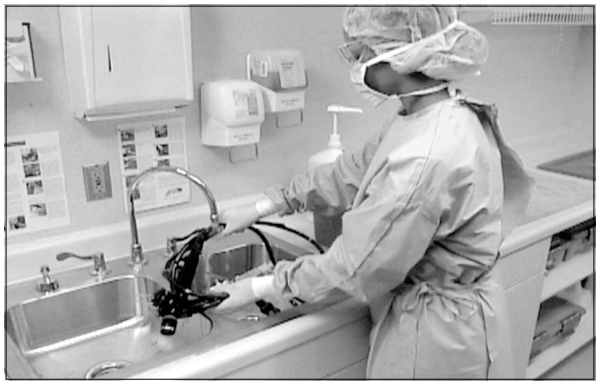
Critical Objects

- Surgical instruments
- Cardiac catheters
- Implants

Sterilization of "Critical Objects"

Steam sterilization
Hydrogen peroxide gas plasma
Ethylene oxide
Peracetic acid (0.2%)-chemical sterilization
Ozone
Steam formaldehyde



Semicritical Items

- Endoscopes
- Respiratory therapy equipment
- Anesthesia equipment
- Endocavitary probes
- Tonometers
- Diaphragm fitting rings

High Level Disinfection of "Semicritical Objects"

Exposure Time ≥ 12 m-30m (US), 20°C

Germicide	Concentration
Glutaraldehyde	≥ 2.0%
Ortho-phthalaldehyde (12 m US)	0.55%
Hydrogen peroxide*	7.5%
Hydrogen peroxide and peracetic acid*	1.0%/0.08%
Hydrogen peroxide and peracetic acid*	≥7.35%/>0.23%
Hypochlorite (free chlorine)*	650-675 ppm
Glut and phenol/phenate	1.21%/1.93%
Glut and alcohol	3.4%/26% IPA

*May cause cosmetic and functional damage

Pasteurization

65-77°C for ~30 minutes

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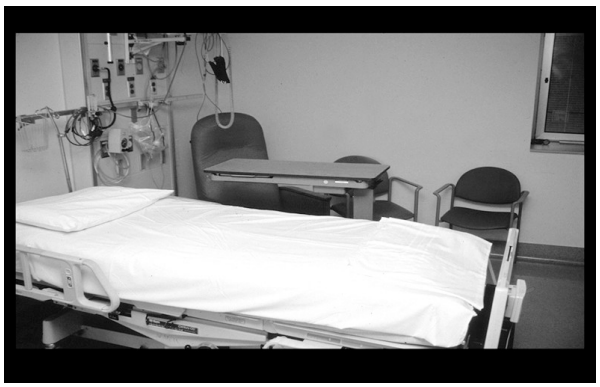

Low-Level Disinfection for "Noncritical" Objects

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

Critical Items/Sterilization

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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

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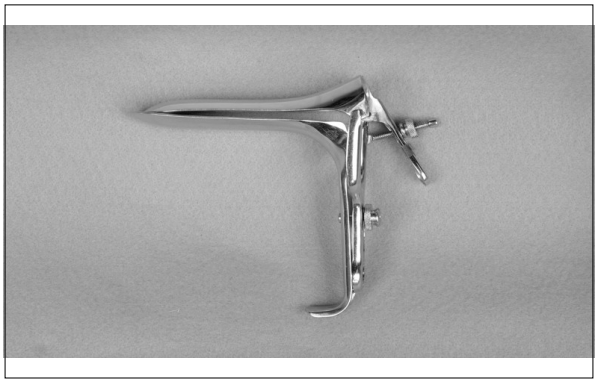
Washer/Disinfector

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 (150ºF) 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 (180ºF) 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

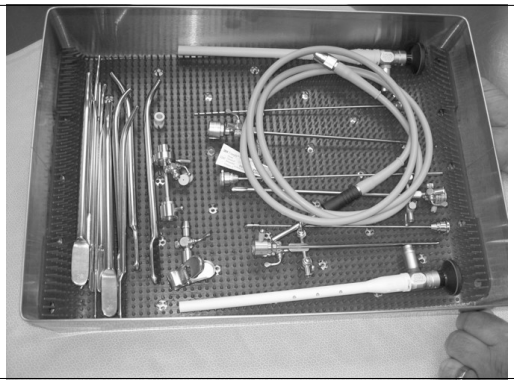


Washer/Disinfector

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/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.

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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.

Flash Sterilization
AORN, CDC Guidelines

- Flash used for items that must be used immediately
- Acceptable for processing items that cannot be packaged, sterilized and stored before use
- Because of the potential for serious infections, implanted surgical devices should not be flash sterilized unless unavoidable (e.g., orthopedic screws)
- Do not use flash sterilization for reasons of convenience, as an alternative to purchasing additional instrument sets, or to save time

Flash Sterilization

- In 1942, Underwood defined flash sterilization as 3 minutes at 250^{o}F for instruments when there is an "extreme emergency".
- In 1969, Perkins redefined flash sterilization of an unwrapped item to the current definition of 270^{o}F for 3 minutes in a gravity sterilizer.

Flash Sterilization

- Flash sterilization principles as defined by Underwood/Perkins and perpetuated by professional organizations are no longer applicable as the longstanding concerns have changed over the past 40 years. Historically, these issues included:
  - Lack of a timely biological indicator to monitor performance (now 1 hr) ;
  - Possibility for contamination of processed items during transportation to the Operating Rooms (containers ensure aseptic delivery to the OR);
  - Sterilization cycle parameters are minimal (extended exposure times) .
- And while no compromise with patient safety can be tolerated, prohibitions and principles regarding flash sterilization should be reassessed by professional organizations.
- Recommendation: comply with current recommendations

Ozone

- Advantages
  - Used for moisture and heat-sensitive items
  - Ozone generated from oxygen and water (oxidizing)
  - No aeration because no toxic by-products
  - FDA cleared for metal and plastic surgical instruments, including some instruments with lumens
- Disadvantages
  - Sterilization chamber small, 4ft^3
  - Limited use (material compatibility/penetrability/organic material resistance?) and limited microbicidal efficacy data

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Document ETO Sterilizer Loads

Federal Register, December 28, 2007

- The new regulation requires the following actions:
  - Make sure to run full loads in the ETO sterilizer
  - Run partial sterilizer loads if it's medically necessary to do so (left to discretion of hospitals; keep records)
  - Document every sterilizer load, and when loads aren't full, note the medical reasons and who authorized them (CSP, Adm, MD)
- EPA estimates that the new rule will prevent 2-9 tons of ETO from being released into the air nationwide
- Hospitals have until December 29, 2008 to comply

Creutzfeldt Jakob Disease (CJD): Disinfection and Sterilization

Prion Diseases

- Etiology
  - Prions
    - Proteinaceous infectious agent
    - No agent-specific nucleic acid
    - Host protein converts to pathologic isoform
    - Accumulates in neural cells, disrupts function
    - Resistant to conventional D/S procedures

Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Prions
Spores
Mycobacteria
Non-Enveloped Viruses
Fungi
Bacteria
Enveloped Viruses

Iatrogenic Transmission of CJD

- Contaminated medical instruments
  - Electrodes in brain (2)
  - Neurosurgical instruments in brain (4?)
- Dura mater grafts (>110)
- Corneal grafts (3)
- Human growth hormone and gonadotropin (>130)

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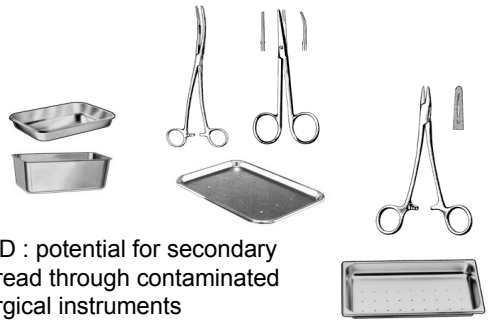

CJD : potential for secondary spread through contaminated surgical instruments

CJD: Disinfection and Sterilization

Conclusions

- Critical/Semicritical-devices contaminated with high-risk tissue from high-risk patients requires special prion reprocessing
  - NaOH and steam sterilization (e.g., 1N NaOH 1h, 121ºC 30 m)
  - 134ºC for 18m (prevacuum)
  - 132ºC for 60m (gravity)
- No low temperature sterilization technology effective*
- Noncritical-four disinfectants (e.g., chlorine, Environ LpH) effective (4 log decrease in LD_{50} within 1h)

*VHP reduced infectivity by 4.5 logs (Lancet 2004;364:521)

Risk Assessment for Special Prion Reprocessing: Patient, Tissue, Device

- High-Risk Patient
  - Known or suspected CJD or other TSEs
  - Rapidly progressive dementia
  - Familial history of CJD, GSS, FFI
  - History of dura mater transplant, cadaver-derived pituitary hormone injection
- High-Risk Tissue
  - Brain, spinal cord, eyes
- High-Risk Device
  - Critical or semicritical

Inactivation of Prions

Recent Studies

- Yan et al. Infect Control Hosp Epidemiol 2004;25:280.
  - Enzymatic cleaner (EC)-no effect
- Fichet et al. Lancet 2004;364:521.
  - Phenolic (Environ LpH), alkaline cleaner (AC), EC+VHP-effective
- Baier et al. J Hosp Infect 2004;57:80. AC-effective
- Lemmer et al. J Gen Virol 2004;85:3805.
  - SDS/NaOH, AC, 0.2% PA, 5% SDS-effective (in vitro)
- Jackson et al. J Gen Virol 2005;86:869. E (Pronase, PK)-effective
- Race R and Raymond G. J Virol 2004;78:2164.
  - Environ LpH-effective
- Peretz et al. J Virol 2006;80:1. Acidic SDS and SDS+SS-effective
- Fichet et al. JHI 2007;67:278. Gaseous HP-effective
- Yan et al. Zentr Steril 2008;16:26-34 HP Gas Plasma effective (Sterrad NX)

Prion Disease Transmission: Can We Apply Standard Precautions to Prevent Risks?

Gerald McDonnell July 2008

- Alkaline detergents and some enzymes are good at removing and breaking down prions from surfaces
- Alkaline detergents vary dramatically on pH, alkalinity, contact time, concentration, temperature and compatibility with device material.
- In Europe some detergents are CE marked as “Prion Inactivating Detergents”
- These technologies will be available and may eliminate “special prion reprocessing”

Instruments contaminated with high-risk tissue from a high-risk patient require “special prion reprocessing”. New technologies may alter the need for “special prion reprocessing” in the future.

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Semicritical Items/HLD

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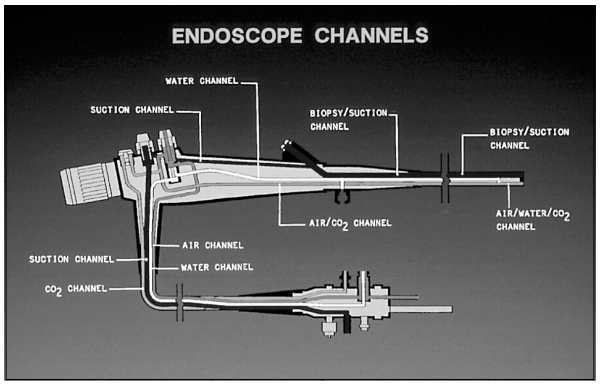
C. difficile spores

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



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

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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

EVOTECH w/Cleaning Claim

- Product Definition:
  - Integrated double-bay AER
  - Eliminates manual cleaning
  - Uses New High-Level Disinfectant (HLD) with IP protection
  - Single-shot HLD
  - Automated testing of endoscope channels and minimum effective concentration of HLD
  - Incorporates additional features (LAN, LCD display)

Reliance™ EPS

Endoscope Processing System

Reliance™ DG

Endoscope Processing Support

Klenzyme®, CIP® 200

Reliance™ PI

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.

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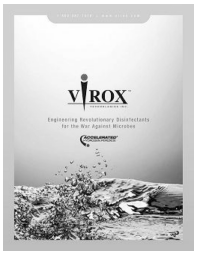
Reprocessing of Rigid Laryngoscopes

JHI 2008, 68:101; ICHE 2007, 28:504; AJIC 2007, 35: 536

- No guideline for reprocessing laryngoscope's blades and handles
- Many hospitals consider blade as semicritical (HLD) and handle as noncritical (LLD)
- Blades linked to HAIs; handles not directly linked to HAIs but contamination with blood/OPIM suggest its potential and blade and handle function together
- Ideally, clean then HLD/sterilize blades and handles (UNCHC-blades-Steris, handle (without batteries)-Sterrad; blade/handle with batteries-Sterrad



Hydrogen Peroxide Liquid-Based High Level Disinfection

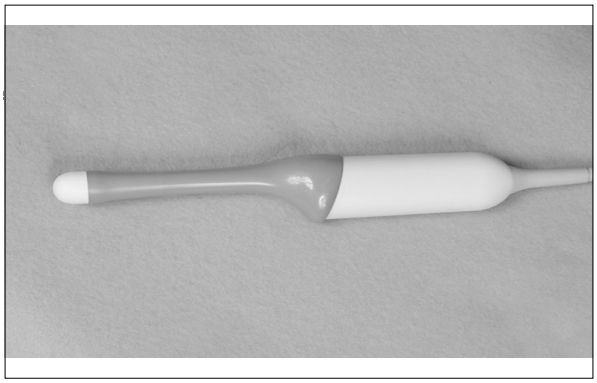
Not Currently Available In the U.S.

Resert™ HLD

- High Level Disinfectant - Chemosterilant
- 2% hydrogen peroxide, in *formulation*
  - pH stabilizers
  - Chelating agents
  - Corrosion inhibitors
- Efficacy (claims need verification)
  - Sporicidal, virucidal, bactericidal, tuberculocidal, fungicidal
- HLD: 5 mins at 20ºC
- Odorless, non-staining, ready-to-use
- No special shipping or venting requirements
- Manual or automated applications
- 12-month shelf life, 14 days reuse
- Material compatibility/organic material resistance (Fe, Cu)?

STERIS®

*The Accelerated Hydrogen Peroxide technology and logo are the property of Virox Technologies, Inc. Modified from G MacDonald. AJIC 2006;34:571



Endocavitary Probe Covers

- Sterile transvaginal probe covers had a very high rate of perforations before use (0%, 25%, 65% perforations from three suppliers)
- A very high rate of perforations in used endovaginal probe covers was found after oocyte retrieval use (75% and 81% from two suppliers) but other investigators found a lower rate of perforations after use of condoms (0.9-2.0%)
- Ineffectiveness of probe covers (latex condoms and probe sheaths) in preventing contamination of endocavitary, 68.4%
- Condoms superior to probe covers for ultrasound probe (1.7% condom, 8.3% leakage for probe covers)

Endocavitary Probes

- Probes-Transesophageal echocardiography probes, vaginal/rectal probes used in sonographic scanning
- Probes with contact with mucous membranes are semicritical
- Guideline recommends that a new condom/probe cover should be used to cover the probe for each patient and since covers may fail (1-80%), HLD (semicritical probes) should be performed

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Noncritical Items/LLD

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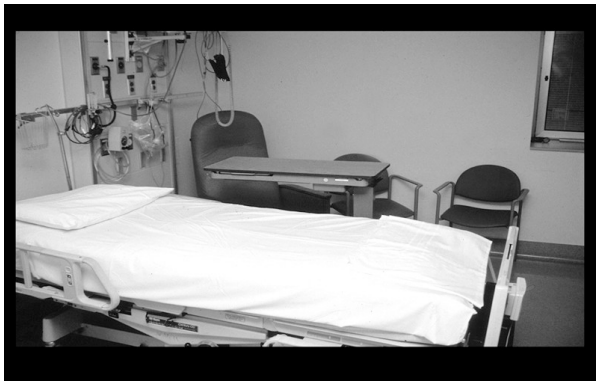

Low-Level Disinfection for "Noncritical" Objects

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

ACCELERATED HYDROGEN PEROXIDE

AHP-Based Surface Disinfectant

- Advantages
  - 1 min bactericidal (VRE, MRSA) and virucidal claim
  - 5 min mycobactericidal claim
  - Safe for workers, environment
  - Good cleaner
  - EPA (0.5% RTU, wet wipe)
- Disadvantage
  - Cost (RTU $5.80/32oz/pt, $92.83/512oz/gal; RTU QUAT $3.21/32oz/pt)

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)

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C. difficile spores

Environmental Contamination

C. difficile

- 25% (117/466) of cultures positive (<10 CFU) for *C. difficile*. >90% of sites positive with incontinent patients. Samore et al. Am J Med 1996;100:32.
- 31.4% of environmental cultures positive for *C. difficile*. Kaatz et al. Am J Epid 1988;127:1289.
- 9.3% (85/910) of environmental cultures positive (floors, toilets, toilet seats) for *C. difficile*. Kim et al. J Inf Dis 1981;143:42.
- 29% (62/216) environmental samples were positive for *C. difficile*. 8% (7/88) culture-negative patient, 29% (11/38) positive cultures in rooms occupied by asymptomatic patients and 49% (44/90) in rooms with patients who had CDAD. NEJM 1989;320:204
- 10% (110/1086) environmental samples were positive for *C. difficile* in case-associated areas and 2.5% (14/489) in areas with no known cases. Fekety et al. Am J Med 1981;70:907.

Role of the Environment

C. difficile

- The presence of *C. difficile* on the hands correlated with the density of environmental contamination. Samore et al. Am J Med 1996;100:32.
  - 0-25% environmental sites positive-0% hand cultures positive
  - 26-50% environmental sites positive-8% hand cultures positive
  - >50% environmental sites positive-36% hand cultures positive
- 59% of 35 HCWs were *C. difficile* positive after direct contact with culture-positive patients.
- *C. difficile* incidence data correlated significantly with the prevalence of environmental *C. difficile*. Fawley et al. Epid Infect 2001;126:343.
- Environmental contamination does not play a major role in nosocomial CDAD in some endemic situations. Cohen et al. Clin Infect Dis 1997;24:889.

Disinfectants and Antiseptics

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- ~4 $\log_{10}$ reduction (5 *C. difficile* strains including BI-9)
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  - Wavicide, 2.65% glutaraldehyde
  - Aldahol, 3.4% glutaraldehyde and 26% alcohol

Disinfectants and Antiseptics

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

- No measurable activity (1 *C. difficile* strain, J9)
  - CHG
  - Vesphene (phenolic)
  - 70% isopropyl alcohol
  - 95% ethanol
  - 3% hydrogen peroxide
  - Clorox disinfecting spray (65% ethanol, 0.6% QUAT)
  - Lysol II disinfecting spray (79% ethanol, 0.1% QUAT)
  - TBQ (0.06% QUAT); QUAT may increase sporulation capacity- Lancet 2000;356:1324
  - Novaplus (10% povidone iodine)
  - Accel (0.5% hydrogen peroxide)

Control Measures

C. difficile

- Handwashing (soap and water) , contact precautions, and meticulous environmental cleaning (disinfect all surfaces) with an EPA-registered disinfectant should be effective in preventing the spread of the organism. McFarland et al. NEJM 1989;320:204.
- In units with high endemic *C. difficile* infection rates or in an outbreak setting, use dilute solutions of 5.25-6.15% sodium hypochlorite (e.g., 1:10 dilution of bleach) for routine disinfection. (Category II)
- For semicritical equipment, glutaraldehyde (20m), OPA (12m) and peracetic acid (12m) reliably kills *C. difficile* spores using normal exposure times

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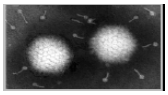
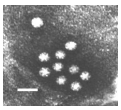
Norovirus

Virus Morphology

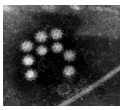
Rotavirus (60-80 nm)



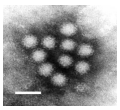
Adenovirus (70-90 nm)



Astrovirus (27-30 nm)



Sapovirus (27-35 nm)



Norovirus (27-35 nm)

www.virology.net/Big_Virology/BVFamilyIndex.html

Noroviruses

- Norovirus (formerly Norwalk-like viruses-NLV) is a genus within the family *Caliciviridae*. SS-RNA with a capsid structure provides increased resistance to chemical disinfection.
- Causes acute gastroenteritis in humans; fecal-oral transmission primarily, although droplet and fomite transmission may facilitate spread.
- Infective dose as low as 10-100 particles.
- Outbreaks have been reported in hospitals, homes, camps, schools, restaurants, hotels, rehabilitation centers and cruise ships
- Outbreaks in hospitals have increased in recent years and this may lead to the closure of wards
- This group of viruses cannot be grown in cell culture so feline calicivirus used as a surrogate

Environmental Contamination

Norovirus

- Hospital-11/36 (31%) environmental swabs were positive for RT-PCR. Positive swabs were from lockers, curtains and commodes and confined to the immediate environment of symptomatic patients. J Hosp Infect 1998;39:39.
- Hotel-61/144 (42%) were positive for NLV RNA. Cheesbrough et al. Epid. Infect 2000;125:93.
- Rehabilitation Center-Norovirus detected from patients and three environmental specimens (physiotherapy instrument handle, toilet seat (2-room of symptomatic guest, public toilet) RT-PCR. Epid Infect 2002;129:133-138.
- LTCF-5/10 (50%) of the environmental samples were positive for norovirus by RT-PCR. Wu et al. ICHE 2005;26:802.

Some positive PCR results may represent non-infectious virus.

Environmental Survival

Norovirus

- Distilled water or saline: Survival 0-2 days West AP, et al. J Clin Path 1992;48:228
- Sterile river water: Survival 2 to 20-30 days Shahamat M, et al. Appl Environ Micro 1993;59:1231
- Tap water at 4°C: 4 days Fan EG, et al. J Gastroenterol Hepatol 1998;13:1096
- At 20°C a 9-$\log_{10}$ reduction of FCV between 21-28 days in a dried state Doultree et al. J Hosp Infect 1999;41:51
- At 20°C a 9-$\log_{10}$ reduction of FCV between 14-21 days in suspension Doultree et al. J Hosp Infect 1999;41:51
- At 20°C a 3-$\log_{10}$ reduction in infectivity (two animal caliciviruses) occurred in 1 week. Duizer et al. Appl Env Micro 2004;70:4538.

Role of the Environment

Norovirus

1. Prolonged outbreaks on ships suggest NLV survives well
2. Outbreak of GE affected more than 300 people who attended a concert hall over a 5-day period. Norwalk-like virus (NLV) confirmed in fecal samples by RT-PCR. The index case was a concert attendee who vomited in the auditorium. GI illness occurred among members of 8/15 school parties who attended the following day. Disinfection procedure was poor. Evans et al. Epid Infect 2002;129:355
3. Extensive environmental contamination of a hospital ward.
   Suggest transmission most likely occurred through direct contact with contaminated fomites.

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Inactivation of Feline Caliciviruses

Doultree et al. J Hosp Infect 1999;41:51

Disinfectant	Log Reduction	Contact Time
Glutaraldehyde, 0.5%	5	1
Hypochlorite, 1000 and 5000 ppm	5	1
QUAT	0	1
Iodine, 0.8%	5	1
Ethanol, 75%	1.25	1

Surface Disinfection

Norovirus

- School outbreak of NLV-cleaning with QUAT preparations made no impact on the course of the outbreak. The outbreak stopped after the school closed for 4 days and was cleaned using chlorine-based agents. Marks et al. Epid Inf 2003;131:727
- Detergent-based cleaning to produce a visibly clean surface consistently failed to eliminate norovirus contamination. A hypochlorite/detergent formulation of 5000 ppm chlorine was sufficient to decontaminate surfaces. Barker et al. J Hosp Infect 2004;58:42.

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]

Effect of Hydrogen Peroxide Vapor (HPV) on *Clostridium difficile* (CD)

- HPV was injected into sealed wards and individual patient rooms using generators until approx 1 micron film of HP was achieved on the surface
- 5% (8/165) environmental sites cultured before HPV yielded CD compared to none of 155 cultures obtained after HPV
- HPV was effective in eradicating CD environmental contamination that remained following routine cleaning, which included use of dilute bleach
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Boyce JM and others. Society of Healthcare Epidemiology of America (SHEA), 2006 (abstract 156, page 109); Passaretti and others. SHEA, 2008 (abstract 80, page 70).

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  - Semicritical items-*C. difficile* spores, laryngoscopes, new AERs/HLDs
  - Noncritical-surface disinfection
    - **Accelerated hydrogen peroxide (AHP)**
    - **Norovirus and *C. difficile* spores (HP vapor)**
    - **Microfiber**
    - **Computers-sustained antimicrobial activity, touchscreen cleaning**
    - **Germicides-MRSA inactivation by disinfectants, technique**

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?

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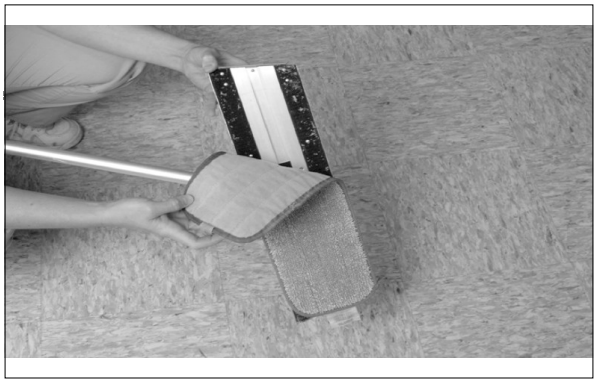

Effectiveness of Microfiber Mop

- 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

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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

Risk of Acquiring MRSA and VRE from Prior Room Occupants

- Admission to a room previously occupied by an MRSA-positive patient or VRE-positive patient significantly increased the odds of acquisition for MRSA and VRE (although this route a minor contributor to overall transmission). Arch Intern Med 2006;166:1945.
- Prior environmental contamination, whether measured via environmental cultures or prior room occupancy by VRE-colonized patients, increases the risk of acquisition of VRE. Clin Infect Dis 2008;46:678.

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

	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
Vesphene IIse	>4.3	>4.3	>4.8	>4.8	>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	>4.8	>4.8	>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

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S aureus*; VRE, vancomycin-resistant *Enterococcus*; VSE, vancomycin-susceptible *Enterococcus*. Data represent mean of two trials (n=2). Values preceded by ">" represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of N0/Nx, where N0 is the titer of bacteria surviving after exposure and Nx 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.

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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

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Boyce JM and others. Society of Healthcare Epidemiology of America (SHEA), 2006 (abstract 156, page 109); Passaretti and others. SHEA, 2008 (abstract 80, page 70).

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)**
- **Microfiber demonstrated superior microbial removal compared to cotton-string mops with a detergent**
- **Disinfectants demonstrate excellent activity against MRSA but practices are deficient. QUATS have sustained antimicrobial activity.**

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Thank you

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The Next Few Teleclasses

14 Aug. 08	(Free Teleclass) Extended Spectrum Beta Lactmases and Infection Control Speaker: Prof. David Patterson Broadcast live from New Zealand infection control conference
04 Sep. 08	We Get the Infection Control We Deserve Speaker: Gary Phillips, NorthWest Training & Development
11 Sep. 08	LTC - Surveillance in Long Term Care Speaker: Mary Andrus, CDC
16 Sep. 08	(British Teleclass) *Clostridium difficile* - Prevention is Better Than Cure Speaker: Prof. Mark Wilcox, Leeds University
23 Sep. 08	(Free Teleclass) Voices of CHICA (Part 2) Speaker: CHICA-Canada Board Members and Guests
24 Sep. 08	Nosocomial Transmission of Scabies Speaker: Dr. Helena Maltezou, Hellenic Centre for Disease Control and Prevention, Greece

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