

# OUTBREAKS ASSOCIATED WITH DISINFECTANTS AND STERILANTS

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## GOALS OF LECTURE

- Review mechanisms of germicide associated outbreaks
- Review antiseptic-associated outbreaks
- Review disinfectant-associated outbreaks
- Describe germicide failures associated with endoscopy
- Describe prevention of germicide associated outbreaks

# GERMICIDES

- Antiseptics
  - Germicides used on the skin or mucous membranes
- Disinfectants
  - Germicides used on equipment and inanimate environment
- Preservatives
  - Germicides incorporated into medications

## OUTBREAKS RELATED TO GERMICIDES: AN ONGONG PROBLEM

### Editorials and Comments

- Sanford JP. Disinfectants that don't. *Ann Intern Med* 1970;72:282-283.
- Dixon RE, et al. Aqueous quaternary ammonium antiseptics and disinfectants: use and misuse. *JAMA* 1976;236:2415-2417.
- Rutala WA, Cole EC. Antiseptics and disinfectants – safe and effective? *Infect Control* 1984;5:610-613.

## MECHANISMS OF OUTBREAKS

- Ineffective antiseptics
  - Lack of intrinsic activity of antiseptic or resistant pathogen
  - Contaminated antiseptic
  - Concentration of germicide too low (over dilution)
- Inadequate disinfection process
  - Concentration of germicide too low
  - Duration of disinfection too short
  - Lack of contact of germicide with microbes
  - Recontamination following disinfection

## OUTBREAKS RELATED TO ANTISEPTICS

### **Antiseptic**

- Benzalkonium chloride
- Benzalkonium chloride/picloxydine
- Centrimide
- Chlorhexidine
- Chloroxylenol (PCMX) soap
- Hexachlorophene
- Poloxamer-iodine
- Povidone-iodine
- Propamidine
- Triclosan

### **Pathogens**

- *Pseudomonas* spp.
- *P. aeruginosa*
- *Stenotrophomonas maltophilia*
- *Burkholderia cepacia*
- *Enterobacter* spp.
- *E. agglomerans*
- *Serratia marcescens*
- *Flavobacterium* spp.

## OUTBREAKS ASSOCIATED WITH BENZALKONIUM CHLORIDE

Reference	Pathogen	BC+cotton	Improper dilution	Infection
Tiwari T (03)	<i>M. abscessus</i>	Yes	Yes	Intra-articular
Tiwari T (03)	<i>M. chelonae</i>	Yes	Yes	Skin abscesses
Nakashima A (87)	<i>S. marcescens</i>	Yes	NA	Septic arthritis
Sautter R (84)	<i>S. marcescens</i>	No	NA	Meningitis
Fox J (81)	<i>S. marcescens</i>	Yes	No	IV catheters, misc.
Frank M (76)	<i>B. cepacia</i>	Yes	No	Bacteremia
Dixon R (76)	<i>Pseudomonas</i>	Yes	No	Pseudobacteremia
	<i>B. cepacia</i>	No	No	UTI
	<i>B. cepacia</i>	No	No	UTI, pneumonia
Kaslow R (76)	<i>B. cepacia</i> <i>Enterobacter</i> sp.	Yes	Yes	Pseudobacteremia
Lee J (61)	<i>Pseudomonas</i> - <i>Achromobacteria</i>	Yes	Yes	Bacteremia
Malizia W (60)	<i>E. aerogenes</i>	Yes	No	Bacteremia

Tiwari T, et al. CID 2003;36:954-962

## OUTBREAKS RELATED TO DISINFECTANTS

### Disinfectant

- Chlorhexidine
- Quaternary ammonium
- Phenolic
- Glutaraldehyde
- Formaldehyde
- Pine

### Pathogens

- *Pseudomonas* spp., *P. aeruginosa*
- *Burkholderia cepacia*
- *Flavobacterium* spp.
- *Serratia marcescens*
- *Alcaligenes* spp.
- *Stenotrophomonas maltophilia*

## EXAMPLE: INEFFECTIVE DISINFECTANT

- Disease: Person-to-person transmission of CJD (N=2)
- Device: Silver electrodes used for stereotactic electroencephalographic exploration
- Disinfection method: 70% ethanol and formaldehyde vapor
- Proof: 3 years after use the electrodes were surgically implanted into a chimpanzee which later developed CJD

Bernoulli C, et al. Lancet 1977;1:478-479

## GERMICIDE EFFICACY AGAINST PRIONS

### Ineffective (<3-log<sub>10</sub> ↓ in 1 h)

- Alcohol 50%
  - Formaldehyde 3.7%
  - Glutaraldehyde 5%
  - Hydrogen peroxide 3%
  - Iodine 2%
  - Peracetic acid
  - Phenol/phenolics 0.6%
- 
- Steam sterilization (121 °C for 15 min)
  - Ethylene oxide for 1 h

### Effective (≥3-log<sub>10</sub> ↓ in 1 h)

- Chlorine >1000 ppm
  - Sodium hydroxide ≥1 N
  - Phenolic >0.9%
- 
- Autoclaving (134 °C for 18 min)\*\*
  - Autoclaving (121-132 °C for 1 h)\*
  - 0.9 N NaOH for 2 h plus 121 °C for 1 h\*
- \* Gravity displacement sterilizer  
\*\* Prevacuum sterilizer

Rutala WA, Weber DJ. CID  
2004;39:702

## EXAMPLE: INEFFECTIVE DISINFECTANT

- Disease: Epidemic keratoconjunctivitis (adenovirus)
  - Jernigan JA, et al (1993): 126 patients (AR 7.3%)
  - Koo D, et al (1989): 102 patients (AR 16.7%)
- Procedure: Pneumotonometry (risk demonstrated by case-control studies)
- Tonometers disinfected with 70% isopropyl alcohol
- CDC (1990) & APIC (1996) recommendations for disinfection: immerse tonometers tips for 5-10 minutes in 500 ppm chlorine, 3% H<sub>2</sub>O<sub>2</sub>, 70% ethyl alcohol, or 70% isopropyl alcohol

## GERMICIDE EFFICACY AGAINST ADENOVIRUS TYPE 8

- *In vitro* study of efficacy of germicides against adenovirus type 8
- Test conditions
  - Hard water, 1 min; hard water, 5 min; hard water + 5% FCS, 1 min; hard water + 5% FCS, 5 min; sterile water, 1 min
- Effective (>3-log<sub>10</sub> kill within 1 min, ≥4 test conditions, tonometers)
  - Recommended: **70% ethanol, ~6,000 ppm chlorine**
  - Other: ~1,900 ppp chlorine, 0.55% ortho-phthalaldehyde, 2.5% glutaraldehyde, 2.65% glutaraldehyde, 65% ethanol with 0.063% QUAT, 79.6% ethanol with 0.1% QUAT, 0.2% paracetic acid
- Ineffective
  - 3% H<sub>2</sub>O<sub>2</sub>, 70% isopropyl alcohol, 4% chlorhexidine, 1% chloroxylenol, ~80 ppm chlorine, ~218 ppm chlorine

Rutala WA, et al. AAC 2006;50:1419-1424

## CHALLENGES OF FLEXIBLE ENDOSCOPES

- Requirement to use low temperature disinfection
- Multiple lumens
- Lengthy lumens
- Narrow lumens
- Blind channels
- Angled channels
- Dried blood and proteinacious material

## ENDOSCOPY: TRANSMISSION OF INFECTION

- Gastrointestinal endoscopy
  - >300 infections transmitted
  - 70% agents *Salmonella sp.* and *P. aeruginosa*
  - Clinical spectrum ranged from colonization to death (~4%)
- Bronchoscopy
  - 90 infections transmitted
  - *M. tuberculosis*, atypical *Mycobacteria*, *P. aeruginos*

Spach DH, et al. Ann Intern Med 1993;118:117-128;  
Weber DJ, Rutala WA. Gastrointestinal Disease, 2002

## ENDOSCOPE REPROCESSING

### Unacceptable Disinfectants for HLD

- Benzalkonium chloride
- Iodophor
- Hexachlorophene
- Alcohols (ethanol, isopropyl alcohol)
- Chlorhexidine gluconate
- Cetrimide
- Quaternary ammonium compounds
- Glutaraldehyde (0.13%) with phenol

## ENDOSCOPE REPROCESSING: INAPPROPRIATE DISINFECTANTS

- Benzalkonium chloride (Greene WH. Gastroenterol 1974;67:912)
- 70% alcohol (Elson CO. Gastroenterol 1975;69:507)
- QUAT (Tuffnell PG. Canad J Publ Health 1976;67:141)
- Hexachlorophene (Dean AG. Lancet 1977;2:134)
- Hexachlorophene (Beecham HJ. JAMA 1979;1013)
- 70% alcohol (Parker HW. Gastro Endos 1979;25:102)
- Povidone-iodine (Low DE. Arch Intern Med 1980;1076)
- Cetrimonium bromide (Schliessler KH. Lancet 1980;2:1246)
- 3% hexachlorophene (Schousboe M. NZ Med J 1980;92:275)



## ENDOSCOPE REPROCESSING: INAPPROPRIATE DISINFECTANTS

- 0.5% CHG in 70% alcohol  $\Rightarrow$  0.015% CHG + 0.15% cetrimide  $\Rightarrow$  87 sec exposure to 2% glutaraldehyde (Hawkey PM. J Hosp Inf 1981;2:373)
- 1% Savlon (cetrimide and CHG) (O'Connor BH. Lancet 1982;2:864)
- 0.0075% iodophor (Dwyer DM. Gastroint Endosc 1987;33:84)
- 0.13% glut with phenol (Classen DC. Am J Med 1988;84:590)
- 70% ethanol for 3 min. (Langenberg W. J Inf Dis 1990;161:507)

## ENDOSCOPE REPROCESSING: INAPPROPRIATE DISINFECTANTS

- Disease: Epidemic hypochlorhydria (presumed *H. pylori*)
    - Ramsey EJ, et al. (1979)
    - Gledhill T, et al. (1985)
  - Device: Esophageal pH electrodes
  - Disinfection: None
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- Disease: Acute gastritis (*H. pylori*)
  - Device: Endoscope
  - Disinfection:
    - Langenberg W, et al. (1990): 3 patients; disinfection with 70% ethanol
    - Miyaji H, et al. (1995): 1 patient; disinfection with 0.2% benzalkonium chloride

## GERMICIDE EFFICACY AGAINST *CLOSTRIDIUM DIFFICILE*

- *In vitro* test using AOAC method
  - 2% glutaraldehyde effective against *C. difficile* spores
  - Rutala WA, et al. ICHE 1993;14:36-39
- Experimentally contaminated endoscopes
  - 2% glutaraldehyde effective
  - Peracetic acid effective
  - Fantry GT, et al. Am J Gastroenterol 1995;90:227-232.

## ENDOSCOPE REPROCESSING: INAPPROPRIATE DISINFECTION

- Air/water channel not exposed to glutaraldehyde (Birnie GG. Gut 1983;24:171)
- Air/water channel not exposed to glutaraldehyde (Cryan EMJ. J Hosp Inf 1984;5:371)
- No glutaraldehyde (water only) between patients. (Earnshaw JJ. J Hosp Inf 1985;6:95)
- Steris AER (MMWR 1999;48:557-560)
  - 50% flow reduction and 25% flow pressure reduction when biopsy port cap of bronchoscopes removed (*M. tuberculosis* pseudo-infection)
  - Incorrect connectors used (*M. avian* pseudo-infection)
  - Failure to properly connect scope to Steris (imipenem resistant *P. aeruginosa*)

## POTENTIAL SOURCES OF OUTBREAKS IN THE FUTURE

- Human error (most important)
- Malfunction of disinfection process
- Use of nonsterile water to dilute antiseptic
- Waterless alcohol hand hygiene products not effective against all potential pathogens
  - Non-enveloped viruses (e.g., norovirus, adenovirus)
  - Spore forming bacteria (e.g., *C. difficile*)
- Failure of current standard disinfection processes to eliminate prions
  - Efficacy of cleaning plus standard disinfection unknown

## PREVENTING GERMICIDE-ASSOCIATED OUTBREAKS

- Use of EPA or FDA approved germicides
- Requiring early training and competency testing of persons disinfecting endoscopes
- Development and introduction of endoscopes able to withstand steam sterilization
- Rigorous adherence to forthcoming HICPAC Guideline on Sterilization and Disinfection
  - Special prion disinfection (known or suspected CJD, blind Bx)
  - Cleaning and disinfection of endoscopes

## RECOMMENDED ANTISEPTICS

- Ethanol, 60-95%
- Chlorhexidine gluconate, 0.5-4% (2-4% more effective)
- Parachlorometaxyleneol (PCMX), 0.3-3.75%
- Iodine, 1%
- Iodophors, 7.5-10%
- Tricolsan, 0.2-2%

Products may combine more than 1 antiseptic

Boyce J, Pittet D. MMWR 2002;51(RR-16):1

## RECOMMENDED HIGH LEVEL DISINFECTANS

- Glutaraldehyde >2%
- Glutaraldehyde 1.12% and phenol/phenate 1.93%
- Ortho-phthalaldehyde 0.55%
- Hydrogen peroxide 7.5%
- Hydrogen peroxide 7.3% and peracetic acid 0.23%
- Hydrogen peroxide 1.0% and peracetic acid 0.08%
- Hypochlorite 650-675 ppm free chlorine

Rurala WA, Weber DJ. MMWR (In press)