Sterilization, Disinfection, and Antisepsis

Dr. Recep ÖZTÜRK

Definitons

- Sterilization-use of physical procedures or chemical agents to destroy all microbial forms including bacterial spores, mycobacteria, nonenveloped viruses and fungi
- Pasteurization:heating of materials to 60^{o}C for 30 minutes or 71^{o}C for 30 sec.
- Disinfection- use of physical procedures or chemical agents to destroy most microbial forms; bacterial spores and relatively resistant organisms may viable
  - Disinfectants:high-, intermediate-, low-level agents

Definitons

- Antisepsis-use of chemical agents on skin or other living tissue to inhibite or eliminate microbes; no sporicidal action is implied
- Germicide- chemical agent capable of killing microbes; spores may survive
- Sporicide- germicide capable of killing bacterial spores
- Sanitation-Process by which microbial contamination on inanimate surfaces is reduced to a safe level

Descending order of resistance to antiseptics and disinfectants

Prions*
(CJD, BSE)
⬇
Coccidia
(*Cryptosporidium*)
⬇
Spores
(*Bacillus, C. difficile*)
⬇
Mycobacteria
(*M. tuberculosis, M. avium*)
⬇
Cysts
(*Giardia*)
⬇
Small non-enveloped viruses
(Polio virus)
⬇
Trophozoites
(*Acanthamoeba*)
⬇
Gram-negative bacteria (non-sporulating)
(*Pseudomonas, Providencia*)
⬇
Fungi
(*Candida, Aspergillus*)
⬇
Large non-enveloped viruses
(Enteroviruses, Adenovirus)
⬇
Gram-positive bacteria
(*S. aureus, Enterococcus*)
⬇
Lipid enveloped viruses
(HIV, HBV)

Sterilization methods

- Physical
- Gas vapor
- Chemical sterilants

Sterilization methods
Physical sterilants

- **Steam under pressure**
  - **121 °C or 132 °C for various time intervals**
- **Dry heat**
  - **1 h at 171 °C, 2 h at 160 °C, 16 h at 121 °C**
- **Filtration**
  - **0.22- to 0.45 μm pore size**
  - **HEPA(high efficiency particulate air) filters**
    - **Air control systems for removing particles(microorganisms)**

Sterilization methods
Physical sterilants

- **UV radiation**
  - **Variable exposure to 254 nm wavelength**
  - **Have low penetrability; direct exposure is required**
  - **It causes skin erythema and conjuctivitis**
- **Ionizing radiation**
  - **Variable exposure to microwave or gamma radiation**

Sterilization methods
Gas vapor sterilants

- **Ethylene oxide**
  - **450 to 1200 mg/L at 29 ºC to 65 ºC for 2 to 5 hr**
  - **Higly efficient, but extremely toxic**
- **Formaldehyde vapor**

  2% to 5% at 60º to 80 ºC

  Carcinogenic!
- **Hydrogen peroxide vapor**
  - **30 % at 55º to 60 ºC**
- **Plasma gas**
  - **Highly ionized hydrogen peroxide gas**
- **Chlorine dioxide gas**
  - **Variable; lack of toxicity**

Sterilization methods
Chemical sterilants

- **Gluteraldehyde**
  - **2%**
- **Peracetic acid**
  - **an oxidizing agent**
  - **0.2%**
  - **Has excellent activity**
  - **The end products are nontoxic**
- **Beta-propiolactone**

Disinfection

- Disinfection process have beeen categorized as high level(≅sterilization), intermediate level (spore forms can survive) and low level(many microbes can remain viable)
- High level disinfection: certain type of endoscopes, surgical instruments with plastic or other instruments that can not be autoclaved
- Intermediate level: flexible fiberoptic endoscopes, laryngoscopes, vaginal specula, anesthesia breathing circuits...
- Low-level: blood culture cuffs, electrocardiogram electrodes, stethoscopes

The effectiveness of disinfectans is influenced by:

- The nature of the item to be disinfected
- Number and resilience of the contaminating organism/s
- Amount of organic material present (which can inactivate the disinfectant)
- Type and concentration of disinfectant
- Duration and temperature of exposure

Methods of disinfection

Method	Concentration(level of activity)
Heat	
Moist heat	75 ^{o} to 100 ^{o}C for 30 min(high)
Liquid	
Gluteraldehyde	2%(high)
Hydrogen peroxide	3 % to 25% (high)
Formaldehyde	3% to 8% (high/intermediate)
Chlorine dioxide	Variable(high)
Peracetic acid	Variable(high)

Methods of disinfection

Method	Concentration(level of activity)
Liquid	
Chlorine compounds	100 to 1000 ppm of freee chlorine (high)
Alcohol(ethyl, isopropil)	70% to 90% (intermediate)
Phenolic compounds	0.4% to 5%(intermediate/low)
Quaternary ammonium compounds(QAC)	0.1% to 1.6 %(low)

The uses of common disinfectants

- **Hand hygiene body surfaces**
  - **Chlorhexidine**
  - **Isopropyl alcohol**
  - **Povidone iodine**
    - **Allergy risk**
- **Medical equipment**
  - **Gluteraldehyde**
    - **Respiratory irritant**
- **Hospital, clinical environment**
  - **Pheolic compounds**
    - **Avoid skin contact**
  - **Hypochlorite**
    - **Corrosive to metal**

Antisepsis

- Antiseptic agents are used to reduce the number of microbes on skin surfaces
- These compounds are selected for their safety and efficacy

Antiseptic agents

Antiseptic agent	Concentration
Alcohol(ethyl, isopropyl)	70% to 90%
Iodophors	1 to 2 mg of free iodine/L
	1% to 2% available iodine
Chlorhexidine	0.5% to 4%
Parachlorometaxylenol	0.5% to 3.75%
Triclosan	0.3% to 2%

Germicidal properties of disinfectants and antisetic agents

Agents	Bacteria	Myco-bacteria	spores	fungi	viruses
Disinfectants					
Alcohol	+	+	-	+	+/-
Hydrogen peroxide	+	+	+	+	+
Formaldehyde	+	+	+	+	+
Phenolics	+	+	-	-	+
Chlorine	+	+	+/-	+/-	+
Iodophors	+	+/-	-	-	+/-
Gluteraldehyde	+	+	+	+	+
QAC	+	-	-	-	+/-

Germicidal properties of disinfectants and antisetic agents

Agents	Bacteria	Myco-bacteria	spores	fungi	viruses
Antiseptic agents					
Alcohol	+	+	-	+	+
Iodophors	+	+	-	+	+
Chlorhexidine	+	+	-	+/-	+
Parachlorometa-xylenol	+/-	+/-	-	+	-
Triclosan	+	+/-	-	-	?

The mechanisms of antibacterial action of antiseptics and disinfectant

Target	antiseptics or disinfectant	mechanisms of action
Cell envelope(cell wall, outer membrane)	Glutaraldehyde EDTA, other permeabilizers	Cross-linking of proteins, Gram-negative bacteria: removal of Mg 2+ , release of some LPS
Cytoplasmic (inner) membrane	QACs	Generalized membrane damage involving phospholipid bilayers
	Chlorhexidine	Low concentrations affect membrane integrity, high concentrations cause congealing of cytoplasm

The mechanisms of antibacterial action of antiseptics and disinfectant

Target	antiseptics or disinfectant	mechanisms of action
Cytoplasmic (inner) membrane	Diamines PHMB, alexidine Phenols	Induction of leakage of amino acids Phase separation and domain formation of membrane lipids Leakage; some cause uncoupling

The mechanisms of antibacterial action of antiseptics and disinfectant

Target	antiseptics or disinfectant	mechanisms of action
Cross-linking of macromolecules	Formaldehyde Glutaraldehyde	Cross-linking of proteins, RNA, and DNA Cross-linking of proteins in cell envelope and elsewhere in the cell
DNA intercalation	Acridines	Intercalation of an acridine molecule between two layers of base pairs in DNA

The mechanisms of antibacterial action of antiseptics and disinfectant

Target	antiseptics or disinfectant	mechanisms of action
Interaction with thiol groups	**Silver compounds**	**Membrane-bound enzymes (interaction with thiol groups)**
Effects on DNA	**Halogens** **Hydrogen peroxide, silver ions**	**Inhibition of DNA synthesis** **DNA strand breakage**

The mechanisms of antibacterial action of antiseptics and disinfectant

Target	antiseptics or disinfectant	mechanisms of action
Oxidizing agents	**Halogens**	**Oxidation of thiol groups to disulfides, sulfoxides, or disulfoxides**
	Peroxygens	**Hydrogen peroxide: activity due to from formation of free hydroxy radicals (OH), which oxidize thiol groups in enzymes and proteins; PAA: disruption of thiol groups in proteins and enzymes**