CHAPTER (8)

DISINFECTION & STERILIZATION

Definition and principles of terms:

Sterilization:

- Validated process used to render a product **free of all viable microorganisms including all bacterial spores**
- **Steam under pressure, hydrogen peroxide gas plasma, ethylene oxide gas** and **dry heat** are the main validated sterilization processes for use in health care facilities
- Sterilization is essential for **culture media**, and **critical items intended to enter the vascular system** and **sterile tissues** such as vascular catheters and surgical instruments

Disinfection:

- It is a process that **eliminates most**, if **not ALL pathogenic microorganisms, EXCEPT spores**.
- Thus unlike sterilization, **disinfection is NOT sporicidal**
- Disinfection is required for devices or equipment that **don't penetrate tissue but used in contact with:**
  * **The skin** (e.g., stethoscope diaphragm swabbed with 70% alcohol) or
  * **Mucous membranes** (e.g., immersion of endoscope in 2% ortho-phthalaldehyde "OPA" disinfectant for 12 min.)

Disinfectant:

- Usually a **chemical agent (but sometimes a physical agent)** that achieves disinfection.
- It refers to substances **applied to inanimate objects**.

- **Disinfectants may be categorized into 3 levels: high, intermediate and low:**

1. High level disinfectant:

* Germicide that **kills all microbial pathogens except** large numbers of spores.
* Examples include → OPA for endoscopes, hydrogen peroxide for contact lens chlorine for blood spills.

2. Intermediate level disinfectant:

* Germicide that kills all microbial pathogens except bacterial spores
* Examples include → isopropyl alcohol and iodophors.

3. Low level disinfectant:

* Germicide that kills **most vegetative bacteria** (except tubercle bacilli) and **lipid-enveloped and medium-sized viruses** such as human immunodeficiency virus and hepatitis B virus
* e.g., quaternary ammonium compounds for disinfection of floors and food preparation areas.

Antiseptic:

- A **chemical disinfectant** which can be safely **applied to skin and mucous membranes →** but **not suitable for systemic administration**
- The term is used especially for **preparations applied topically to living tissue**
- e.g. * **70% isopropyl alcohol** to prepare skin for injection
  * **Preoperative skin preparation** with alcohol-based iodine compound in surgical operations.

Germicide:

- Agent **that destroys microorganisms →** may be **virucide, bactericide, fungicide, sporicide and tuberculocide** indicating the microorganisms the germicide kills.
- The term germicide includes **both antiseptics and disinfectants**.
- **Antiseptics are:** * Germicides applied to living tissue and skin.
  * Disinfectants applied only to inanimate objects.

Sterilant: **Chemical germicide** that **achieves sterilization**

Cleaning (or precleaning):

- **Removal of foreign material** (organic or inorganic contaminants) from medical devices as part of **decontamination process**.
- It is usually done with **water and soap, detergents or enzymatic products**.
- Cleaning must always **precede disinfection and sterilization**.

Decontamination:

- **Reduction of pathogenic microorganisms** to a level at **which items are safe to handle**
- Decontamination includes **sterilization and all disinfection levels**

MAIN METHODS OF DISINFECTION:

1. Chemical disinfectants

2. Boiling water:
Boiling (100°C) for 20 minutes achieves high disinfection → and it can be useful in emergencies **if sterilizer is not available**

3. Pasteurization:
* Pasteurization of milk by heating at 63°C for 30 min. or at 72°C for 20 sec., followed by rapid cooling
* Destroys important pathogens → e.g. *Mycobacterium tuberculosis, Brucella, Salmonella* and *Coxiella burnetti*

4. Thermal disinfection:
By hot water can be performed in special washing machines → e.g. for linen in hospital laundry, dishes and devices which cannot withstand higher temperature

5. Ultraviolet radiation (UV):
* UV can be artificially produced by mercury lamps.
* UV rays have weak penetration power & is used only for air and surface disinfection → e.g. laboratory safety cabinets

U.V disinfection lamp

MIETHODS OF STERILIZATION:

1. Steam sterilization
2. Low tempera sterilization methods
3. Dry heat sterilization
4. Other sterilization methods.

1. Steam sterilization

- It is **the most safe and commonly used sterilization method.**
- It is accomplished in an **autoclave** and uses moist heat in the form of **saturated (dry) steam** under pressure for a specified exposure time and at a specified temperature, as the sterilizing agent.
- Thus, there are four parameters of steam sterilization: **steam, pressure, temperature, and time.**
- **The ideal steam for sterilization is saturated steam**.
- It is essential to make steam saturated which means free of air because air acts as an insulator and hinders penetration
- Pressure serves as a means to obtain the high temperatures necessary to quickly kill microorganisms.
- The two common steam-sterilizing temperatures are **121°C (maintained for a minimal exposure time 30 minutes) and 132°C (maintained for 4 minutes).**
- As regard mode of action, moist heat destroys microorganisms by coagulation and denaturation of enzymes and structural proteins.
- Steam sterilization is **nontoxic**, **inexpensive** and **rapidly heats and penetrates fabrics**
- **It is the most widely used and the most reliable.**

Monitoring of steam sterilizers (autoclaves), use following 3 monitors:

1. Mechanical indicators:	Using a printout graph that monitors the time, temperature and pressure of the sterilization cycle.
2. Chemical indicators or (integrators):	• Chemically impregnated paper strips that must be used with each sterilization cycle to monitor the temperature or time and temperature. • Visible colour changes occur at specified temperature and time.
3. Biological indicators:	• Paper strips impregnated with the spores of Geobacillus stearothermophilus. • The biological indicators are placed at **the coldest point of the chamber**. • After finishing the cycle of sterilization, spore strips are incubated in a fluid medium **at 37°C for 48 hours** → absence of bacterial growth indicates efficient sterilization cycle.

2. Dry heat sterilization

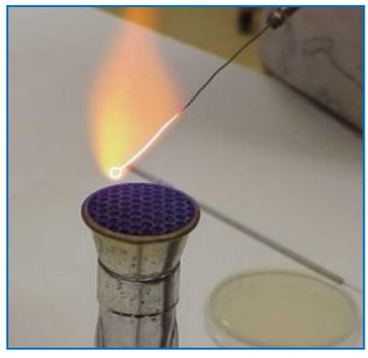
Includes the following forms:

1. Incineration

Particularly applicable for **dead animal bodies**, **infectious hospital waste** such as used surgical dressings, needles...etc.

2. Red heat

Inoculating **wires**, **loops** and **points of forceps** are sterilized by **holding them in the flame until they are red hot**.



Red heat

3. Dry heat sterilizers o hot air ovens

- The method employs **dry hot air as the sterilizing agent**.
- The most common time-temperature relationships are:
  - → **170°C for 60 minutes**
  - → **160°C for 120 minutes**
  - → **150°C for 150 minutes**
- ***Bacillus atrophaeus*** spores should be used as a **biological indicator**.
- Mode of action → **killing** is **due to oxidation of the microbial cell constituents**
- This method is used for materials that might be damaged by moist heat **(e.g., powders, petroleum products, sharp instruments)**.

- **The advantages for dry heat include the following:**
  - * **It is non-toxic**
  - * **Relatively inexpensive**
  - * **It is noncorrosive for metal & sharp instruments**.

- **The disadvantages are:**
  - * **The slow rate of heat penetration**
  - * **Time-consuming**
  - * **High temperatures** are **not** suitable for most materials.

3. Low temperature sterilization methods

1. Hydrogen peroxide gas plasma

- Gas plasmas have been referred to as **the fourth state of matter** (i.e., liquids solids, gases, and gas plasmas).
- **Gas plasmas are generated in an enclosed chamber under deep vacuum using radio frequency or microwave energy** to excite the gas molecules and produce charged particles, many of which are in the form of free radicals.
- The free radicals interact with essential cell components **(e.g., enzymes, nucleic acids)** end thereby disrupt the metabolism of microorganisms, in addition to the direct inactivation by hydrogen peroxide.
- Total time of sterilization cycle is about **50 minutes.**
- **Medical materials and devices that cannot tolerate high temperatures and humidity**, such as some plastics, electrical devices, and corrosion-susceptible metal alloys, can be **sterilized by this method**.
- G. stearothermophilus **(formerly Bacillus stearothermophilus)** spores are used as a biological indicator to monitor efficiency of the sterilization process

2. Ethylene oxide gas sterilization

- Exposure time is long and varies **from 3 to 6 hours**.
- The method is expensive with probable toxicity.
- It can be used for instruments that cannot be subjected to steam.
- **Bacillus atrophaeus (formerly B. subtilis)** spores are used as a **biological indicator.**

3. Peracetic acid sterilization

- It is used to sterilize medical, surgical, and dental instruments **(e.g. endoscopes, arthroscopes).**
- Peracetic acid denatures proteins, disrupts cell wall, and oxidizes proteins and enzymes of microbes.

4. Other sterilization methods

1. Ionizing radiation

* Sterilization by ionizing radiation can be obtained by **cobalt 60 gamma rays** or **electron accelerators (β-rays)**

* Ionizing radiation has a **high penetrating power** → and is, therefore, used for sterilization of prepacked heat-sensitive items such as bone grafts, surgical sutures, disposable plastic syringes, gloves, catheters and plastic Petri dishes.

* ***Bacillus pumilus*** spores are used as a biological indicator to monitor efficiency of radiation sterilization**.**

2. Filtration

* A process used to remove bacteria from **thermolabile pharmaceutical fluids (antibiotic solutions hormones, vitamins)** that cannot be purified by any other means.

* Fluids can be rendered free of bacteria by passage through bacterial membrane filters with pore size as small as **0.22 µm**.

* Filters can also be used to remove microorganisms from air supplied to critical areas such as operating rooms, drug factories and laboratory biosafety cabinets.

* Such filters are known as high efficiency particulate air **(HEPA)** filters which can provide sterile air at the filter face

* The endopigment producing ***Serratia marcescens*** may be used to **test the efficiency of bacterial membrane filters**,
→ while spores of the fungus Aspergillus may be used to test the efficiency of HEPA filters.

3. Ozone

* Ozone **(O_3)** consists of **O_2** with **a loosely bonded third oxygen** atom that makes ozone a powerful oxidant that destroys microorganisms.

* Ozone has been used for years as a **drinking water disinfectant**.

4. Formaldehyde Steam

* Low-temperature sterilization method that involves use of **formalin**, which is vaporized into **formaldehyde gas**.

* The method may be used in healthcare facilities to sterilize heat-sensitive medical equipment such as the mechanical ventilator and incubators for neonates.

* Unfortunately **formaldehyde is a mutagen and a potential human carcinogen**, therefore must be regulated and fully contained to guarantee the permissible exposure limit of healthcare workers for formaldehyde.

5. Infrared radiation

Test Yourself

1) **One of the following statements is CORRECT:**
   a- Sterilization is complete removal or inactivation of all forms of microbial life
   b- Disinfection is elimination of all pathogenic organisms including spores
   c- Low level disinfection is effective against Mycobacterium tuberculosis
   d- Antiseptics are chemical disinfectants applied to surfaces and floors
   e- High level disinfection is enough for surgical instruments and needles

2) **Pasteurization:**
   a- Is generally performed at 87°C for 30 minutes
   b- Can destroy important pathogenic organisms
   c- Is a method of sterilization
   d- Is done by hot water at temperatures higher than 100°C
   e- Cannot destroy Mycobacterium tuberculosis

3) **Regarding hot air oven:**
   a- It is used to sterilize powders and petroleum products
   b- The sterilizing agent is moist heat
   c- It has a corroding effect
   d- It doesn't necessitate prolonged exposure
   e- It is characterized by rapid and even penetration of heat into the materials to be sterilized

4) **Regarding biological indicators for monitoring autoclaves:**
   a- They are placed at the hottest part of the chamber
   b- They change their colour at 121°C
   c- They are paper strips containing the spores of G. stearothermophilus
   d- Presence of bacterial growth indicates an efficient sterilization cycle
   e- They are checked for colour change at the end of each sterilization cycle