HYGIENE IN MEDICAL TECHNOLOGY
Recommended Reference

- Springer Handbook of Medical Technology, Rüdiger Kramme, Klaus-Peter Hoffmann, Robert S. Pozos (Eds), Springer-Verlag, Heidelberg, 2011.
The application of new technologies in medicine leads to therapeutic and diagnostic advancements, yet also causes risks for patients to acquire health-care associated infections.

- Almost half of all infections contracted by patients in hospital were fully or partly associated with medicotechnical measures.

- It is important to know precautions to prevent the transmission of infectious agents from inanimate medicotechnical sources.
Goals of Hygiene Measures

- Hygiene measures in the context of medical technology devices must pursue the following goals:
  - Protection of employees during handling
  - Protection of patients during use of medical devices against transmission of germs, which can lead to:
    - Contamination
    - Colonization
    - Infection

- Disinfection aims to prevent transmission of pathogens
  - Complete freedom from germs (sterility) is not guaranteed in disinfection

- Sterilization aims to guarantee complete killing of germs
Causes of Infection

- Natural bacterial colonization present in human skin can be divided into permanent and temporary
  - Permanent germs are always present, whereas temporary germs are acquired and therefore change according to what the person has been handling or what work he/she has been carrying out
  - Washing the hands eliminates the majority (> 90%) of this acquired contamination but leaves the permanent bacterial colonization undisturbed
  - Disinfecting the hands or skin should completely eliminate acquired germs, but it also has an adverse effect on the permanent skin colony

- Skin and mucous membranes are mechanical barriers which, when intact, prevent microorganisms from penetrating into our bodies
  - Damage to skin and mucous membranes is always accompanied by increased risk of infection
Causes of Infection

- **First Step:** germ manages to attach to skin or mucous membranes
  - If this colonization persists, although it does not result in illness, the patient or member of staff would become an (undetected) source of further transmission

- **Second Step:** germ is able to deploy its pathogenic properties and this would lead to an infection
  - depending on state of health of affected individual, this can result in illness which varies in its severity

- **Requirements for infection to develop are:**
  - Infectious agent
  - Person susceptible to infection
  - Contact which enables the germs to colonize individual such that infection can develop
## Chemical Disinfection

- Chemical disinfection
  - Disinfection of hands, skin, and mucous membranes
  - Disinfection of surfaces
  - Disinfection of instruments

<table>
<thead>
<tr>
<th>Active substance</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Field of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohols</td>
<td>Fast-acting, no residues, low toxicity, pleasant odor</td>
<td>Not sporocidal, combustible/explosive, expensive</td>
<td>Hand disinfection, skin disinfection, small surfaces</td>
</tr>
<tr>
<td>Iodine/iodophosphorus compounds</td>
<td>Does not irritate mucous membranes, fast-acting</td>
<td>Allergies possible, naturally colored, (side-effects on thyroid?)</td>
<td>Skin disinfection, mucous membrane disinfection, hand disinfection</td>
</tr>
<tr>
<td>Formaldehyde/aldehyde</td>
<td>Broad spectrum of activity, biodegradable</td>
<td>Irritant, allergenic, moderately toxic, (carcinogenic?)</td>
<td>Surfaces, instruments, disinfection of rooms</td>
</tr>
<tr>
<td>Quaternary ammonium compounds</td>
<td>Good detergent action, low odor, low toxicity</td>
<td>Gaps in effectiveness, inactivated by soap and protein</td>
<td>Disinfection of surfaces in special areas (kitchen)</td>
</tr>
<tr>
<td>Peracids/peroxides</td>
<td>Broad spectrum of activity, fast-acting</td>
<td>Inactivated by protein, corrosive, irritant, unstable</td>
<td>Surfaces, instruments</td>
</tr>
<tr>
<td>Phenols</td>
<td>Low impact because of environment</td>
<td>Gaps in effectiveness, barely biodegradable</td>
<td>Disinfection of excretions, otherwise obsolete</td>
</tr>
</tbody>
</table>
Thermal Disinfection

- Items are subjected to effect of saturated steam
- **Steam flow process**
  - Air is forced out of chamber and items using saturated steam
  - Disinfection temperature is 100–105 °C, applied for at least 15 min
- **Fractionated vacuum process (vacuum–steam–vacuum (VSV))**
  - Steam which is largely free of air and foreign gases is necessary
  - Disinfection chamber must be vacuum-tight
Application Times and Ranges of Action

- A – suitable for killing vegetative bacteria, including mycobacteria, as well as fungi, including fungal spores
- B – suitable for inactivating viruses
- C – suitable for killing spores of the anthrax pathogen

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Duration (min)</th>
<th>Range of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>20</td>
<td>A, B (except viral hepatitis)</td>
</tr>
<tr>
<td>105</td>
<td>1</td>
<td>A, B</td>
</tr>
<tr>
<td>105</td>
<td>5</td>
<td>A, B, C</td>
</tr>
</tbody>
</table>
Comparison of Chemical and Physical Disinfection Processes

Disadvantages of Chemical Disinfection
- Gaps in effectiveness, contamination
- (Primary) bacterial resistance
- Adaptation (biofilm formation)
- Possible distribution of germs in the hospital (central units)
- Dependence on concentration, temperature, and pH
- Decomposability, loss of effectiveness
- Inactivation by soap and protein
- Limited ability to penetrate organic material
- Risk of decontamination
- Disinfectant residues in the material (e.g., rubber)
- Material corrosion
- Health effects for staff and patients
- Pollution of the workplace and environmental damage
- High costs
- Increase in the volume of refuse.

Advantages of Physical Disinfection Processes
- Lower costs
- Lower impact on the environment
- Higher degree of reliability
- Automated operation possible
- Cleaning, disinfection, and drying in one process
- No toxicity and no allergization
- Testing for effectiveness.
Sterilization

- Processes validated to perform required sterilization function
  - Physical processes
  - Steam sterilization
  - Hot air sterilization
  - Physicochemical processes
  - Ethylene oxide gas sterilization
  - Formaldehyde gas sterilization
  - H$_2$O$_2$ low-temperature plasma sterilization

<table>
<thead>
<tr>
<th>Level of resistance</th>
<th>Temperature (°C)</th>
<th>Application time</th>
<th>Pathogens recorded</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>100</td>
<td>Seconds to minutes</td>
<td>Vegetative bacteria, fungi including fungal spores, viruses, protozoa</td>
</tr>
<tr>
<td>II</td>
<td>105</td>
<td>5 min</td>
<td>Bacterial spores with a lower level of resistance, e.g., anthrax spores</td>
</tr>
<tr>
<td>III</td>
<td>121 or 134</td>
<td>15 min or 3 min</td>
<td>Bacterial spores with a higher level of resistance</td>
</tr>
<tr>
<td>IV</td>
<td>134</td>
<td>Up to 6 h</td>
<td>Bacterial spores with a high level of resistance</td>
</tr>
</tbody>
</table>
Targeted Measures to Prevent Transmission of Germs and Infections

<table>
<thead>
<tr>
<th>Type of transmission</th>
<th>Features</th>
<th>Examples</th>
<th>Protective measures</th>
</tr>
</thead>
</table>
| Airborne transmission| Microorganisms attached to particles in the air with size of <5 μm, movement over a relatively long period of time therefore possible | 1. Reasonable suspicion of or confirmed tuberculosis  
2. Measles  
3. Varicella/disseminated herpes zoster  
4. HIV patients with cough, fever, and opaque pulmonary infiltrates, provided TB cannot be ruled out | 1. Isolation in a single room (door and windows closed), cohort isolation potentially possible  
2. Respiratory protection when entering the room if open-lung TB is identified or there is strong clinical suspicion  
3. In the case of certain diseases (measles, varicella) nonimmune people should not enter the room; if unavoidable, only with respiratory protection |
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| Droplet transmission | Microorganisms attached to particles >5 μm (these droplets are created when speaking, coughing, and sneezing) | 1. Bacterial diseases: *H. influenzae* (type B) infections, meningococcal infections, multiresistant pneumococcal infections, diphtheria, pertussis, mycoplasma pneumonia infections  
2. Viral diseases: influenza, mumps, rubella, parvovirus infections | 1. Single room, cohort isolation if necessary; if not possible a distance of at least 1 m should be kept between the infectious patient and other patients or visitors  
2. Mouth and nose protection required when working close to the patient (<1 m distance) |
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| Contact transmission | Direct contact (touching) or indirect contact (secondary, e.g., via contaminated surfaces) with epidemiologically important pathogens in the case of infected or colonized patients | 1. Infectious diarrheal diseases  
2. *C. difficile* enteritis  
3. Respiratory infections in children (bronchiolitis, croup)  
4. Multiresistant pathogens such as Methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant *Enterococcus faecium* (VRE) (except multiresistant TB)  
5. Abscess or secreting wounds which cannot be covered | 1. If possible single room; cohort isolation if necessary  
2. Gloves and gowns depending on the pathogen and site of the infection (follow infection control recommendations)  
3. Disinfect hands on leaving the room |
Suggested Readings and Assignments

- Chapters 3 of Recommended Reference
- Problem set posted on web site