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Advanced Infection prevention Management Solutions

Thermal reduction

Destruction of microorganisms

Key facts

- Heat is the most reliable means of inactivating/ killing microorganisms
- Microorganisms show high variability in heat tolerance
- Thermal reduction is mathematically described as a logarithmic process

Heat as a means of inactivation or rather destruction of **microorganisms** can either be applied as moist or dry heat. Both methods are reliable but when applicable moist heat is more effective as steam is a better heat conductor than air and thus exposure times shorten significantly because proteins lose their functionality more readily in moist conditions [1].

Microbial heat resistance

Each microbial species has its own particular heat tolerance. Important variants in microbial resistance are the composition of the outer membrane, metabolism and developmental stage of the microbial organism. Outer membranes vary in their chemical composition not only across species but also during developmental stages e.g. spores and resting stages which are encased in special hulls to protect the organism from external influences. Viruses have no metabolism of their own and are dependent on their host's cells to replicate, so there is no metabolic activity to be targeted. Furthermore, contrary to other microorganisms viruses without an outer protein hull are more resistant than enveloped ones [2, 3].

The principle of heat destruction

Heat targets proteins. These essential biomolecules are sensitive to temperature and start losing their functionality at 55°C, dependent on composition and intermolecular binding. This process is called **denaturation** and is based on breaking and rebonding on a molecular structural level. Once the native structure of a protein is destroyed through the process of denaturation it cannot be reassembled to regain its biological activity [1].

The thermal death time curve and the D-value

Killing microorganisms is a time and temperature dependent process which results in a thermal death time curve for each organism. The process of microbial elimination by means of heat follows a logarithmic procession (see also **logarithm, exponentiation**). Meaning that during each passing time unit at a certain temperature the number of viable bacteria will be reduced by the same percentage, regardless of the number of bacteria. Also, by altering the applied temperature, holding times shorten or lengthen respectively. Consequently, anywhere along a death time curve represents the same degree of lethality [2].

Based on this dependence the **D-value** (decimal reduction time) has been defined as the necessary holding time, at a certain temperature, to eliminate 90% of a microbial population, thus can be determined for different microbial species and temperatures [2, 3]. Hence the D-value serves as parameter in evaluating and monitoring sterilisation procedures.

Bacteria species	Temperature (°C)	D-value (time)
Salmonella thyphi	65	1 s
Vibrio cholerae	65	3 s
Mycobacterium tuberculosis	75	5 s
Staphylococcus aureus	80	2 s
Bacillus anthracis	100	15 min
Bacillus stearothermophilus (endospores)	121 (121/134)	2-5 min (15/3 min)
Clostridium botulinum A and B	121	10-20 s
Endospores C. botulinum	120	20 min
Endospores C. tetani	134	3 min

The table shows selected bacteria species or developmental stages and their respective D-values at defined temperatures e.g. when a temperature of 65°C is applied to a population of Vibrio cholerae 90% of the present population will be killed off after 3s.

Bibliography:
[1] ÖSGV Fachkundelehrgang: Weiterbildung Sterilgutversorgung – Grundlagen der Aufbereitung von Medizinprodukten
[2] Thermal destruction of microorganisms, Article by Goff D. University of Guelph
[3] ÖSGV Fachkundelehrgang: Weiterbildung Sterilgutversorgung – Grundlagen der Sterilisation
[4] Medizinische Mikrobiologie und Infektiologie, Kapitel Sterilisation und Desinfektion